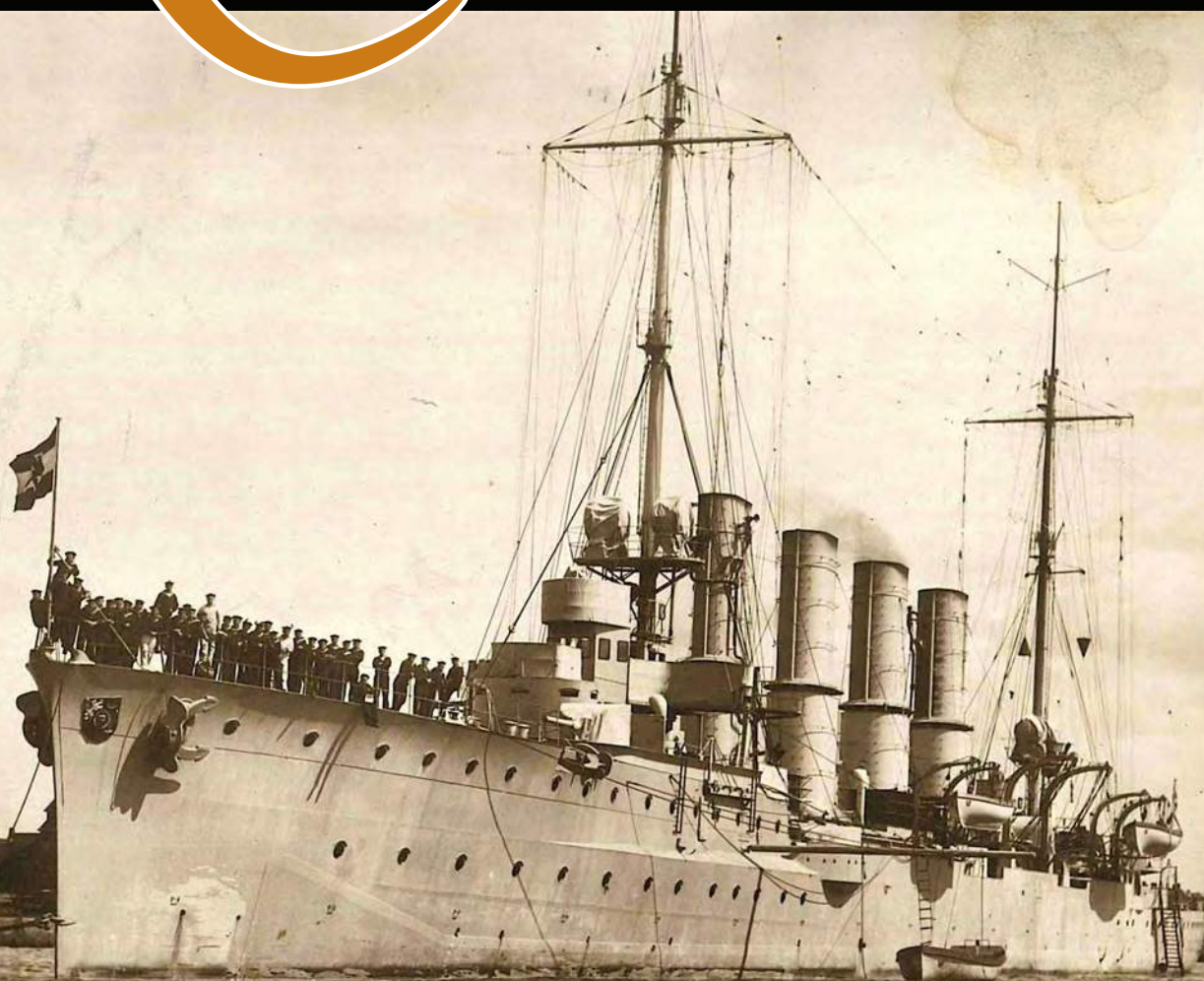


The Journal of Global Underwater Explorers

Quest

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S.M. Turbinenkreuzer „Breslau“

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- A Different Light
- The Ship That Changed History: The German Imperial Light Cruiser S.M.S. *Breslau*
- The PBM Mariner Project
- Bombs at Bikini: Operation Crossroads
- The Glamorous World of Underwater Cave Exploration

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Beth Murphy

SENIOR EDITOR

Panos Alexakos

DESIGN EDITOR

Sheila D. Hardie

PHOTOGRAPHERS

Kathryn Arant

Kees Beemster Leverenz

JP Bresser

Katy Fraser

Dimitri Galon

Natalie Gibb

John Kendall

Jesper Kjøller

Megan Lickliter-Mundon

Claudio Provenzani

Derk Remmers

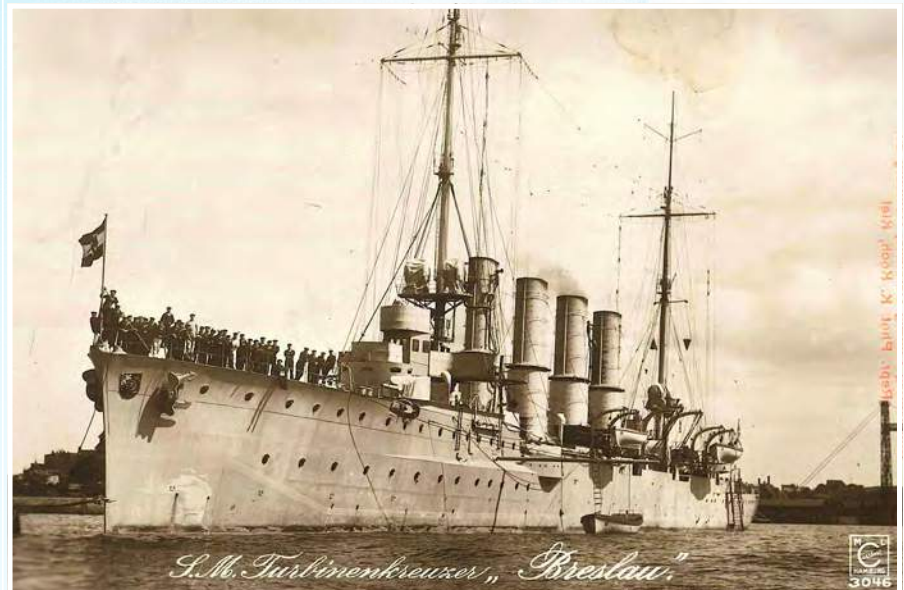
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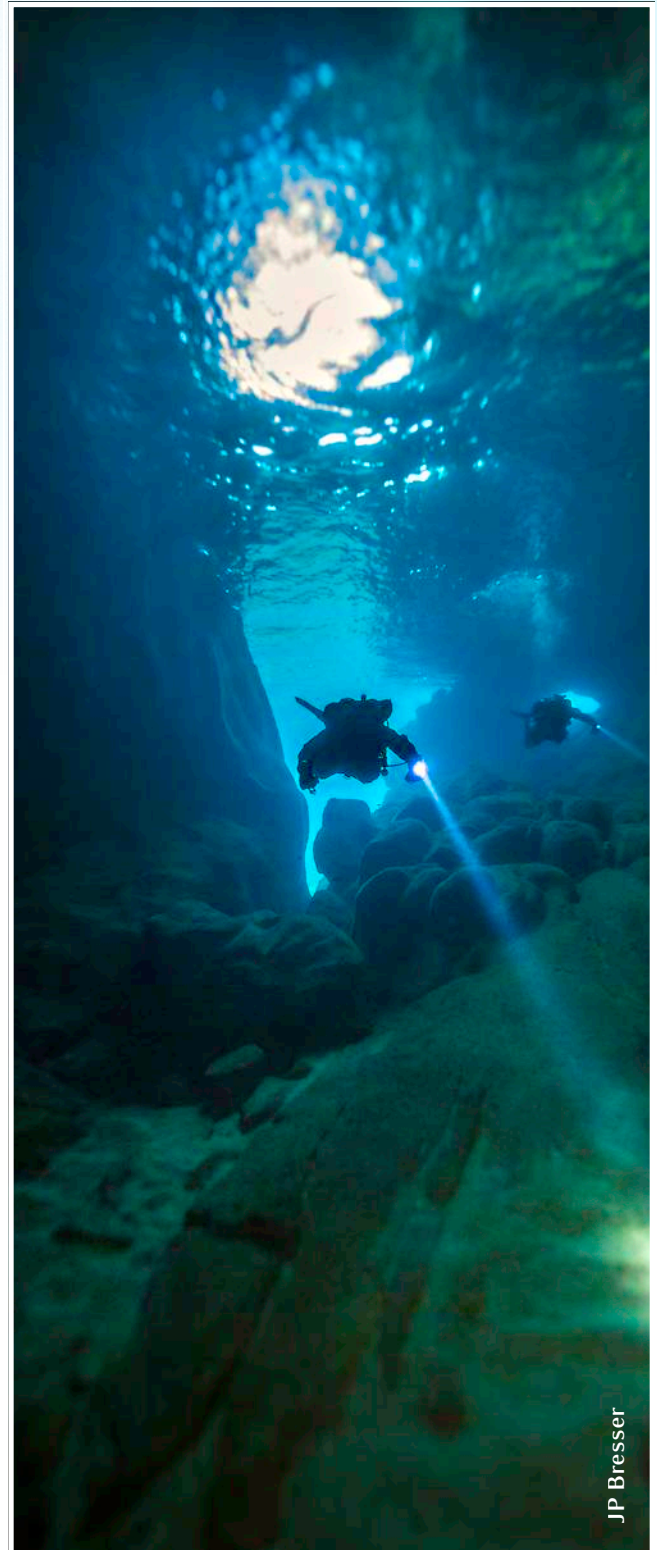
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JP Bresser



Decompression: Revisiting Old Assumptions

By Sergio Rhein Schirato



Decompression sickness is a complex condition that is still not entirely understood.

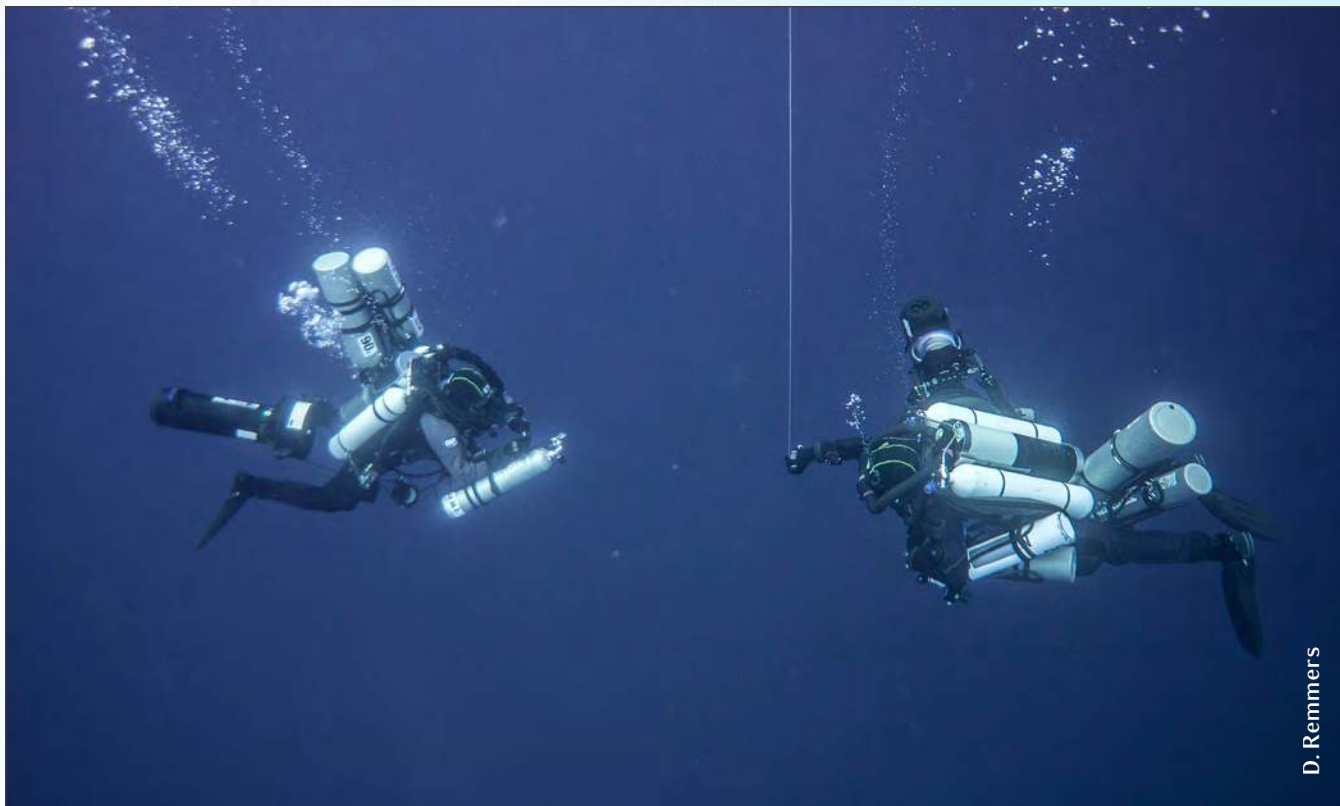
THE first comprehensive attempt to understand the illness related to the exposure to hyperbaric environments was led by John Scott Haldane in collaboration with Arthur Edwin Boycott and Guybon Chesney Castell Damant, and published early in the 20th century as “The Prevention of Compressed-air Illness.”¹ In retrospect, the methodology used in the study, the assumptions that different tissues would absorb and eliminate gas at different rates and how he modeled it, and the arguments used against the linear decompression (a method widely used at the time) are remarkable, especially if the knowledge and resources available at the time are taken into consideration. In many respects, most of Haldane’s conclusions remain the basis for many procedures still in use today. With a few improvements to supersaturation values, and other refinements (or “fit-to-reality adjustments”), the differential equations used

by Haldane are the same ones used in almost every computer or software available on the market today.

Given the information that was available at the time, it is understandable that Haldane and his coworkers treated the matter as a physical (or mechanical) problem caused by bubbles forming during decompression. Having said that, it is worthwhile to note that in this study they specifically recognized that many of the animals that died did not reveal signs of bubbles during necropsy and Haldane speculated that bubbles may have formed in parts of the body they did not study.

Nevertheless, he laid the foundation for an idea that is still very much accepted: decompression sickness (DCS) is a mechanical problem caused by bubbles.





It's long been thought that a lack of bubbles indicated a successful decompression.

The purpose of this article is to discuss this and some other assumptions widely accepted as true by the diving community in light of recently published studies.

ASSUMPTION 1: VENOUS GAS EMBOLI ARE FORMED DURING DECOMPRESSION AND FILTERED BY THE LUNGS, WHILE BUBBLES FORMED IN OR TRANSPORTED TO THE TISSUES ARE THE CAUSE OF DECOMPRESSION SICKNESS.

For many years it was believed that bubbles were related to decompression sickness and that their absence would mean a successful decompression. However, with the development of Doppler ultrasound technology late in the 1970s, it became clear that even mild exposures to hyperbaric environments and subsequent decompression would lead to bubble formation in the venous circulation. Though bubbles were commonly found in the right chambers of the heart, Doppler echocardiograms showed that most of them were filtered by the lungs and were not observed in the left chambers of the heart. In theory, bubbles would be pumped from the left chambers into the systemic circulation, which would send them to the central nervous system, causing the neurological symptoms of decompression sickness. This finding led to the endless discussion about the role of cardiac or pulmonary shunts in decompression sickness since the existence of a shunt would allow the migration of bubbles from the venous to the arterial (i.e., systemic) circulation, bypassing the filtering effect of the lungs.

While this statement might hold true for large venous gas emboli most of the time, there are other facts that must be considered:

(1) Patent foramen ovale (PFO), a remnant of our fetal circulation, is found in approximately one-third of the population; (2) pulmonary shunts are, among other things, a physiological response to handle the cardiac afterload, and different studies with high-performance athletes have shown that all subjects studied presented some level of pulmonary shunting as the physical effort to which they were submitted increased; (3) the central nervous system has fast inert gas kinetics,² meaning that bubbles eventually shunted through the heart to these tissues tend to lose gas to the media, being reduced in size and quickly collapsing. This assumption can be supported by the fact that the gold standard for PFO detection is the transesophageal echocardiogram coupled with the injection of agitated (full of bubbles) saline solution, in which gas serves as a contrasting media to the ultrasound. There are no known cases of decompression sickness-like symptoms related to the use of such contrast, even when bubbles are clearly shunted to the left atrium.

Additionally, post-dive bubbles detected by Doppler have diameters larger than 30 μm . A recent study using contrast-enhanced imaging techniques capable of detecting bubbles with diameters smaller than 10 μm indicated the presence of smaller emboli in both sides of the heart, demonstrating that: (1) there are small bubbles in humans that are not filtered by the lungs; (2) there are small bubbles even in the absence of larger venous gas emboli; and (3) smaller bubbles follow a different timeline than larger venous gas emboli.³ Bubbles forming in the arterial circulation have also been identified in previous studies though their role in decompression sickness, especially in the presence of neurological symptoms, is yet to be understood. Vascular bubble

models, designed to study nucleation on a flat hydrophobic surface and how they expand to form bubbles after decompression, hold great promise for the improvement of decompression procedures in the future.⁴

ASSUMPTION 2:
MECHANICAL DAMAGE
CAUSED BY BUBBLES IS DUE
TO DECOMPRESSION
SICKNESS.

Several studies over the past two decades have shown that decompression has many physiological implications, ranging from reduction in endothelial function to activation of the immune system. As discussed above, formation of bubbles is a common finding in subjects exposed to hyperbaric environments and subsequent decompression. The causal relationship between bubbles and physiological alterations, however, is yet to be proven. In recent years, the endothelial dysfunction hypothesis, which postulates that microparticles associated with endothelial damage act as nucleation sites for bubble formation, has drawn attention and gained support. This has resulted in decompression sickness being seen not as merely a physical or mechanical problem, but instead as a result of a complex biochemical process.

Recent studies have shown that the exposure to high-pressure environments is sufficient to increase the production of IL-1 β , an interleukin that belongs to cytokines, which is an important mediator in inflammatory responses.⁵ The mechanism behind the formation of such microparticles is related to high inert gas pressure through a mechanism that causes singlet oxygen formation, a potentially toxic free radical initiated by a cycle of actin S-nitrosylation, nitric oxide synthase-2, and NADPH oxidase activation ultimately leading to microparticle formation.⁶ Despite their harmful effects to the host, the production of reactive oxygen species (ROS) is part of an orchestrated physiological response of the immune system to stop bacteria and fungus. Exposure to high inert gas pressures, even in the absence of decompression, is apparently linked to an increased production of ROS. The potential to trigger this reaction depends on the gas and follows the rank: argon \sim nitrogen $>$ helium.⁷ This ranking might explain the reduced endothelial dysfunction identified after hyperbaric exposures where helium was part of the breathing mix.⁸

The mechanism behind decompression sickness appears to be more complicated than the simple growth of bubbles, and a lot remains to be understood.



Decompression sickness is not just a physical or mechanical issue.

ASSUMPTION 3: DECOMPRESSION PROFILES WITH DEEP
STOPS ARE SAFER.

With divers pushing the boundaries of deeper diving beyond military and commercial diving, and the introduction of helium in the breathing mixes in the 1990s, different decompression techniques for bounce (non-saturation) dives started to be tested. Richard Pyle, an American ichthyologist from Hawaii, was probably one of the first to publicly advocate for decompression stops deeper than those calculated by algorithms derived from Haldane's theory. On dives ranging in depth from 40 to 70 m, he correlated catching fishes with his overall feeling after diving, and attributed feeling better to the fact that when a fish was caught, he had to stop much deeper than determined by decompression algorithms to release gas out the fish's swim bladder. Decompression algorithms based on the control of bubble formation and growth including the Varying Permeability Model developed by David Yount, which is the most well-known algorithm based on this strategy (probably because it is open code software), require decompression stops at greater depths, corroborating Richard Pyle's conclusions. At some point, it became well-established within the diving community that deeper stops were mandatory and even Albert Bühlmann's ZHL 16 algorithm was adjusted; gradient factors were implemented to calculate deeper stops.

There is, however, no scientific data available to support the belief that the modification of the decompression schedule with the inclusion of deeper stops reduces the expected probability of decompression sickness. In reality, studies showed that slower ascents are related to higher counts of bubbles upon surfacing.⁹ Nevertheless, whether this translates to a higher probability of decompression sickness is another matter.



In what was probably the largest study comparing the incidence of decompression sickness in bubble-based models versus dissolved gas-based models (derived from Haldane's work), the Navy Experimental Diving Unit¹⁰ concluded that decompression schedules with deeper stops had higher incidence of decompression sickness. In this study, dive profiles with equal decompression times and to a depth of 51 m were calculated using each model. These were then compared for decompression sickness and venous gas emboli count. The deep stops schedule resulted in a significantly higher incidence of decompression sickness than the shallow stops schedule (10 cases versus three, a result significant at the 5% level of confidence). Interestingly, the bubble-based profile resulted in a higher maximum venous gas emboli grade count, as well as higher average grade count.

The reason behind the findings mentioned above might be related to the different supersaturation observed in tissues with higher half-times upon surfacing. Figure 1 illustrates total inert gas in each tissue upon surfacing, based on Albert Bühlmann's ZHL 16 algorithm, for two profiles calculated with different gradient factors (GF) to simulate decompression schedules generated by dissolved gas- and bubble-based models.

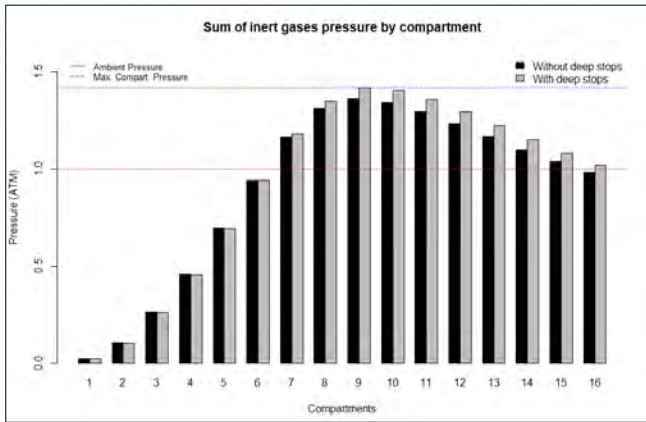


Figure 1

Both profiles were calculated to provide similar decompression times for a dive to 51 m of depth and a bottom time of 30 minutes. The profile with deeper stops generated higher supersaturation values in the slower compartments upon surfacing, while the profile without deeper stops generated higher supersaturation values in the faster compartments, which, presumably, tolerate higher inert gas pressures.

A better way to compare these two decompression schedules would be to compare the supersaturation in a given compartment produced by each one by subtracting the ambient pressure from the total inert gas pressure in a compartment (all calculations were made using an ambient pressure of 1 atmosphere). In Figure 1, only compartments 7 to 15 have internal inert gas pressures higher than ambient pressure upon surfacing, meaning that compartments 1 to 6 and 16 had total inert gas pressures below ambient pressure upon surfacing. The comparison between the two profiles can be seen in Figure 2.

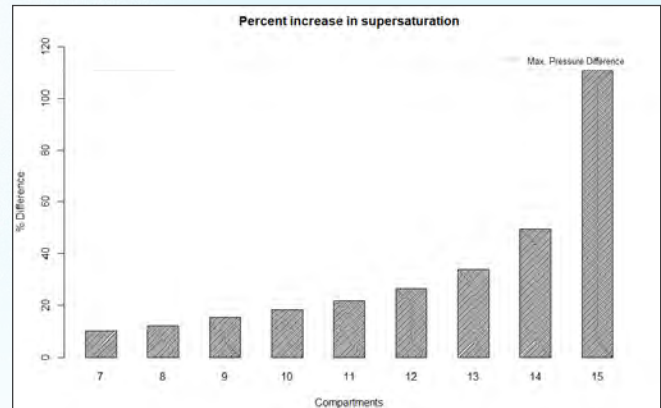


Figure 2

The decompression schedules with deeper stops generated supersaturation values as high as 2.15 times the supersaturation produced by the profile with shallower stops. This difference might be a possible explanation for the conclusions from the above-mentioned studies.

CONCLUSION

Over the past decades, many beliefs about decompression and decompression sickness have permeated the diving community, many of them based on ideas not supported by scientific evidence. Recent studies have demonstrated that in some cases, evidence points in the opposite direction. Decompression sickness is a multifactorial condition that involves the activation of many biochemical pathways, and the mechanisms behind it are still not fully understood. There is still a long way ahead and each new study helps to add another piece to this complicated puzzle.

"Decompression is an area where you discover that, the more you learn, the more you know that you really don't know what is going on. For behind the 'black-and-white' exactness of table entries, the second-by-second countdowns of dive computers, and beneath the mathematical purity of decompression models, lurks a dark and mysterious physiological jungle that has barely been explored."

— Karl E. Huggins, 1992





D. Remmers

Efficient decompression is as much an art as it is a science.

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The Sardinia Project

By Andrea Marassich



C. Provenzani

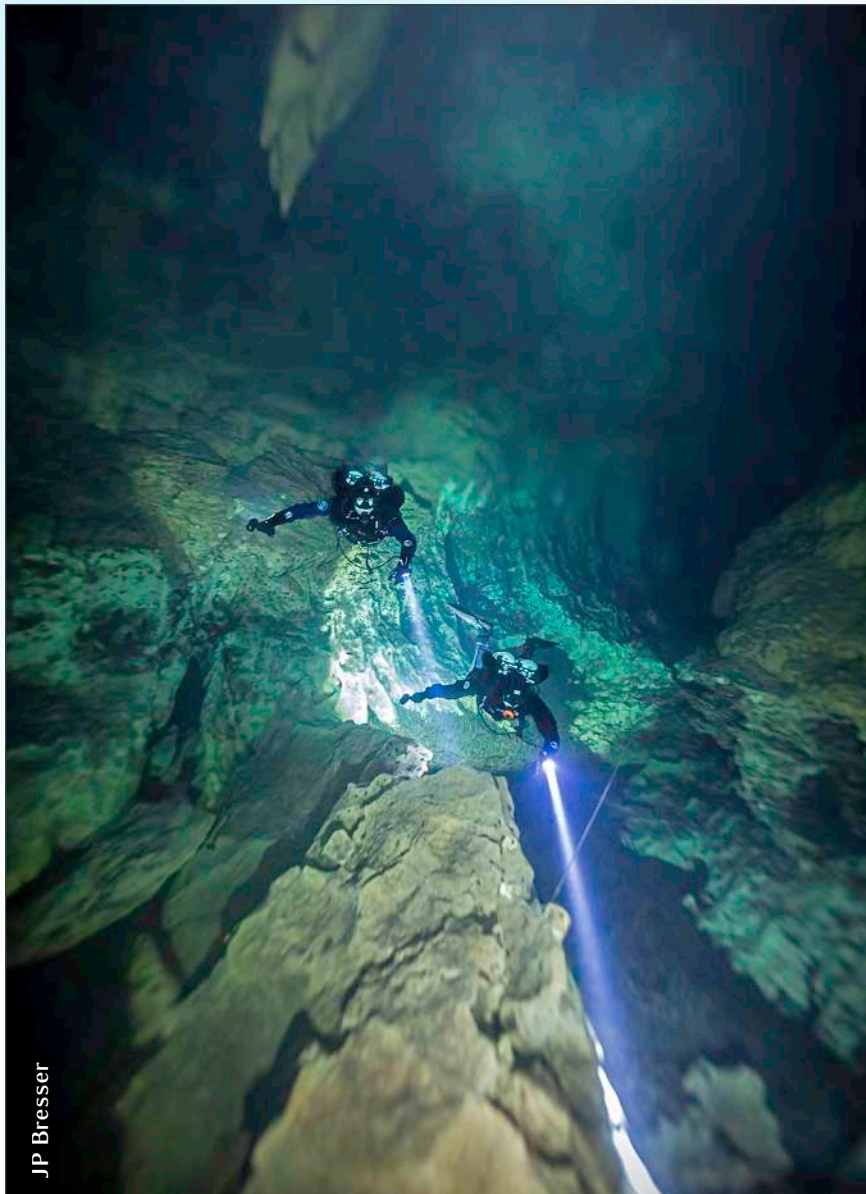
Sardinia is a hidden cave diving paradise full of exploration potential.

THE Mediterranean's marine caves are renowned for their biodiversity and ecological value, yet they are often poorly understood habitats due to the difficulties encountered in their exploration and monitoring. Citizen science can be the missing link in sorting this issue and we, as an organization, have the tools and capacity to provide researchers and local communities the ability to understand the ecosystem while promoting sustainable development.

Nine years ago, a friend invited me to dive the caves in Sardinia for a couple of days. Conditions were amazing and I discovered a hidden cave diving paradise in Europe. It was so good I immediately organized another week of cave diving with friends and started setting up classes in Cala Gonone.

Initially, most of the focus was recreational diving and learning to shoot pictures as the environment was ideal with its shallow decorated caves and great visibility. However, after learning that the entire coast of the Gulf of Orosei was once inhabited by a colony of monk seals, we decided to pursue the rumors that some fossilized bones might be found in the Bel Torrente Cave. As we began to collect imagery, we realized that our expectations of finding a few bones were inaccurate; we quickly learned that there were many more than we had anticipated.

While taking photos of monk seal fossils, we also began collecting sediment samples at the request of Dr. Elena Romano. These samples were taken from the initial portion of the caves to verify if some specific type of microscopic shells belonging to benthic



JP Bresser

Project Basline Sardinia focuses largely on helping researchers collect data.

foraminifera, like those she was studying in other marine sites, were present. After a lengthy wait, the laboratory of the research institute doing the analysis informed us that they were, in fact, present.

SCIENCE IS FUN

Project Baseline Sardinia developed exponentially during the last four or five years, growing from a friendly meet-up in the beautiful location of Cala Gonone, to an organized and structured operation dedicated to scientific research and conservation. Over time we focused more and more on science, devoting most of our first campaign in 2013 to the study of benthic foraminifera found in the marine coastal caves of the Gulf of Orosei. Our efforts have helped document the presence of foraminifera and to assess their reliability as ecological indicators in

submarine caves of temperate seas, such as the Mediterranean Sea, something that has never before been done.

By analyzing these organisms and species assemblages in the different parts of the caves, researchers were able to differentiate between cave environments using the presence or absence of specific benthic foraminifera species and the variability of abiotic parameters such as pH, salinity, dissolved oxygen (DO), temperature, and grain size.

In the long-term, this research may also provide a baseline for future sea-level monitoring of the Mediterranean Sea as the distribution of ecological zones is regulated by a mutual relationship between saline and fresh water masses. Finally, knowledge of the role of benthic foraminifera as indicators of environmental stress may benefit from studies in extreme environments such as marine caves where they respond to the wide temporal and spatial variation of environmental parameters.

Collecting these samples was labor-intensive and began with a precise survey of the cave with marked stations. Sampling stations were positioned 30 m (100 ft) apart along a transect from the entrance of the cave, where the water is brackish and a halocline is present, into the cave, where only freshwater is present. Water and sediment samples were collected in different plastic probes and containers, following a precise protocol to maintain standard quality and reliability of the data. Over the years we developed simple but efficient procedures to carry a bag with materials for up to 15 stations. Needless to say, trial and error was involved in the learning process and we

went from losing containers because they were too buoyant (and all of our bottom time was devoted to recovering them) to not having enough water in containers, which resulted in their being cracked by pressure. Divers also collected sediment cores in areas of the caves to specifically study the chronological evolution of the sedimentary records and of the foraminifera associations. Scootering back while holding a vertical sediment core can be quite challenging.

Another project goal is to protect, by documenting and mapping, Bel Torrente Cave's fossilized monk seal bones, which are today an endangered species on the IUCN red list. Despite having been partially discovered in 2004 by Professor Sgualdini¹ and dated 5,000 - 6,000 years old by Dr. De Waele et al in

¹ Sgualdini, L., 2004, Il cimitero delle foche: Anthe'o, review of the Gruppo Speleo-Archeologico Giovanni Spano Cagliari, v. 8, p. 20-25.



2009,² there was no complete published survey or documentation to date. After initially mapping and geo-referencing all the bones in 2014, we realized there are more than 248 pieces spread in a passage between 750 and 1,500 m (2,000 – 4,000 ft) inside the cave. Of course, seals could not have reached such a distance in an underwater cave and the fossils' presence that far into the cave is explained only by the different sea levels during ice ages. How they managed to get there and whether there was another entrance still have to be studied but we are now documenting all major bones and jaws with photogrammetry and 3D models.

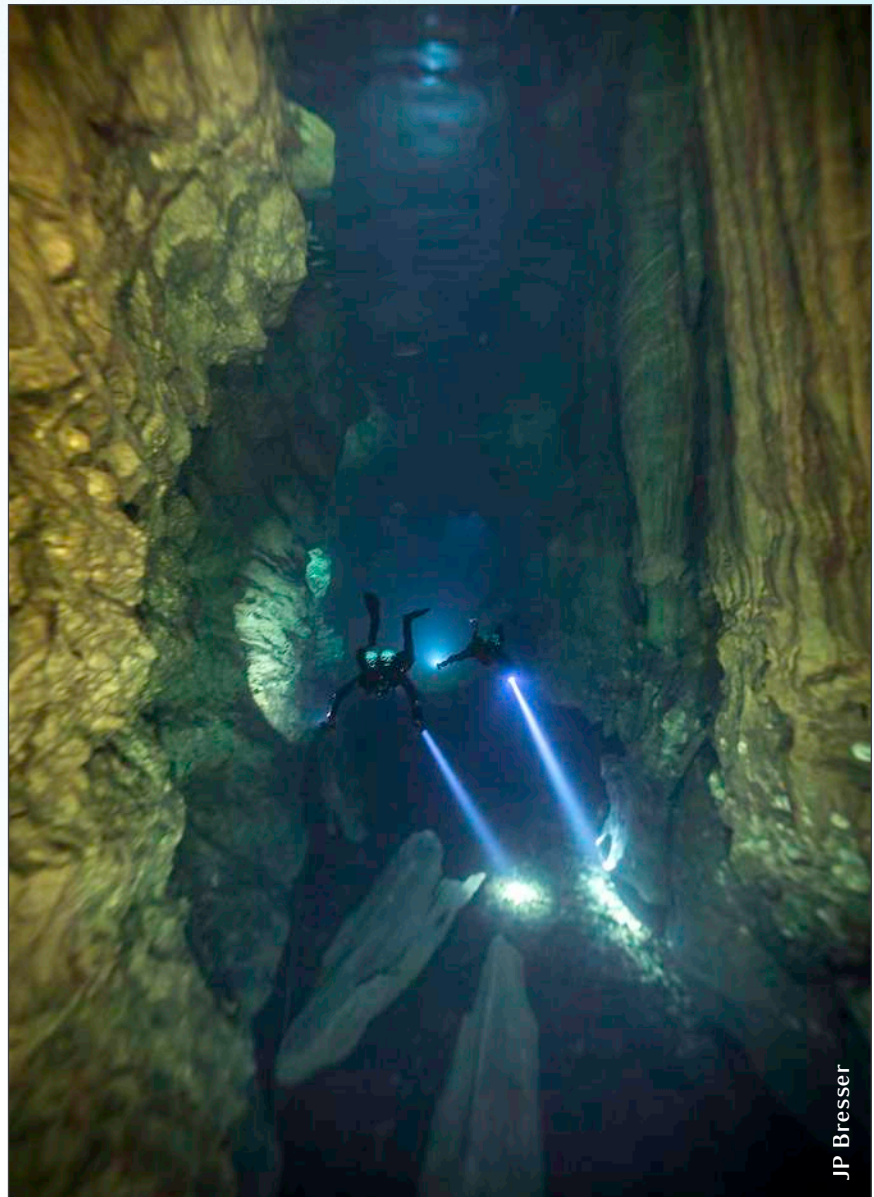
Next steps are both challenging and exciting; we are planning to create physical models of the bones and potentially some of the section of the cave where the fossils are located. Of course, this will require close cooperation with local organizations and some serious effort in photogrammetry and digital modeling.

Despite being one of the few projects of its kind, we hope the benthic foraminifera research could be reproduced in different areas of the Mediterranean and involve more scientific and research organizations.

THE SARDINIAN COASTLINE

The Sardinian coastline is one of the most beautiful geological features of the Mediterranean; high cliffs of white limestone dropping down into turquoise water were carved during geological eras by winds and the force of the sea. It is a well-known tourist destination because of the beauty of the landscape. In the north of the island there are many caves, both dry and submerged, which offer incredible opportunities not only to tourists and outdoor enthusiasts, but also to researchers.

North of the Gulf of Orosei, the village of Cala Gonone rests by the sea under a mountain made of basaltic rock; south of the Gulf, the town of Baunei returns the visitor to human civilization. Between the two lies the Gennargentu National Park, also known as Barbagia, an area that proved to be so wild and tough to conquer that only the ancient Nuragic civilization managed to create settlements here. They were the ancestors of the Sardinian inhabitants and left the remains of settlements, forts, and stone-carved glyphs in front of caves. Today, there are no



JP Bresser

Monk seal bones dated 5,000 to 6,000 years old were found in Bel Torrente Cave.

human structures remaining except for shepherds' sheds from the 19th century and trails for goats and mouflons, a subspecies of the wild sheep.

In the Gulf there are five major resurgences, underground freshwater rivers that discharge their waters into the sea. These resurgences are characterized as freshwater rivers with salt water intrusion from the sea (a similar genesis as the caves in Mexico). The features inside the underwater passages are extremely beautiful. They were formed partially as dry caves, and inside are multiple decorations and speleothems that document the different water levels during different ice ages.

² J. De Waele, G.A. Brook, and A. Oertel – Monk seal (*Monachus monachus*) bones in Bel Torrente Cave (central-east Sardinia) and their paleogeographical significance. *Journal of Cave and Karst Studies*, v. 71, no. 1, p. 16–23.

The caves are mostly long sumps with multiple connections with dry areas. This creates massive systems like the Bue Marino Cave, which now totals about 70 km of dry and underwater passages. The plateau above the cliffs, named Supramonte, hides a massive aquifer, which reappears only in the springs. The area is so vast that there are still huge portions to be explored. We can distinguish between the western Supramonte, where caves are inland and water is fresh, and eastern Supramonte, where the freshwater rivers end up in the above-mentioned springs on the coastline.

RAISING ENVIRONMENTAL AWARENESS IN THE COMMUNITY

During the 2018 summer session, we had more than 40 volunteers work together for two weeks. Though all GUE divers had different levels of experience and qualifications, ranging from Cave 1 to Rebreather (RB80 and JJ), they shared one common goal: assist researchers in their scientific studies.

The project carries out annual operations dedicated to sediment sampling, documentation, cave mapping, and geo-referencing the paleontological remains. This has been possible through the support of multiple volunteers who specialize in cave diving and surveying, dry caving, and photo/video rendering. There are also side tasks during these operations including organizing photo expositions and producing video documentaries to show local community members and tourists the treasures they can find in these waters, as well as increase community awareness of this extremely delicate habitat. Also, we try to assist local decision makers in supporting the development of the long-awaited marine protected area. More and more organizations, including research institutes, local entities like the aquarium of Cala Gonone, and private companies are becoming interested in these studies.



J. Kendall

Citizen science is a valuable tool to aid researchers limited by resources.

These collective efforts resulted in the spontaneous development of a vibrant community of divers who participate in the project on a regular basis. Their involvement gives them all a much deeper appreciation of the connections between diving and science, particularly in a region replete with biodiversity and exploration potential. We are very proud of our efforts to make citizen science a reality by involving all levels of divers, allowing them not just to work together, but to learn from each other.



The Ecological Features of Mediterranean Submarine Caves

By Elena Romano, Ph. D. and Luisa Bergamin



C. Provenzani

The submarine caves in the Gulf of Orosei are ideal for studying the effects of environmental change on a marine ecosystem.

THE Gulf of Orosei in Sardinia, Italy, hosts many submarine caves. Their origin, dating back to more than 3 million years ago, is mainly the result of the dissolution of carbonate rocks, increased by the mixing of salt and fresh water. Quaternary sea level changes also played an important role in their morphology (De Waele et al., 2009). The hydrographic network contributes to the increased flow rates inside the caves, especially during heavy rainfall. In particular, Bel Torrente Cave owes its name to high flow, which occurs generally twice a year.

Since these caves are located at the boundary between marine and inland areas, they are impacted when environmental conditions change due to the varied influence of fresh and salt water masses, which may be mixed or stratified, during rainy or dry periods. They are extreme environments due to the lack of light, scarcity of nutrients, and in some cases, low oxygen levels. For these reasons, submarine caves might be thought of as natural laboratories in which it is possible to study the effects of environmental variability of a marine system on a global scale, while looking for suitable organisms that can function as ecological indicators.

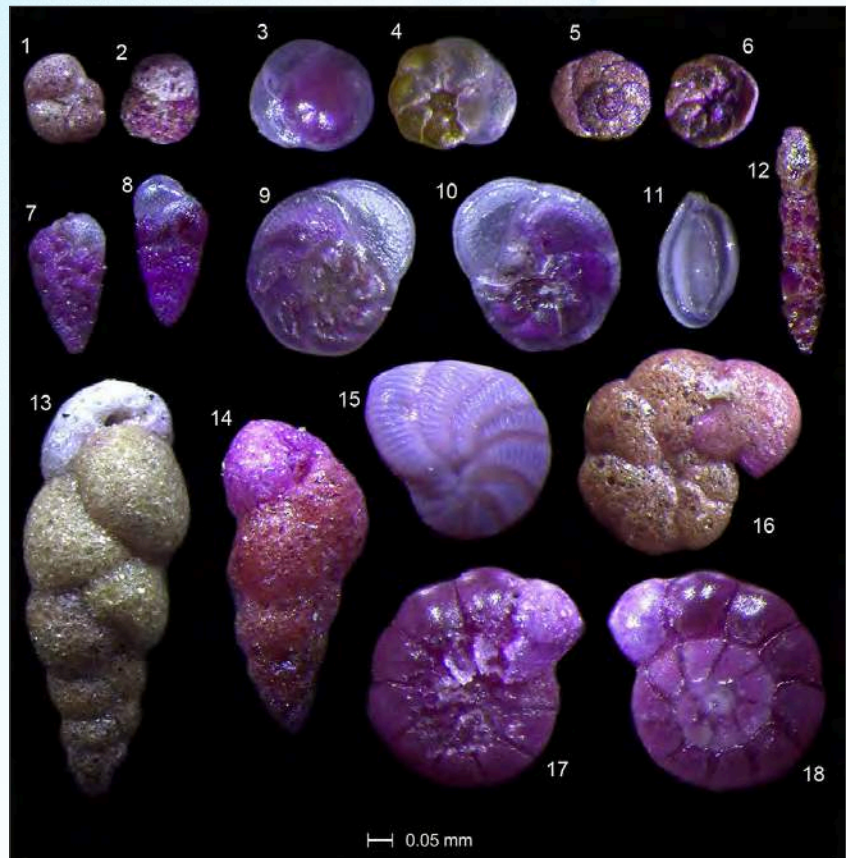


Although submarine caves are considered reservoirs of biodiversity, scientific research has been limited to only a few areas of the world, and organisms living in these habitats are still only partially known. This is mainly due to the difficulty of exploring and sampling, which must be carried out exclusively by divers who are trained both technically and scientifically. Sponges, crustaceans, and mollusks are among the most studied taxonomic groups in submarine caves; however, more recently, benthic foraminifera, a group of eukaryotic protozoa, were used as environmental indicators for the ecological zonation found exclusively in Mexican and Bermudian caves (van Hengstum et al. 2008; van Hengstum and Scott 2011).

Dr. Elena Romano is a researcher who conducts studies on benthic foraminifera in different marine coastal sites. Because they generally live in marine and transitional habitats, not freshwater, Romano was not sure she would find them in the caves. She was lucky, however, because she knew many GUE cave divers who were interested in participating in projects like hers. So, in 2014, she joined colleagues to conduct a study to determine if benthic foraminifera live inside caves and if these environments could be characterized from an ecological point of view.

Benthic foraminifera are abundant and diversified in marine sediments, and the different assemblages are in response to changes in environmental parameters such as salinity, sediment grain size, dissolved oxygen, and nutrient load. Most foraminifera have a hard shell called a *test*, which is preserved after the death of the organism, and may be calcareous perforate (hyaline), calcareous imperforate (porcelaneous) or made of sediment grains (agglutinated). Tests are sensitive to environmental changes and, consequently, well-differentiated communities (assemblages) characterize different environments; because of this, they are widely used in environmental and paleoenvironmental studies. Since they are generally abundant in transitional environments, foraminifera are considered to be an ideal tool to identify distinct environments in submarine caves and indicate where a strong environmental gradient is present.

The Sardinia Cave Project began in 2014 with the aim of applying scientific diving to the exploration and investigation of the submarine caves of the Gulf of Orosei. The scientific research focused on biotic and abiotic aspects of these environments, with particular attention devoted to the ecological response of benthic foraminifera to the spatial and temporal changes of the environmental conditions inside the caves (Bergamin et al., 2018; Romano et al., 2018b).



Common species in Bel Torrente and Bue Marino Caves.
In details: 1) *Ammoglobigerina globigeriniformis*; 2) *Ammoglobigerina globigeriniformis*; 3, 4, 6) *Gavelinopsis praegeri*, dorsal and ventral view; 5) *Lepidodeuterammina ochracea*; 7) *Bolivina pseudoplicata*; 8) *Bolivina variabilis*; 9, 10) *Rosalina bradyi*; 11) *Quinqueloculina stelligera*; 12) *Reophax dentaliniformis*; 13, 14) *Eggerella advena*; 15) *Peneroplis pertusus*; 16) *Cribrostomoides jeffreysii*; 17, 18) *Ammonia inflata*. (Courtesy of Dr. Elena Romano)

We started with two caves, Bel Torrente and the north branch of Bue Marino, each with a different morphology and setting. Bel Torrente's cavern area is at sea level, followed by a 5 - 20 m wide tunnel, where flow rate ranges from 100 to 1,000 s^{-1} during overflow periods. During dry conditions, the water discharge is scarce (Fancello et al., 2000; De Waele et al., 2009; Romano et al., 2018b). The Bue Marino Cave is a large system totaling more than 70 km and is composed of three main branches: southern, northern, and middle. The north branch is characterized by large conduits and a long succession of more than 40 sumps with many dry sections, for a total development of 7 km. It has a base flow of 40 s^{-1} , comes from four different subterranean springs, and discharges large amounts of fresh water (over 1 $m^3 s^{-1}$) during heavy periods of rain. The Ramo Mezzo is the least considerable in dimension and is probably linked to some smaller sinks. During base flow, sea water penetrates 300 m into the south branch, where a flowstone dam inhibits further mixing, and 1,500 m into the north branch (De Waele, 2004).



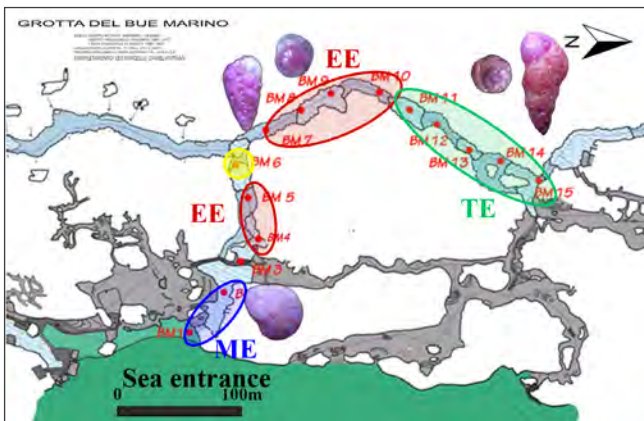


C. Provenzani

Divers collect sediment samples for a study on benthic foraminifera.

EXPLORATION, SAMPLING, AND ANALYSES

At present, four surveys (August 2014, April - May 2015, August 2016, and July 2018) have been conducted in Bel Torrente and Bue Marino caves, with the intent to monitor spatial and temporal changes of biotic and abiotic characteristics of the cave environments. They were re-surveyed and sampled by GUE cave divers with extensive scientific diving experience in a variety of underwater environments, especially those affected by extreme conditions. On the first survey, they defined the morphology of the cave environments and positioned a geo-referenced line on which 15 sampling stations were established at 30 m intervals,



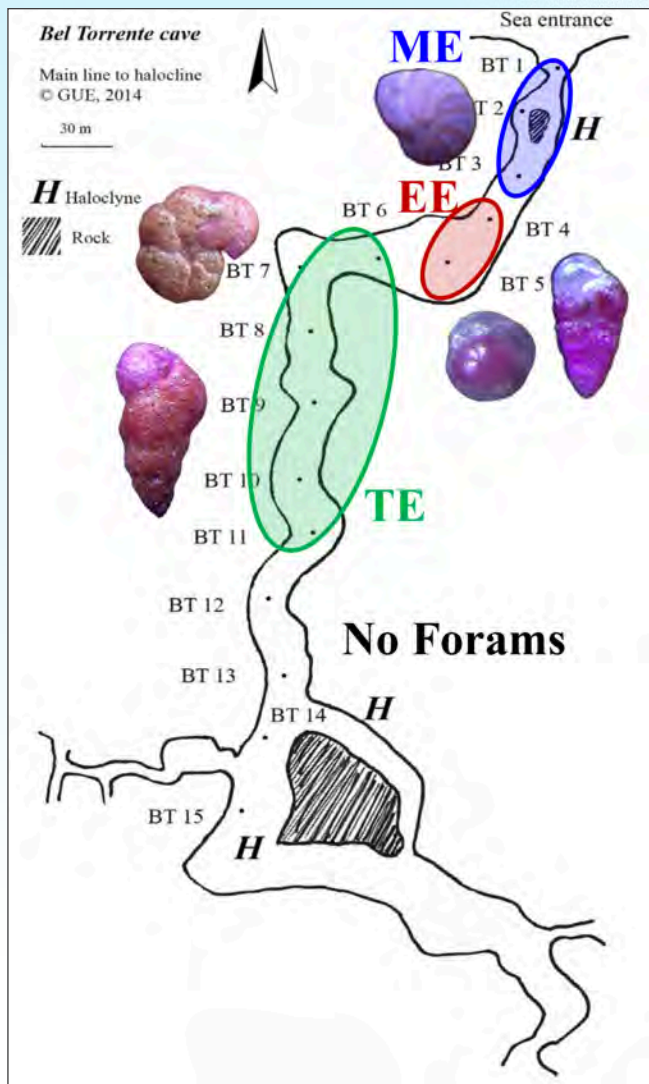
Ecological distribution of benthic foraminifera in Bue Marino Cave (Courtesy of Elena Romano)

starting at the cave entrance. These stations were successively sampled and in the last two years, based on the first data collection, the area of study was widened beyond the first 450 m in both caves, resulting in the collection of samples in cave sectors never before studied.

When sampling, divers measured temperature, salinity, dissolved oxygen (DO), and the acidity (pH) of the water. They also collected, according to a standard protocol, two aliquots of sediment to be analyzed in the Italian Institute for Environmental Protection and Research (ISPRA) laboratories: one for grain size and mineralogy, and the other for benthic foraminifera. Grain size was considered important for this study because it supplies information on hydrodynamic conditions, patterns of transport, and it strongly influences the distribution of benthic foraminifera. The study of benthic foraminifera, which starts under a microscope with the classification of a high number of individuals, is conducted on a quantitative basis using statistics to identify different assemblages, each one corresponding to a distinct environment, called “ecozone.”

RESULTS AND INTERPRETATION

During Summer 2014, more than 100 species of benthic foraminifera were collected from Bel Torrente and Bue Marino. In Bel Torrente, individuals were found up to 330 m from the entrance. However, the last explored sector up to 450 m from the entrance was barren. In Bue Marino, specimens were found in the whole sampled sector. The first results of our study



Ecological distribution of benthic foraminifera in Bel Torrente Cave (Courtesy of Elena Romano)

indicate that these organisms may live in the cave environment of the Mediterranean basin, not only close to the entrance, but even at a considerable distance in the cave.

The foraminiferal assemblages followed a general pattern, revealing the same succession of ecological zones in the two caves.

- The Marine Ecozone (ME) was identified close to the cave entrance: in the first 90 m in Bel Torrente and 60 m in Bue Marino. It was characterized by typical porcelaneous and hyaline shallow water Mediterranean species (*Peneroplus pertusus*, *Elphidium crispum*), very common along the Sardinian coast, and indicative of marine conditions. These taxa were exclusive to this ecozone.
- The Entrance Ecozone (EE) was identified up to 150 m and 300 m in Bel Torrente and Bue Marino, respectively. It was characterized by prevalingly hyaline species (*Gavelinopsis praegeri*, *Bolivina* spp.), common in the Mediterranean basin. Agglutinated species, such as *Reophax dentaliniformis*, started to be abundant. Marine benthic foraminifera taxa,

adaptable to a wide range of environmental conditions, revealed an increase in environmental stress due to the changing conditions as the distance from the cave entrance increased.

- The Transitional Ecozone (TE) was identified up to 330 m and 450 m in Bel Torrente and Bue Marino, respectively. The prevalence of agglutinated taxa (*Eggerelloides advenus*, *Cribrostomoides* spp.), uncommon in shallow-water Mediterranean environments but abundant at the high latitudes, suggested that decreased temperature and periodic freshwater intrusion in the inner cave established unfavorable conditions for calcareous foraminifera. This indicated the decreased marine influence.
- The Inner Ecozone (IE) was the part of the cave barren of foraminifera.

The clear zonation in both caves indicates that benthic foraminifera are incredibly sensitive to environmental changes and consequently, they may be considered reliable environmental indicators of these ecosystems.

During Spring 2015, at the end of the rainy period, benthic foraminifera nearly disappeared in Bel Torrente; only a few specimens were found very close to the cave entrance. This was probably due to the considerable inland water flow that occurred during the rainy season; this influenced the renewal of the sediment layer and re-colonization. In Bue Marino, a new ecozone associated with abundant phytodetritus was identified between 120 and 180 m, while in the inner part of the cave up to 360 m, the TE was noted. Moreover, the IE, not studied the previous summer, was detected from 360 to 450 m, which indicated the strong influence of seasonal water flow (Romano et al., 2018a).

These results indicate that monitoring the foraminiferal ecozones in caves supplies information on seasonal climatic variability, as well as sea level changes, because a possible increase in sea level would lead to the enlargement of the ecozones more affected by marine influence.

The ecological zonation does not appear to be determined by a single factor but rather by an environmental gradient associated with increasing environmental stress for benthic foraminifera. The high environmental variability for episodic high energy floods, alternating with periods of water stratification, which possibly introduces areas of reduced oxygen levels, determines the presence of tolerant species not common in shallow water assemblages of the Sardinian coast. The decrease of seawater salinity and temperature probably promotes periods of water acidification, especially after rainy periods, encouraging the presence of agglutinated taxa. Consequently, assemblages similar to the ones found in high latitude marine coastal zones may be found especially far from the cave entrance (Bergamin et al., 2018; Romano et al., 2018a, 2018b).

Understanding the response of benthic foraminifera to the wide temporal and spatial changes of environmental parameters may be useful not only for the monitoring of cave environments, but may also be applicable to detect the effects of global changes in the marine environment.





C. Provenzani

Understanding how benthic foraminifera respond to temporal and spatial changes in environments may enable the detection of the effects of global changes in the marine environment.

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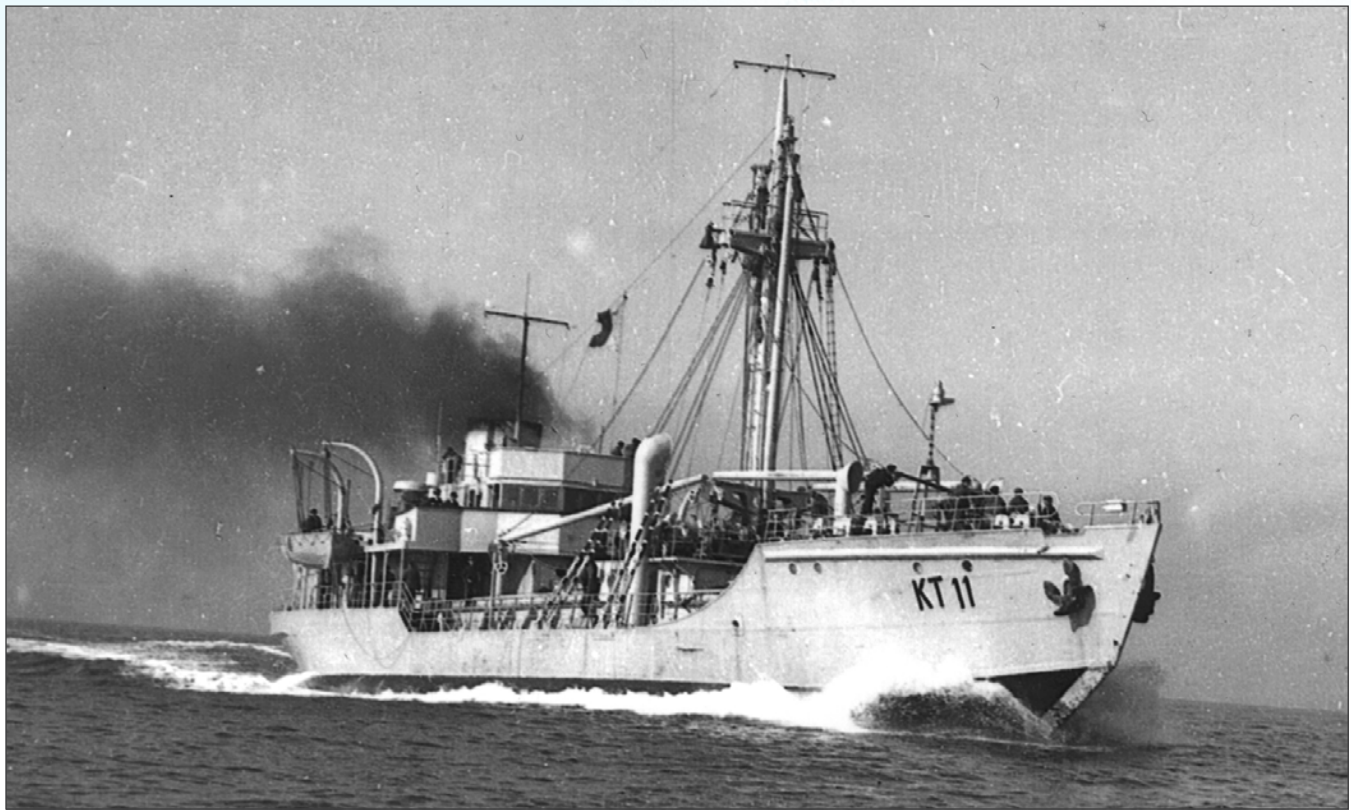
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KTs: A Special Class of World War II Cargo Ship

By Claudio Provenzani, Elena Romano, Ph.D., and Luisella Zocca



The Kriegstransporter was a class of cargo ship built during World War II. (Courtesy of Dr. Elena Romano)

AMONG the most complex and exciting adventures for divers is the discovery and identification of a previously unknown wreck, especially when that wreck lacks clear, distinctive identifying features. In such cases, adventure also includes exploration and historical research. This is the case of a Kriegstransporter (also referred to as KT), a wreck unknown until 2003 that lies on the seabed near the town of Agropoli (Salerno, Campania, Italy, Tyrrhenian Sea). Its existence was known only to some local fishermen who thought it to be an airplane, probably sunk during Operation Avalanche, when the Allied troops landed in Salerno during World War II. The first divers to explore the site discovered a wreck at twice the expected

depth and thought it to be a phantom ship, probably due to suboptimal gas choices.

Based on initial underwater images it was possible to start developing valid hypotheses on the identity of the vessel: the wreck had the lines of a German steam-powered military ship known as a KT, however, the presence of a bilingual machine telegraph (Italian/German) suggested that it had been built in an Italian shipyard.





The wreck of the unknown Kriegstransporter lies at a depth of 75 m off the coast of Italy.

KRIEGSTRANSPORTER

The KT was a special class of cargo ship that was built out of necessity for the North Africa war operations during World War II. In 1941, the Afrikakorps grew from a relatively small expeditionary force into a full-fledged corps comprised of five divisions. At the time, supplies to Libya were mostly entrusted to the Italian merchant navy, supplemented by a limited group of German ships unable to leave the Mediterranean Sea at the start of World War II and a few small vessels chartered from Spain. With the increase in troops, supplies became insufficient, requiring an alternative supply chain.

On November 13, 1941, in his Rastenburg headquarters (the “Wolf’s Lair”), Hitler was informed by Grand Admiral Erich Raeder that supplies for North Africa were lacking due to the inadequacy of Italian transportation. This prompted Hitler to give the order “to mass-produce transport vessels for the Mediterranean service of about 1,000 tons with a speed of 15 - 16 knots, capable of bringing 3 - 4 heavy vehicles plus their personnel, to North Africa” (Donko, 2017).

In the naval conference that followed in Berlin on December 12, 1941, Raeder again reported to Hitler that “the plans for 40 1,200-ton ships have been defined [at the Marine Command], the machines were drawn from the quantity originally addressed to minesweepers, and there are now eight available shipyards in Italy. Special construction plans are being defined by the Deutsche Werft with the result that the production of metal plates can start as soon as the documents for the allocation of

the quantities of material are ready. This is the only obstacle.” Hitler then ordered the OKW (Oberkommando der Wehrmacht, High Command of the German Armed Forces) to solve the problem by obtaining iron, oil, and coal for the Ukrainian factories where plates were produced, with the intention to build the KT’s by the summer or autumn of 1942 (Donko, 2017).

Hitler’s orders were fulfilled and the prototype KT 3 was ready at the Deutsche Werft in Hamburg on September 16, 1942, and the KT 1 at Ansaldo-Sestri shipyard on November 14. The Kriegsmarine ordered 62 ships, 25 of which were built in Italian shipyards (Sestri, Riva Trigoso, Livorno, and Ancona) while the others were constructed in France, Hungary, and Austria.

The KT’s were relatively small vessels at 67 m long, 11 m wide, with a 3.1 m draft, and a maximum speed of 14.5 knots. The vessels could be produced quickly not only because of their small size, but also because the prefabricated serial production and the use of soldering instead of riveting metal plates reduced the construction time to 30 days.

During World War II, several countries built a large number of standard merchant ships: Great Britain (OCEAN, EMPIRE, Scandinavian, etc.), Germany (HANSA ships), Japan, Canada (Canadian Liberty, North Shields, etc.), and USA (Liberty, VICTORY, T2, C2, C3 tanks, Baby Liberty, etc.). These ships shared fast production rates necessary to replace losses and meet the requirements of intended routes and harbors.



Artifacts like this cannon are used to help identify the wreck in question.

IDENTIFYING THE WRECK

Preliminary archival research did not report any sunken KT in the stretch of sea where we found “our” wreck. Taking into account the presence of the bilingual telegraph which provided evidence of an Italian shipyard, our research only focused on the 25 ships built in Italy, including those whose last registration was “bombed to” or “lost by bombing in the harbor.” The second more demanding phase of research was reviewing hundreds of documents, some incomplete or with incorrect transcriptions, at the Historical Office of the Navy (AUSMM) and the Italian Central State Archives of Rome. Ultimately, only two ships’ histories matched the wreck’s location: KT 11 and KT 22.

The KT 11 was built in Leghorn and launched on March 2, 1943. Used for transport to North Africa, she was damaged for the first time by aerial bombing on May 6, 1943, while in Reggio Calabria Harbor. From there she was moved to deeper water to prevent the obstruction of the quay in case of sinking. A message received on May 8 by the Ministry of the Italian Navy describes the ship with “hull planking, topside of bow, and cargo hold slashed for about twenty square meters with its broken and twisted bulkhead.” She was towed to Messina on May 15 to repair the damage and moored at the Libya dock. There she was bombed a second time on the night of July 29, 1943, and caught fire.

The KT 22 was built in Ancona and delivered on April 27, 1943. She was also meant to carry supplies to North Africa, but both Bizerte and Tunis were lost to the Axis on May 7 and the organized resistance ceased on May 9. Unable to find a suitable harbor in Tunisia, the KT 22 joined a group of small Axis vessels escaping North Africa with the last few isolated German and Italian troops on board by May 13. The group managed to evade the Allied air and sea blockade and reached Sicily. On May 25, just back from her one and only attempt to reach Tunisia, she

was in Reggio Calabria Harbor for bunkers. She was loaded with 390 tons of gasoline and was still refueling coal when a violent fire broke out, which quickly became uncontrollable.

Following the Allied invasion of Sicily in 1943,¹ the main ports of Southern Italy were found cluttered with wrecks. All wrecks were precisely mapped by location and nationality for their successive disposal or reuse.

It remained unclear which KT our target vessel might be. The last records we found indicated that the KT 11 was in Messina through December 1946, when she was assigned to a recovery company. On November 27, 1947, she left for

Genoa, towed by the *Impero* tugboat. In turn, the KT 22 was in Reggio Calabria through the end of the war together with many other salvageable ships. On March 6, 1945, there is a record revealing the Ministry of the Italian Navy requested that the ship be scrapped.

At this point, the details collected during our dives have become key to identifying the vessel: we have an empty and clean ship, as if it had been unused for a long time before sinking. There were blackened bulkheads, probably due to a fire, a bilingual machine telegraph (Italian/German) suggesting construction was completed in an Italian shipyard, unnaturally small props (as if they had been reduced and did not guarantee autonomy of navigation), a non-functional cannon lacking parts, a leak in the left-hand side, and a tow-line on the bow. The ship at the time of sinking was surely not operative and she was most likely towed to the north, especially considering how she is oriented underwater. The question remains: which KT is this?

THE WRECK

The wreck lies at a depth of 75 m in navigation trim on a coarse, sandy bottom; this guarantees good-to-excellent visibility conditions for most of the year. Unlike many other wrecks, this one appears bare; there are no artifacts or objects scattered on the deck or in other service areas and the holds are empty. The bow is significantly damaged and only the hole of the funnel remains. The mast still stands intact and the machine room’s skylights are open; access inside the wreck is uncomplicated though the instability of the superstructure needs attention. The cannon is clearly visible as are the bilingual telegraph without levers and the abnormally small propellers, complete with the whole shaft. There are also gauges and grid walkways placed on the lateral side. On deck there are winches and the potential location of a dismantled shooting post. After rummaging in the mud close to the castle, we discovered some dishes.

¹ Cf Operations Husky and Avalanche: <https://history.army.mil/books/wwii/sp1943-44/chapter7.htm>





C. Provenzani

The unknown KT is an important piece of World War II nautical history.

Until a few months ago, it was impossible to determine which of the two ships the wreck might be. The damage to the bow is compatible with the description of the state of the KT 11 after the May 6 bombing. However, a 20 m² break on the topside of the bow noted in the document was not visible. If this is the KT 22, the damage on the wreck could also be the result of a number of other events that provides no further support to the wreck's identity.

Thanks to the constant erosive nature of the ocean, we noted another possible identifying feature. On the left side of the bow, a few metal plates have detached. Resembling tiles fallen from a wall, these are riveted rather than welded. They differ from the other bulkheads, and seem to have been used to cover a top-side leak and gash, which would match the description of the KT 11.

Furthermore, the wreck is found along the Messina-Genoa route which the KT 11 would have traveled. There are still doubts about the cause of the sinking; it could have been the failure of the repair on the leak, or a sudden storm, or the need to cut the tow-line and abandon the ship. The KT 11 ended in an inglorious way, but she is part of Italian industrial history. If she had arrived in Genoa, as was the plan, she would have been dismantled in a shipyard and used to reconstruct a damaged country.

Though we have yet to determine which KT our wreck might be, we will continue our efforts to assess this piece of World War II nautical history in hopes of properly identifying the vessel.

ACKNOWLEDGEMENTS

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A Different Light

By Katy Fraser



K. Fraser

Creative lighting can illuminate the unique features of an underwater cave.

FOR me, a dive always begins the night before as my mind starts to fixate on checklists: Charge the video lights, format the SD memory card, put the battery in the camera, prep O-rings, make sure the zoom gear is on and lined up. Then, my mind moves onto shot lists, which always focus on the question, “How can I represent this cave in a different light?”

For me, filming caves is like painting a picture. I stare down the cave passage and the video lights act like a paintbrush dipped in a Photoshop highlighting tool. It’s not only about picking out the more prominent formations, but also identifying the negative spaces in the cave that lie around and between subjects. This

may be a fissure in the rock or light cascading between stalagmites and columns. Directing the light in different directions appropriately illuminates several sections of large spaces of wall, flow stone or heavily decorated areas to create scale and depth. There are many facets of caves to focus upon; it may be sections of ceiling with soda straws, tree roots, several small formations or, simply, the diver itself.

Divers tend to be the focus in a film. That is because they link the footage together by serving as a character guiding the viewer through the cave. The responsibility to make a film interesting falls on the diver when the camera is rolling. This can be done





K. Fraser

Caves are not normally dynamic locations, so divers often become the focus of a film.

by communication, line laying, staging, looking around, and sweeping primary light beams. A creative filmmaker can also have divers play with some of the few dynamic features in a cave such as halocline, percolation, and reflection. Caves, as beautiful as they are, tend not to be dynamic. Most everything in a cave moves slowly or not at all, unless prompted by a diver. The challenge is to make something that forms on a geological timeline come alive in a span of minutes.

The placement of lighting for a film is probably the largest challenge when filming in a cave. For example, if the divers are filmed as they swim from one direction, the lights will most likely have to be rearranged if the divers must be shot from another direction. I see a lot of films where the camera operator shoots on the fly, meaning putting lights in the divers' hands and tracking them as they move through larger cave spaces, often from behind. This is a great way to save time and potentially get more shots out of the day.

Having lighting support on the team is essential as the person who helps place lights plays an important role in ensuring the project runs in a timely and efficient manner. In my case, I am grateful to have Mauro Bordignon who has a lot of experience lighting for Laurent Benoit, a well-known photographer. We have collaborated to form quite a special partnership with some stunning results. I am lucky to have someone to help place my lights who just naturally "gets it." Lighting is a great skill to learn for those who don't fancy taking up a camera but want to be creative and play an invaluable role in shoots.

The most difficult aspect for an audience to appreciate with any film is the time and effort it takes to create a seemingly effortless video. Time is a crucial element as it works hand-in-hand with safety, the non-negotiable priority on all my shoots. There is a lot to factor in to the dive planning and gas management, as there are so many variables. Placing light takes time, especially as it is rarely successful on the first try. If playing with haloclines, a filmmaker will have to wait for it to settle for 5 to 10 minutes before shooting a second shot. Not surprisingly, shooting a sequence will take a considerable amount of time and gas. When it comes to percolation and getting those bubbles to rain down clouds of calcite in caves less traveled, a filmmaker really only has one shot before the cave is blown out, unless there is some flow.

Small, attainable objectives are the key to safety and efficiency when filming in a cave. The cave is not going anywhere and I would much rather get one or two really good shots than a lot of rushed mediocre shots that would essentially have to be shot again.

Gauging what is feasible to accomplish in a particular cave, or with certain divers, is a pre-dive operation, not an in-water one. In my opinion, it is a misconception that a successful film can be done without first diving that cave. Further, it is imperative that all those involved in the project are used to working as a team. It is the filmmaker's responsibility to properly brief the team on positioning, communication, and light handling. Patience and empathy are also great qualities to have. A filmmaker needs to appreciate that proper positioning and finning



K. Fraser

Members of a film team should possess solid dive skills but also be enthusiastic about the dive project.

techniques, all the while juggling 1000s of lumens of video light and swimming from point 'a' to point 'b' essentially blind is no easy feat, especially when under the pressure of being on camera. I have seen many a competent diver unravel in the face of the camera and become a swimming cyborg with the charisma of a block of wood.

When selecting the film team, it is wise to choose people that are not only solid in the water but also have a genuine enthusiasm for lighting and helping to make the film. Trying to coerce non-interested divers into being a model will result in boredom, closely followed by loss of attention and ultimately, a waste of everyone's time. A lot of a model's time involves waiting around while the set is put together. They will have to push through a bit of cold and boredom, as even a few shots can take hours.

Once the shoot is done and SD cards are offloaded, I begin to edit through my footage. I start by cutting down the material to the usable clips. Sometimes I have a piece of music that inspires my shoot and other times I find a track that inspires my editing. Doing my own post-production is the final piece in the puzzle. It provides the opportunity for me to critique my own work, meticulously hone in on fine details in my composition and camera work, and it fundamentally helps me improve by showing me the way to shoot it bigger and better the next time.

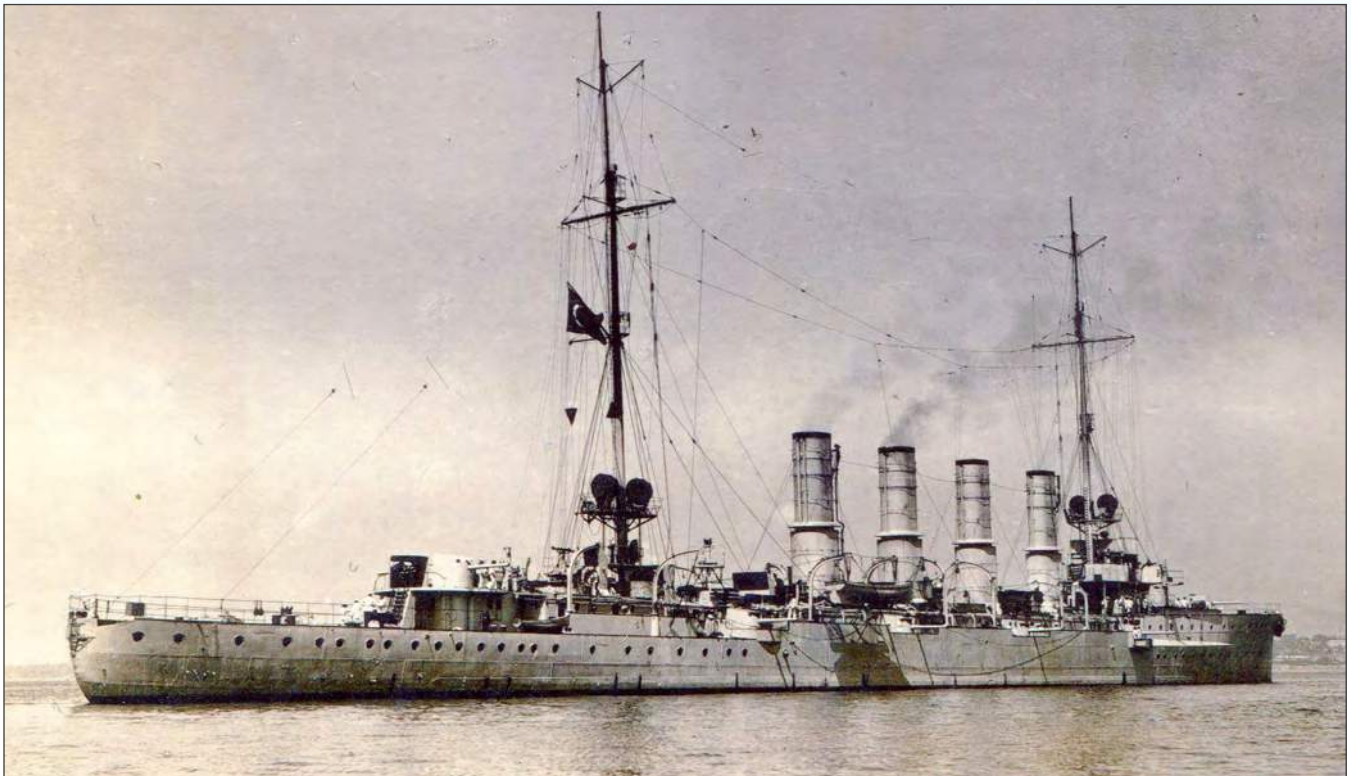
Filming underwater caves is a challenging process, demanding a great deal of technical sophistication and cave diving skills. The rewards, however, are singular as it enables the videographer and his/her team to share with the general public one of our planet's unique wonders.



Divers Explore A Vestige of War in
the Eastern Mediterranean

The Ship That Changed History: The German Imperial Light Cruiser S.M.S. *Breslau*

By Dimitri Galon



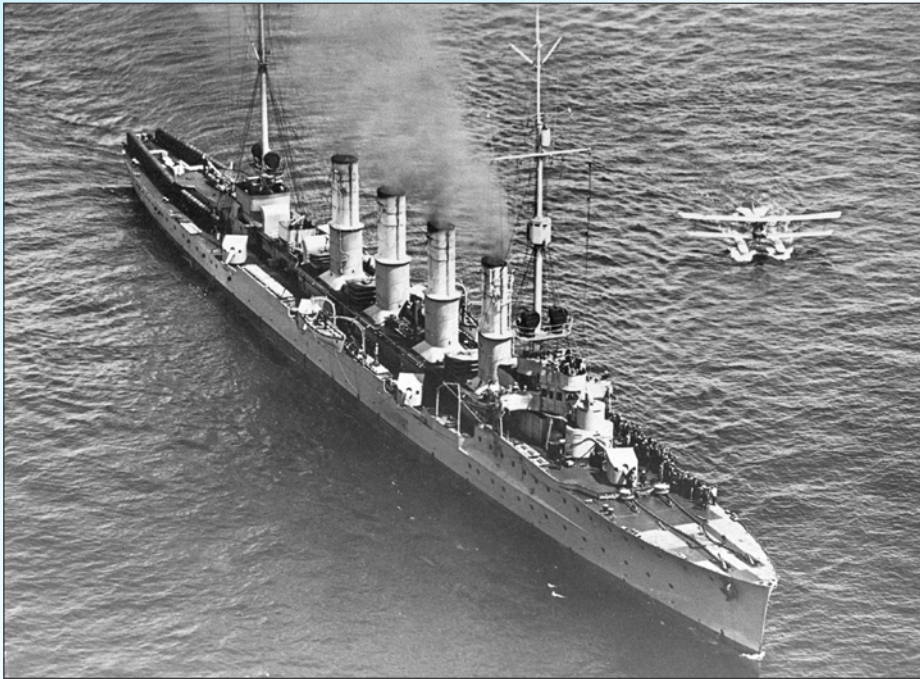
The S.M.S. Breslau in Istanbul during 1914 flying the Ottoman flag as Midilli. (Collection B. Langensiepen & A. Güleryüz)

MORE than a century after the outbreak of the World War I, the wreck of the German light cruiser S.M.S. *Breslau* remains on the bottom of the Aegean Sea near the entrance to the Dardanelle Straits. Likely the most historically significant shipwreck of the eastern Mediterranean, we succeeded in diving, examining, and documenting her between September 2 and 5, 2018, equipped with a dive permit from the Turkish Ministry of Culture.

The S.M.S. *Breslau* is the last surviving wreck of the German Imperial Mediterranean Division¹ and one of the main warships involved in all Black Sea naval operations during World War I. She was also involved in the Caucasus Campaign, the conflict between the Russian and Ottoman Empires over territories in Caucasus between 1914 and 1918, and fought in all the major naval battles between the Russian and the Ottoman Imperial

¹ German: "Mittelmeerdivision"





Midilli (ex S.M.S. Breslau) in 1917. Notice the eight 150 mm SK L/45, which replaced the twelve 105 mm SK L/40 cannons. (Collection B. Langensiepen & A. Güleryüz)

fleets. The *Breslau* and her “big brother,” the heavy cruiser S.M.S. *Goeben*,² had a profound effect on world history. The pair played an important role in the Ottoman Empire’s and Bulgaria’s entry into the war, the slaughter of the Gallipoli Campaign where more than 500,000 lives were lost, the Struma Campaign, and the troubles of the Entente Powers not only in Asia Minor but also in Palestine and the Middle East. As the London Times wrote on January 22, 1918, two days after the loss of the *Breslau*, “Despite their nefarious career, no other two ships have had such a significant impact on the war as the *Goeben* and *Breslau*.” The first lord of the British Admiralty, Winston Churchill, echoed this thesis with his statement that the two ships who forced the Ottoman Empire into World War I “brought more slaughter, more misery, and more ruin than has ever before been born within the compass of a ship.”³

CONSTRUCTION AND TECHNICAL DATA

The *Breslau* was ordered in 1910 under the name of *Ersatz Kreuzer Falke* at the shipyard A.G. Vulcan in Stettin.⁴ She was one of the four Magdeburg-class light cruisers⁵ built in 1911 and commissioned for the Imperial German Navy⁶ in 1912. The vessel was named after the city of Breslau,⁷ the historical capital of Silesia, which had been part of the Kingdom of Prussia since 1740; after 1871, the city became part of Imperial Germany. The *Breslau* was the only ship of this class with four propellers and had remarkable protection. Her deck was covered with a

60 mm armor plate; amidships she had a 60 mm thick waterline armored belt, while her tower walls were 100 mm thick. The general key data and the construction specifications of the vessel were:

- **Name:** In 1912: Seiner Majestät kleine Kreuzer *Breslau*.⁸ In 1914: “Osmanlı İmparatorluğu Kruvazörü *Midilli*.”⁹
- **Builder:** A.G. Vulcan, Stettin
- **Class:** Magdeburg
- **Laid down:** 1910
- **Launched:** May 16, 1911
- **Commissioned:** May 10, 1912
- **Displacement (tons):** 4,570
- **Length (m):** 138.7
- **Beam (m):** 13.5
- **Draft (m):** 4.4
- **Propulsion:** 2 AEG-Vulcan steam turbines (19,000 kW) and 16 water-tube boilers. In 1912, the boilers were fired only with high quality coal. However, from 1916, the firing system was altered and oil was used to increase the burn rate of the coal due to the lack of coal.
- **Indicative speed (knots):** 27.5
- **Propellers:** 4 (2.47 m each)
- **Range (marine miles):** 5,820
- **Armament:** In 1912: 12 x 105 mm SK L/40¹⁰ naval guns and 2 x 50 cm torpedo tubes. In 1916: 10 x 105 mm and 2 x 150 mm SK L/45 naval guns, 120 mines, and 2 x 50 cm torpedo tubes. In 1917: 8 x 150 mm SK L/45, 120 mines, and 2 x 50 cm torpedo tubes
- **Complement:** 10 officers and 336 enlisted (officially)

IN THE GERMAN IMPERIAL NAVY

Immediately following her commission into the Imperial German Navy, the *Breslau* was assigned to accompany the S.M.Y. *Hohenzollern*,¹¹ the yacht of the German Kaiser Wilhelm II. She did this until September 26 after which she joined the reconnaissance forces of the German High Seas Fleet.¹² On November 3, under the command of the Fregattenkapitän¹³ Leberecht von Klitzing, she joined with the heavy cruiser S.M.S. *Goeben*, the light cruiser *Geier*, and the vessels *Hertha*, *Vineta*, and *Lorely* to form the new Mediterranean Division,¹⁴ which was commanded by Rear Admiral Konrad Trummler. Although the Mediterranean Division initially consisted of six vessels, the main ships were the *Goeben* and the *Breslau*, which formed the nucleus of the

⁸ “His Majesty Light Cruiser *Breslau*”

⁹ “Cruiser of the Ottoman Empire *Midilli*”

¹⁰ “SK” stands for “Schnelladekanone” (quick loading cannon) and “L” stands for “Länge in Kaliber” (length in caliber).

¹¹ Named after the Imperial House of Hohenzollern

¹² German: “Hochseeflotte”

¹³ Frigate captain

¹⁴ German: “Mittelmeerddivision.” The Mediterranean Division was founded in November 1912 when the First Balkan War broke out on October 8. At the request of the Ministry of Foreign Affairs, the German Admiralty decided to set up a naval organization mainly for protecting the German citizens in the eastern Mediterranean and the Balkans.





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The aft 150 mm SK L/45 cannon of the S.M.S. Breslau

unit until the dissolution of the division in 1914. After the arrival of the ships in the Mediterranean, the *Goeben* sailed to Constantinople¹⁵ while the *Breslau* sailed to Alexandria (Egypt) and then to several Aegean ports.

After the assassination of King Georgios I of Greece on March 18, 1913, the *Breslau* transported Prince Ernst August von Cumberland and Heinrich von Preußen, brother of the German Kaiser William II, to the king's funeral held in Piraeus (Athens). On April 10, she went on to participate in the international blockade of the Montenegro coast. The multinational operation aimed to prevent Montenegro from occupying the city of Shkodra,¹⁶ which had been assigned by international treaty to Albania after the independence of the region from the Ottoman Empire. It also served to support the shaky throne of Prince William of Wied, the nominal king of Albania. Between August 10 and October 27, 1913, the *Breslau* and *Goeben* were stationed in Constantinople. During that time the Ottoman government offered to buy the two ships for the Ottoman fleet, which was outdated and urgently needed new warships. The Germans declined the offer, as the vessels were completely new and were considered by all the naval powers to be the fastest ships in the Mediterranean.

After the assassination on June 28, 1914, of Archduke Franz Ferdinand of Austria, the successor to the throne of the Austro-Hungarian Empire, and his wife in Sarajevo by the Serbian nationalist organization Black Hand,¹⁷ the Austro-Hungarian

Empire declared war on Serbia. This was in effect the beginning of World War I. Germany then entered the war on the side of Austro-Hungary, forming the so-called Central Powers, while Russia, France, and Great Britain stood beside Serbia as the Triple Entente. On August 1, 1914, the day on which Germany declared war on Russia as an ally of the Austro-Hungarian Empire, the *Breslau*, under the command of Fregattenkapitän Paul Kettner, was off Durres (Albania) carrying military and diplomatic envoys to Messina in Italy. On August 3, 1914, while the declaration of war with France was pending, the *Breslau* and *Goeben* were ordered to head to Algeria to block the transfer of French troops from the naval bases of North Africa to mainland France. On August 4, 1914, immediately after the declaration of the French-German war, the *Breslau* and *Goeben* bombed the French naval bases of Philippeville and Bône in North Africa. Returning to Messina for coaling, they met with the British heavy battleships H.M.S. *Indomitable* and H.M.S. *Indefatigable*. Initially, no conflict arose because war had not yet been declared between Germany and Great Britain.

However, England declared war on Germany a few hours after the two German ships arrived in Messina, where the Italians had approved a 36-hour stay but did not grant permission to get coal and supplies from Italian sources. The commander of the German Mediterranean Division, Vice Admiral Wilhelm Anton Souchon¹⁸, succeeded in finally getting coal from the

¹⁵ Istanbul

¹⁶ Albanian: "Shkodër"

¹⁷ The organization "Unification or Death," popularly known as "Black Hand," was a secret military society formed on May 9, 1911, by officers in the Army of the Kingdom of Serbia.

¹⁸ Vice Admiral Wilhelm Souchon replaced the Rear Admiral Konrad Trummer on October 23, 1913.





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Project diver surveying the wreck

German merchant steamers *General*¹⁹ and *Barcelona*²⁰ docked in Messina. By opening holes on the sides of the steamers for convenience, the *Breslau* and *Goeben* managed to carry out the coaling within the Italian time frame, and then sailed from Messina on August 6, 1914, in an unknown direction. That was the beginning of the legendary breakthrough of *Breslau* and *Goeben*; being chased by half the Mediterranean British fleet, they succeeded in reaching the neutral Ottoman Empire and found protection in the Dardanelle Straits.

THE ESCAPE OF THE S.M.S. *BRESLAU* AND S.M.S. *GOEBEN*

After the *Breslau* and *Goeben* left Messina, they headed northeast, feigning a course towards Adria. Five hours later, they turned and sped towards the Aegean Sea trying to approach Cape Matapan²¹ at the southwest side of the Peloponnese peninsula in Greece. The plan was to first meet the German cargo steamer *Bogados*²² at the small Cycladic Island of Donoussa where they would continue their coaling, as the bunkers of the two

vessels were incompletely filled, and then head straight to the Dardanelle Straits.

While the two German vessels were planning to make their way east, the commander of the British Mediterranean Fleet, Admiral Sir Archibald Berkeley Milne, expected them off Gibraltar. He therefore posted his battle cruisers, the *Indomitable* and *Indefatigable*, at the western end of the Strait of Messina. Only the light cruiser H.M.S. *Gloucester* guarded the eastern side of the strait. The French fleet was also ordered to guard the Strait of Gibraltar to prevent a breakthrough of the German ships into the Atlantic. At the same time, the British First Cruiser Squadron, under the command of Rear Admiral Ernest Troubridge, consisting of the armored cruisers H.M.S. *Defence*, *Duke of Edinburgh*, *Warrior*, *Black Prince*, and eight destroyers patrolled northeast of Malta.

While steaming to Adria and then towards Cape Matapan, the German ships were pursued by the *Gloucester* until the morning of August 7. Trying to slow down the speed of the German ships, she engaged in a short battle with the *Breslau*, which received a hit on her side. The action broke off after the *Goeben* intervened and the British vessel finally ceased its pursuit, “being too slow to follow them.” Consequently, the only naval force in the vicinity able to stop Admiral Souchon’s breakthrough was the First Cruiser Squadron of Admiral Ernest Troubridge. Unfortunately, the squadron had sailed to intercept the German ships in the mouth of Adria, allowing the *Breslau* and *Goeben* to evade their pursuers undetected. Troubridge broke off the chase on August 7, convinced that any attack by his four armored

¹⁹ The passenger-cargo steamer *General*, 8,063 GRT, 137 m long, was constructed in 1911 by Blohm & Voss in Hamburg for the German Maritime Co. “Deutsche Ost-Afrika Linie.” In 1919, she was given as war reparation to the French government. In 1922, she became property of the Messageries Maritimes and renamed *Azay-le-Rideau*. She was broken up in 1937 in La Seyne, France.

²⁰ The cargo steamer *Barcelona* (ex *Arabia*), 5,550 GRT, 122 m long, was built in 1897 by Harland & Wolff in Belfast. In 1907, she belonged to the fleet of the German Maritime Co. Hamburg-Amerika Line. In November 1915, she became a prize of the Italian government and renamed *Ancona*. She was broken up as Robinia on February 26, 1924, in La Spezia, Italy.

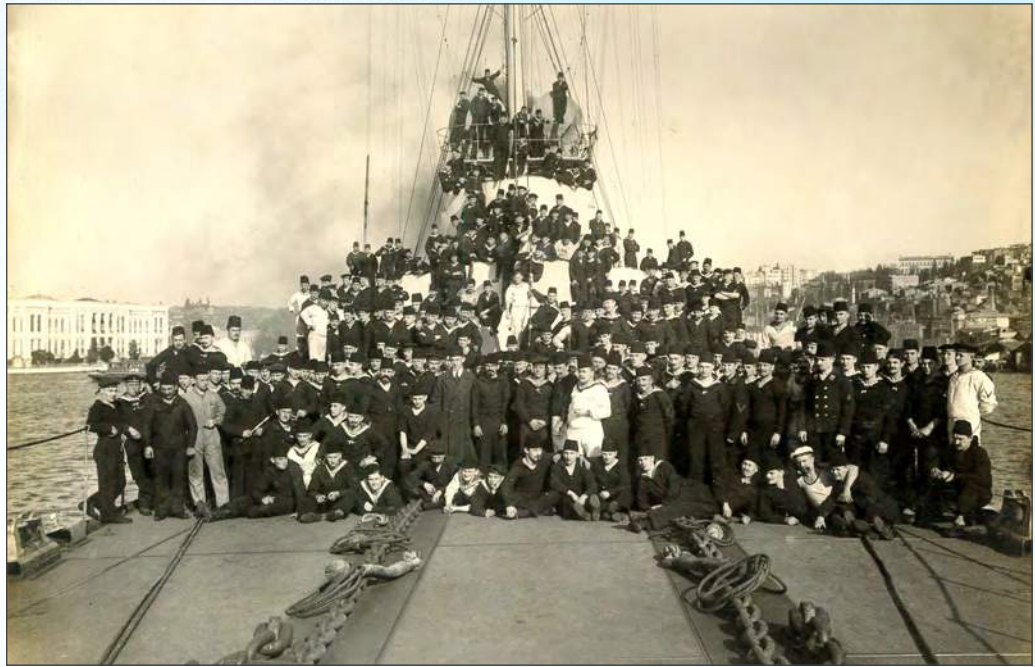
²¹ “Cape Tainaron” in Greek

²² The cargo steamer *Bogados* (ex *Antares*, ex *Mirzapur*, ex *Braunfels*), 3,007 GRT, 104 m long, was constructed in 1891 by the Sunderland Ship Building Co. at South Dock (Sunderland) for the German Maritime Co. “Deutsche Dampfschiffgesellschaft Hansa.” On September 3, 1916, she became an Allied prize in Piraeus, Greece, and renamed *Moulin Blanc*. On July 12, 1920, she wrecked near Les Baleines, France.



cruisers against the 280 mm guns of the *Goeben* would be suicidal.

On August 9, the *Breslau* and *Goeben* met with the German steamer *Bogados* off the rocky island of Donoussa in the Greek Archipelago. Heavily loaded with coal, the *Bogados* waited for them disguised as a Greek steamer named *S/S Polymitis*. After filling their bunkers with coal, the *Breslau* and *Goeben* headed with an average speed of 18 knots to the Dardanelles where they arrived early in the morning of August 10, 1914.



The S.M.S. Breslau in front of the Dolmabahçe Palace, the summer palace of the Ottoman Sultan in Bosphorus in Fall 1914 (Archive of Dimitri Galon)

Following the breakthrough of the *Breslau* and *Goeben*, the two British Admirals, Archibald Milne and Ernest Troubridge, were court-martialed in Portland Harbor. After a long trial, they were acquitted of the charge of cowardice before the enemy, but they never again received any significant command.

THE OTTOMAN NAVY

After their legendary escape, the *Breslau* and *Goeben* found shelter at Nağara Burnu²³ under the protection of the Ottoman Empire. After tedious agreements between Imperial Germany and the Ottoman government, the ships were turned over to the Ottoman Navy²⁴ and their names were changed from the S.M.S. *Breslau* to the *Midilli* and the S.M.S. *Goeben* to the *Yavuz Sultan Selim*. Though the crew remained German, they wore distinctive Ottoman Navy insignia. The command of the ships remained under Vice Admiral Wilhelm Souchon, who was given the honor of becoming the Ottoman Navy's Admiral. Also noteworthy is that the Grand Admiral, head of the German Submarine Weapon during World War II and last Reichspresident, Karl Dönitz (1891-1980), was an officer with the rank of Leutnant zur See²⁵ of the *Breslau* from 1912 to 1916.

On August 15, 1914, the Ottoman Empire cancelled its naval agreement with Great Britain, which had worked since 1910 on reforming and modernizing the Ottoman fleet.²⁶ After the British left, the Dardanelle Straits were fortified with German aid and the *Breslau* (now *Midilli*) and *Goeben* (now *Yavuz Sultan Selim*)

secured the Bosphorus Strait. On September 27, both straits were officially closed for international shipping and on October 29, 1914, the *Midilli* and *Yavuz Sultan Selim*, sailing under the Ottoman flag together with various Ottoman war vessels, attacked and bombed the Russian naval bases of Novorossiysk and Sevastopol in the Black Sea. Those attacks led to Russia's declaration of war on the Ottoman Empire on November 2, 1914, and to the Ottomans' entry into the war on the side of the Central Powers.

WORLD WAR I OPERATIONS OF THE *MIDILLI* (EX S.M.S. *BRESLAU*)

The *Yavuz Sultan Selim* (ex *Goeben*) and the *Midilli* (ex *Breslau*) were the Ottoman Empire's strategic assets in undermining Russia's control of the Black Sea. From the very beginning of the war with Russia the two ships, accompanied by vessels of the Ottoman fleet, succeeded in undermining Russian Imperial Navy supremacy. With relentless attacks against Russian military positions, bombardments of enemy ports and escorts of military convoys for the "Caucasus Front," sinking Russian merchant and warships, and numerous battles in the open sea, they successfully took over control of the Black Sea. This instilled a great sense of national pride in the Ottoman population, a fact that became particularly noticeable during the Gallipoli Campaign.²⁷ The *Midilli*'s most important actions were:

- November 7, 1914: Attack on the port of Poti²⁸ in Georgia and bombing of several Russian military installations.

²³ The Ottoman Naval Base in the Dardanelle Straits

²⁴ Turkish: "Osmanlı Donanması"

²⁵ The Imperial German rank of the Leutnant zur See was equivalent to the Royal Navy rank of the Sub-lieutenant.

²⁶ A major reason for this decision was the latent hostility of the Ottoman population against Great Britain, which arose from the following event: In 1910, the Ottoman Empire ordered and prepaid a group of two dreadnought battleships in England, the *Reşadiye* and the *Fatih Sultan Mehmed*. The *Reşadiye* was laid down in 1911 and completed in August 1914. After the outbreak of World War I, she was seized by the Royal Navy and commissioned as H.M.S. *Erin*. The *Fatih Sultan Mehmed* had only been laid down in April 1914 and after the outbreak of the war, she was broken up for scrap.

²⁷ The Gallipoli Campaign was a World War I campaign that took place on the Gallipoli peninsula (in Turkish, it is known as Gelibolu) in the Ottoman Empire, between February 17, 1915, and January 9, 1916. The campaign ended with the defeat of the Entente Powers and cost the lives of approximately half a million combatants.

²⁸ The city and the port of Poti are located on the eastern Black Sea.





The S.M.S. Breslau with the German Imperial war flag and the coat of arms of the city of Breslau, now Wrocław, Poland. (Archive of Dimitri Galon)

- November 18, 1914: Battle with a Russian squadron off Crimea. The Russian Imperial battleship *Svyatoy Evstafiy* was hit four times, while the *Midilli* was undamaged. The *Yavuz Sultain Selim* was hit and sixteen members of the crew were killed.
- December 5, 1914: Bombing Sevastopol and damaging a number of anchored Russian minesweepers.
- December 25, 1914: Laying two minefields off Zonguldak²⁹ and sinking the blockship *Athos*³⁰ by gunfire at position 42° 10' N/31° 50' E before reaching the approaches to Zonguldak.
- January 6, 1915: Battle with a Russian squadron. Several hits were registered on the Russian Imperial battleship *Svyatoy Evstafiy*.
- March 17, 1915: Bombing the port of Feodosia in Crimea.
- June 10, 1915: Encounter with the Russian Imperial destroyers *Derzkiy* and *Gnevny*³¹ off Zonguldak. *Derzkiy* was badly hit and had to be towed by *Gnevny* to Sevastopol. The *Midilli* was hit seven times but suffered only slight damage and light casualties.
- July 18, 1915: While departing the Bosphorus Strait to escort the Ottoman steamer *Keşan*, she hit an enemy mine that exploded under boiler room no. 4. Eight members of the crew were killed. Although flooded with over 600 tons of seawater, she managed to reach İstinye at the Bosphorus. The *Midilli* remained off duty until February 1916. Repairs were executed slowly due to the shortage of materials and qualified personnel. During repairs she was modernized and re-equipped. Instead of two aft 105 mm SK L/40, she received two 150 mm SK L/45 naval guns. That was the first stage of modernization. During the second and final stage, which

²⁹ Zonguldak is a city and the capital of Zonguldak Province in the Black Sea region of Turkey.

³⁰ She was constructed as the *Marsburg* by the Helsingør Værft, Denmark, in 1891 for the German Maritime Co. Deutsche Dampfschiffgesellschaft Hansa. In 1900, she was sold to Deutsche Levante Linie and renamed *Athos*. On August 1, 1914, she became a Russian prize at Mariupol.

³¹ Both destroyers had 1,100 ton displacement and were built in 1914 at Nikolayev.

took place from July 1916 to June 1917, the remaining 105 mm SK L/40 guns were replaced by 150 mm SK L/45 guns. The total gun count reached eight pieces: one at the bow, one at the aft, and three on each side of the vessel.

- February 6, 1916: While Russian troops attacked the Ottoman positions at Trabzon³², the *Midilli* and *Yavuz Sultan Selim* were used to transport fast infantry units to the threatened front.
- April 18, 1916: In concert with the German submarine U 33 (Kptlt. Konrad Gansser),³³ she attacked enemy shipping near the front line. The Russian auxiliary minesweeper T 233 was

attacked and heavily damaged and the Russian sailing vessel *Nikolay* (108 t) was sunk.

- May 6, 1916: Deployed 60 mines in three barrages off Cape Tarchankut and subsequently shelled the port of Yevpatoriya.³⁴
- July 4, 1916: Sank the Russian steamer *Marina Anetta* N-103 (961 GRT), the sailing vessel *Rezviy*, and finished off the steamer *Rockcliffe* N-55 (3,073 GRT, 98 m long, built 1904), which was torpedoed two days previously by the German submarine U 38 (Kptlt. Max Valentiner).
- July 16, 1916: Deployed a 65-mine barrage off the approaches to Novorossiysk.
- July 22, 1916: During battle with the Russian battleship *Imperatrissa Mariya*,³⁵ the *Midilli* succeeded in escaping by laying a smoke screen and dropping mines in the path of the enemy ship.
- November 10, 1917: During the October Revolution in Russia, the *Midilli* made a round trip to the city of Sinop³⁶ to assure the civilian population that the Ottoman Navy was still active.

THE BATTLE OF IMBROS AND THE SINKING OF THE *MIDILLI* (EX S.M.S. *BRESLAU*)

Following the armistice on the eastern front due to the Russian Revolution of October 1917, there were no more tasks for the *Midilli* and the *Yavuz Sultan Selim* to perform; therefore, they were stationed mainly in Istanbul. In December 1917, the Admiral of the Ottoman Navy, Vice Admiral Hubert von Rebeuer-Paschwitz, who had replaced Wilhelm Souchon in September 1917, sought to draw the Entente naval forces away from Palestine to support the Ottoman forces in the Middle

³² Trabzon is a city on the Black Sea coast of northeastern Turkey and the capital of Trabzon Province.

³³ The German submarines, which operated in the waters of the Ottoman Empire, remained under the command of the German Imperial Navy during the entire war.

³⁴ Both locations are in Crimea, near Sevastopol.

³⁵ 23,413 t, 168 m long, 4 x triple 305 mm and 20 x single 130 mm guns, built in Nikolayev from 1911 to 1915.

³⁶ Sinop is located on the most northern edge of the Turkish side of the Black Sea coast.





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Ralf Wissel (left) and Derk Remmers documenting the wreck of the S.M.S. Breslau

East who were under enormous pressure. To do so, he planned an attack on the North Aegean Entente naval bases on the islands of Imbros and Lemnos to force the British to relocate a part of their fleet there.

On January 20, 1918, the *Midilli*, under the command of Kapitän zur See Georg von Hippel, and the *Yavuz Sultan Selim*, under the command of Kapitän zur See Albert von Stoelzel, left the Dardanelles and attacked the British naval base of Imbros³⁷ early in the morning. They bombed and sank the British monitors H.M.S. *Raglan* (6,150 t, 102 m long, built 1915) and H.M.S. *M28* (550 t, 54 m long, built 1915) off Agios Kirikos,³⁸ on the northeast coast of the island. While en route towards Lemnos, the *Midilli* struck five mines at the British mine field no. 36³⁹ and sank aft-first approximately five marine miles off Cape Kephalos south of the island of Imbros. From the ship's crew, 334 Germans and 38 Ottomans were lost while 133 were rescued by the British destroyers H.M.S. *Lizard* and H.M.S. *Tigress*, who approached the site of sinking one-and-a-half hours later. Fifty-five crew members lost their lives from the mine explosions, while the rest died due to the cold water of about 6 – 8°C according to the German Imperial War Diaries. Among the casualties was the vessel's commander Kpt.z.S. Georg von Hippel. The survivors were brought first to Moudros (Lemnos Island) and then as prisoners of war to Alexandria (Egypt) and Malta, where they were held until the end of World War I.

During the same operation, the *Yavuz Sultan Selim* hit three mines as well but remained afloat. She retreated to the Dardanelles and was intentionally beached off the Nağara Burnu. With the *Midilli* sunk and the *Yavuz Sultan Selim* heavily damaged, the threat of the Ottoman Navy to the Entente Powers was greatly reduced for the remainder of the war.

THE WRECK

The renowned Turkish naval researcher, and one of our group members, Selçuk Kolay, located the wreck of the *Breslau* in 1993. The vessel rests in one piece almost upright on her keel in 77 m of water on a sandy bottom, while her bow points to 240 degrees. The aft section is badly damaged and partly collapsed, while the bow and the amidships section remains in extremely good condition. The two masts of the cruiser are broken and lie on the port side, while the four funnel holes are partly visible and easily recognizable. The bridge, the wave breaker at the forecastle, the rangefinder tower, the two anchors at the bow, the davits amidships, and the auxiliary steering wheel are conspicuous and in good condition.

The mine damages are not clearly visible due to encrustation and growth of marine life. Mine no. 1 detonated on the starboard aft, mine no. 2 detonated on the port side between the two rearmost boiler rooms, and mine no. 3 detonated on the port side between the engine rooms. These impacts along with the violent collision of the stern with the seabed led to severe damage to the aft section. The damage of mine no. 4 could not be observed as this mine detonated under the fourth boiler room. Mine no. 5 detonated under the forecastle at the level of the

³⁷ Now known as Gökçeada

³⁸ Agios Kirikos is located on the northeast coast of the island of Imbros and today is known as Kuzulimanı.

³⁹ Deployed on November 8, 1917



bridge. According to the archival sources, the detonation was particularly violent and could have been caused by two simultaneously detonated mines. All the 15 cm naval guns of the vessel are still mounted in their towers and still obvious. Of the four propellers of the vessel, only the two propellers at the starboard site are visible.

Finally, as a sign of respect to this legendary ship for her outstanding action and to the great loss of life during her sinking, we left a commemorative plaque to honor the 100-year anniversary of the sinking of the S.M.S. *Breslau* alias “Osmanlı İmparatorluğu Kruvazörü *Midilli*” at the tower of the 150 mm naval gun at the ship’s bow.

This article is dedicated with respect to Mario Arena, the great master and inspirer of technical diving.

PARTICIPANTS (ALPHABETICALLY)

Ali Ethem Keskin, Erol Öztunalı, Hasan Tan, Remzi Tuğrul Varol, Savaş Karakaş, and Selçuk Kolay from Turkey

Derk Remmers, Markus Kerwath, Ralf Wissel, and Wilhelm Mönnikes from Germany

Dimitri Galon from Greece

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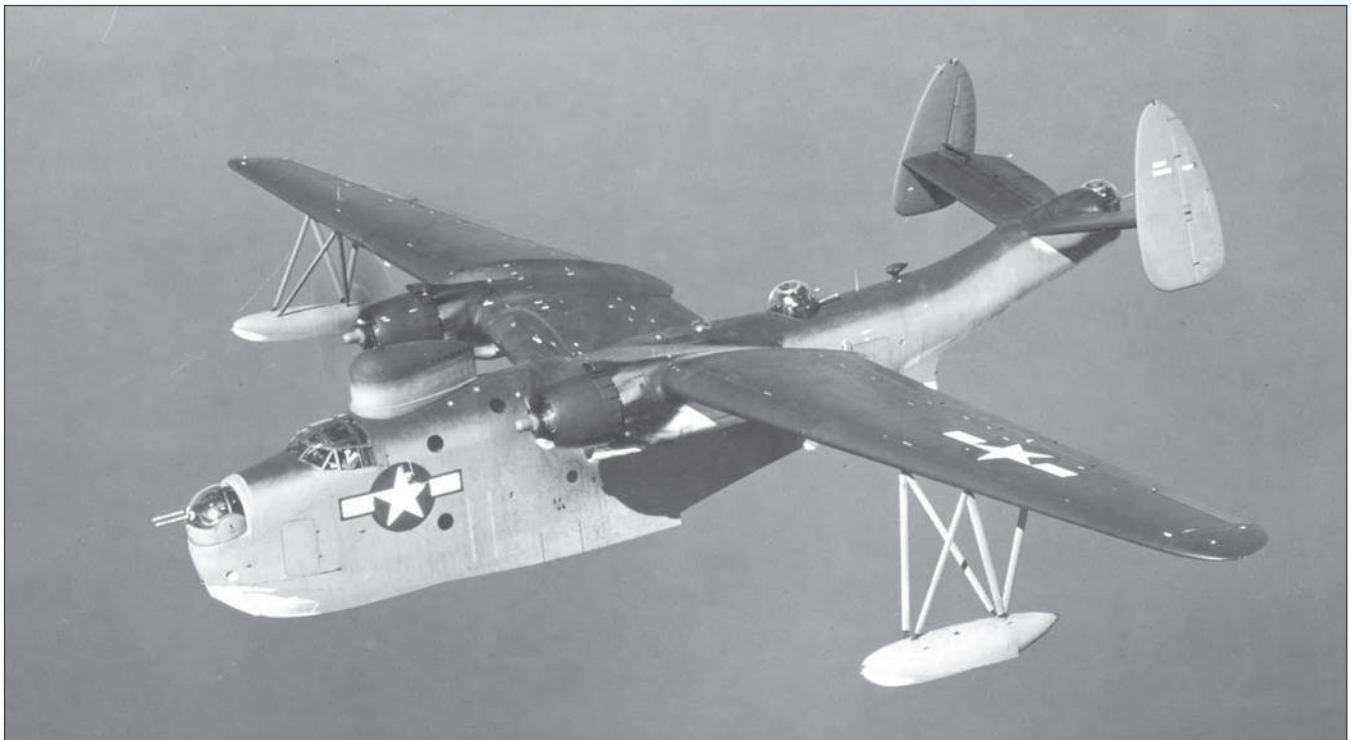
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GUE Divers Collaborate with Scientists to Document a Historically Important Artifact

The PBM Mariner Project

By Kees Beemster Leverenz



The Martin PBM-5 Mariner (Courtesy of US Navy/Barth)

TWENTY minutes from downtown Seattle, at the bottom of Lake Washington, the fuselage of a rare and historically significant airplane has been settling into the silt for 70 years. While relatively unknown to the public, the plane has long been a subject of interest for World War II enthusiasts and local divers.

In December 2017, members of GUE Seattle received an unexpected email from Megan Lickliter-Mundon, a Ph.D. candidate in nautical archaeology. She has been digitally documenting planes around the world using a technique known as 3D photogrammetry as part of her Ph.D. dissertation. She had an exciting mission that pertained to our group: she sought to create a 3D model of a rare seaplane known as PBM Mariner, located 70 feet underwater in Seattle's Lake Washington. She hoped to eventually display a complete model of the Mariner in the Pima

Air & Space Museum for the public. While the plan was ambitious, we were thrilled to hear from her and excited to help.

While Megan had experience documenting aircraft in tropical water with good visibility, Lake Washington is notorious for poor visibility, cold temperatures, and negligible ambient light. She sought our expertise, as we had already completed several successful 3D photogrammetry projects in the area. It can be challenging enough to take one or two decent pictures in these conditions, but for this project to be a success, we would need to take thousands of perfectly-lit images to assemble our interactive digital 3D model. As this seemed a fascinating project, and Megan had already secured the necessary funding and approvals, we were more than happy to assist and set out to document the Mariner.





V. Wright

The tail of the BuNo 59172 during the U.S. Navy's recovery attempt

HISTORY OF THE PBM MARINER

During World War II, the navies of the world faced a serious problem: both the Atlantic and Pacific theaters featured vast oceans. Combatants desperately needed to control the oceans to win the war, and those in charge knew that airplanes would be key. Unfortunately, most airplanes have a critical flaw: they require either a land-based airport or an aircraft carrier to operate. With few islands from which to operate, land-based airports were of limited use. Aircraft carriers were vulnerable and expensive, as well as difficult to produce. To support smaller, remote operations that couldn't demand the presence of an aircraft carrier, flying boats were used extensively.

While float planes use pontoons fitted beneath the fuselage to land on water, flying boats rely on their main fuselage to provide buoyancy directly, although they may often employ small pontoons for stability. Flying boats built during World War II had significant range and endurance, making them particularly useful in the war effort.

The U.S. Navy made extensive use of flying boats during the war to provide air support for their ships. The two most widely used designs were the PBM Mariner and PBY Catalina patrol bombers. The Navy used both in the roles that helicopters fill today, including anti-submarine warfare, search and rescue, and escort missions. Flying boats were so useful that they became commonplace around the world during the war.

Although the United States produced thousands of both the PBM and PBY model flying boats, the vast majority of PBM Mariners produced could only land on water. However, the most

common PBY Catalina variant produced was an amphibious plane, capable of landing on the water or on a runway. The PBY Catalina survived the decades after the war far better than the PBM Mariner because it could more easily be stored in a hanger or in a field, while storing a floating 58,000-lb PBM Mariner required quite a bit more infrastructure.

There are numerous PBY Catalinas in museums around the world, and some are still in service putting out fires and ferrying passengers around remote islands. Unlike the PBY Catalina, there is only one known fully intact PBM Mariner in existence. This plane is owned by the Smithsonian National Air and Space Museum and is displayed by the Pima Air & Space Museum in Tucson, Arizona. However, there is one more largely intact PBM Mariner that is known to exist: the particularly well-armed model that lies at the bottom of Lake Washington.

OUR PLANE: PBM-5 BUREAU NUMBER 59172

On Friday, May 6, 1949, Lieutenant Ralph Frame and his crew of six received orders to ferry PBM Mariner Bureau Number (BuNo) 59172 from Sand Point Naval Air Station in Seattle, Washington, to a Boeing storage facility in nearby Renton. Although it's unlikely to have been considered a difficult task, the flying boats can be unforgiving aircraft in poor conditions. In particular, they are difficult to steer in windy conditions. The conditions that day were not favorable, with wind speeds exceeding 10 knots (20 kph).

The crew successfully ferried their plane to the water in front of the Boeing storage facility at the south end of Lake Washington, but a gust of wind blew the airplane off course while taxiing. A



piling caught the starboard stabilizing float, which caused the plane to tilt dangerously to the side. Although Lieutenant Ralph Frame and his copilot B.F. Nicholls performed a series of maneuvers to keep the plane level, reportedly even ordering the crew to stand on the undamaged wing to balance the plane, the PBM Mariner ultimately flipped and sank in approximately 80 ft of fresh water, coming to rest upside down on the silty bottom of Lake Washington. The crew survived, and the pilot made a simple note in his log: “Sank this one.”

Throughout the following decades, recreational scuba divers in the area became interested in salvaging the plane. The first attempt occurred between 1980 and 1981, when a non-profit group known as the Underwater Historical Research and Recovery Foundation (UHRRF) attempted to recover the plane. In preparation for bringing the PBM Mariner to the surface, the UHRRF recovered several artifacts, which they reportedly wanted displayed in the local Museum of Flight.

However, sunken U.S. Navy materials remain the property of the Navy regardless of their location or age. Even though the aircraft may have been salvageable if it had been privately owned, the Navy determined that the recovery was illegal. After a legal battle, the Navy required that the UHRRF cease their efforts and turn over the artifacts they had recovered. The Navy then took interest in continuing the recovery on their own.

A decade later, a U.S. Navy dive team known as Mobile Diving and Salvage Unit 522 (MDSU 522) began recovery work on PBM Mariner BuNo 59172 as a training exercise. Unfortunately,

during the exercise, a naval diver with a pre-existing heart condition had a medical emergency and died underwater. The tragic death caused the Navy to suspend further work on the project. While MDSU 522 reported success in their training mission despite the fatality, they did not recover the aircraft.

In 1996, a non-profit group of veterans called the Mariner/Marlin Association joined forces with the Naval Historical Center in an effort to resume the recovery. After the substantial effort of securing funding for the salvage and restoration of the plane, MDSU 1 and MDSU 522 resumed the U.S. Navy’s recovery efforts. The teams determined that the fine silt in the lake was keeping the plane suctioned to the bottom. After performing hundreds of dives to prepare the wreck, the Navy team was finally able to try to lift the plane. Unfortunately, this attempt resulted in the tail section of the aircraft being torn from the fuselage. The Navy discontinued recovery efforts yet again and delivered the damaged tail section of PBM BuNo 59172 to the National Museum of Naval Aviation for restoration. The tail of BuNo 59172 (featuring the only surviving example of a PBM Mariner rear turret) is now on display in the Pima Air & Space Museum.

PLANNING THE PROJECT

While we had the coordinates of the sunken PBM Mariner, our team needed to visit the wreck to assess its current condition. We also needed to decide on what techniques to use to safely and efficiently document the plane. In these initial stages of the project, and as preparation for a larger archaeological survey of Lake Washington shipwrecks, we were curious about trying to



Diving conditions on the wreck with multiple divers providing light

use a remotely operated vehicle (ROV) to supplement the images taken by the dive team. ROVs have a few notable functional advantages over divers: they can operate underwater for far longer, they can't get hurt, and they can withstand depths and temperatures that would make even the most seasoned cold-water diver shiver.

The team decided to focus the first dive on the PBM Mariner solely on scouting the wreck and testing the feasibility of using our team member's ROV to collect data. We launched for our first dive on a chilly winter morning in January 2018. We assembled a small team composed of divers, a surface team, and an ROV pilot, and went underway aboard the cabin cruiser *Hat Trick*. The ROV was equipped with small video lights and an onboard camera for data collection. The dive team brought a larger camera system along with four sets of 30,000 lumen Big Blue video lights for our initial tests.

While the dive team and the ROV pilot were both able to collect data, it became clear that the ROV was not the best tool for this project. The limited visibility and high-silt environment made it difficult for the ROV to maneuver without reducing visibility significantly. The maneuverability and equipment carrying capacity of our divers exceeded the capability of the ROV and would be better suited to our mission. We decided to continue the project under the assumption that the dives would be conducted by divers.

DOCUMENTING THE WRECK WITH PHOTOGRAMMETRY

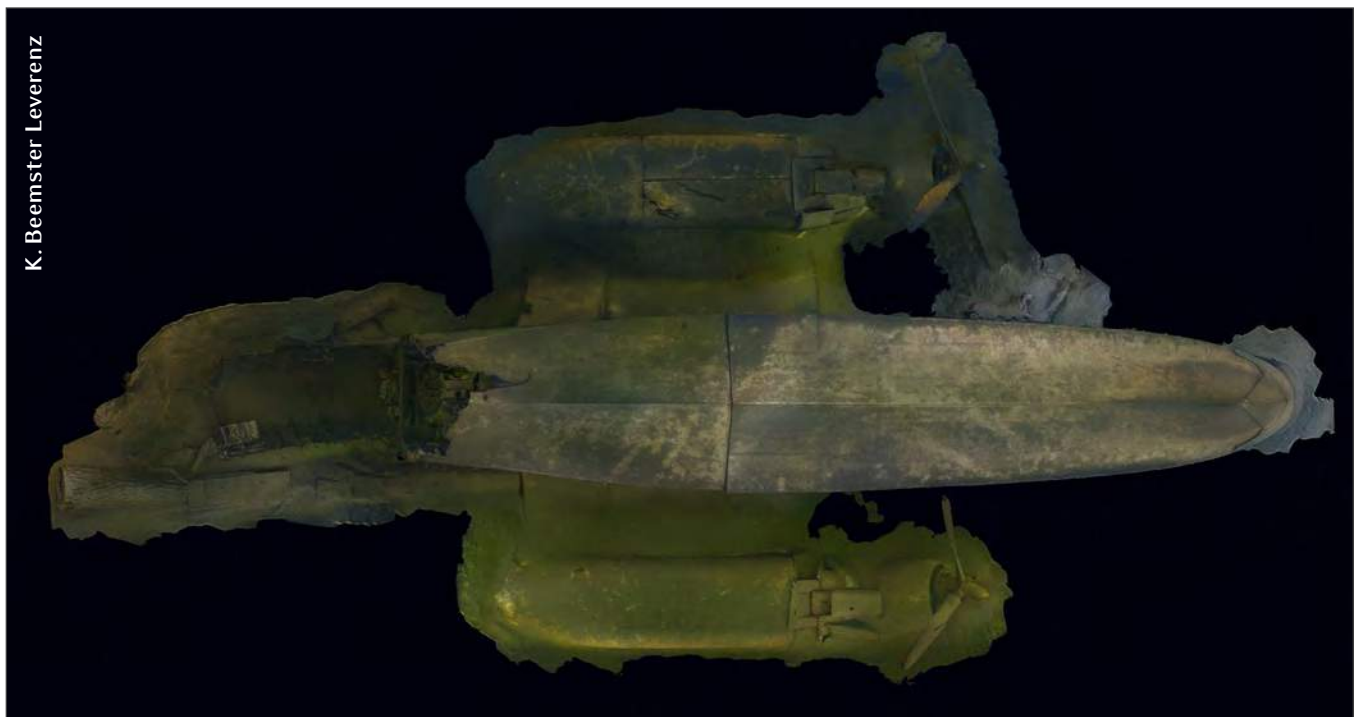
In good conditions and with the selection of a suitable target, 3D photogrammetry can be relatively straightforward. The

process is like creating a photomosaic in three dimensions. You take many images of each part of the wreck from every angle, and then use software (we use Agisoft PhotoScan) to assemble all the photos into a 3D model. With good data, this process is almost entirely automated, and takes only a few hours on a home computer. Once complete, you have an extremely accurate 3D model of what your wreck looks like in situ without having to deal with cold temperatures, hazy water, or even diving equipment.

However, in the conditions of Lake Washington and with a relatively large target like the PBM Mariner, our team expected challenges. The sediment on the wreck reduces contrast, since it makes everything in the area a flat, tan color. Compounding that, visibility is generally poor in the lake. These two factors meant that we would likely need to gather several thousand images to ensure we captured every part of the wreck. Unfortunately, photogrammetry software can take many days or even months to process projects with a lot of images, and we had a deadline.

The best way to reduce processing time is to build the model in smaller pieces, or "chunks," and then align each together into the complete model as a final step. The process is like assembling a model airplane in smaller parts, painting and assembling the wings first, then the fuselage, and then gluing each completed part together.

We decided to model the wreck in four chunks: the port wings, the starboard wings, the fuselage, and the tail. While small, the wings are intricate because of their unique four-bladed propellers, which we anticipated would require many images to model.



K. Beemster Leveren

An orthographic view of the PBM Mariner





The completed model of the PBM Mariner

Getting photos of every side of every blade was critical, as the propellers are particularly recognizable parts of the wreck. The fuselage would be another chunk. Though large, this area is structurally simple, and we were initially quite confident that it would be easy to model. Finally, we photographed the broken tail section, which includes some of the interior of the plane. Interior spaces are enormously challenging underwater, as the large camera systems are difficult to maneuver without disturbing silt. The silt in Lake Washington can take hours to settle, so any disturbed silt would mean we would be unable to continue work in that area and would increase the number of dives required to finish the project.

After our initial scouting dive, we focused our next dives on the fuselage. Although we had expected this piece of the wreck to be relatively easy to model, we weren't able to assemble anything significant after processing several dives worth of images. After careful examination of how Agisoft PhotoScan was using the images, we determined that we weren't getting enough contrast on any horizontal surface to assemble anything useful. It was clear that the amount of silt that settled on the plane's horizontal surfaces was subtly obscuring details and reducing contrast. The contrast was so low on the hull that Agisoft PhotoScan could only place a handful of pictures and therefore couldn't create a 3D model.

We returned for our next photography dive equipped with the knowledge that our images would have to be near perfect to get a model of the fuselage. We restarted the modeling process with our most experienced lighting and photography team. Our plan for the second attempt was to photograph the wreck from very short range to maximize the contrast and minimize the effect of poor visibility on the images. Of course, this would mean post-processing time would be substantial due to the large

volume of images we'd have to use, but it was a necessary sacrifice. In addition to being more methodical with our photogrammetry techniques, we suspected that our prior activity near the airplane might have reduced the amount of silt present on the surface of the hull.

Our second attempt was successful. We were able to capture the sides of the wreck along with the gently curved hull, the plane's biggest horizontal surface. To our great pleasure, the PBM Mariner's distinctive hull and its ball turret were easily visible in the partially completed model.

After completing the model of the fuselage, the wing surfaces and propellers didn't prove to be nearly as much of a challenge to scan as we had initially anticipated. Although the propellers were difficult to photograph, modeling these areas was a matter of executing a process that we'd practiced before with another smaller airplane wreck in Lake Washington.

After completing three of the four major chunks, Megan partnered this project with conservationists from the Navy's Underwater Archaeology Branch Conservation Laboratory, which allowed us to acquire a small sample of fuselage metal from the airplane as part of a study on corrosion. After a short search for an appropriately-sized sample, we were able to collect a small piece of fuselage from where the tail was ripped from the rest of the airplane. After we collected the sample, we placed it in wet storage, photographed it, and delivered it to a lab for analysis.

We focused our final dives on mapping the interior space where the tail of the PBM Mariner had broken free. The challenge in this space was largely logistical: the team needed to light up a small and silty interior space while leaving enough room to



M. Lickliter-Mundon

The completed exhibit installed in the Pima Air & Space Museum

maneuver a bulky underwater camera. Ultimately, we decided on a low-tech solution; we took all the lights we had available and gave them to support divers. The photographer used a JJ closed circuit rebreather (CCR) to avoid percolation from above and shot the images using the camera without any attached lighting. While the results aren't flawless, we were able to model most of the space successfully.

RESULTS

The final model of the PBM Mariner includes most of the wreck, which is in surprisingly good shape for the abuse that it has taken over the years. The analysis of the sample that the dive team recovered shows that the airplane's paint may be helping to keep the skin from corroding. Areas without paint do show signs of corrosion. The team completed the model just in time for Megan's Ph.D. dissertation, and she installed the final exhibit in the Pima Air & Space Museum immediately thereafter. The museum uses a tablet to display the 3D model of PBM BuNo 59172 right next to the recovered tail section of the aircraft, which in turn is on display next the final remaining intact and restored PBM Mariner. Megan filed her final report to the U.S. Navy's Underwater Archaeology Branch, which is part of the Navy History and Heritage Command, and the Department of Archaeological Preservation and History at the Washington State Department of Natural Resources.

The PBM Mariner project was a test case, an example of what can be achieved when people from a wide variety of organizations collaborate with a common goal. Overall, the project was a resounding success. We hope to continue documenting other historically significant wrecks in Lake Washington and to encourage others to become involved in documentation projects in their local areas as well.

Note that the complete model is available for viewing online at <https://skfb.ly/6AoOr>. Full team credits are also available there. Special thanks to Megan Lickliter-Mundon, Ph.D., who enabled the project and assisted with editing this article.



Bombs at Bikini: Operation Crossroads

By Jesper Kjøller



The Bikini Atoll nuclear weapons test, known as the Baker explosion, was captured by invited media. (Courtesy of Jesper Kjøller)

OPERATION CROSSROADS

IN July 1946, the United States conducted a series of nuclear weapon tests on Bikini Atoll known as Operation Crossroads. These were the first detonations of nuclear devices since the bombing of Hiroshima and Nagasaki in August 1945.

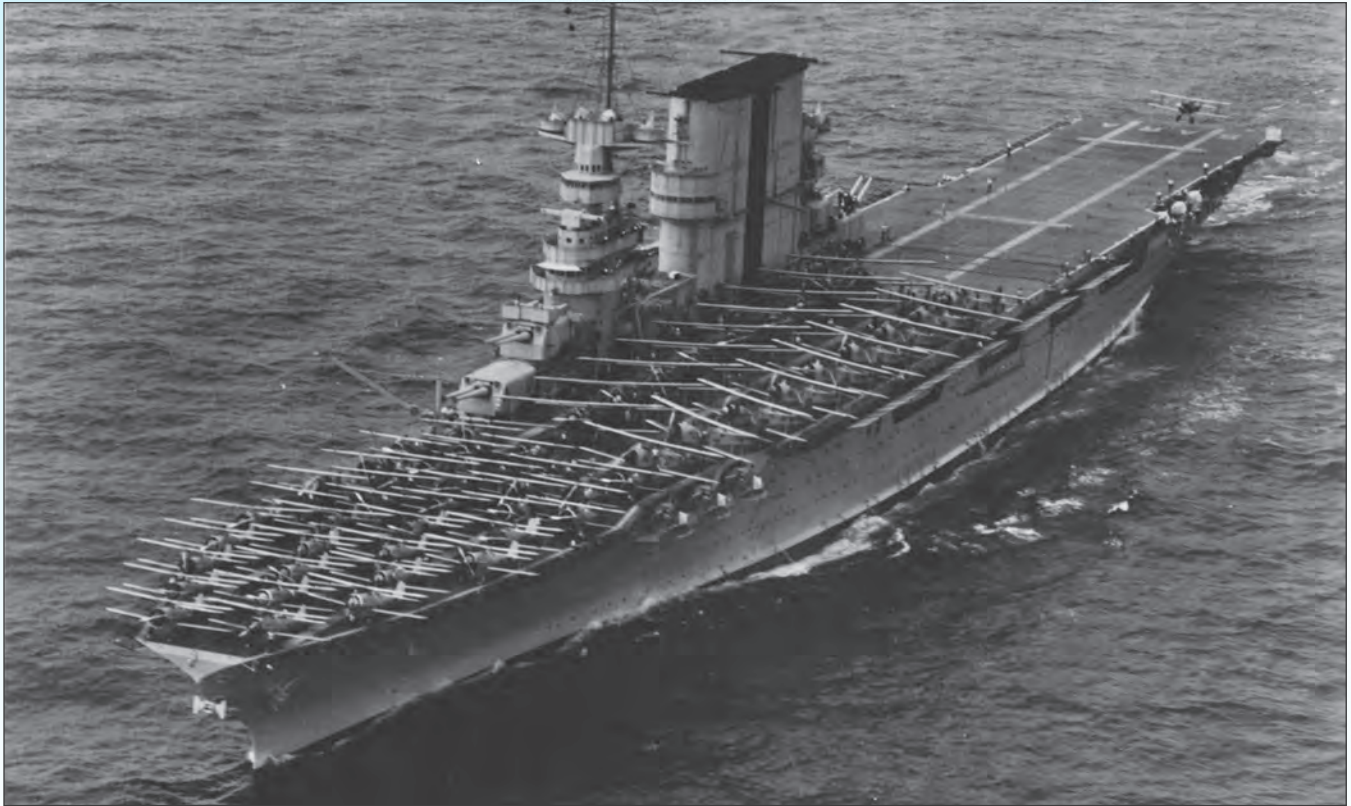
Operation Crossroads was conceived after President Truman ordered his generals to initiate a series of tests “to determine the effect of atomic bombs on American warships.” But many historians also agree that the Americans had a hidden agenda; they wanted to flex their nuclear muscles to deter the new emerging East Bloc superpower. Truman wanted to show the world that

he had nuclear weapons under his control and could detonate them at will.

The U.S. Generals searched for a remote location far away from shipping lanes and air traffic. The Marshall Islands in the middle of the Pacific Ocean seemed an ideal choice, with Bikini Atoll meeting all of the criteria; however, there was one small snag: The islands were inhabited.

In February 1946, the military governor Ben H. Wyatt persuaded the local chief King Juda to convince his people to evacuate the islands. The Americans claimed it was “for the good of all mankind and to end all world wars.”





U.S.S. Saratoga prior to the weapons test (Courtesy of Jesper Kjøller)

In preparation for the nuclear test program, 242 naval vessels, 156 aircraft, 25,000 radiation devices, and thousands of experimental rats, goats, and pigs were put in place. The massive operation also included 42,000 military and civilian personnel.

The tests conducted during Operation Crossroads were the first of many nuclear tests conducted in the Marshall Islands. Further, the detonations were the first to be announced to the public in advance and open to an invited audience, including the press. The huge media presence at the nuclear tests revealed the Truman Administration's desire for the event to be broadcast all over the world and supports the hidden agenda theory. The second detonation test, known as the Baker explosion, was at the time the most filmed event in history.

A fleet of 95 vessels served as the target of the nuclear tests. The vessels were hit with two nuclear weapons each with a yield of 23 kilotons of TNT. The plutonium implosion-type nuclear weapons were the same type used in Japan. The first test, code-named Able, occurred on July 1, 1946. Dropped from a B-29 Superfortress, the weapon detonated 158 m above the target and missed its aim point by 649 m, causing less damage than expected. The second test, codenamed Baker, occurred on July 25, 1946. Detonated underwater, the explosion resulted in radioactive sea spray which caused extensive contamination throughout the area. A third deep-water test named Charlie was planned for 1947. However, the U.S. Navy was unable to decontaminate the target ships after the Baker test, so Charlie was ultimately cancelled.

Today, this isolated area offers an unrivaled historic collection of gigantic aircraft carriers, battleships, destroyers, and cruisers and it must be every serious wreck diver's dream destination.

BIKINI ATOLL

Bikini Atoll appears on the horizon after a 24-hour cruise from Kwajalein Atoll, part of the Marshall Islands. We have made good time on the unusually calm Pacific Ocean and arrive a few hours earlier than expected. We have an opportunity to do a quick orientation dive on the aircraft carrier USS *Saratoga* to get acquainted with her so we can explore her more confidently in the following days. On board we have a handful of GUE trained CCR-divers and we are eager to get in the water after the long voyage.

As I swim on the surface towards the descent line attached to the bow of the *Truk Master*, I look down and see the flight deck of the 270 m-long aircraft carrier. The famed *Saratoga* is one of the largest diveable shipwrecks in the world and among the very few aircraft carriers accessible to divers.

We descend to the deck at around 30 m to get our bearings. The entire flight deck is covered by teak planks. Teak was the chosen material for the aircraft landing surface because it is solid and easy to repair. Even with the deck covered by a layer of seaweed and corals, it is still possible to make out the individual planks.



TRAVEL FACTS: THE MARSHALL ISLANDS

HISTORY

After World War I, Japan was given the power to govern the former German colonies in the Pacific as part of the Treaty of Versailles. The South Pacific Mandate included Micronesia (Chuuk or Truk Lagoon) and the Marshall Islands. The low-lying Marshall Islands did not offer the same protection as the mountainous lagoon in Truk, but the Japanese understood Bikini's strategic position and they built a watchtower to guard against American invasions. American forces captured Kwajalein Atoll during Operation Flintlock from January 3 to February 4, 1944.

GEOGRAPHY AND CLIMATE

The Marshall Islands rest on submerged volcanoes on the ocean floor. The country has 29 atolls and a few isolated islands and is situated halfway between Australia and Hawaii. The Kwajalein Atoll is the largest with 16 km² of land that surrounds a 1,700 km² lagoon.

Bikini Atoll is probably the most remote diving destination on the planet. Bikini is located just north of the equator in the Pacific Ocean halfway between Australia and Hawaii and consists of 23 islands of which only two were habitable.

The dry season is between December and April and the wet season is May to November. The weather changes all the time, and though it rains heavily now and then, it usually does not last long. The climate is stable, hot, and humid with temperatures lingering around 29 - 30°C all year both on land and in the water.

TRAVEL

United Airlines operates two routes to Kwajalein, one from Guam and one from Honolulu. From the U.K. or U.S. mainland, Honolulu is the shortest option, but from Central Europe going to Guam via Manila is the shortest. Guam and Honolulu are a U.S. territory and state, respectively, and even if you are only in transit, you must have a valid entry clearance to the United States.

Kwajalein is a U.S. army base and they do not particularly care for civilians. You must carry a sponsor letter from the tour operator to gain entry and as soon as formalities are complete, military personnel will escort you to the ferry which will transport you to the neighboring island, Ebeye. Here you will either embark directly on the *Truk Master* or stay in a hotel until the boat is ready. To reach Bikini Atoll from Kwajalein takes about 25 to 30 hours, depending on the weather.

CURRENCY

U.S. dollars

COMMUNICATION

There is limited cell phone coverage in the Marshall Islands. The *Truk Master* offers satellite Wi-Fi, so if you absolutely have to be on Facebook while you are in Bikini, you can. But beware, it is expensive.

TIME ZONE

The Marshall Islands are on GMT +12 – almost on the dateline.

DIVING

The diving is relatively easy with only weak or no current. The visibility varies from wreck to wreck and seasonally, but it is usually quite good. Most wrecks are at 50 m, and we usually did two hours run time. The decompression stops are pleasant with virtually no current and a solid deco bar as support on the last stops.

SCHEDULE

The long run times on a rebreather limit the number of daily dives to two. The normal daily routine is a dive in the morning after breakfast and a dive in the afternoon. The *Truk Master* enforces a mandatory and sensible minimum surface interval of four hours between technical dives.

HEALTH

There is no chance of recompression therapy in the Marshall Islands. Serious DCS problems require evacuation to Guam or Honolulu. Make sure you have your diving insurance in order and that it covers emergency evacuation. Dive conservatively, make extended stops, and stay hydrated to prevent decompression sickness.

ELECTRICITY

Guam, Honolulu (Hawaii), and the Marshall Islands use U.S.-style plugs with 110 V. On board the *Truk Master*, the central European plugs have 220 V. Bring an adapter if you are staying in hotels before or after the diving part of the trip.

PERMITS

The Marshall Islands requests a mandatory marine park fee of 500 U.S. dollars.





J. Kjølner

A diver explores the U.S.S. Saratoga.

TIGER ON THE SARATOGA

To give the pilots as much possible space for take-offs and landings, aircraft carriers have a narrow and tall bridge-structure pushed to one side. The *Saratoga* had four sets of 55-caliber MK9 eight-inch double barrel guns, two pointing forward and two pointing aft. Only one of the four-gun turrets was not removed before the blast, and the smokestack has since collapsed. However, the superstructure is surprisingly intact. Here we find map rooms, radar rooms, coding rooms, and radio rooms, but they are all small and cramped. Space was limited on such a narrow bridge.

We swim into the wheelhouse. It has no windows; only narrow slits, which I assume were designed to protect officers in the high and exposed position. The design of the command bridge on an aircraft carrier tends to present as small a target as possible. In front of the wheelhouse is an outside navigating bridge, from where the commanding officers had a better view of the ship and its surroundings when docking or performing complicated maneuvers.

We leave the bridge and swim towards the upline to begin our decompression. On this dive we stayed relatively shallow so we didn't rack up more than 30 minutes of decompression. Suddenly, my buddy points at something behind me: A tiger shark is checking us out and stays with us for a while. We later hear that he is a common sight on the *Saratoga*. As if the dive is not already fantastic, the tiger shark is the icing on the cake.

FLOATING CITY

We have a nice selection of blueprints and schematics of the wreck and study them closely between dives to plan our routes and to make sure we visit the most interesting places in the most efficient manner.

An aircraft carrier is a floating city. When fully operational, the *Saratoga* was the home of some 2,800 crew, so there were many practicalities to be considered. On the drawings, the different compartments are marked with functions such as bakery, barbershop, dentist, laundry, sickbay, blacksmith, potato peeling room, butcher, and dive locker.

BIKINI AND TRUK TECH EXPEDITIONS

Between 2019 and 2021, the wreck explorer Aron Arngrímsson is hosting a series of expedition-style trips with *Truk Master* exclusively for technical divers on CCR. The Dirty Dozen trips in Truk and the Critical Experiment trips visit Bikini Atoll. You can get in touch with Aron Arngrímsson through Facebook or e-mail him at info@thedirtydozen.org.



With so many penetration possibilities and an abundance of details inside and outside, you could easily go to Bikini and only dive the *Saratoga* for a week. In fact, if the aircraft carrier was the only wreck here, it would still be worth the long trip. We did five long dives on the enormous vessel and I still felt that we only scratched the surface.

NO BUBBLES

While the *Saratoga* theoretically has several kilometers of passageways to explore, not all levels are accessible or safe to penetrate. From the enormous forward aircraft elevator, it is possible to enter via a few different routes. We peek into a promising doorway but the water beyond looks silty and hazy, so we deploy a safety spool and make a tie-off so we can find our way back to the exit if we experience a silt-out. After swimming past the first couple of rooms, the visibility opens up and we can now clearly see the permanently attached penetration line that leads further into the wreck. Apparently, staff from the now-defunct dive center on Bikini Island laid the line.

We attach our safety line to the main line and start exploring. Everything is rusty and the floor is covered by a thick layer of extremely fine sediment. Open circuit exhaust bubbles would dislodge a shower of rusty particles from the roof. I'm hindered by my big camera system and for every doorway or bulkhead we pass, I have to fold the strobe arms and cautiously push the camera in front of me while taking extra care not to scratch the dome.

After only a few minutes of swimming, we find a surprise. On the floor sits a U.S. Navy Mark V diving helmet – a perfect specimen in good shape. The original design was from 1916, but the 30 kg helmet was still in use in the mid-1980s. Its presence here speaks volumes of the limited number of divers that have visited Bikini. In most other places it would have been long gone. A diving helmet from the *Saratoga* is a valuable collector's item. We take a few shots of the artifact and continue our journey.

A TRIP TO THE DENTIST

From studying the maps, we know that after swimming down a flight of stairs, we need to make a sharp right turn to reach our final destination. My dive buddy in Bikini, Richard Lundgren, swims in front of me down the narrow passageway. Suddenly, Richard disappears into a doorway to the left. Is this it? Did he find it? I peek in and am met by a fantastic scene. We find what we were looking for: the dental operation room on the *Saratoga*. Inside, everything is intact: Three dentist chairs arranged with all the bells and whistles of a dentist work station including drills, wash bowls, hoses, and lights. We move around the small compartment slowly and carefully to avoid disrupting the delicate environment or stir up any silt.

On the way back, we spot more hidden gems such as telephones on the walls, fire extinguishers, and signs reading "Sickbay." Old school Coca-Cola bottles are scattered all over the place. In numerous rooms and corridors, we see filing cabinets.



A GUE diver examines a U.S. Navy Mark V diving helmet inside the wreck of the Saratoga.



The wrecks of the Marshall Islands should be on the bucket list of every passionate wreck diver.

Apparently, in the pre-digital age, the Navy had a lot of paperwork to store.

On a later dive, we also find the dive locker complete with umbilical-hoses and dry suits hanging on the wall and we explore crew lounges with sofas and coffee tables.

TORA! TORA! TORA!

All the warships in the lagoon played important roles in World War II before they ended up on the sea floor in the nuclear blasts. But the one with the most impressive historic pedigree has to be the Japanese battleship HIJMS *Nagato*. It was from this floating fortress that Admiral Isoroku Yamamoto directed the attack on Pearl Harbor on December 7, 1941. The *Nagato* was

impounded by the Americans after the Japanese surrender and just as the German *Schwerer Kreuzer PrinzEugen*, the *Nagato* was included in Operation Crossroads to gather information on enemy shipbuilding techniques in an atomic explosion. But I suspect that the opportunity to seek revenge for Pearl Harbor also played a role.

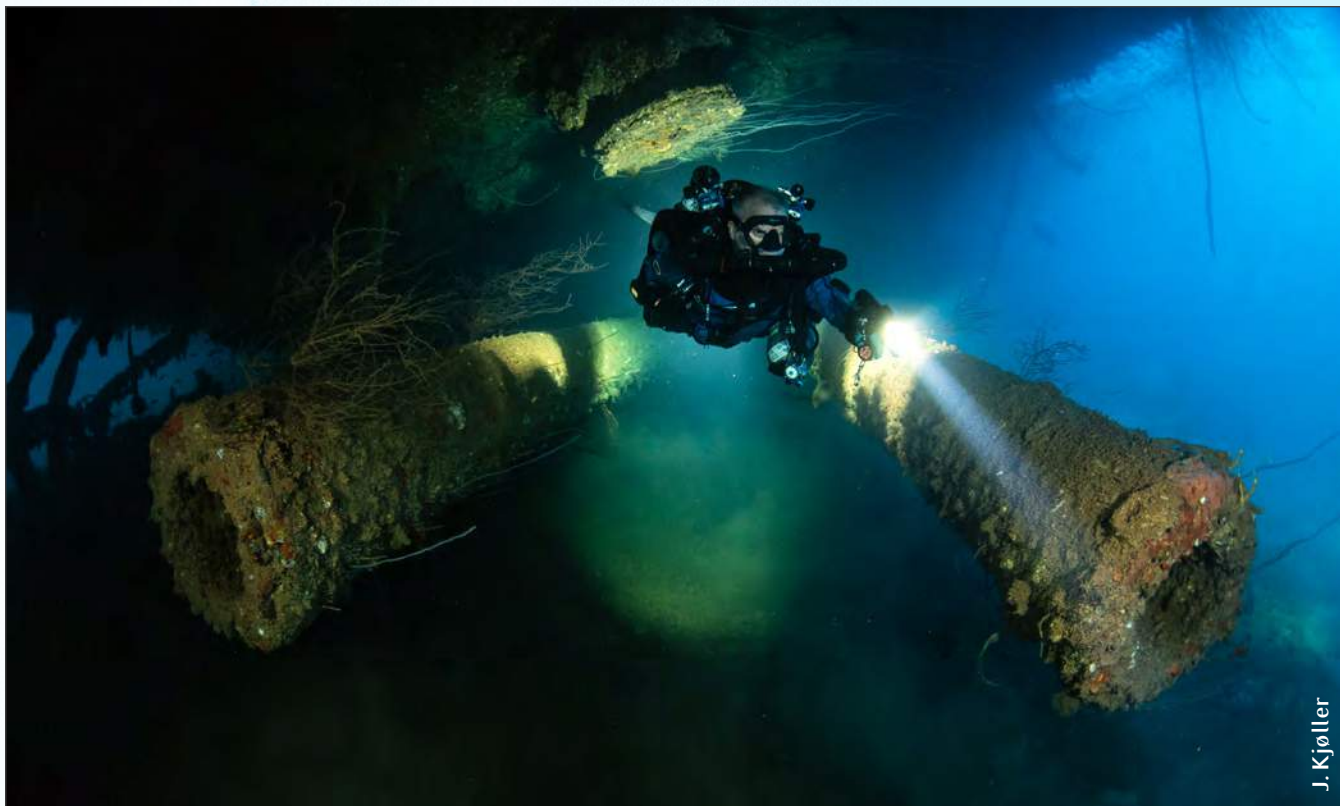
When a heavy battleship sinks, it almost always lands upside down. The tall superstructure, the weapons, and the solid armor make the ship so heavy over the waterline that it invariably topples over when lethally damaged by a shock wave created by an underwater A-bomb.

TRUK MASTER IN BIKINI

Master liveaboards are the only regularly scheduled dive operator in Bikini Atoll since the dive center was abandoned some ten years ago. *Truk Master* spends three months in Bikini every year from July to October and her four decks provide ample space for relaxation, dive equipment, and camera preparation. The vessel caters to the needs of tech divers on open and closed circuit and is equipped with twin oxygen-makers, an ample supply of helium, twin-sets, rebreather-tanks, deco-tanks, and scooters for rent. It is a huge challenge to run a liveaboard operation in such a remote location, where everything has to be shipped from far away. But the crew on *Truk Master* makes it look easy and you almost forget how far you really are from civilization.

www.masterliveaboards.com





A GUE diver examines the massive guns of the Nagato.

Just as the *PrinzEugen*, the *Nagato*'s greatest highlights are the four enormous propellers and the twin 16, 1-inch guns, the biggest in the world at the time. The pagoda-style superstructure is partly squashed under the weight of the hull, but it is possible to squeeze into the bridge and pretend you are Admiral Yamamoto listening to the famous radio codeword that launched the attack on Pearl Harbor: *Tora! Tora! Tora!*

USS LAMSON

The *Saratoga* is, of course, the crown jewel of Bikini Atoll, with the *Nagato* a close second. The size, the history, and the details of these two wrecks make them incomparable not just on Bikini, but everywhere in the world. However, during our expedition, we have a chance to dive a handful of other wrecks from Operation Crossroads, including destroyers, battleships, and submarines. My absolute favorite among those smaller vessels (everything is small compared to the *Saratoga* and the *Nagato*) is the destroyer the USS *Lamson*.

We descend along the mooring line and are met with a pleasant surprise. The *Lamson* sits upright on the sandy bottom and the visibility is the best we have seen in Bikini so far. The *Lamson* was armed to the teeth when she was sunk by the Able detonation test. The ship is full of artillery, canons, deck guns, racks with mines, depth charges, and torpedoes. However, the mangled mid-section reveals the impact of the blast.

TIME BOMB

I've been fortunate enough to dive some of the most iconic shipwrecks in the world including the *Umbria*, *Thistlegorm*, and *Britannic* and the wrecks of Truk Lagoon. But the wrecks of Bikini are in a league of their own. It feels meaningful to be able to document the history of this place, not only the war records of all the wrecks, but also the impact the Truman Administration's decisions have had on the environment and the island's population. Radiation still prevents permanent sustenance living in the island paradise, effectively banishing those native to Bikini Atoll.

Also, the wrecks themselves are ticking time bombs. At the time of their sinking, many of the vessels were fueled to 80% capacity. That fuel will eventually escape when the wrecks decompose, which could result in an environmental disaster of *Exxon Valdez*-magnitude. It is not a matter of if it will happen, only when.

If you are a serious wreck diver, you should make plans to go to Bikini Atoll. With Aron Arngrimsson's Critical Element expeditions in partnership with the *Truk Master*, it has never been more convenient and fun to explore Bikini's nuclear fleet.



So, You Want to Find Virgin Cave?

The Glamorous World of Underwater Cave Exploration

By Natalie Gibb



N. Gibb

Discovering a virgin cave often entails hard work

DUSK settled over the jungle. The air was about 40° C, eight-gazillion percent humidity, and fifty-percent mosquitos. My exploration partner Vince and I stared at a bifurcation in what could only euphemistically be called a trail. We were lost, again.

Cave exploration in Mexico is primarily a terrestrial pursuit, and involves working with landowners to discover new holes in

the ground (most of which do not have diveable cave). The land-based portion of underwater cave exploration is often challenging. There's no Yucatan Jungle Navigation 101, or Techniques for Avoiding Drunk Porters workshop, and so Vince and I have been forced to pursue our passion for cave exploration while learning the hard way: by really screwing things up. Repeatedly. We have too many stories of total failure to share all at once, but here are three of my favorites.





N. Gibb

Learning to explore is a time consuming and challenging process

SIMPLE GOAL #1

Scout a cenote 17 kilometers back in the jungle on a ranch belonging to a fellow named Oscar.

HARSH REALITY

Oscar's cenote was our very first exploration project. We drove out at 6:00 am on an August morning and arrived at the ranch around 8:30 am. The team included Vince, Jason, and myself, and we brought along two AL40's and 8 pounds of weight, intending to hike the 500 m to the cenote, drop under the surface, and take a quick peek to see if the cenote was worth exploring. We hoped this would be done quickly, as Vince had to catch a flight to France at 5:00 pm.

We met Oscar as arranged, and I immediately marveled that this older gentleman still had enough energy to work on his ranch. The path to the cenote began as a meter-wide clear-cut trail, but disappeared into dense jungle after a kilometer. Oscar paused. We paused. Oscar furrowed his brows. The sun moved higher in the sky. Oscar grabbed his machete and started to cut a trail to the right.

I was impressed; this 65-year old man was tough! The three of us traipsed along behind Oscar, futilely slapping at mosquitos. It was sweltering. I wrung out my hair. Oscar paused and narrowed his eyes. We took a break and shifted the tanks around between people. Oscar headed left down a slope, stepping over a termite-infested tree. We continued to follow along.

By 11:00 am, even Oscar looked exhausted, but he kept hacking away with his machete. Everyone was thirsty, and I was developing a bruise from carrying a tank on my shoulder. Oscar's trail alternated between dense overgrowth that ripped at our clothes and faces, and open clearings where the sun scorched our foreheads and shoulders. Wheezing, Oscar sat down on a rotten log on a gentle incline.

Wait a moment. Was that the tree we had stepped over a little while ago? We had certainly hiked more than 500 meters.

"Are you certain this is the right way to the cenote?" I asked Oscar. Vince and Jason hushed me. I was being rude.

"Yes, yes," panted Oscar, standing back up. "It's just 500 more meters." We trudged off into the jungle again, the vegetation closing behind us as if we had never passed.

"I am giving this half an hour," I mumbled to myself. I looked up at the sun to get a sense of direction, but it was almost noon and the sun was in the middle of the sky. Oscar was now stumbling forward while directing Vince, who had taken over the machete work. I saw ticks crawling on my arms but no longer had the energy to pick them off while carrying the tank.

"Vince," I hissed, "We are lost." He shushed me, not wanting to offend Oscar. I was past caring.





N. Gibb

Being the first to explore a cave means being the first to meet the challenges of the new location.

I stated the fact everyone was avoiding: “You don’t know where the cenote is.” Oscar simply hung his head and sweated silently in defeat.

“We have to leave now and try to find our way back.” I turned around to find myself staring at a green wall of leaves. Where had we come from? This was bad. Vince had to be in an airplane in less than five hours.

Livid at being led astray and furious at myself for not speaking up sooner, I began to force my way through the dense branches and vines. However, I quickly realized that without any references, this was pointless. In cave instructor parlance, we needed to “establish a point of lostness” to avoid continuously circling back on ourselves. I began to tear my shirt into thin strips, and tie the strips onto trees at eye-level to mark our path as we miserably dragged ourselves in what we thought was the direction of Oscar’s ranch.

I still don’t know how we found the original path, but I remember that we popped out onto it unexpectedly while Vince and I were having a serious discussion about what to do if Oscar collapsed in the middle of the jungle.

We made it back to Vince’s house about two hours before his flight, shoved his clean laundry (still in the plastic bag from the wash-and-fold laundromat) into a suitcase, and rushed to the airport in blatant disrespect of traffic laws and other drivers. He hopped out of my truck and ran for the check-in counter barely

an hour before his flight, muddy and sweaty in his jungle garb. Including the layover, he journeyed over 24 hours to reach his parent’s house in France, where he removed 36 ticks when he finally got to shower.

I went straight from the airport to a marine supply store to purchase a GPS. With Oscar’s help, Vince and I did eventually dive the cenote, which turned out to be a 120-ft-deep sinkhole. Jason never came exploring with us again.

IN HINDSIGHT

We never should have relied on someone else for navigation. I wouldn’t do it underwater, so why did I do it on land? It’s also a terrible idea to carry tanks without having first established a clear route to a dive site. Don’t go exploring when you have to be at the airport (this was not the last time I made this mistake), and, in what would soon become a theme in our lives, if someone claims a cenote is 500 meters away, they have no idea how far it really is. Did we learn from these lessons the first time? Not a chance.

REASONABLE GOAL #2

Drive to a cenote way south of Tulum and check it out with the landowner.

UNFORTUNATE RESULT

The man pacing back and forth in front of the taco stand in Tulum at 7:00 am had to be Juan. I pulled over, and he jumped up when he saw my truck.



“Are you Juan?” I asked. “Yes, you’re Natalie?” he responded. As far as meeting a landowner for the first time goes, this was too easy. He hopped in my truck, which I had optimistically loaded with two sets of tanks and my gear, and we headed south.

The first surprise came about 45 minutes later. “Turn right!” Juan directed. I was confused. Juan was directing me to Chumpon, a town about 20 minutes inland to the west. The ranch with the cenote was supposed to be south along the coast.

“We just need to make a quick stop,” he explained. “The landowner is going to come with us.” I thought Juan was the landowner, but okay.

I pulled up in front of a palapa in Chumpon where five guys waited excitedly. The eldest, who turned out to be the actual landowner, hopped into the front seat of my Ford Ranger. Juan perched on the armrest between the owner and me and the other four piled into the back. Thank goodness Maya people are small. Everyone chatted away, and the mood was jolly. I had a suspicion that beer was involved.

Back to the main highway the seven of us bounced, crammed together like we were flying economy. I had to reach between Juan’s legs every time I needed to shift gears, which inspired a flurry of giggles from the gentlemen in the back and much embarrassment from Juan. No one was paying attention to the road.

“You missed it!” screamed the landowner as we sailed past an overgrown path on the left. More giggles from the back. I hit the brakes and everyone flew forward. Juan gasped as he hit the gear shift, and then crawled to join the four in the back who were now in hysterical laughter at Juan’s pain. I turned left. “It’s about 500 meters,” the landowner explained.

Two kilometers later, I stopped the truck in front of a large, turbid puddle.

“Is this the cenote?” I asked doubtfully.

“No,” the landowner explained. “You have to drive through this and keep going about 500 meters on the other side.” I looked across the water; the road did indeed continue up a slope, but I would have to drive through about 20 meters of water. Having recently gotten the Ranger stuck in mud, I was concerned.

“How deep is the water?” I asked. The landowner looked annoyed. Culturally, it’s quite rude to question an older person, especially when he is doing you a favor.

“It’s not deep,” he said. I hesitated. He frowned. The truck fell silent.

“My brother and I drove through here two days ago,” the landowner said, “My brother’s truck is smaller than yours.” I wanted to get out and check the water to make sure the ground was



N. Gibb

The payoff for hard work and for frequent failure during exploration is discovering pristine cave in which you are the first cave diver to enter.



N. Gibb

Beautiful decorated cave makes all the false starts worthwhile.

solid enough to drive on, but if I got out now, I was basically calling him a liar. Not a good way to start a friendship. Anyhow, I had six people in the truck to help if it sank in the mud.

The Ranger entered the water with a huge splash, and immediately slowed from the water resistance. This was not a shallow puddle.

“Drive, drive, go, go, go!” shouted everyone. “Don’t stop!” But as the water crept over the hood of the truck, the truck rolled

to stop. Out of some insane, adrenaline-fueled intelligence, I hit the power windows and unrolled them just before the electrical system shorted out.

Have you ever heard a Maya person scream? As a culture, Maya are generally quite stoic, but given sufficient encouragement, anyone will lose their cool. As water poured in through the cracks in the door jams, panic filled the truck. The guys tried to open the doors, but the pressure of the water made this impossible, and we all tumbled out the windows into what we quickly learned was not clean water.

Cell phones hoisted above our heads, we waded back to shore and stood, stinky and silent, overlooking the partially submerged Ranger. Minutes passed. The landowner spoke first.

“It will be fine,” he said. “The truck just needs to dry off a bit.” I was dumbfounded. The engine had certainly flooded.

I was now faced with a challenge: I had to avoid turning into the stereotypical crazy, overreacting gringa that everyone in Mexico hates. Strong emotions were not going to go over well with this group, and I didn’t want to frighten them away. There was no cell phone signal and I really didn’t know where I was. I forced a smile and a laugh, and agreed with him.

When a truck is partially filled with water, it weighs a great deal more than one might expect. It took all six guys pushing at maximum power to get the truck out of the water. As it rolled up onto the road, water streamed from the doors in brown waterfalls. It smelled. We opened the doors and began to scoop poop water out of the

interior using coffee mugs and shoes.

“How long should we leave it to dry?” I asked the landowner.

“It should be fine after a few hours,” he said with authority. “Do you want to see the cenote?”

So, there I was, floating my dive gear though the dirty water to the far shore with the help of five bedraggled, soggy, partially inebriated Maya guys, while Juan sat with my broken truck





N. Gibb

Exploration is not for the meek.

nursing his testicles. Once everyone had dog paddled across the water, two guys hoisted my tanks onto their shoulders and another grabbed my gear bag and we headed off for the cenote. They were being pretty good sports.

“How far do we have to walk?” I asked.

“Just about 500 meters.”

Two minutes, and about 40 meters later we arrived at the cenote. The first thing I noticed was the color: turbid yellow. The second thing I noticed was the stench. This was clearly the same water that filled Cenote Ranger back down the road. The guys waited with anticipation. Admiration for the intrepid diver filled their eyes as they proudly presented me with the single most repulsive cenote I have ever seen. There was no way I was getting out of this. I was going to have to dive it.

Equally disgusted and curious, I lowered myself into what I could only assume was E. coli soup. I groaned into my regulator as the tepid water covered me. Diving by touch, I held my reel in my left hand and ran my right hand down a wall. The wall was soft and stringy, with hair-like growths covering it. I pushed my arm into the particulate all the way to my shoulder before I could feel actual rock. How repugnant. I worked my way down and around the cenote in a search pattern. The water never cleared and there was no cave passageway. I have never been so happy to *not* find cave in my life.

I surfaced from the cenote like some strange swamp monster, strings of pale whatever-that-was trailing from my arms and head.

“I am so sorry,” I said, trying to look disappointed. “There is no cave to dive in this cenote.”

Leaving Cenote Shithole, we trekked back to Cenote Ranger and hauled all the gear back across the water and loaded it back into the truck.

“We can bump start it!” exclaimed the landowner. Now, I am no mechanic, but I was pretty sure that if you force a flooded engine to turn over, you will destroy any chance of salvaging it. I said as much.

“Don’t worry,” he said. “It will be fine! It’s dry now.” After several attempts at bump starting my poor, flooded Ranger, the group determined that it was indeed, not fine. Several members of our party set out to find help.

Miraculously, one member’s brother happened to be driving down the road, and about five minutes later, they showed up with a truck. Even better, they had a rope. We attached the fraying rope to my truck and began the most illegal, dangerous towing operation I have ever participated in. The first few kilometers on the dirt road were manageable, but we picked up speed pulling onto the highway.

Truck in neutral, foot on the break, I muscled my truck through the turns, sometimes swinging wildly side to side as the car full of guys made sounds as if they were on a roller coaster. They were having a blast; my nerves were shot. They were taking me back to Chumpon to their mechanic instead of to Tulum where we would have a cell phone signal because they didn't want to get caught towing my truck illegally on the highway. Just as we rounded the turn off the main highway, the rope frayed apart and my truck slid off to one side. I hung onto the wheel with all my weight, the lack of power steering making the turn difficult, and narrowly missed trees as we rolled onto the Chumpon road.

"We need beer!" chirped someone in the back. Me too, buddy.

We rolled into the beer store, illegally open on a Sunday, and I purchased and distributed nine 40's of slightly warm Corona. We rolled through town, still being towed, with dive gear poking out over the truck bed, my muddy, stinky team hanging out the windows of the broken truck pounding 40's straight from the bottle while their friends and neighbors either cheered or stared in disbelief. It's a small town.

We stopped at the side of the town square, and someone went to fetch the mechanic from his house. Everyone else hung out. This was the most thrilling thing that had happened in a while, and my team was excitedly regaling everyone the story of, of all things, my 30-minute dive. About half an hour later, the mechanic stumbled up, clutching his own Corona, and began an assessment of the Ranger.

"It won't start," he said.

"Is there any way we can get a tow truck?" I asked.

"We just need to replace the starter," advised the mechanic.

"Where could I get a tow truck?" I asked again.

"My friend in the next town has a starter for a Ranger," said the mechanic. Cheers from my team.

So, now the original seven of us, our two rescuers, and the mechanic piled into our rescuer's truck and headed down the road to find the starter in the next town.

"I am out of beer!" someone called up to the cab from the truck bed as we passed the second beer store illegally open on a Sunday. This time I had to purchase eleven 40's, including one for the mechanic's friend.

We arrived at the mechanic's friend's house about ten minutes later. "Do you know anyone who has a tow truck?" I asked as I handed the mechanic's friend a Corona. The mechanic said something to his friend in Maya.

"Yes, I have a starter!" he exclaimed, thrilled to be of service. I took a swig of my beer.

Back in town, we lazed around the square sipping beer as darkness fell, the mechanic tinkering with my truck while I



Before undertaking exploration, divers should be experienced and skilled.





N. Gibb

Entering a new cave means that you will be the first to encounter any hidden challenge.

obsessively checked for a cell signal every thirty seconds. Around 8:00 pm the starter was installed. We waited with bated breath as he inserted the key and turned it. Nothing. Not even a click.

“There could be water in the engine,” the mechanic said.

“Do you think someone could tow me back to Tulum?” I asked. “It’s night time now. There won’t be any police on the road.” Doubtful silence. “I will buy the beers.” Smiles. We had a deal. And that’s how I ended up rolling into the small town of Muyil, 20 kilometers south of Tulum, at 10:00 pm with a entourage of ten drunk Maya guys from Chumpon, my truck towed by a braided length of laundry line, stinking of rancid water and covered in mud. They didn’t want to take me all the way to Tulum because they didn’t want to risk the police stopping us with our questionable towing method, but from Muyil I was able to call a tow truck.

I left my truck at my mechanic’s in Playa del Carmen at midnight, and sent him a text message. The next morning I had a reply: “What did you do to your truck? It stinks, it’s wet, and the engine is destroyed!”

“I was exploring,” I texted back. “It’s a long story.”

THE LESSON?

DO NOT drive through water without checking the depth. Carry a lot of extra cash in case you need to buy beers. Never lose your cool. If I had started crying or yelling, I doubt I would have had as much help as I did.

RATIONAL GOAL #3

Accompany a dry caving team to check a sump at the back of a semi-flooded cave.

HOW IT ACTUALLY WENT

Access to this cave was a bit difficult, so the entire team, led by renowned dry caver Peter Sprouse, camped at the entrance to the cave. I was in bad shape from the very beginning of the trip, with a high fever and a stomach infection, but I really wanted to see the cave and figured I would improve in a few days.

My husband Rory had been on a similar expedition, and while he hadn’t dived the last time, he was familiar with the routine: we would use small inflatable rafts from Walmart, optimistically branded the Explorer100 and the slightly larger Explorer200 to float the tanks and gear back to the sump. These bright orange rafts were designed for children to play with in pools. The largest had a maximum capacity of 90 kgs.

There were approximately 12 people at the camp. On the first day, everyone inflated their flotation devices while Peter briefed us on the plan. Some people had inner tubes, others had also brought Explorer100s, and there were two tiny children’s inner tubes as back-ups for the team. The final push would involve floating the gear and tanks four kilometers into the semi-flooded cave, hiking everything over three portages, and then dragging the tanks through a crawlway to the final sump. After arriving at camp around noon on the first day, we would do a trial run with two tanks to the second portage and leave them there for the next day.





N. Gibb

At the heart of exploration are adaptability and perseverance.

I vomited in the bushes, downed a few more paracetamol, and joined the team at the entry point, the edge of a meter-deep pool with sparkling turquoise water. The scale of the cave was incredible; it measured 30 meters wide in some places. Thick white columns rose from the water, soda straws covered the ceiling, and helictites sprung from the most unexpected places. Rory and I put the tanks on our rafts, belly flopped on top of them, and used hand fins to swim like turtles through the cave.

This was fun! Everyone was having a blast. We made it to the drop point for the first day after about one hour. We stashed the tanks on an island and the dry cavers did a bit of survey while Rory and I checked a few leads for sumps. After a short break, the group started to paddle back to camp, joking and chatting as we went. One caver was really getting into the experience, speeding through the water on her Explorer100 and making race car sounds, when she miscalculated and brushed against a stalagmite underwater. We immediately heard a soft hissing sound.

RaceCar's Explorer100 started to wilt. Peter pulled out one of the back-up tubes, inflated it, and reminded everyone to take care with the sharp rocks. We paddled on out of the cave, excited for the next day's adventure.

On the second day, we had two more tanks and our gear to float out to the first day's drop point, and then we had to take all four tanks over a third portage to the sump. We distributed our gear and tanks between the five remaining Explorer rafts and the

whole team headed out. Fewer people came along this time, so we had both back-up inner tubes free again.

Near the first portage, what was to become a familiar hissing sound erupted from the rear of the group. Lifting her tube like a sad, soft donut above her head, one caver at the back of the team struggled over to a shallow area where she could deploy a back-up inner tube. Peter chastised the group again, and we all nodded in appreciation of the need for care. I ducked my head underwater to cool my throbbing headache, and continued on, mildly stressed about the integrity of the rafts.

Undeterred from yesterday's experiences, RaceCar continued to zip through the cave, laughing maniacally, and occasionally colliding with other rafts. About half-way to the second portage, she bumped Rory, who ran aground on a shoal. Rory, the Explorer200, his gear, and his tank all slowly began to submerge. We called ahead for help, but the rest of the group kept on moving. With one raft between us, we put both tanks and Rory's gear into my raft, and dragged it behind us while we swam for about 500 meters to catch up with the group.

I don't know if it was the headache, the nausea, or the actual situation, but I was done.

"I am calling the dive!" I proclaimed. "This isn't safe. We are going to end up abandoning either dive gear or people in here because we are losing all the rafts. You guys all just ditched us when we had a problem. This isn't okay." But Peter is persuasive,



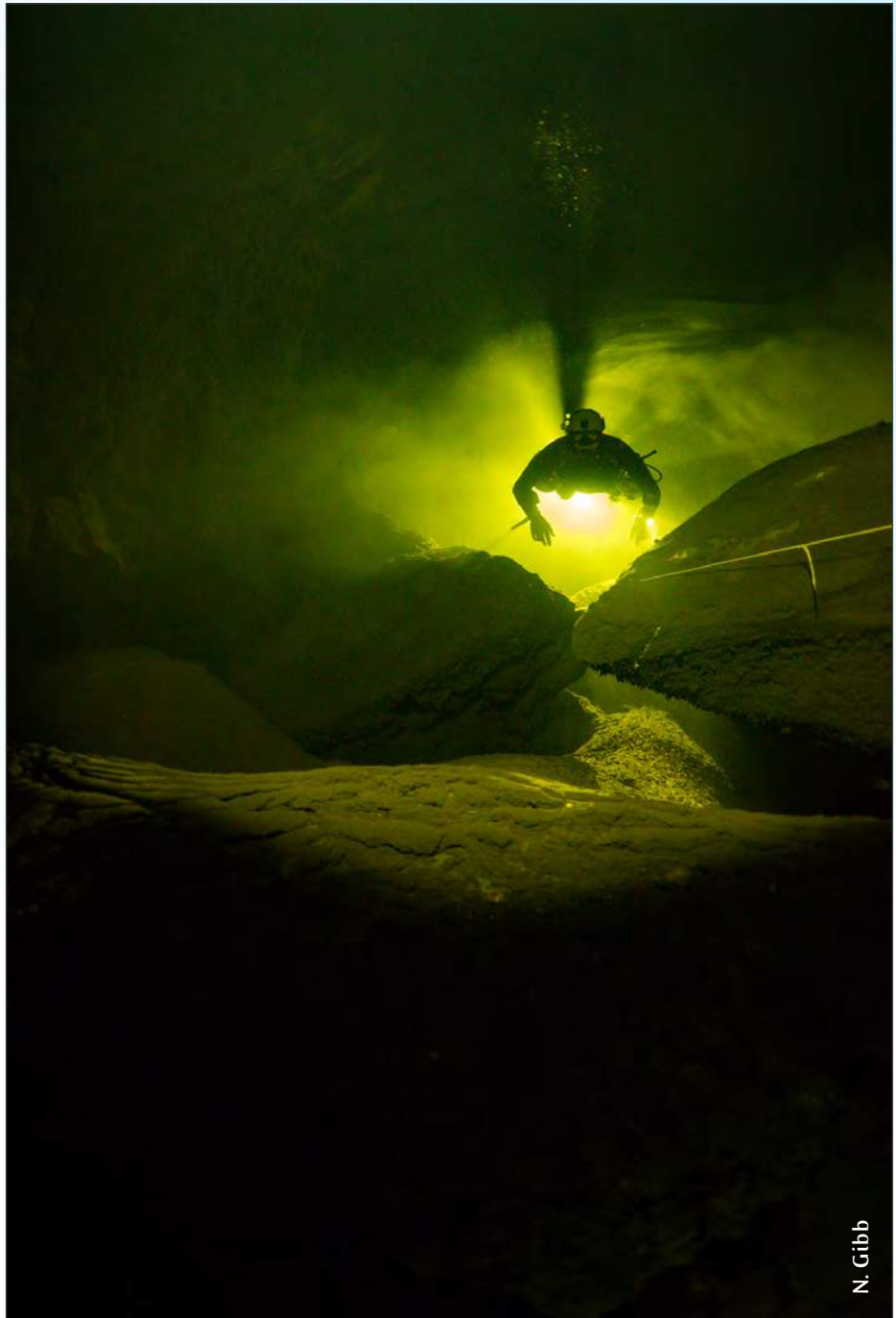
and somehow convinced me to keep going against my better judgement. We redistributed the gear and continued to the second portage, and then the third.

From here, we had to drag the tanks to the sump. Peter pulled out the cave map from the last expedition, glanced around, and started off with one of the tanks on his back. Rory and I followed with one more tank and my dive gear. The cave got smaller and smaller. We slid down a slope on our backs, dragging the tanks behind us, and then belly crawled over a low mound covered with sharp shards of flowstone and inconveniently placed stalagmites. About twenty minutes into it, Peter pulled out his map, took a look, and called from the narrow tunnel ahead that we were going the wrong way.

“I have never actually been here before!” he explained. So, we backtracked through fifteen minutes of miserable passage, banging the tanks along and ripping our wetsuits on the sharp rock until we located the correct passage. We crawled on our elbows and knees up and down for another twenty minutes. Simultaneously sweating and shivering, covered in abrasive mud and holding back my nausea, I was more preoccupied with the difficulty of returning to camp with only four rafts and no back-ups than the current situation.

Once I saw the sump, my stress melted away. It was a perfect pool of sapphire water, with tunnels clearly running in three directions. I have rarely seen a more enticing entrance. Underwater, the cave continued. I found a room filled with geode-like crystals, and another with yellow and orange bedrock. I discovered two tunnels that clearly continued, and surfaced with a clear head feeling surprisingly fresh after three hours. Then, we had to schlep all the gear back.

We pulled my tanks and gear out of the crawlway and loaded it into the rafts. We left Rory’s tanks (still full) for the next day. The mood was tense as we all carefully paddled back, nervously finessing our motley assortment of floatation devices over shallow, spiky hills and around razor sharp crystalline formations.



N. Gibb

Diver exploring a new cave

All of us, that is, except RaceCar, who bumbled blithely along taking selfies and bouncing off the walls on one of our four remaining Explorers. We arrived without further incident at camp.

On the last day, we headed back to the sump with a reduced team: we took four rafts, one inner tube, and two back-up inner tubes. Unencumbered with gear, I started spotting sumps along



N. Gibb

Successful exploration often requires an extended team comprised of both divers and members of the local community.

the entire semi-flooded cave. We arrived at the far sump and Rory’s cartography dive went well.

Crossing back over the second portage on the return trip, however, I leapt onto my raft a little too hard, propelling me and the raft straight into a wall. Shhhhhhhh, went my Explorer100. We shifted my boat’s cargo to another raft, and finished the day with barely enough flotation to get all the gear and cavers out of the cave.

On the last day of the expedition, I wised up and hiked two tanks 100 ft into the semi-flooded cave to one of the many exploration leads near the camp. I laid 600 ft of line. It took 20 minutes and zero effort, and I only turned because we had to hike out of the forest in an hour.

WHAT DID I LEARN?

This was a good opportunity to relearn the lesson I should have learned long ago: establish a route to the dive site before lugging tanks. Nothing pop-able should be taken into a cave. Finally, check easy leads first. There was no need to drag everything four kilometers back in the cave when we could be diving from the entrance. It all needs to be mapped, and it may be easier to reach the far regions underwater. I give myself points, however, for throwing an adult temper tantrum on the second day. We wouldn’t have made it out with all of our gear on the last day if I had not.

THE MISERY IS PART OF THE FUN

If cave exploration simply required divers to hop in the water and run a line, it wouldn’t be nearly as fun. It’s slightly masochistic, but half the reason I love exploring caves is that it is difficult and uncomfortable. I find myself on bizarre adventures—sometimes bad and sometimes good—and I wouldn’t have it any other way.



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LOS ANGELES





This Issue's Contributors

Kees Beemster Leverenz is a GUE instructor and technical diver based in Seattle, Washington. He is actively involved in building the GUE Seattle community and the implementation of underwater documentation using 3D photogrammetry. Kees has a degree in geology and now works in the technology industry.

Katy Fraser made the decision to pursue a career in underwater film at the age of 18. Since discovering her passion at such an early age, it has been her goal to become a proficient technical diver in a range of environments, and then apply the skill to her camera operation. In 2014, Katy moved to Mexico, and over the past six years she has focused on directing, producing, shooting, doing post-production, and developing unique lighting techniques for her own independent films through her company She Dives Tech. In May 2017, she landed her first major underwater camera operation role in two episodes of BBC's new 10-part series 'Expedition.' Her next step is to continue expanding into the natural history film world as an in-house camera assistant for Silverback Films LTD in Bristol, where she works alongside some of the most prolific blue-chip camera operators in the world.

Dimitri Galon was born in Istanbul, Turkey, in 1958. He lived for many years in Athens, Greece, and since 1984, he has lived in Germany. He studied historic and comparative musicology, informatics, philosophy, Byzantinology, and ethnology at the Universities of Cologne, Düsseldorf, and Hamburg. He worked in the Ethnographic Museum and the City University of Hamburg, and has been an editor of the international publishing house Sikorski since 1994. He is also involved with various maritime history projects in the Eastern Mediterranean region. His articles have been published in numerous magazines. Dimitri is a GUE educated diver (Tec 2+ and JJ-CCR).

Natalie Gibb's passion in life is underwater cave exploration. She teaches cave diving for TDI and co-owns Under the Jungle in Mexico with her wonderful business partner Vincent Rouquette-Cathala.

Jesper Kjoller is a former professional musician who fell in love with diving almost 20 years ago. He became a PADI Instructor in 1994 and a PADI Course Director in 1999. In 2004, he was offered the editor chair of the Danish version of DYK: The Scandinavian Diving Magazine, a position he has held for the past ten years. In 2011, he founded *Dive the World: The International Dive Magazine*. He completed his first GUE course in 2007 and is very proud to now be part of the GUE instructor team. He is equally happy exploring a tropical reef or a deep wreck in Scandinavia, as long as he has his underwater camera.

Andrea Marassich has been diving shipwrecks in the Adriatic and Tyrrhenian Seas since 1993. He is a former member of the Wreck Diving Society and among the founding members of DIR Italia. Andrea has collaborated on several projects with Cultural Heritage Authorities in Italy and Croatia, helping to locate, identify, and film a number of unexplored shipwrecks. Currently, he is involved in different cave diving projects in Italy, France, and Portugal, with the main goal of strengthening local cave diving communities and gathering data necessary to preserve groundwater resources (detailed surveys of the systems, water data collection, pictures, and video). Andrea is an active GUE instructor.

Claudio Provenzani is a passionate wreck and cave diver as well as an active underwater photographer. He joined several GUE projects using his camera skills to document the different goals of the projects. His pictures are often used for underwater exhibitions intended to promote the protection of the underwater environments. He's also an active GUE instructor for all the recreational training classes working to improve the GUE community in Italy through the activity of several scuba associations like diveRevolution and Big Blue Xplorers, of which he is currently the president.

Sergio Rhein Schirato is a researcher at the Laboratory of Energetics and Theoretical Physiology at the Biosciences Institute of the University of Sao Paulo (USP). He holds a Master's in Finance, jointly granted by New York University and the London School of Economics, and post-graduation studies in applied math. His current research includes the application of neural networks in decompression modeling and heart rate variability. Additionally, he is a GUE Fundamentals and Rec 1 instructor, as well as a GUE Rebreather certified diver.

Dr. Elena Romano is a marine geologist who works as a researcher in the Italian Institute for Protection and Environmental Research. Her research is generally focused on marine sediments, from transitional and coastal environments, and sedimentological/geochemical aspects connected to the environmental stress induced by human activity. Also, the response of benthic foraminifera as bio-indicators are studied to quantify the anthropogenic environmental stress. She has been an active GUE diver since 2000, participating in several projects and promoting the participation of GUE trained divers in scientific projects as added value for underwater sampling and documentation activity.

Luisella Zocca is a passionate GUE trained wreck diver with a great interest in the historical events connected to the wrecks. She is an academic law librarian at Verona University and board member of AIDMEN (Associazione Italiana di Documentazione Marittima e Navale).



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Photo by Claudio Provenzani

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