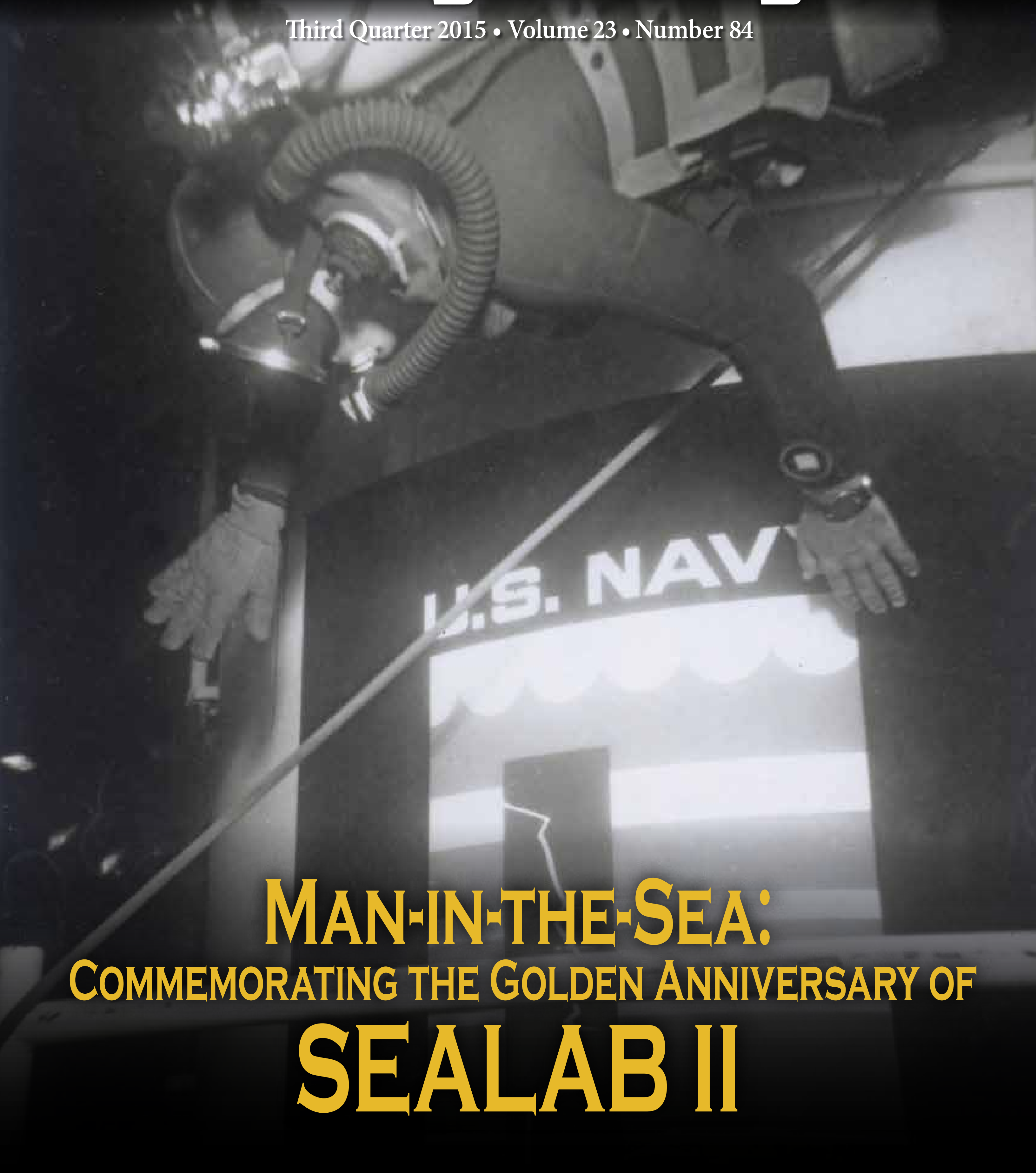
The Journal of Diving History

Third Quarter 2015 • Volume 23 • Number 84



MAN-IN-THE-SEA:
COMMEMORATING THE GOLDEN ANNIVERSARY OF
SEALAB II

U.S.NAVY

SEALAB

You are cordially invited to join
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the Marine Technology Society
at the

AQUANAUT REUNION

commemorating the
Golden Anniversary of

SEALAB II

and the beginning of
saturation diving

Thursday, October 29, 2015

6-10 pm
San Diego, California

MORE INFORMATION AND RSVP AT
www.mts-sandiego.org

SEALAB II off the coast of Scripps Institution of Oceanography, 1965

Program

6-7: Happy hour (no host)
7-8: Dinner
8-9: Program and Raffle
9-10: Reception

Program details: Keynote address by author and journalist **Ben Hellwarth** ("SEALAB: America's Forgotten Quest to Live and Work on the Ocean Floor"); talks by Aquanaut **Robert Bornholdt**, and Diving Unlimited founder **Dick Long**. Displays of artifacts and a raffle with great prizes!

Dinner Menu:

Petite Filet & Shrimp Scampi
(5 oz. Petite Filet Mignon wrapped in bacon, charbroiled and served with three tender jumbo Shrimp Scampi)

Gourmet Spring Mix Salad
Dinner Rolls and Butter
Rice and Fresh Seasonal Vegetables
Kona Coffee, Brewed Decaf, Hot Tea
Black Forest Cake

Cost: $58/person
includes commemorative SEALAB II 50th Anniversary coffee mug.

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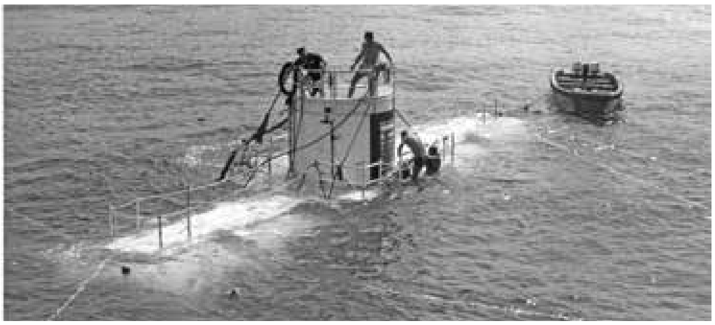
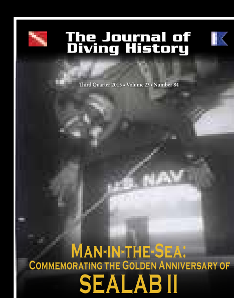
FEATURES



COLUMNS

THIS ISSUE

ON THE COVER
U.S. Navy Aquanaut Berry L. Cannon descends over the access trunk on top of SEALAB II at 205-ft off the coast of La Jolla, CA. (Official Photograph, U.S. Navy)



SEALAB II

With this issue of the *Journal* we are taking a break from our usual format, and and have invited our colleague Kevin Hardy to serve as guest editor of the detailed accounting in this issue of SEALAB II and its unique position in the history of diving on the occasion of the project's 50th anniversary.

Kevin will be familiar to members who are involved in oceanography and deep ocean research, having spent a career spanning over 40 years at Scripps Institution of Oceanography / UCSD in La Jolla, California, before starting his own marine technology company, Global Ocean Design. More recently his name has appeared in numerous media outlets as the unmanned vehicle Lander Commander for our Advisory Board member Jim Cameron's deep dive to the Challenger Deep / Mariana Trench in 2012. With this SEALAB II issue, he and HDS Advisory Board Member Ian Koblick will begin a series on the History of Underwater Habitats.

The history of SEALAB has played an important role during the formative decades of the HDS. USN Captain Paul Linaweaver was at one time Chairman of the HDS, Aquanuats Scott Carpenter, Bob Barth and Joe MacInnis are all members of our Advisory Board, and this *Journal's* Vintage Patents column is headed up by USN Captain Jim Vorosmarti.

Sponsor company Kirby Morgan manufactured the famous SEALAB clamshell series of helmets, one of which appeared on the cover of *Life Magazine* in 1968, and Dick Long's DUI company manufactured hot water suits for the project.

HDS members were always welcome guests at the SEALAB reunions in San Diego and Panama City, and these reunions were often co-hosted by the Deep Submersible Pilots Association (DSPA). From this unique group the Society has benefited from the support of Ross Saxon, Phil Nuytten, the late Dr. Andreas Rechnitzer and others.

Ben Hellwarth, who wrote the 2012 book *SEALAB: America's Forgotten Quest to Live and Work on the Ocean Floor,* was introduced to the program after covering the HDS visit of Hans and Lotte Hass to Santa Barbara in 1998.

In addition to these connections HDS is co-sponsoring the SEALAB Aquanaut Reunion in San Diego, California on October 29, 2015. This event presents a very rare opportunity to meet some of these aquanauts who helped lay the foundations of saturation diving and its uses in both commercial and military diving. Event details are on the HDS website. Try not to miss it!

–Leslie Leaney, Executive Editor

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Photo: Bev Morgan

2015 HDS Diving Pioneer Award: Bob Kirby

The Board of Directors are pleased to announce that Bob Kirby is the recipient of the 2015 HDS Diving Pioneer Award for his contributions to the development of commercial diving equipment. In announcing the award the Board made special reference to Kirby's 1964 development and manufacture of the recirculating helium helmet. The helmet was not proprietary to any diving company and was available to the working diver, increasing the safe range of depth operations to over 500 feet. The initial success of the R. Kirby helium recirculator helmet was a major factor in the formation of the Kirby Morgan Company with Bev Morgan in 1965. That company has now grown to be the dominant manufacturer of surface supplied equipment worldwide.

Bob started his diving career in the US Navy during the 1950's and migrated to abalone diving as a civilian before joining the group of commercial divers working in the offshore oil industry in Santa Barbara, California during the early 1960's. After leaving Kirby Morgan he went on to be an instructor at the Marine Diving Technology Department at Santa Barbara City College, passing on his several decades of knowledge to younger generations. He designed and built the helmets for his friend Jim Cameron's movie *The Abyss*, and self published his autobiography, *Hard Hat Divers Wear Dresses*, in 2002. In addition to his career in diving Bob had one in aviation and co authored the 2008 book *Aviation Visionary*, detailing the history of Jack Conroy and the Conroy Aircraft Corporation.

Now fully retired Bob volunteers his time with the Historical Diving Society, as a Director, and the Santa Barbara Maritime Museum, which maintains an exhibit of his equipment. In recognition of his career contribution to diving he was inducted into the Commercial Diving Hall of Fame in 2000.

All at the HDS congratulate Bob on his HDS Diving Pioneer Award.

2015 HDS Diving Pioneer Award: Dr. Eugenie Clark

The Board of Directors are pleased to announce that Dr. Eugenie Clark is the recipient of the 2015 HDS Diving Pioneer Award for her contributions to marine science.

Genie, as she was known amongst her diving colleagues, was a world authority on sharks who defied society's expectations about both women's roles in science and the much-feared underwater creatures. In 1942 she graduated from Hunter College with a zoology degree and worked as a research assistant at the Scripps Institution of Oceanography in California, among other jobs, before completing her doctorate in zoology in 1950 at New York University.

An ichthyologist and oceanographer, she divided much of her career between the University of Maryland and the Mote Marine Laboratory in Sarasota, which she co-founded in 1955. Her career preceded Rachel Carson's book "The Sea Around Us" and oceanographer Jacques-Yves Cousteau's book and documentary "The Silent World," which in the 1950s helped generate broad interest in undersea research. Her first book, "Lady with a Spear," was published in 1953 at the dawn of recreational diving in America. She became known as The Shark Lady and in 1969 published "The Lady and the Sharks." As a leading champion of marine life and conservation, Genie criticized the 1975 fright-movie "Jaws" and other popular depictions of sharks that gave them "a bad rap." For decades she had traveled with the creatures underwater, studied them in captivity and saw them as a way to understand the globe's vast seas. An unabashed adventurer and prolific researcher, Genie traveled the globe to study reef fish, sharks and mollusks. She made 71 dives in submersibles, a practice that is still done by a relatively small number of explorers, plunging at one point to 12,000 feet. She appeared in dozens of documentaries and television specials and wrote for National Geographic and other publications, often about the need to protect shark species and their surroundings.

As a pioneer female diver Genie was an example to all divers of what was possible if they were committed and stayed true to their goals. She passed away on February 25, 2015, at her home in Sarasota, Florida, at the age of 92.


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Man-in-the-Sea:
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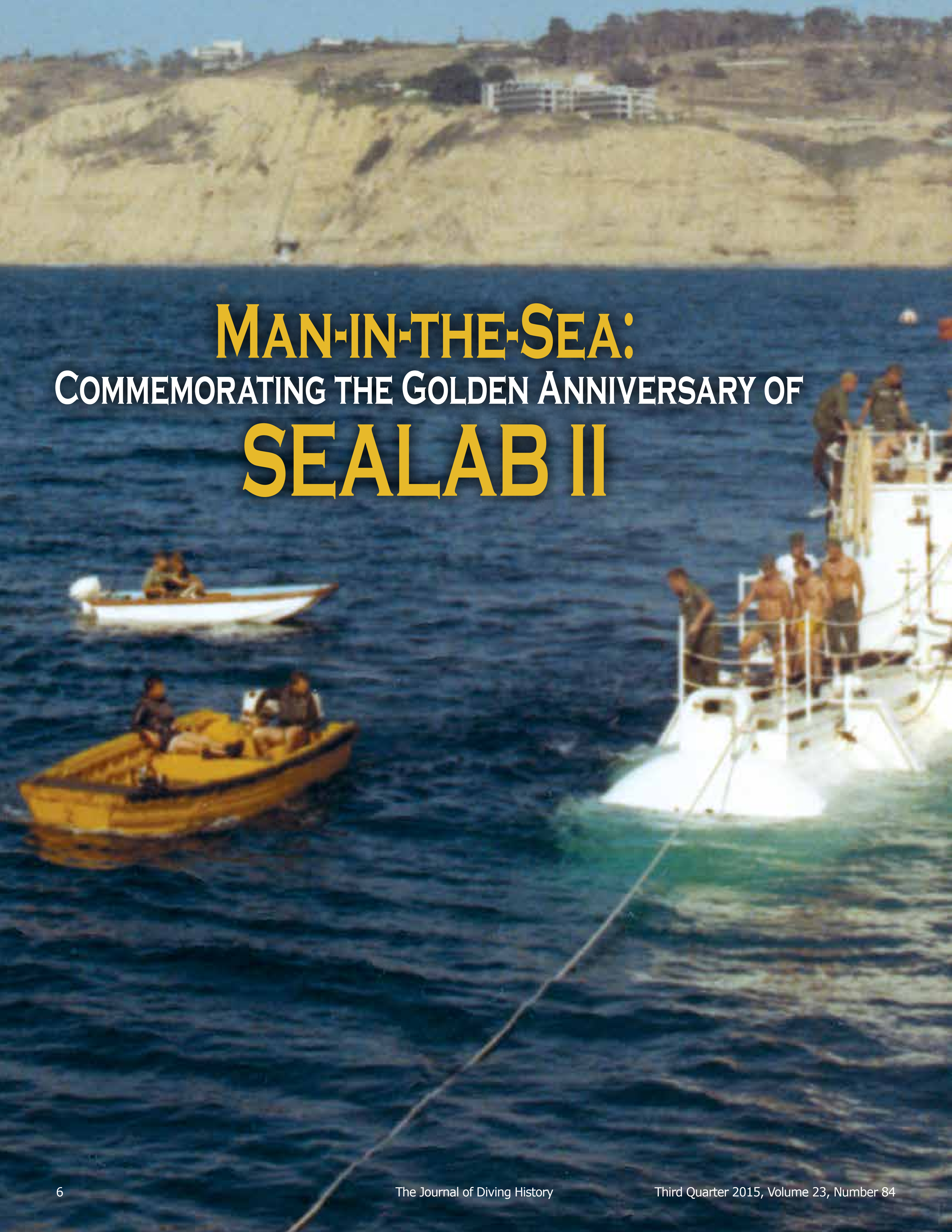


FOREWORD

Kevin Hardy, Guest Editor

The Promethean Fire of SEALAB II

Guest Editor Kevin Hardy, at 17 years old, 1970, San Diego, CA, with MouseHouse.

There are heroes. There are pioneers. Above both are Legends. Fifty years ago on the edge of the Scripps Submarine Canyon off La Jolla, California, SEALAB II moved the boundaries of human dominion into sea. What eons of evolution had moved us away from, new technology and techniques brought us back to.

There are footnotes to history, and there are milestones. George Bond, Walter Mazzone, and their dedicated band of Dive Medical Officers and Aquanauts changed the world of deep sea diving as much as the bathyscaph *Trieste* changed deep submergence systems. Nothing was ever the same again for offshore oil, marine archaeology, ocean science, underwater film making, amateur tech diving, national defense, and even hyperbaric medicine.

The SEALAB II timeline was stunning. Eight men met in January 1965, and 7 months later the Tiltin' Hilton was up and running on the bottom at 205-ft.

This issue includes a look back to deep-sea diving operations before SEALAB, a new article on SEALAB II by noted author and journalist Ben Hellwarth, and distant thoughts from Papa Topside, still relevant today.

Leslie Leaney, Bonnie Toth and the Historical Diving Society are commended for their encouragement and support in bringing SEALAB II front and center on the occasion of its 50th Anniversary. There's a notion that those who do not study history are doomed to repeat it. It's also true that others study history and hope to repeat it.

I was 12 when SEALAB II was in the water, 15 with SEALAB III, and 16 at the time of Apollo 11. It was a perfect age to be influenced by such wonders. Taken with the details of Life Support Systems (LSS), at 17 I built a crude miniature unpressurized habitat called "MouseHouse". It had a chemical CO_2 scrubber. It functioned without pressurized gases, decomposing water molecules by electrolysis. H_2 was overboarded, O_2 circulated freely inside. Could be just dumb luck, but the mouse lived, and I found my career in ocean engineering, retiring from Scripps Institution in 2011.

So thanks, SEALAB II. This is for you.

Dedication to Berry Cannon, Aquanaut SEALAB II/III

By Bob Barth, Aquanaut SEALAB I/II/III

Aquanaut Berry Cannon (Official Photograph, U.S. Navy)

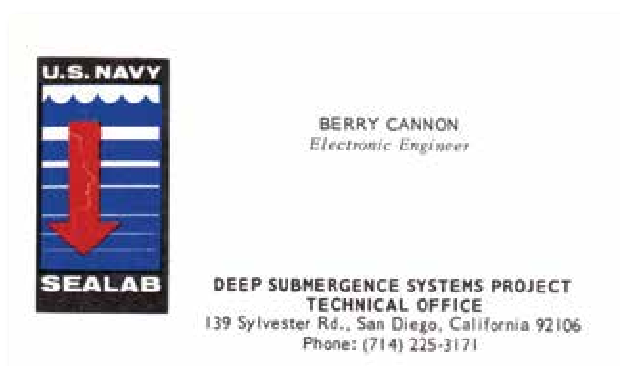
I have been asked to speak at the passing of a friend several times in my life, each occasion was different and had emotions which guided my words, but with Berry I had over a week of decompression before any words could be said. I had a long time to sit and think in the small confines of the DDC as the HeliOx saturation process was reversed and slowly returned me to the surface. The words I found in the chamber were, "In the period of just a few hours Berry Cannon visited two places he had never been to before, at the second place he remains."

Berry came into the Man-in-the-Sea program right after SEALAB I. He was an experienced diver as well as a hands-on engineer, and was assigned to SEALAB II, Team 1. We both spent 15 days on the bottom at 205 feet off the California coast. He earned his assignment to Team 1 on SEALAB III. But SEALAB was perhaps Berry's destiny before then because he started as a Navy engineer at the Mine Defense Laboratory, Panama City, Florida. This Navy base has played a very important role in the development of saturation diving, its required equipment and new techniques. It built and tested SEALAB I in 1963. In 1964 they took it to Bermuda where four Navy divers, including me, spent 11 days at 193 feet. The following year this same Navy base was involved in the building of SEALAB II with the San Francisco Bay Naval Shipyard Hunters Point Division. Today, Panama City is the home of the premier U.S. Navy diving school, the Naval Diving and Salvage Training Center (NDSTC), and the home of the U.S. Navy Experimental Diving Unit (NEDU). These two are the vanguard of all U.S. Navy diving operations today.

I had known Berry Cannon since the latter part of SEALAB I, got to know him better with SEALAB II, and knew he was going to be a great asset in getting SEALAB III on the bottom and set up for the many dives that were scheduled to follow. His experience with SEALAB II, his engineering background, and of course, his excitement to get into deep water made him one hell of an asset for Team 1, SEALAB III. We spent a lot of time together training for our particular dive. Berry Cannon was my friend, but more so, he had my respect.

A lot has happened with the diving fraternity since those many years ago. There is a lot to remember, and in my quiet moments I do just that. For me, Berry was the SEALAB program. I remember his good nature, uncompromising work ethic, understanding of complex underwater systems, commitment to the program, and willingness to give whatever it took to get the job done. He was determined to advance the state-of-the-art of saturation diving. He accomplished that.

These many years later he is being remembered one more time. Berry is seldom far from things I think about. In memories, old friends still drop by to say "hello."



Berry L. Cannon

SEALAB Aquanaut Berry Cannon prepares a Mk-6 rebreather, prior to a training dive in summer 1968. (Official Photograph, U.S. Navy)

Berry Louis Cannon was born 22 March 1935 at Red Level, Florida, a community 5 miles north of Crystal River, Florida, to Jimmie and Arthur L. Cannon. His maternal grandmother raised him after his parents divorced when he was 3. The family moved to Williston, Florida, where Berry attended school. He was captain of the Williston High School Varsity football team, and graduated in 1953.

Berry served in the U.S. Navy from 1953 to 1957, becoming a Mineman Second Class. At one time he was stationed at the Hawthorne Naval Ammunition Depot in Hawthorne, Nevada, where he was on the boxing team. After leaving the Navy he attended the University of Nevada before transferring to the University of Florida where he earned a Bachelor of Science degree in Electrical Engineering in 1962.

Cannon joined the U.S. Navy Mine Defense Laboratory 1 February 1963 as an electronic engineer in the Mine Hunting Division. He was reassigned to the Swimmer-Diver Division in 1964 and to the Electronic-Electrical Division in 1966. An experienced, knowledgeable diver, Cannon was accepted into the U.S. Navy's Man-in-the-Sea program, an active research program to create the fundamental systems and techniques of saturation diving, including mixed gas breathing mixtures and compression/decompression schedules. The program was a watershed in man's ability to live and work in the sea. Cannon's blend of tech diver-engineer-problem solver got him an assignment as Aquanaut, Team 1, on the SEALAB II experiment, conducted August to October 1965 off La Jolla, California. For his participation he received a Superior Achievement Award and the Navy Superior Civilian Service Award.

During long periods of decompression, Cannon enjoyed the works of Zane Grey. He was fascinated with technology and extending man's reach into unexplored worlds. He was an accomplished cave diver. He followed the U.S. Space program with tremendous interest, and was looking forward to seeing the first man set foot upon the moon. As a father, he anticipated with great pleasure the day he would take his sons camping when they were a little older.

Cannon died on the first day of the SEALAB III operation, 17 February 1969, while working 610-feet underwater off San Clemente Island, California. The habitat was loosing HeliOx through fittings in the hull. Cannon was one of four Aquanauts in Team 1 sent twice to stop the leaks and open the habitat for occupation. It was later found that the baralyme canister in his rebreather, used to scrub the carbon dioxide Cannon exhaled, was empty.

He was awarded the Distinguished Civilian Service Award posthumously. The citation reads: "For dedicated and distinguished service to the United States Navy in demonstrating man's ability to perform productive work at great ocean depths. . . . In so doing, he clearly defined critical problem areas which are now being resolved and which will make future diving operations safer and more effective. . . . In recognition of his dedicated service and courage in the face of known risks, this award is granted posthumously to Mr. Berry L. Cannon."

The Berry L. Cannon Marine Museum, located at the Marine Science Station, Crystal River, Florida, near the place of his birth and burial, was dedicated in honor of Aquanaut Berry Cannon on 10 January 1970.

On 5 March 1993, the Cannon Deep Submergence Life Support Facility was dedicated at the Naval Surface Warfare Center, Panama City, Florida.

Mr. Cannon's widow, Mary Louise Rutkowski Cannon, presently resides in Jamul, California. Berry and Mary Lou's four sons, Patrick, Michael, Kevin, and Neal rest with their father at Wacahoota Baptist Cemetery in central Florida.

In her own words:

The Woman Behind the Man-in-the-Sea:
Mary Lou Cannon

*Editor's note: Our deepest thanks to **Mary Lou Cannon.** She opened her family archives, lovingly preserved for 50 years, sharing photographs and memories, some sweet, others very personal. Her core strength to overcome huge repetitive tragedy, yet remain optimistic, and her never-ending curiosity to learn new things are among the most impressive qualities of this remarkable lady. This Journal could not have been done without her encouragement.*

Kevin Hardy, Guest Editor

A Cannon family photo: (l to r) Berry, Mary Lou, son Patrick, Mary Lou's sister, Theresa, son Kevin, and Mary Lou's father, Bill Rutkowski, San Diego, CA, 1964.

My name is Mary Louise Rutkowski Cannon. I first met Berry in January of 1957, he was 21 and in the Navy. I was 16 and a senior in high school, a member of a dance troupe and the USO. We were both taking physics in adult school. We were married in June of 1958. After years of hard work and study, Berry graduated from the University of Florida in December 1962 with a BS/EE. We moved to Panama City in 1963. Berry truly loved his work. It was what he always wanted. I remember him telling me he wanted to work underwater when we first met.

After Berry died, the boys and I moved back from FL to CA, where all of my family lived. Here were my parents, grandparents, sisters, cousins, aunt and uncles. I bought a house in Chula Vista, made new friends, started classes at Southwestern College. I continued with life.

One of the things Berry used to talk about was taking our boys camping when they got a little older. When Berry died in 1969, our boys were Patrick 9, Kevin 5, Neal 24 mos., maybe not old enough for camping, but, by golly, these boys were going camping. I knew nothing about camping, but nothing was going to stop me. Off I went and bought a camping van, with a small stove, sink, and refrigerator. Not wasting a minute, off we went. It took a couple of years but we got used to the routine. We traveled all over the U.S., and even started using a tent. We would go two or three times a year for weeks at a time.

In late 1973 our family friends, Bob and Joanna, joined the Peace Corps and moved to Kenya, East Africa. They kept writing, saying how they loved it and please come for a visit. By summer 1974, I had permission to take the boys out of school for a year, saved enough for tickets and other expenses, and then, with stopovers in London and Brussels, we were off to Kenya.

Our friends had told us what to bring and what to send ahead of time: tent, extra jeans, hiking boots, back packs, etc. They helped us get a car, an apartment, and introduced us to their friends. We loved it so much we were there for a year and a half. While we were there, we went on safari often, and learned about the ways of the people. The boys got one semester in the international school. Then it was time to come home. I sent the boys ahead to stay with their grandparents. Knowing that I wouldn't have another chance to see these special things, I went to Ethiopia for 2 weeks, then to Sudan, Egypt, and Rome.

In 1977 our house in Chula Vista started to fall apart. The walls were moving away from the floor, the house was over 100 years old! Thank goodness my Dad was in real estate. He found someone who was interested in the property.

I moved to east county San Diego, to a little place called Deer Horn Valley. There I directed the construction of the home I live in today. I insisted its design be energy efficient and water wise. But that's another story for another day.

Early Days: Deep Diving Before SEALAB

By Leslie Leaney, Co-Founder, Historical Diving Society-USA, Santa Barbara, CA

All images courtesy Leslie Leaney Archives except where noted.

Craig Nohl lowered for record dive of 420-ft.

As we appropriately pause to celebrate this SEALAB II Golden Anniversary it is an opportune moment to also reflect on some of the historical deeper dives achieved and recorded on the path to the beginnings of the Genesis/SEALAB program.

The desire to go deeper and longer has driven mankind for centuries and history records numerous deep dives by individuals and groups.

As the technology of diving in the early 1800's started to evolve, diving bells were gradually replaced by individual divers supplied by the same means with air pumped down to their helmets from the surface.

As the diving equipment gradually improved, so did the depth capability of the diver, and history records several individual dives to great depths.

During the latter half of the 19th century to the early part of the 20th, recovery of anchors off Greece, the harvesting of pearl shell off Australia, and other dives to depth in excess of 200 feet were reported.

However, to research deep dives that are accurately recorded and witnessed, it is best to look at operations where there is an organized group that operates and oversees the dive.

It is not in the scope of this article to produce a record of all deep international deep dives that preceded SEALAB, but rather to note some of the milestones of depth that can withstand historical scrutiny and thereby illuminate the path that leads to George Bond's Genesis desk in 1957.

One of the major factors in the development of SEALAB was the availability of **helium**, which has been correctly described as "the key to the deep." The fact that America had a domestic supply of the gas was to be of the greatest benefit, as the only other known supplies were in Russia and Poland.

Air was the standard medium for deep diving, and one of the accurately recorded working deep air dives before the introduction of helium, was undertaken by the U.S. Navy in 1915.

In March of that year the submarine F-4 sunk off Oahu, Hawaii, with all hands lost. The submarine was located in 304 feet of water, a depth far beyond the range that the Navy divers were trained to, and beyond that of any type of salvage equipment available.

The F-4 was the first submarine that the U.S. Navy had lost and there was keen interest in discovering what had caused her to sink, in addition to honoring the crew by recovering their bodies.

Navy divers did remarkable work diving on air to successfully salvage the F-4, with diver Chief Petty Officer Frank Crilley later being awarded the Congressional Medal of Honor for heroism in rescuing his trapped comrade Chief Petty Officer William Loughman.

The dives on the F-4 had been on the razor's edge of safety, with bottom times of only 10 minutes to combat lengthy decompression and nitrogen narcosis.

Craig Nohl being dressed in for record dive.

Early version of Craig Nohl suit.

Shortly after the F-4 salvage the American inventor Elihu Thomson began working on his theory that helium could perhaps replace nitrogen in a gas mix and gain divers at least a 50% increase in their working depth.

At this time the Bureau of Mines was the primary organization controlling the supply of helium, and by 1924 their staff members Sayers and Yant were working with the U.S. Navy on the advantages of helium over air for decompression.

In 1927 their tests were moved to the U.S. Navy Experimental Diving Unit (NEDU) in Washington D.C. where the first human dives took place.

By 1937 Lieutenant "Swede" Momsen was at NEDU, working with Captain Albert Behnke, Captain O.D. Yarbrough, and Lieutenant K. Wheland, on further helium research. While there, Momsen and Wheland made a simulated dive to 500 feet and thus moved the U.S. Navy program forward.

During this period American civilians were also pursuing the use of helium for deep diving. Milwaukee divers Max Gene Nohl and Jack Browne had been working with Dr. Edgar End of Marquette School of Medicine who was a pioneer in hyperbaric physiology.

Nohl's successful diving career had already attracted the attention of Hollywood film producer John D. Craig, who had ambitions to dive and film the USS Lusitania, which was off the coast of Ireland in 312 feet of water. To accomplish this he would need equipment not yet

Test dive of Craig Nohl system April 12, 1937.

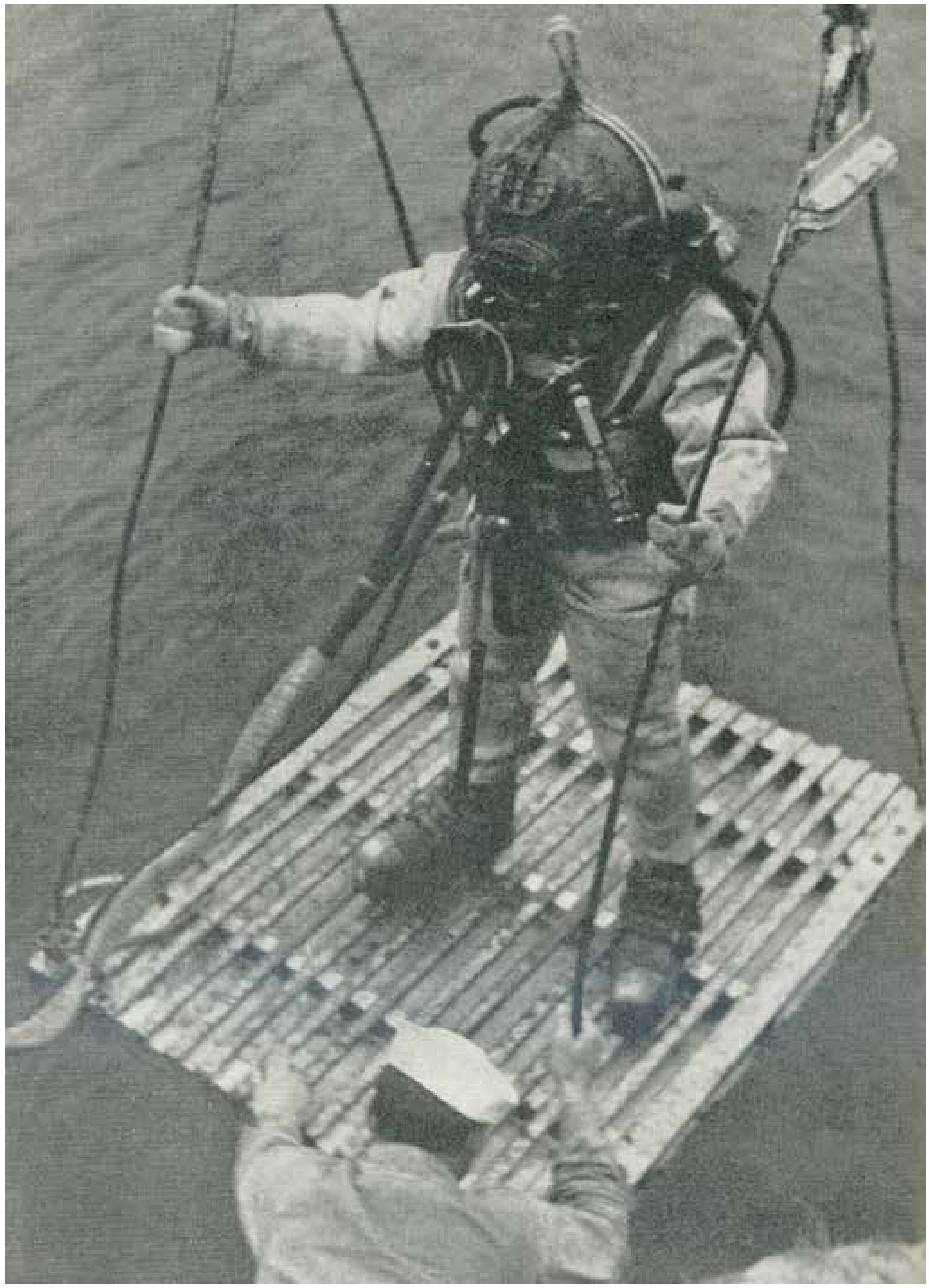
available and he and the Milwaukee team designed, constructed, and tested what became known as the Craig-Nohl suit, which was a self-contained diving system. Dr. End produced the decompression schedules and gas mixtures and after tests a major deep water dive with the Craig-Nohl suit was scheduled.

In December 1937, Max Gene Nohl undertook a successful dive with the new suit to 420 feet in Lake Michigan. Public interest in the dive was high and it was report live on the radio. The team of Nohl, Browne and End went on to play a major role in the American development of diving equipment, and were all involved in establishing Diving Equipment & Salvage Corporation (DESCO). During the course of the coming Second World War the company would grow into the largest diving equipment manufacturer in the world and play a continuing role in the development of helium diving.

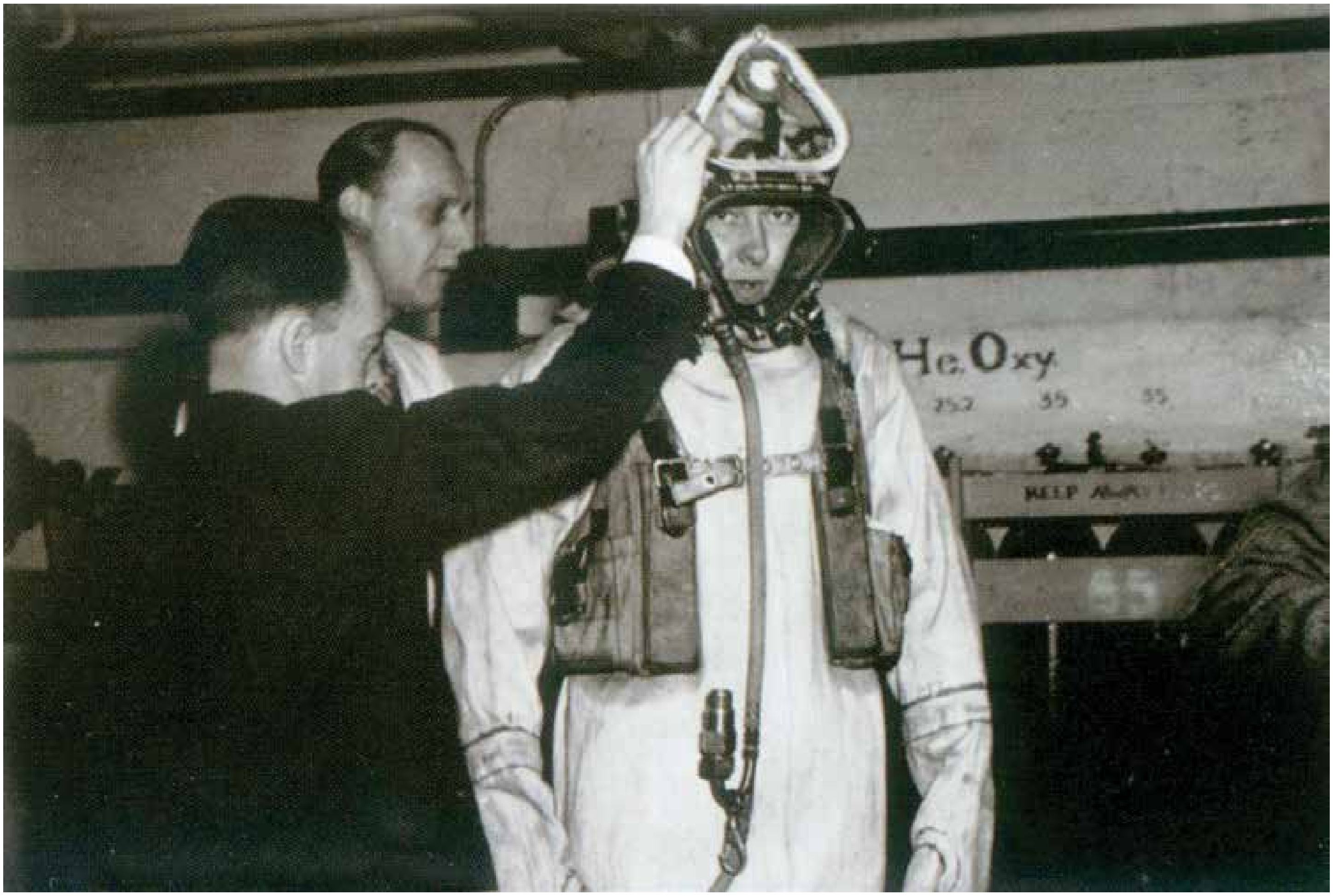
In 1939 the U.S. Navy helium program was field-tested when the submarine USS Squalus sank in 240 feet of water at the Isles of Shoals off Portsmouth, New Hampshire. The rescue of the survivors was carried out by divers using air, but the actual salvage involved dives using a Mark V helmet system modified for the use of a helium mixture. The salvage effort lasted throughout the summer of 1939 and provided invaluable experience for the U.S. Navy who would, in a few years, be faced with salvage projects around the globe in the major theatres of action in WWII.

After America officially entered WWII in December 1941, a refined version of the USN Mark V helium helmet system went into full production with the Morse Diving Equipment Company of Boston, Massachusetts, and DESCO of Milwaukee, Wisconsin. The details of this new American helium diving system were published in the 1943 U.S. Navy Diving Manual.

As WWII progressed, the American military shared information on diving with helium with their military allies in Russia, a country that also had access to a domestic supply of helium.



A U.S. Navy diver wearing an early Mark V helium helmet about to be lowered down to the wreck of the USS Squalus in 1939.



Jack Browne prepares for his 1945 wet-pot dive to 550 feet at the DESCO factory in Milwaukee. Photo courtesy of the DESCO Corporation.

In April 1945, as WWII wound down, Jack Browne undertook a successful helium dive to 550 feet in a wet-pot at the DESCO factory in Milwaukee. The dive was classified and supervised by Dr. End and Dr. Behnke, but was attended by numerous U.S. military officers and also Russian military officers.

America was certainly willing to assist their Russian allies and U.S. Navy Mark V helium helmet systems were sent to the Russian's, who, in 1945, published their own diving manual with details and illustrations of the U.S. Navy Mark V helium helmet system. They followed this in 1946, publishing a translated version of the 1943 U.S. Navy Diving Manual.

The Cold War between the two former allies seems to have stopped the flow of information on helium diving and it was only in recent years, with the establishing of the Historical Diving Society of Russia that information started to be released to the public.

In his 2002 paper presented at the HDS-USA Conference, HDS-Russia Founder Alexander Sledkov stated that the Russians had a helium capability during WWII and manufactured their own style of helium diving helmet.

Sledkov further noted that the Russian's had reached depths of more than 100 meters (328-ft) in 1939 in the Black Sea, and during a 1940 chamber test in Leningrad had reached 200 meters (656-ft).

Another of the WWII Allies, Great Britain, also experimented with helium. Prior to WWII the Royal Navy had worked with England's famed Siebe Gorman & Co. Ltd. on research into helium mixtures, which involved contributions from Captain G.C.C. Damant and Sir Leonard Hill. During 1930-1931 the Royal Navy had reached a depth of 344 feet on air while development of a deeper diving capability was curtailed because of the restricted availability of helium, of which they did not have a domestic supply.

Whereas the American company diving equipment company DESCO was less than a decade old, the English company Siebe Gorman traced their origins back to 1819, and it was the company's founder, Augustus Siebe, who in 1840 had constructed the diving helmet and dress in a practical configuration that successfully launched the trade of the helmet diver.

The company had been involved in developing diving equipment for over a century and their managing director, Sir Robert H. Davis, had developed a helmet for use with helium that used a canister and injection system. Additionally, he had designed a Submersible Decompression Chamber (SDC), which was staffed by an attendant, into which a diver ascending from a deep dive could enter at 60 feet and start decompressing on oxygen.

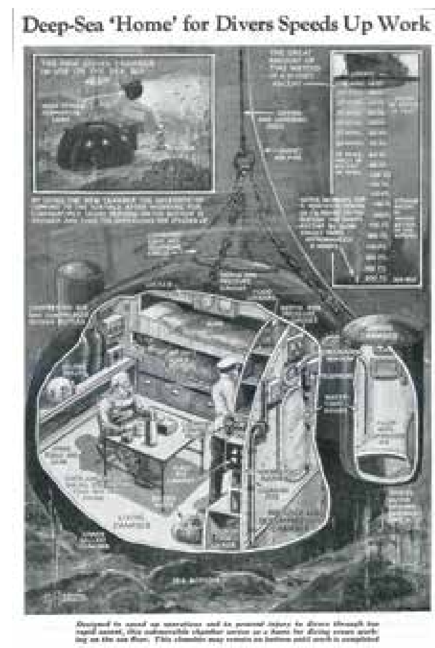
Using the combination of the Siebe Gorman injector helmet and the SDC, Petty Officer Wilfred Bollard made a successful open water dive from HDS Reclaim to 165 m (540 feet) in Loch Fyne, Scotland in 1948.

Building on this success, the Royal Navy Lieutenant George Wookey made an open water dive from HMS Reclaim to 183 m (600 feet) in a Norwegian fjord in October 1956. Wookey also used the SDC in his ascent.

In addition to his Submersible Decompression Chamber, Sir Robert had also designed two early underwater habitats: the Davis Deep Diving Chamber, and his proposed Diver's "Home from Home," as it was called.

The Davis Deep Diving Chamber appeared in print and in illustrated form in the 1935 4th edition of his book Deep Diving & Submarine Operations. It was equipped with its own air supply and regenerating equipment for keeping the atmosphere pure and fresh. It housed two divers and an attendant and had an air lock which lead to the diving chamber from which divers could exit and enter. The illustration shows an air supply hose coming from the surface to the diving chamber, and the complete habitat chamber was attached to a lifting cable to the surface vessel.

Robert Davis Deep Diving Chamber.



Robert Davis Deep Diving Chamber guide.

The proposed "Home from Home" followed much the same principle but had no connection to the surface apart from a small marker buoy. The concept was that the "home" could be manned by a technical staff equipped with listening devices to detect the presence of enemy submarines. Free swimming self contained divers could enter and exit through an air lock, and had a diver's attendant to assist them. It appeared in the 1962 7th edition of Sir Robert's book.


Robert Davis Submersible Decompression Chamber (SDC), 1948.

Robert Davis' Home from Home

ROBERT H. DAVIS'S PROPOSED DIVERS' "HOME FROM HOME"

FOR PROLONGED SUBMERSION
EQUIPPED WITH LISTENING DEVICES FOR DETECTING THE PRESENCE OF ENEMY SUBMARINES

KEY TO DRAWING ON PAGE 220B

1. Detection Buoy on surface
2. Surface of sea
3. Detection Buoy retracted into housing
4. Lifting eyes
5. Diver wearing self-contained breathing apparatus emerging through hatch of Diving Chamber
6. Ventilation ducts
7. Diving Chamber
8. Lockers
9. Bunks
10. Galley
11. Entry hatch for steel cylinders containing air, oxygen, etc.
12. Diving Compartment
13. Watertight door to Diving Compartment
14. Radar Screen
15. Second Diver waiting to enter Diving Chamber
16. Diver's Attendant
17. Compass
18. Detecting equipment control panel
19. Storage compartment for cylinders of air, oxygen, etc.

Key to Drawing, Robert Davis' Home from Home

With just a little imagination you could combine one of these chambers with the Submersible Decompression Chamber and a Transfer Under Pressure (TUP) system, (which Siebe Gorman manufactured and installed on HMS Reclaim around 1962) and you would have an operational sat system.

America, Russia, and Britain were not the only nations pursuing deep diving. Germany, Japan, France, Italy, and others all had significant military diving programs, but access to helium was "the key to the depths," and without that, development was very restricted. However, individual divers and their teams from different countries were also pursuing the depths, and had success without using helium.

In 1945 a team lead by the Swedish diver Arne Zetterstrom used hydrogen for deep diving tests and reached a depth of 159 m (520 feet). Unfortunately Zetterstrom died on his ascent from this depth due to an error by his surface crew. His death seems to have suspended research into hydrogen as a diving gas until several decades later when the U.S. Navy and COMEX began their research into the topic.

In 1957, George Bond took the first steps in his Genesis program to increase time at great depth through the application of the physics of gas saturation of fluids.

In 1959, Swiss mathematician Hannes Keller reached 400 feet on a mix of 95% nitrogen and 5% oxygen at a lake near Zurich. Keller's program was assisted by the research of Professor Albert Buhlmann. Later that year he made a dive to 728 feet in Lake Maggiore, Italy. There was a great deal of interest in his methods and in November 1962, he made a successful dive in a bell to 1,000 feet off Catalina Island, California, but his partner on the dive, Pater Small, lost his life as did safety diver Chris Whittaker.

The deaths on the Keller dive made headlines around the world. The stage was now set for the next intellectual breakthrough: George Bond, Water Mazzone, and the physics of saturation diving.

Readers interested in further historical insights are encouraged to visit the Historical Diving Society-USA website www.hds.org.

Acknowledgements: I am indebted to my colleague Christopher Swann for access to his research published in his book The History of Oilfield Diving, *and also to* Deep Diving & Submarine Operations, *by Sir Robert H. Davis. Both books are available from the Historical Diving Society USA at www.hds.org.*

The Medical and Human Performance Problems of Living Under the Sea

By Joseph B. MacInnis, M.D., Saturation Diving Medical Specialist, Writer, Explorer

(Excerpted and adapted by the author from his article of the same name in the Canadian Medical Association Journal*, July 30, 1966, Vol. 95, No. 5, pp 191-200)*

Pioneering undersea experiments in the United States and France showed that divers can live and work effectively for many days from benthic dwellings placed on the continental shelf, and even deeper. If prolonged exposure to the hostile underwater environment is to be tolerated successfully, existing physical, biological and equipment hazards must be recognized, prepared for and, when possible, circumvented.

Figure 1. Final outfitting of SEALAB II at San Francisco Bay Naval Shipyard, Hunters Point Division. (Official photograph, U.S. Navy)

Mankind has awakened to the scientific, military, and economic potential that awaits him beneath the surface of the world's oceans. In the past 40 years, there has been a surge of enthusiasm for the recovery of the natural resources that have existed in the sea for countless millennia. This interest has been supported by widespread military activity in such development areas as underwater defense systems, submersibles, and submarine rescue. Also, great stimulation has been provided by undersea scientific, salvage, construction, and archeological efforts. To unlock this inherent undersea potential, man must descend beneath the waves and expose himself to the hazards of a new environment. Man has been diving for centuries, but only in the past half-century has he been able to dive deep and to live there for prolonged periods.

The diving expeditions to the depths of the continental shelf off the United States and France have brought into focus the potential medical and human performance problems associated with living for extended periods deep beneath the sea.

In past experiments, living under the sea has involved the three-chamber concept. The most important of the chambers is the undersea dwelling in which the divers live. Resting on the ocean floor, it contains a gaseous environment at a pressure equivalent to the ambient water pressure. This enables the divers to carry out sorties into the surrounding waters and to return to a dry, comfortable base. After the work on the ocean floor is completed, the divers transfer from the dwelling into a submersible decompression chamber, sometimes called a Personnel Transfer Capsule (PTC). This chamber transports them to the surface of the sea, while holding them at bottom pressure. At sea level they transfer again, this time to a deck decompression chamber (DDC) on the surface support ship. Here, under the watchful eyes of the "life-support" team, decompression that frequently lasts several days is carried out.

"Saturation" diving refers to dives made to a given depth for periods usually longer than 24 hours. A diver is "saturated" when his tissues will absorb no further measurable quantities of inert gas. Once this saturation point is reached, the decompression period is essentially the same regardless of the duration at depth. Consequently the bottom time/decompression ratio is much more efficient in saturation dives as compared to short-duration dives. For example: the short-duration diver must decompress after each day's dive. In a long job he spends considerably more time decompressing than he does working on the bottom. However, the reverse is true of a saturated diver. Once saturated, he can stay as long as he wishes at the bottom depth and, after the work is completed, can return to the surface after a single decompression.

However, because of the extended depths and times of saturation dives, many medical and human performance problems, unique to this type of exposure, may arise. This paper will describe briefly the most significant aspects of both the old and new problems as they relate to man's attempts to live under the sea.

Problems Arising from the Environment

The Physical Environment

The average depth of the oceans is 12,000 feet, and the deepest recorded depth is about 35,800 feet in the Mariana Trench near Guam. However, the immediately available economic potential of the oceans is concentrated on the continental shelves, an area nearly equal in size to the surface of Africa. The continental shelves average 300 feet in depth and they are rarely much deeper than 1000 feet. It is important then to concentrate manned diving efforts to all depths down to 1000 feet. However, to determine the significant adaptation, performance and reserve limits of the working diver, pressure-research studies must be done on man to depths greater than 1000 feet.

At 1000 feet the diver will be subject to a **pressure** of 460-lb./sq. in. absolute. The seawater pressure of any dive, because of its direct and indirect effects on gases and tissues in the body, presents the greatest potential hazard to the diver; all other problems are usually related in some manner to the effect of pressure. Two serious direct pressure effects, recognized previously in short-duration dives, are otic barotrauma and air embolism.

The **temperature** of the world's oceans varies between -2° C. and +30° C. (28.4° F. 86° F.). However, manned diving operations will probably be carried out in water well towards the lower middle of this range. Work has shown that effective underwater performance requires diving suits which have a supplemental heat source as well as thermal insulation. Even in shallow water, temperatures are usually in the range of 45-60° F. It is a well-known fact, emphasized in undersea living experiments, that exposure to cold water rapidly and seriously decreases the diver's efficiency and accentuates several other hazards. Several of the early deep saturation experimental dives were carried out in tropic seas because of the excellent visibility and warm water in these areas.

Figure 2. SEALAB II Team Leader Cdr. Scott M. Carpenter USN (NASA) is fitted for an experimental electrically heated wet suit by Dick Long, Diving Unlimited, San Diego, CA. (Official photograph, U.S. Navy)

Visibility in ocean waters can range from hundreds of feet in a clear tropic area to zero in certain locations. Clear water is the exception; the diver is usually limited to a few feet of visibility. Poor visibility reduces underwater maneuverability and work efficiency. A very real hazard of poor visibility is that it increases the diver's chance of fouling on man-made or natural obstructions.

The **currents** of the continental shelf are frequently strong and unpredictable, and a diver rarely works under "no current" conditions. Most men can work in currents of 1/2-I knot. However, when the current reaches 3-4 knots, it becomes almost impossible to carry out any effective task other than observation. Under these conditions the diver is so busy maintaining his free-floating position that he is unable to do much effective work.

The **composition** and **contours** of the continental shelf seabed vary from the flat mud bottom near the Mississippi delta to the craggy walls of Scripps Canyon off California. Because the average slope of the shelf is about two fathoms per mile, it is commonly pictured as a flat and monotonous place. On the contrary, the shelf has underwater ridges, boulder-strewn slopes, and deep rutted canyons. These variations in the topography of the ocean floor pose potential hazards in the positioning and performance of the diver and his support equipment.

Serious potential physical dangers may develop in the relatively short time it takes the diver and his equipment to enter and leave the water. The transition of the suited diver or his support equipment (submersible decompression chamber, underwater dwelling) during the placement and retrieval phases should take only a few moments to accomplish under normal circumstances. However, unpredictable environmental situations, such as high winds and sea states, often develop.

Mechanical failure of placement and retrieval equipment can further complicate the picture. In any event, when heavy loads, including the diver, are transferred from the ship to the sea, and back, the potential hazard to the diver at the air-sea interface is high. If the loads are not kept from swinging or moving in relation to the vessel, the divers (or deck crew) may suffer severe impact trauma.

When the diver, or his equipment, is attached to the surface work-platform by an umbilical line containing his breathing gas, communication and power supply, he becomes subject to surface weather activity. The ship or barge must maintain a fixed position otherwise the umbilical line will be subjected to dangerous tension stress. Decompression, which usually must proceed in exact depth-time stages, can be very hazardous if the diver and his line to the surface ship are subject to the rolling action of heavy seas.

In many underwater tasks heavy loads may have to be placed at or removed from the underwater work site. Particularly in waters of poor visibility, when heavy equipment is lowered from the surface ship (and hence is moving with it), the diver or his support equipment may be injured or damaged. It is therefore important to "uncouple", as soon as possible, the relative motions of the equipment being lowered and the diver receiving the equipment on the ocean floor.

The Marine Environment

Much has been written about the hazards of sharing the underwater world with certain creatures of the sea. Potential hazards for divers who live for long periods in dwellings on the ocean floor include marine organisms that range from unicellular bacteria to the unpredictable shark.

Figure 3.
The SEALAB II habitat acted like an artificial reef, attracting many marine creatures to it's lights and frame. Sculpin, also called scorpion fish, were a constant danger, their sharp spines containing a painful poison that could disable a diver for a day or two. (Official photograph, U.S. Navy)

Seawater has such a rich variety of unicellular organisms that pathogenic bacteria or fungi may develop and multiply in the synthetic environments of future sea-dwellings. The respiratory and dermatological systems, and particularly the external ear appear to be most vulnerable to infectious diseases when man is living under the sea, as they are exposed to constantly changing conditions of pressure, temperature, and humidity.

Tropical waters have their own spectrum of hazards. For example, coral lacerations decrease diver efficiency, not only because of the initial trauma, but because these wounds tend to become infected and take many weeks to heal. In both tropic and temperate waters, divers risk increased exposure to the poisonous barbs and spines of stingrays and scorpion fish as well as the painful stab of sea-urchin spines.

Divers frequently work around barnacled, or rusted, steel frames or structures.

Lacerations, particularly of the hands, are a hazard common to all men working in such situations. Not only do underwater abrasions and lacerations take longer to heal than those suffered in air, but such trauma may draw blood and lead to a shark attack. It was reported by Cousteau during ConShelf II that wounds suffered inside the dwelling air healed faster than similar wounds on shipboard. Hyperbaric medicine has benefitted from such undersea observations.

Sharks are common to all oceans and particularly to the warm waters of the tropics. Fortunately, however, few divers have reported unprovoked attacks. It should be stressed that although there are many possible hazards from marine animals, the chance of a diver's incurring even one such hazard while he lives under the sea is slight.

However, the attitudes of the marine animals may change as the diver and his equipment become more or less permanent fixtures on the ocean floor.

According to Stenuit, Cousteau, and Bond, certain fish species (large groupers) were at first shy, and then became increasingly curious. Some fish, after exposure to the human divers, became definitely aggressive.

Ultimately we hope that we can increase our knowledge of marine biology to the point where we can enlist certain marine animals as our allies in undersea activities. In U.S. Navy experiments a porpoise was trained to deliver messages 200 feet to the surface and to search and help recover 'lost" divers. In future prolonged deep dives, man will have to give considerable thought to, and carefully control, his changing relationship with the natural inhabitants of the deep and shallow seas.

The Gaseous Environment

Man's success at working at continental shelf depths depends on his inhaling gases at a pressure equal to the surrounding water pressure. The selection, concentration and purity of these gases present specific problems, particularly with regard to the oxygen carrier or diluent. The question of the optimal tolerable partial pressure of oxygen (PO_2) in the breathing mixtures used beneath the sea is still under investigation. Sea-level experiments have shown that, for periods of several days, PO_2's of less than 100 mm Hg and more than 400 mm Hg may induce hypoxia and hyperoxia, respectively. It has become evident that during a saturation dive it is unwise to attempt to maintain PO_2 at a sea-level equivalent of 160 mm Hg. One reason for this is that reliable analysis and control devices for narrow oxygen ranges are not generally available. Another reason is that relatively low partial pressures of oxygen increase the time required for decompression. Due consideration must also be given to such factors as the duration of exposure, the diver's metabolic activity, requirements for muscular effort, inert-gas partial pressure, need for decompression and the specific phase of the "dive profile." In undersea-living experiments to date, the PO_2 has been kept between 150 and 400 mm Hg. During the latter phases of decompression, PO_2's of 1500 mm Hg and greater are occasionally used.

There seems to be more general agreement about the optimal level of PCO_2. For dives of several days' duration, the PCO_2 should probably be maintained below 7 mm Hg, although in sea-level experiments, man has adapted to a PCO_2 almost twice as high. It is most important that this gas, and others that make up the underwater environment, be accurately analyzed and controlled. Only in this way can the various potential toxicities be anticipated and prevented.

In the atmosphere of the underwater dwelling there are a large number of **micro-contaminants** that, if allowed to build up, can become toxic. It is an axiom of undersea living that the concentration, or toxic level, of most gases are directly proportional to the number of atmospheres of pressure in the breathing mixture. In other words, if a gas which exerts a partial pressure of 7.6 mm Hg at sea level is compressed to 200 feet or seven atmospheres absolute, it would exert a partial pressure of seven times 7.6, or 53.2 mm Hg. If this calculation is applied to CO, it is apparent that, at 200 feet, breathing such a mixture would rapidly lead to hypercapnia. The design of any underwater dwelling, diver's breathing apparatus, or decompression chamber must take into consideration and exclude or remove all potential micro-contaminants, such as volatile hydrocarbons and oil-base paints. It should be stressed that the possibility of micro-contaminant build-up, such as carbon monoxide, increases with the length of a dive.

Any dwelling or chamber on the ocean floor has a hatch or opening that allows the diver to enter the sea. However, through this opening a great deal of water vapor from the seawater also enters. Other sources of moisture are the diver's wet clothes, his skin and his metabolic processes. If these sources of water vapor are not controlled, **humidity** soon builds up to high levels and gives rise to problems that are proportional to the atmospheric temperature and to the length of exposure. The immediate effect of humidity is to chill the diver and to make him uncomfortable. Everything he touches is wet, including his clothes and blankets, and the dampness can become intolerable. The general effect on the skin of constant exposure to 100% relative humidity is serious. It is similar to, although less serious than, the manifestations seen after prolonged water immersion. Several divers, after long underwater sorties, have reported softening of the skin, particularly of the palms, accompanied by a wrinkling and whitening. If this condition is allowed to continue, the diver becomes unable to work with his hands. The skin tears easily, and the hands become sensitive. In this condition the skin is much more susceptible to infection, and the healing of existing wounds is delayed. To allow the diver to "dry off" effectively, and be comfortable after his daily periods of underwater work, all underwater dwellings must be provided with humidity controls that will maintain the relative humidity in the region of 30-60%.

It has been common knowledge for many years that increased partial pressures of **nitrogen** in the breathing gas at depths greater than 100 feet or so give rise to a condition called "nitrogen narcosis" or 'rapture of the deep". As the depth increases, the narcosis deepens and intellectual and motor efficiency steadily decline. Behavioral changes characterized by euphoria and neuromuscular incoordination are common, and the condition has been likened to alcohol intoxication.

Another hazard develops as a diver descends to greater depths; i.e. as the pressure increases, the **density of the breathing mixture** also increases, resulting in an alteration of his ventilatory pattern. More effort is required to ventilate his lungs, and hence ventilatory efficiency decreases particularly when the diver is working hard under great ambient pressure. These conditions can lead to respiratory fatigue, carbon-dioxide autointoxication, and increased susceptibility to both nitrogen narcosis and oxygen toxicity. For these reasons, compressed air, or atmospheres with high percentages of nitrogen, are not used in prolonged deep saturation diving. Animal studies have also indicated that the use of compressed air for deep saturation diving is dangerous. Shallow saturation dives carried out in 1963 by Cousteau at

33-feet in the Red Sea (ConShelf II) were not affected by these characteristics of nitrogen under pressure.

Helium has been used in all deep open sea diving experiments because at current experimental pressures it is not associated with any measurable narcosis or significantly decreased performance. However, as these experiments are conducted at greater and greater pressures, these undesirable effects may become important, particularly limitations of pulmonary ventilation. Current deep underwater dwellings usually contain only a small amount of the original residual nitrogen, and helium is used as the oxygen diluent. The use of helium as the inert gas gives rise to other unique problems. Helium has very high thermal conductivity (nearly six times that of nitrogen) and this property, combined with the increased molecular availability as depth increases, and chills the diver rapidly. This effect in the synthetic gaseous environment increases with depth, and each dwelling must have a powerful and reliable source of heat to protect the divers. Previous deep saturation dives have required dwelling temperatures between 82 and 86° F. Another unique difficulty in the use of helium is that voice communication breaks down, owing to a multiplicity of factors; in the helium-oxygen atmosphere, the diver's voice is high-pitched and unintelligible both to himself and to the crew topside. Under these circumstances, the listener is subject to "a confusion of cues", a potential hazard if information, passing between divers and the crew topside, is misinterpreted, particularly in an operational emergency. Efficient voice communications in helium is the subject of much intensive current research.

Few attempts have been made to use other gases such as hydrogen and neon and to evaluate them with respect to such critical factors as narcosis, ventilation, voice communication and decompression. So far no open-sea saturation dives have been made using these gases. Hydrogen is particularly difficult to handle because of its explosive characteristics when it is mixed in uncontrolled combinations with oxygen. However, in work carried out by Ocean Systems, two divers breathed a neon-oxygen mixture for 30 minutes at 650 feet without measurable narcosis or decrease in psychomotor efficiency.

Other Important Potential Problems

Compression

As the diver descends, or is compressed in a chamber, he must ensure that the gas pressure in his body cavities, such as the lungs and sinuses, is kept equal to the increasing ambient pressure. If the pressure increase is not equalized, a relative vacuum occurs, and edema and bleeding into the cavity results. Failure to equalize, unsatisfactory chamber gas mixing and turbulence, and the heat of chamber compression are among the hazards facing the diver during compression. These hazards are most likely to be encountered in a chamber that is being rapidly pressurized to some equivalent seawater depth. If the diver is unable to "equalize" his sinuses and middle ears to the increasing ambient pressure, he inevitably suffers pain and tissue damage. If compression is too rapid, he may become hypoxic because oxygen does not mix efficiently with the inert gas. Fortunately the diver carried to the continental shelf in his submersible decompression chamber is in a well-controlled compression situation. Saturation divers are not routinely compressed rapidly, and these problems rarely arise.

Decompression-Uncontrolled and Controlled

Once a diver's blood and tissues are saturated with inert gas during his residence deep in the sea, a sudden return to the surface pressure will almost certainly be fatal. In order to avoid the irreversible effects of decompression that would follow flooding, fire, or other reasons for emergency escape from an undersea dwelling, readily available rescue chambers must be provided. These chambers must be easily accessible and autonomous, and contain the same respirable atmosphere as the dwelling. Standby rescue chambers have been kept available on all undersea living experiments to date.

Exploration of undersea canyons or a steep edge of the continental shelf will require **vertical excursion dives** from the level of the undersea dwelling. Special care must be taken during any such dive carried out by a saturated diver. Previous work indicates that such a diver may be capable of extensive downward excursions. However, it appears that upward excursions of more than about 30 feet above the dwelling may be dangerous. Vertical excursion dive limits will, of course, vary with the depth of saturation, but much intensive research still needs to be done to define these limits. In all probability, early research efforts will be directed at developing diving tables that will not require the diver to decompress before returning to the dwelling. As well, it will be important to develop tables that will allow effective undersea treatment of decompression sickness should it occur following vertical excursion dives. A conservative approach during initial undersea excursion dives is warranted, because the treatment of decompression sickness under these circumstances would be extremely difficult.

All laboratory and open-sea saturation dives to date have emphasized the critical control required during decompression that, in one dive, lasted as long as six days. This control is necessary to prevent the formation of inert gas "bubbles" in the tissues and blood stream, which most workers believe is responsible for decompression sickness. Decompression sickness occurring at great depths creates an extremely difficult medical problem. Not only is a definitive diagnosis difficult, but also the treatment procedure is long and complicated. A serious episode demands that the physician join his patient by compressing to the required depth. In any event the diver must be recompressed to a depth that will give relief as soon as possible. Additional therapeutic steps, such as increasing the P02 or intravenous fluids are taken according to the severity of the problem. Most cases of decompression sickness have been treated in deck decompression chambers that call for a high degree of skill and co-ordination between the divers and the topside "life-support" team.

In previous open-sea experiments linear rates of ascent in the range of about 10-12 min./foot have been used successfully. Breathing 100% oxygen during the latter stages of this type of decompression has been added to diminish the possibility of decompression sickness.

Fire

The introduction of oxygen at high partial pressures into a closed chamber creates a potential hazard of explosion and fire unless sources of ignition and combustion are strictly eliminated and the oxygen is vented out of the chamber. A fire in an underwater dwelling or surface chamber is extremely dangerous because of the rapid build-up of heat and toxic fumes, and because, before the divers can escape from their confinement, they must undergo a long period of decompression.

Electrocution

The high electrical conductivity of seawater increases the possibility of electrocution particularly if high-voltage power tools and welding equipment are improperly used. This is known around docks and marinas as Electro-Shock Drowning (ESD). However, keeping the voltage at electrical outlets as low as possible, and adhering to rigid engineering codes and safe diving procedures, minimizes the risk of electrocution.

Problems Arising from Human Factors

Any review of medical problems that may occur during a prolonged deep saturation dive should include those brought to the dive situation by the diver himself. There is no question that, at present, prolonged deep diving represents potentially serious psychological stress. Past experience, particularly in manned space research, has shown that any such stress, if sustained, can, and probably will, enhance latent psychological or physiological defects. In addition to the more obvious forms of stress, the free diver suffers a diminution in the effectiveness of almost all his senses. Vision, hearing, touch, smell and body orientation are more or less altered according to water conditions. Also the diver's underwater efficiency is handicapped when there is no effective deep underwater communication between divers, or between divers and topside. The saturated diver is in a condition of partial sensory isolation. It is evident, then, that candidates for this type of work must be thoroughly screened by extensive medical and diving histories, and physical and special examinations. Also, only the most experienced divers can qualify for the deeper saturation dives. The ideal candidate is one with a quiet, relaxed disposition, a specialist in some underwater activity that will contribute to the mission's success, and he must have extensive diving experience.

A diver working for long periods at great depths must be in excellent physical condition. The reasons for this are obvious. If a diver's physical condition is inadequate, any stress such as oxygen toxicity or decompression sickness will have a far greater effect. As well, while under water, the diver may encounter an emergency situation that will demand sustained exertion in order to save his life.

Even well conditioned divers are fatigued after a prolonged pressure exposure. Individuals with cardiopulmonary, neurologic, and ear, nose and throat pathology should be disqualified from any kind of advanced diving particularly saturation diving. The list of other disqualifying conditions is extensive, and has been reported elsewhere.

It is important to recognize that the duration of current undersea-living experiments is increasing; for example, Carpenter remained submerged in SEALAB II for 30 days at 205 feet. Therefore, "non-diving" medical problems will probably increase. In our previous laboratory work, during pressure exposures of many days' duration, we treated complaints such as headaches, skin infections, and head colds. On one dive it was extremely difficult to make a differential diagnosis in a diver with acute vertigo and vomiting. Incidents such as this emphasize that all laboratory and open-sea saturation research dives should be carried out under medical supervision, with a diving physician present at all times during and for some time after the pressure exposure. He must have at his command adequate drugs, emergency equipment, and procedures to treat successfully any diving problem. Also, he must be prepared to "compress" to the depth at which the medical emergency has occurred in order to treat the diver under pressure. After he has carried out the treatment, the physician may have to undergo decompression.

It is recognized that there is great variation among individuals in their susceptibility to various diving diseases, both physiological and psychological. For example, one "decompression schedule" may be suitable for a large number of divers, while under this exact schedule another diver may suffer decompression sickness. This variation also applies to other hazards such as oxygen toxicity, and to a diver's response and adaptation to any intensely threatening situation. Individual variation has also been noticed in symptoms of musculoskeletal discomfort encountered while at depths usually greater than 200 feet; this discomfort usually manifests itself as a slight "soreness" of the wrists and larger joints. There will probably also be great variation in an individual's day-to-day and diurnal responses to the stresses of prolonged residence under the sea.

As the duration of prolonged deep diving is extended into weeks and months, the diver's psychological health will become increasingly important. It is unlikely, however, that such psychological problems will represent real dangers in the underwater environment, although some adjustment will be required for long-term stays.

Despite possible antagonistic and synergistic effects from the interaction of the multiple potential stress factors on the deep-dwelling diver, man again appears to be proving his adaptability to unusual environments. To date no significant subjective or measurable decrease in performance has been observed in divers under conditions of prolonged residence in high pressures. Although much work remains to be done, there does not appear to be any insurmountable barrier to human occupation of the world's continental shelves.

SUMMARY AND CONCLUSIONS

I have outlined some of the most important of the potential medical and performance problems inherent in man's current attempts to dwell for long periods deep beneath the sea. This is not an all-inclusive list. Some of these problems cannot be predicted and will appear when we dive deeper and longer. In addition, the degree of interaction and the long-term effects of the various types of stress remain to be ascertained and will be the subjects of future intensive investigation, both in the laboratory and under the sea.

Living under the sea, which is much more efficient than previous modes of diving, has taken on great scientific, military and economic importance. Undersea living depends on the combined efforts of physicians, biologists, physiologists, chemists, mathematicians, and ocean engineers. From the last group comes guidance in the design of the vital, life-support equipment necessary to achieve the maximum in long-term diver performance and safety, with minimum hazard.

Fortunately, up to the present, serious medical problems, while living under the sea, have been rare. More important, none of the recognized medical or performance problems appear insurmountable, at least at continental shelf depths.

To surmount existing obstacles and hazards, man will first have to extend cautiously his ability to live under the sea. Then, as he has in all his previous exploratory endeavors, he will proceed into the depths with great authority.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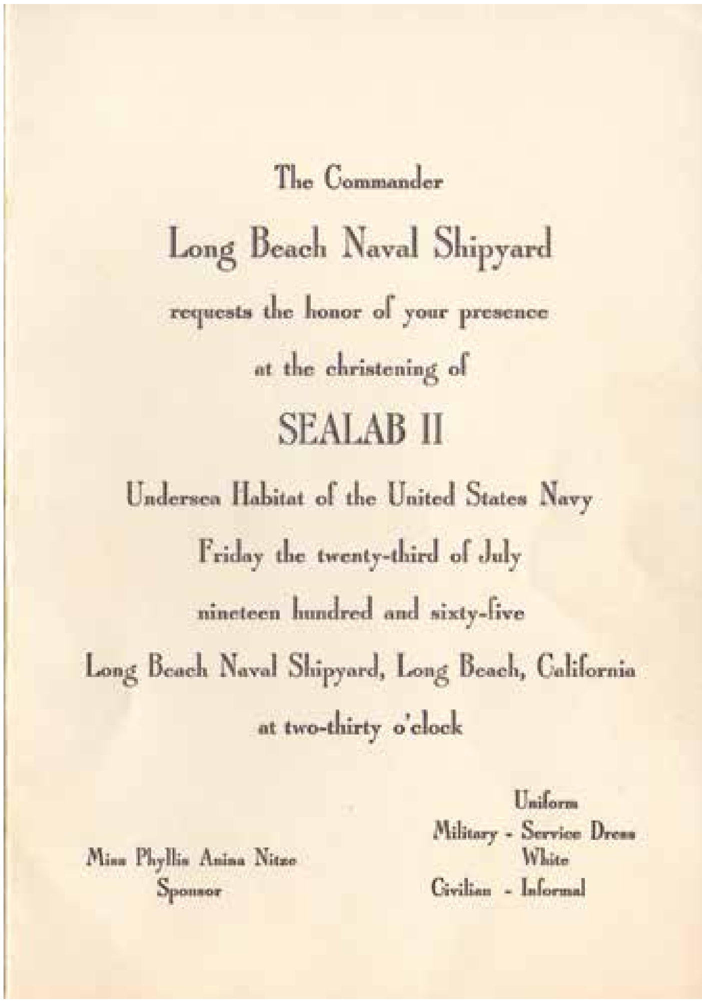
Introduction to SEALAB II

By George F. Bond, Captain, Medical Corps, U. S. Navy
Washington, D. C.

June, 1966



The Commander

Long Beach Naval Shipyard

requests the honor of your presence

at the christening of

SEALAB II

Undersea Habitat of the United States Navy

Friday the twenty-third of July

nineteen hundred and sixty-five

Long Beach Naval Shipyard, Long Beach, California

at two-thirty o'clock

Miss Phyllis Anina Nitze
Sponsor

Uniform
Military - Service Dress White
Civilian - Informal

Invitation to SEALAB II Christening courtesy of Mary Lou Cannon.

Capt. George F. Bond (Official Photograph, U.S. Navy)

SEALAB II represented the most ambitious effort then attempted in the U.S. Navy's Man-in-the-Sea Program. The purpose of this program was to demonstrate man's capability as a free-ranging agent to live on and to explore and exploit the continental shelves of the world. Quite aside from the rich and varied natural resources to be found on these vast and accessible underwater shelves, the frontier of inner space presents a challenge that we dare not ignore. Indeed, it was just this challenge that maintained the enthusiasm of a handful of investigators over the long years of laboratory research that made SEALAB II possible.

At the successful conclusion of the experiment, impressive statistics could be quoted. Four hundred and fifty man-days of undersea life and work had been logged. Two Aquanauts had lived a full month at the bottom of the sea. A tremendous quantity of useful work had been performed by Aquanauts on the ocean floor, work that would have required nearly four years to accomplish using conventional diving techniques. More than one half million separate bits of important scientific information had been collected and stored to be used in preparation of hundreds of technical reports.

Statistics and reports, however necessary, are dry and impersonal; and the true story of SEALAB II is the story of living human beings, locked in an unending struggle with a hostile environment. This is the story which must be told with compassion and understanding.

I hope that it will be appreciated as a bit of history and an interesting narrative.

(Excerpted and adapted from "PROJECT SEALAB: The Story of the United States Navy's Man-In-The-Sea Program" by Terry Shannon and Charles Payzant, 1966)

SEALAB II at 50

Journal of Diving History, September 30, 2015

50 Years Later, the Lesser-Known Legacy of SEALAB II Lives On

By Ben Hellwarth, Author of *SEALAB: America's Forgotten Quest to Live and Work on the Ocean* Floor

Fifty years ago, as the first divers were getting ready to swim into the U.S. Navy's new and improved sea-floor base, dubbed SEALAB II, events on shore provided a considerable distraction from the history being made about a mile offshore from La Jolla, California. The Watts neighborhood of Los Angeles had just exploded into riots. In nearby San Diego, The Beatles were about to put on one of their final American shows of the year, a year that by the start of SEALAB II at the end of August had already seen the Rev. Martin Luther King Jr. leading civil rights marchers from Selma to Montgomery, the ramping up of U.S. troops in Vietnam and the first walk in space, which was actually more like a dive, considering the way Soviet cosmonaut Aleksei Leonov floated outside his capsule on a tether, but the term "spacewalk" stuck. It was, after all, the Space Age.

Tumultuous times and the limitations of mid-1960s media, including the still novel concept of TV news, may help explain how a giant leap like living on the seabed could be eclipsed by other events, especially those having to do with the space race between the United States and the Soviet Union. Even a half-century later, the advances and adventures of SEALAB II linger in historical shadows. Consider, for example, the recent National Geographic issue celebrating the history of exploration. Its extensive timeline – filled with such milestones as the naturalist William Beebe's 1930s plunge in a bathysphere – made no mention of SEALAB I, II or III.

One side effect of the SEALAB program's relatively low visibility has been that the risks and technical challenges that come with living and working on the seabed never seeped into public consciousness in the way that the risks and challenges associated with manned space flights did. Back in the sixties as today, key issues for space flights are part of the popular science lexicon – like enduring multiple G forces, the effects of weightlessness and the haunting prospect of burning up upon reentering the Earth's atmosphere, as the astronaut John Glenn almost did in early 1962. Many earthlings have even felt the physical sensations of G forces and weightlessness for themselves in such places as a rollercoaster ride.

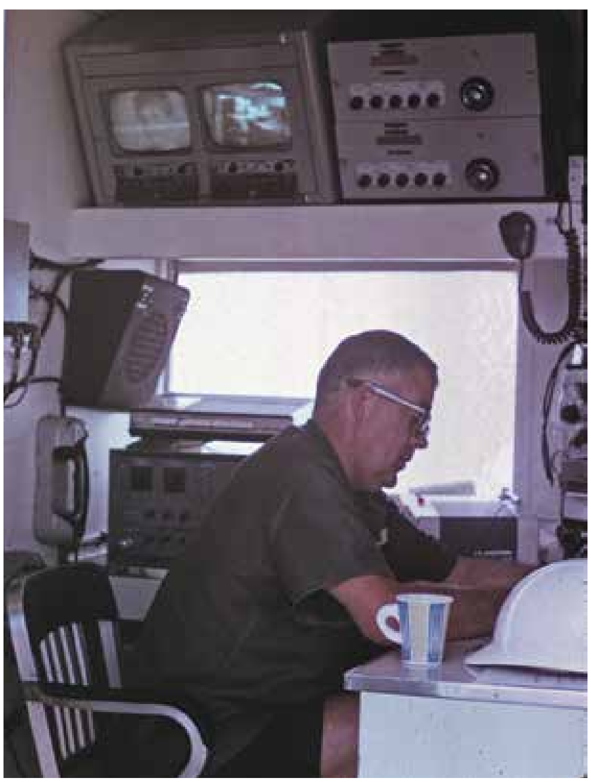


Figure 1. Capt. George F. Bond, affectionately known as "Papa Topside" by the aquanauts below, sits at his command station aboard the SEALAB II surface support vessel, *Berkone.* (Official photograph, U.S. Navy)

Obviously everyone has a primordial dread of drowning and can appreciate the importance of a diver's air supply, whether it's pumped from the surface through a hose, as with the iconic "hardhat" system – featuring a bulbous metallic helmet, bulky rubber-lined canvas suit and lead-weighted boots, as seen in the movies – or whether a diver carries his own air, compressed into a metal tank on his back, as with the self-contained underwater breathing apparatus (SCUBA). By the sixties SCUBA was transforming diving from a strictly professional occupation into a recreational sport.

Still, the notion of divers living in a stationary vessel something like an underwater camper could sound simpler than it was, especially at depths which, while deep by conventional diving standards, might seem unimpressive compared to, say, soaring in a space capsule miles above the Earth. In addition to depth there was duration, no small physiological matter when breathing underwater – and not just because you might run out of air or your gear might fail, but because of the complications that come with breathing air under higher pressures, as is necessary underwater.

These complications, which can be a matter of life or death, remained lesser known. Thanks largely to the popularity of SCUBA, at least one has become more firmly embedded in the lexicon, and that is a diver's need for decompression – a gradual and methodical return to the surface to allow for the safe release of the gases that get absorbed into the blood and tissues while a diver breathes under pressure. Surface too quickly and you can get "the bends," the achingly painful and potentially fatal condition brought about by bubbles forming in the body much as they do in soda when a can or bottle is popped open. Bubbles in the body can cause all manner of physiological short circuits, depending on where they form.

In the late 1950s, a country doctor from western North Carolina named George F. Bond, who had no prior diving experience, joined the Navy and became fascinated by how – at the dawn of the Space Age, no less – divers were still largely abiding by depth and duration limits established decades before. As Bond learned during his training to become a submarine medical officer, whether you were doing a job in heavy hardhat gear or swimming freely in modern SCUBA, the same conventional limits applied: You couldn't dive very deep, and if you did venture much below about 130 feet, you couldn't stay down for very long. During the historic rescue and salvage of the American submarine *Squalus*, which sank in 1939 in Atlantic waters of about 240 feet, Navy divers could spend no more than about a half an hour at a time at the downed sub before they had to begin the gradual process of decompression. It took dozens of divers and many dives to put in the hours needed to get a difficult job done. When Dr. Bond joined the Navy that was still pretty much the state of the art.

Decompression schedules, also known as dive tables, had been worked out in the early 20th century to prevent divers from getting the bends, more formally known as decompression sickness. These tables looked like bus or train schedules, with rows and columns of numbers telling divers how long to pause at given depths en route to the surface depending on the total time they had spent at their working depth. The schedules were always being refined to maximize dive times and minimize decompression times while keeping a diver safe and free of the bends. But these refinements were more like tinkering than a total transformation, and Dr. Bond marveled that with the world fixated on the lofty goal of sending human beings into outer space and to the distant moon, there was no like-minded effort to send human beings in the other direction, deeper into the realm that some liked to call "inner space," perhaps in the hope of siphoning a little enthusiasm from the space program.

Not only were there the longstanding limits on depth and duration intended to prevent the bends, there were other sub-aquatic quandaries, like the drunken stupor brought on at depths of more than about 130 feet when breathing the nitrogen that makes up four fifths of ordinary air. The narcotic effects of nitrogen had successfully been eliminated a couple of decades earlier by substituting helium into a diver's breathing gas. That enabled divers to stay clear-headed when diving deeper – a critical improvement, especially on tricky jobs – but both depth and duration remained restricted by conventional limits, as set forth in the dive tables.

So, while diving had made some progress, Dr. Bond nonetheless found it surprising that no one had the answer to a pair of questions that seemed to him as fundamental as knowing the speed of sound or how fast a human could run the mile: *How long can a diver stay down? How deep can a diver go?*

After serving in the Navy for several years in the early 1950s Bond could have returned to his rural medical practice and he almost did. But he had become hooked on diving and the prospect of achieving breakthroughs that would somehow get around the old decompression limits and afford divers a lot more time underwater. So Bond continued to pursue a career as a Navy medical officer – and he would make it his job to seek answers to those questions about dive depth and duration.

Commander Bond soon got promoted to captain and became officer-in-charge of the Medical Research Laboratory at the U.S. Naval Submarine Base at New London, Connecticut. It was there, in the late 1950s, that he began the laboratory experiments aimed at proving the concept of "saturation diving," a term that referred to allowing a diver's body to fully absorb the gases breathed at a given depth. The greater the depth and pressure, the greater the degree of saturation. The conventional approach to diving didn't allow enough time for a diver to become saturated. Results of some preliminary lab experiments that did allow for total saturation, which took about a day at a given depth, indicated that allowing for total saturation might actually be ineffective, if not downright dangerous.

But Bond and a few others around the New London lab believed that saturation diving could hold the key to enabling a diver to spend hours, days, even weeks at depth instead of mere minutes. There would still be no getting around the need to decompress, but that process might be postponed indefinitely until it was finally time to surface. That was the idea, anyway. To test it out Bond and his team at the lab would begin running

Figure 2. Capt. Walter F. Mazzone, aboard the surface support vessel, *Berkone*, overseeing SEALAB II, August-October 1965. The design of the surface support vessel was attributed to Joe Berkich and Walt Mazzone, and the ship name combines parts of each man's last name. (Official photograph, U.S. Navy)

experiments on assorted animals, much as tests were run on animals in the early years of the space program before humans were allowed to ride rockets into the sky.

The early experiments on saturation diving began quietly, even unofficially, in stark contrast to the animal experiments for the space program – monkeys like Able and Baker made the cover of Life magazine. For a time Bond's Navy bosses weren't entirely aware what he was up to in his lab, and Bond knew that some would not have approved. But Bond had an iconoclastic streak that could serve him well, and he was determined to do what he could to gather favorable evidence and gain support for the revolutionary concept of saturation diving.

Bond's effort might have withered in a hyperbaric test chamber if not for the participation of Captain Walter Mazzone, a top administrator and a decorated veteran of World War II submarine patrols. Mazzone's official job at the New London base involved preparing new submariners for duty but Mazzone had a background in biological science and, perhaps more important, he had an innate sense of curiosity. Before the war, he had hoped to become a medical doctor himself and his interest was piqued the day he was introduced to Captain Bond, rather by chance, during a visit to the Medical Research Lab. Mazzone was not one to be easily impressed, but from his very first conversation with Dr. Bond he was struck by Bond's personal charisma and his professional zeal about pursuing the concept of saturation diving. Bond was even talking seriously about the prospect of creating the marine equivalent of space stations on the seabed.

Fortunately for Bond, and for the future of saturation diving, Mazzone was just the kind of detail-oriented man for the job of running the early saturation experiments, which Bond called "Genesis," not only because he saw them as the beginning of a new era in diving, but because of what the opening lines of the Bible in the Book of Genesis said about man having dominion over the fish of the sea. In addition to being a doctor and scientist, Bond was a religious man and had served as a lay preacher during his half-dozen years as a country doctor. He often gave sermons at the little church in the backwoods of the Blue Ridge Mountains in North Carolina where he lived and worked. What was written in scripture seemed to him welcome corroboration that saturation diving was more than just feasible. It was meant to be.

Favorable results from the animal tests led to the next phase of Genesis, one in which human volunteers would be sealed in hyperbaric chambers, with scant amenities, and subjected to a pressurized environment similar to what they'd have to live in underwater. That meant breathing newly concocted gas mixtures very different from the roughly 79-percent nitrogen and 20-percent oxygen found in ordinary air. Helium was in the mix to avoid the stupor of nitrogen narcosis and the percentage of oxygen had to be reduced because the gas that sustains life reaches concentration levels under pressure that are actually poisonous – one of those complications of living underwater and under pressure that wasn't exactly common knowledge. The Genesis volunteers were also being exposed to heightened pressure for much longer than anyone usually was – about a week was the initial goal. The volunteers in the chamber would also know that, once saturated, there was no quick way out before undergoing a lengthy and carefully orchestrated decompression. Of course there was no way of knowing whether the customized gas mixtures and decompression schedules that seemed to work for rats, monkeys or goats would be safe for humans. In short, there was no way of knowing for sure whether anyone who went into a chamber would come out alive and unharmed.

Even as Genesis was going on Bond was looking ahead to the next step: How to persuade the Navy to build a first prototype sea-floor station. If divers were to spend days or weeks on the seabed instead of mere minutes, they'd need a shelter of some kind, much as a mountaineer needs a tent. They also needed to find out whether the methods that seemed to work in the lab would work at sea, with all the added variables and challenges that come with operating in the ever-changing marine environment.

In the meantime Bond was happy to share the promising results he was getting in the lab – a report on the animal experiments, while not widely distributed, was publicly available. Two prominent figures in undersea exploration were intrigued, and Bond met them both. One was the American industrialist Ed Link, inventor of the first flight simulator, who was turning his attention from aviation to diving and ocean-going technologies. The other was Jacques Cousteau, co-developer of modern scuba, who was fast becoming a household name. Link and Cousteau, both eager to test the concept of saturation diving, had initially planned to join forces and run a first saturation dive at sea but their relations soured and they went ahead separately, with two saturation trials each, between 1962 and 1964. They each took relatively cautious approaches, with Link more focused on achieving depth and Cousteau more focused on duration. Bond and his Navy team – once they could get the kind of official approvals that Link and Cousteau, as private operators, didn't need – were aiming for a more definitive demonstration by achieving both substantially greater depth and duration. They also wanted to continue to gather the physiological data needed to ensure diver safety and to attempt longer, deeper dives. This data they found lacking in the Link and Cousteau ventures.

By early 1964, the Navy agreed to build SEALAB I, its first-ever undersea "habitat" – the Roman numeral optimistically suggesting that this habitat would not be the last, but a lot depended on how this undersea debut turned out. SEALAB I was cigar shaped, about 40 feet long and nine feet in diameter. It had multiple legs, like those on a dining table, and weighed 30 tons. Two pontoon-like feet that ran the length of the habitat could be filled with ballast, a rather primitive system but one that enabled the structure to sit firmly atop its legs, about six feet over the seabed.

SEALAB I was towed to a site about 25 miles southwest of the U.S. Navy base at Bermuda, and lowered to a depth of 193 feet on a flat, sandy expanse of seabed called Plantagenet Bank, close to the benchmark of 200 feet used in the final Genesis lab experiments.

This was a substantial depth, then and even now, and at least as challenging as the depth was the planned duration: The goal was to house four "aquanauts," as Dr. Bond liked to call sea-dwelling saturation divers, in SEALAB I for three weeks.

On July 20, 1964, exactly five years before the first manned landing on the moon, four Navy divers squeezed into a Personnel Transfer Capsule (PTC) that was like a pressurized elevator used for getting saturation divers to and from the seabed safely under pressure, and were lowered to the near vicinity of SEALAB I. Those first four aquanauts, all Navy divers, were Bob Barth, who had been a test subject throughout the human phases of Genesis, along with Lester "Andy" Anderson, Sanders "Tiger" Manning and Dr. Robert Thompson.

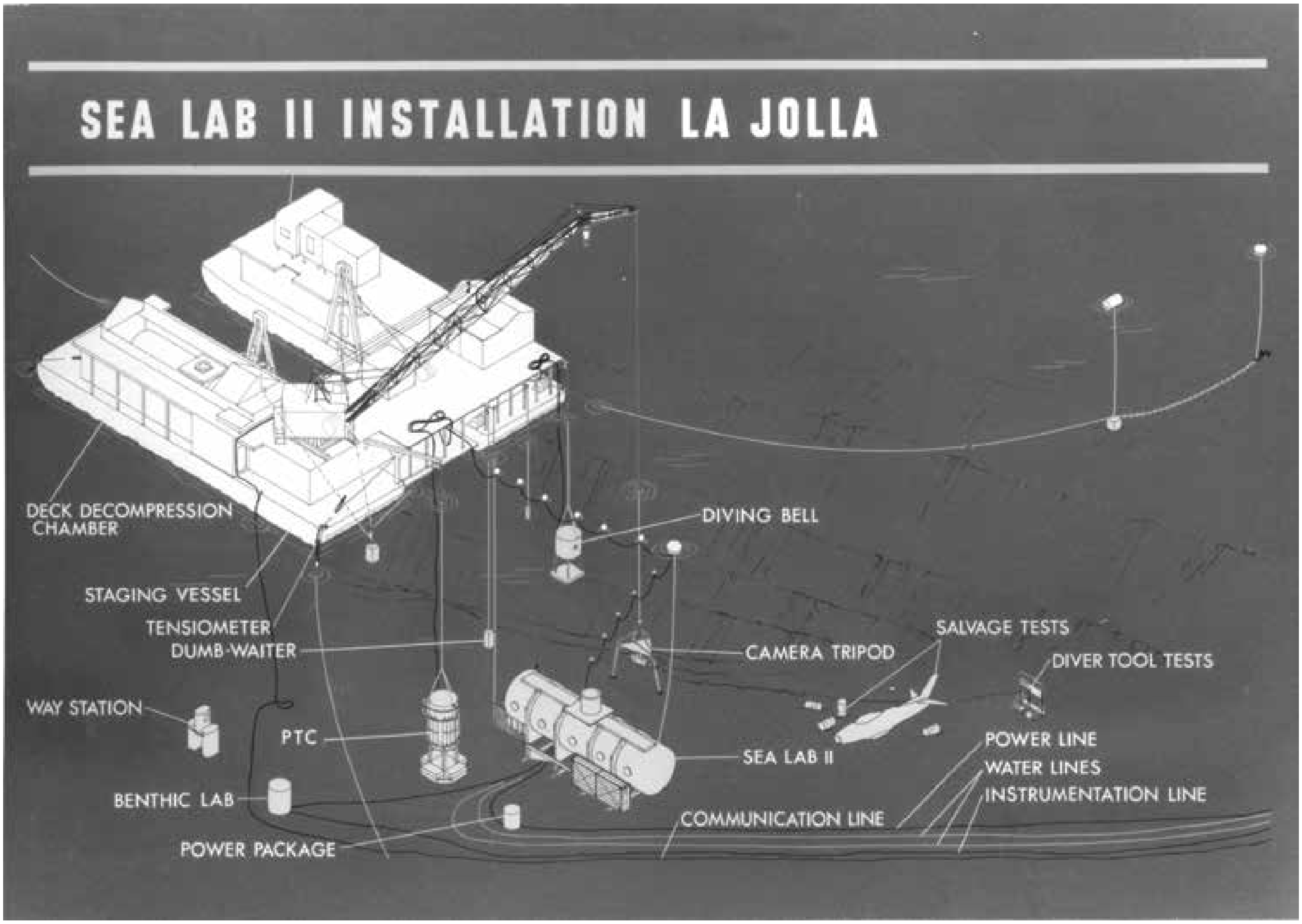


Figure 3: The SEALAB II complex of surface support ship, habitat, PTC, and support lines to shore. (Official photograph, U.S. Navy)

Their stay on the seabed had to be cut short because of an approaching hurricane. They had already collected a lot of the physiological data they were after, however, and the aquanauts had demonstrated the benefits of diving from a sea-floor shelter. That was enough to give the Navy greater confidence that Dr. Bond was onto something.

(See Journal of Diving History, Issue #79, Second Quarter 2014, for an in depth story of SEALAB I).

More money flowed into the young SEALAB program – about $2 million, still a drop in the bucket by space-going standards – and by the following year a bigger, better habitat, with room for 10 aquanauts at a time, called SEALAB II, was built at the Hunters Point Division of the San Francisco Bay Naval Shipyard. SEALAB II was cylindrical like a railway tank car, and much more sturdy and refined in appearance than its predecessor. It was the same diameter, nine feet, but 57 feet long, so almost 20 feet longer than SEALAB I, but within its camper-like confines there still wasn't a lot of space for 10 divers.

When completed SEALAB II was shipped by barge to a site not quite a mile off the coast of La Jolla, just north of San Diego. The 200-ton habitat was lowered by crane, in tandem with a newfangled ballasting and counterweight system they'd devised, to a depth of 205 feet, just a little deeper than SEALAB I had been in Bermuda.

But this time around, instead of remaining at the depth of the habitat, the aquanauts would experiment with making deeper dives from the base depth. They would also have to contend with the darker, colder waters – temperatures in the 40s instead of the 70s. Three teams of 10 divers, including a half-dozen marine scientists from the nearby Scripps Institution of Oceanography, would each spend two weeks in SEALAB II and attempt to carry out an ambitious list of underwater experiments to demonstrate the range of jobs a genuine sea dweller could get done. One of the aquanauts was Scott Carpenter, the famed Mercury Project astronaut who in 1962 had been the second American to orbit the Earth. For both personal and professional reasons, Carpenter had gravitated to the SEALAB program from NASA and was going to serve as leader of the first two aquanaut teams. That role would not only give him a record-setting month living and working on the seabed, but his celebrity might even help raise the program's profile.

The notion that living in SEALAB II could be stressful – cramped, stuffy, humid quarters, suffused with the sweaty stench of a locker room in which falsetto helium voices mangled simple conversation – compelled a team of psychologists to monitor the aquanauts throughout their stay. The aquanauts also knew that if they were ever having a serious case of cabin fever, or something went terribly wrong with the habitat, swimming for the surface was not an option – one of many reasons they might as well have been in orbit.

Scott Carpenter knew what it was like to be in orbit, and the world knew Scott Carpenter, so as the first of the three SEALAB teams got settled into their stuffy quarters Carpenter was put on a radio hookup with his pal Gordon Cooper, who was then whizzing around the globe, a hundred miles up, aboard Gemini 5 with astronaut Pete Conrad. The "sea-to-sky" voice link was the first of several attempts to generate some headlines and public interest in the risk, the thrill and the potential of housing aquanauts in sea bases. Captains Bond and Mazzone later donned SCUBA and dived into SEALAB to join Carpenter for a brief reenlistment ceremony held for one of the aquanauts. "This will certainly be a first in naval annals," Bond mused.

In another such display a phone connection was made between the SEALAB aquanauts and the five divers living in Jacques Cousteau's third and final sea base, a spherical structure called Conshelf III, which was more than 300 feet down in the Mediterranean off the coast of Monaco. Invoking the Cousteau name could be a good way to grab some limelight, but it would take more than a few publicity stunts to make household names out of SEALAB and the aquanauts.

Once settled into the steamy, helium-rich confines of SEALAB II, the aquanauts could cook canned foods on the electric stovetop, but as in SEALAB I frying was verboten – too much risk of contaminating the internal atmosphere. For their dives they had several kinds of gear to choose from, including SCUBA, but to maximize their dive times outside the habitat they often used a rebreather called the Mark VI, which recycled a lot of the diver's exhalations, thus affording longer dive times than ordinary scuba. The gear had to be precisely calibrated and it could be finicky, as had been learned during SEALAB I. A year later, for SEALAB II, the Mark VI was still a choice piece of equipment, despite its quirks. It looked something like SCUBA except that wedged between the twin tanks was a canister filled with a carbon-dioxide-absorbing chemical, plus two inflatable breathing bags that were worn like a life vest.

Once the Mark VI was set up, the diver would know approximately how long his gas supply would last, but that was about it. Approximately was an operative word. The Mark VI had no warning systems and there were none of the kind of dive computers that would later become commonplace. A diver had to be on constant alert for possible signs of trouble – like overly labored breathing or lightheadedness. If you thought you were having a problem you couldn't tell anyone – there was no means of voice communication while in the water, only old-fashioned hand signals.

The issue of voice communication was one they hoped to resolve during SEALAB II. Diver communications would be especially helpful in cases of emergency, of course, and for complex jobs. When hand signals didn't suffice, the aquanauts had to stop what they were doing and swim back to the SEALAB hatch, where they could pop in, pull out their mouthpieces and talk things over in their helium falsettos. Considering all the advances they were making it was ironic that communications between divers and their supervisors at the surface had remained elusive. Even old-style hardhat divers had had telephone systems in their bulbous helmets for the previous half-century, since about 1915. But such systems were more easily devised for the dry interior of a helmet, where a diver's mouth wasn't plugged with a mouthpiece or his face squeezed into a dive mask. Hardhat divers also had an airline on which a phone line could piggyback.

For SEALAB II they were going to use a piece of gear called the Aquasonic, a prototype for diver voice communication. The Aquasonic looked something like a fighter pilot might wear, with a mask fitted around the nose and mouth that was supposed to allow for both breathing and talking underwater. It was also supposed to send a radio signal through the water. But in an early test of the Aquasonic they found that the mask leaked badly and even when the signal was received, helium speech made the diver's words incomprehensible. That something as significant as the Aquasonic hadn't been sufficiently tested was another indication that despite a

Figure 4: Tuffy, a bottlenose dolphin, or porpoise, was trained to assist the SEALAB II Aquanauts. (Official photograph, U.S. Navy)

surge in funding, the SEALAB program was not the space program. Scott Carpenter recognized that as readily as anyone. More than once he remarked that for SEALAB they were "working with mail-order equipment in marginal conditions."

Conditions in and around the habitat were a big part of the challenge. Not only was the water cold, but visibility varied greatly. Equipment lowered from the surface support ship – a pair of boxy vessels that had been customized and linked up to form a floating, U-shaped mission control – could be difficult and sometimes impossible to find. They were also diving at night, but even during the day an aquanaut didn't have to swim far to lose sight of the habitat. The prospect of getting lost, disoriented or injured while working in the water, possibly at some distance from the habitat's hatch, was the reason a porpoise named Tuffy was tapped for duty.

Tuffy was part of a Navy program that trained marine mammals to do a variety of jobs, like coming to the rescue of a lost or injured aquanaut, a skill practiced during SEALAB II. Tuffy lingered near the surface, in a pen, and upon hearing a buzzer he dived to the aquanaut who had summoned him. In these tests Tuffy was to lead the aquanaut back to the habitat, since immediate surfacing was not an option. While not yet flawless in his role as an undersea St. Bernard, Tuffy made progress.

The seabed around SEALAB II became a proving ground for a variety of military and civilian jobs, including the setup and monitoring of a weather station, the salvage of a jet fuselage, a study of plankton and an artificial reef. There was also the daily upkeep and maintenance of the habitat and dive gear. The days were full and often exhausting. When a team finished its two-week stay, the aquanauts would have to swim into their pressurized elevator, a larger version of the oil-drum-shaped capsule made for SEALAB I. It hung near the habitat on a line from the surface support ship. Once the capsule was sealed shut and lifted back onto the ship, with nine or 10 aquanauts crammed inside, it was affixed to a chamber where all the aquanauts could undergo more than 30 hours of decompression – a small price to pay for having spent two weeks living at a depth of 200 feet with some deeper forays. The decompression schedule had even been revised so that it was only about half as long as the more slow and cautious schedule followed for the aquanauts of SEALAB I.

Over the course of the 45-day experiment, lessons were learned and despite some close calls no lives were lost. SEALAB

Figure 5: SEALAB III incorporated extensive modifications to the SEALAB II habitat. (Official photograph, U.S. Navy)

II was considered a success, much to Captain Bond's relief and delight, and the Navy put more money and personnel into its sea-dwelling program for SEALAB III, an expanded and remodeled version of SEALAB II. The program budget grew to about $10 million and in the winter of 1969, after a series of delays, the habitat was placed at the daunting depth of 610 feet, near San Clemente Island, a few miles out to sea from the site for SEALAB II.

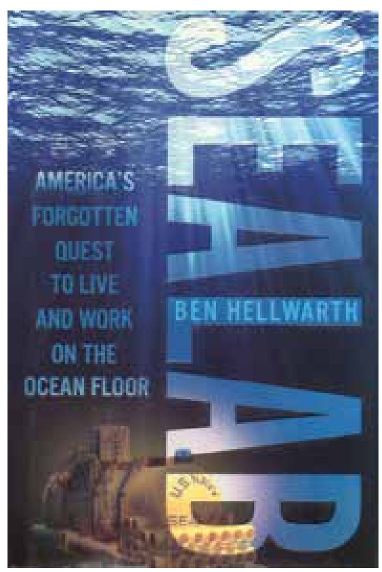
SEALAB III was going to involve five aquanaut teams and a variety of experimental military and civilian projects, expanding on the kinds of jobs done during SEALAB II. The work would be carried out over the course of two months at a depth that divers rarely reached, and if they did they could stay for just a few dicey minutes. It was beginning to look like this could be an undersea feat to match the impending Apollo 11 moon shot. But in the early hours of the deep operation, an experienced and well-liked aquanaut, Berry Cannon, died under mysterious circumstances. Instead of a record-shattering undersea adventure, SEALAB III became the focus of a month-long Navy investigation into the technical difficulties, human error and even allegations of sabotage surrounding the fatal accident.

The program languished for about a year before it was quietly cancelled, but not because of the kind of skepticism that hung over the first SEALAB. The Navy was sold on saturation diving, but instead of creating more undersea bases like SEALAB the Navy had devised top-secret plans to deploy saturation divers from some of its submarines. It was the height of the Cold War and saturation diving became a valuable tool for high-stakes missions involving undersea espionage. Industry, too, was quick to adopt saturation diving, but instead of living on the seabed divers spent their off-hours in pressurized chambers at the surface and commuted to their working depths in Personnel Transfer Capsules (PTC) similar to those developed for SEALAB. The arrival of saturation diving methods and related technology was ideal for offshore oil operations because they were moving into deeper waters and divers were needed who could work at greater depths for hours at a time. They still are.

A motley assortment of SEALAB-inspired habitats designed for ocean research appeared in the U.S. and around the world – marine scientists were enthralled by the prospect of having greater access to the seabed. But funding and maintaining sea-floor bases primarily for science proved to be difficult. One of the better designs, a privately funded, American-made habitat called **La Chalupa**, was used for some impressive jobs around Puerto Rico in the early 1970s before being turned into the Jules' Undersea Lodge, the world's only underwater hotel, which for three decades has been operating about 25 feet below the surface of a tranquil Key Largo lagoon. **Jules' Undersea Lodge** has also housed scientists, including a pair of Roane State Community College scholars who last fall spent 73 straight days at the lodge, teaching classes over the Internet while breaking the previous lodge record of 69 days.

Only one habitat remains in the sea. It's called the **Aquarius Reef Base** – although when first built in the mid-1980s, they considered calling it the George F. Bond, in honor of the father of SEALAB. Aquarius has housed dozens of researchers over the past two decades at its depth of about 60 feet, a few miles south of Key Largo, in the Florida Keys National Marine Sanctuary. In the summer of 2014, Fabien Cousteau, Jacques' eldest grandson, embarked on what he called "Mission 31," a 31-day stay at Aquarius, which gave him a mostly symbolic day longer than his grandfather's team had spent in 1963, dwelling at a depth of about 30 feet in the Red Sea. Fabien's recent stay also bested Scott Carpenter's SEALAB II mission by about a day, although it's difficult to compare, considering the very different conditions in the balmy Keys at 60 feet and in the chilly Pacific at 200 feet, where, among other things, a helium-rich breathing gas and much longer decompression are required.

But what Fabien and his team did was really less about setting records than about drawing attention to the need to better understand and protect our oceans, a need often articulated by Jacques Cousteau himself. One way to enhance understanding, as Fabien Cousteau and others have demonstrated at Aquarius, is to live and work on the seabed, and such aquanaut activities are a reminder that the legacy of SEALAB and saturation diving lives on, in scientific operations, in military and especially commercial diving operations. It's not a stretch to say that since the time of SEALAB II, saturation divers have helped put gas in your tank – just one of the many possibilities George Bond envisioned, if only humans could learn to live and work beneath the waves.



Ben Hellwarth is the author of SEALAB: America's Forgotten Quest to Live and Work on the Ocean Floor *(Simon & Schuster, 2012).*

Aquanaut Rosters

By James H. Osborn, Capt., CEC, USN, Ret.

GENESIS Program

There were numerous dives conducted over a period of time at various facilities in developing the GENESIS project, some manned and some unmanned. Officially, there were three scheduled manned dives, the first at the Naval Medical Research Institute, the second at The Navy Experimental Diving Unit and the third at the Naval Submarine Medical Center. While there were many divers involved in this program, the divers who were in those three dives are listed below.

Naval Medical Research Institute

John C. Bull, Lieutenant, Medical Corps, USN
Albert P. Fisher, Jr., Lieutenant, Medical Corps, USN
Robert A. Barth, Chief Quartermaster, USN

Navy Experimental Diving Unit

Sanders Manning, Chief Hospital Corpsman, USN
Ray Lavoie, Chief Hospital Corpsman, USN
Robert A. Barth, Chief Quartermaster, USN

Naval Submarine Medical Center

John Bull, Lieutenant, Medical Corps, USN
Sanders Manning, Chief Hospital Corpsman, USN
Robert A. Barth, Chief Quartermaster, USN

SEALAB I

SEALAB I team members are known and listed as shown.

Lieutenant Robert E. Thompson, Medical Corps, USN
Lester E. Anderson, Gunners Mate First Class, USN
Robert A. Barth, Chief Quartermaster, USN
Sanders W. Manning, Chief Hospital Corpsman, USN

SEALAB II

SEALAB II team members are known and listed as shown.

Team One

M. Scott Carpenter, Commander, USN
Robert E, Sonnenberg, Lieutenant, Medical Corps, USNR
Berry L. Cannon, Civilian, Naval Mine Defense Laboratory
Thomas A. Clarke, Civilian, Scripps Institution of Oceanography
Billie L. Coffman, Torpedoman's Mate First Class, USN
Wilbur H. Eaton, Gunner's Mate, First Class
Frederick J. Johler, Chief Engineman, USN
Earl A. Murray, Civilian, Scripps Institution of Oceanography
Cyril J. Tuckfield, Chief Engineman, USN
Jay D. Skidmore, Chief Photographer's Mate, USN

Team Two

M. Scott Carpenter, Commander, USN
Robert A. Barth, Chief Quartermaster, USN
Howard L. Buckner, Chief Steelworker, USN
Kenneth J. Conda, Torpedoman's Mate First Class, USN
George B. Dowling, Civilian, Navy Mine Defense Laboratory
Arthur O. Flechsig, Civilian, Scripps Institution of Oceanography
John F. Reaves, Photographer's Mate First Class, USN
William H. Tolbert, Civilian Navy Mine Defense Laboratory
Glen L. Iley, Chief Hospital Corpsman, USN
Wallace T. Jenkins, Civilian, Navy Mine Defense Laboratory

Team Three

Robert C. Sheats, Master Chief Torpedoman's Mate, USN
William. J. Bunton, Civilian, Navy Electronics Laboratory
Charles M. Coggeshall, Chief Gunner's Mate, USN
Richard Grigg, Civilian, Scripps Institution of Oceanography
John J. Lyons, Engineman First Class, USN
William D. Meeks. Boatswain's Mate First Class, USN
Lavern R. Meisky, Chief Shipfitter, USN
John J. Wells, Civilian, Scripps Institution of Oceanography
Paul A. Wells, Chief Mineman, USN

SEALAB III

SEALAB III Team One members were the only divers to actually deploy. Teams Two through Five were in a state of flux and it is possible that people listed as members of those teams could have changed. There may have been reassignments, deletions, or additions. There were alternate personnel who may have been subsequently assigned to a Team. Unfortunately, no confirmation of which Team they were ultimately assigned to has been located. The Aquanauts listed for SEALAB III were those listed in the SEALAB III Press Handbook as well as certain others whose names were in Navy Press releases or who were positively known to be assigned.

Team One

Robert A. Barth, Warrant Officer, USN, **Team Leader**
Richard C. Bird, Engineman First Class, USN
Richard M. Blackburn, Aviation Ordnanceman First Class, USN
Berry L. Cannon, Civilian, Navy Mine Defense Laboratory
Richard A. Cooper, Civilian, Bureau of Commercial Fisheries
George B. Dowling, Civilian, Navy Mine Defense Laboratory
Jay W. Myers, Machinist Mate First Class, USN
John F. Reaves, Photographer's Mate First Class, USN
James Vorosmarti, Jr., Lieutenant Commander, Medical Corps, USN

Team Two

Frank Buski, Shipfitter First Class, USN
Matthew C. Eggar, Lieutenant, USN, **Team Leader**
Richard Garrahan, Warrant Officer, USN
Samuel E. Huss, Damage Controlman, First Class, USN
Frank L. Reando, Machinery Repairman, First Class, USN
Terrell W. Reedy, Hospital Corpsman First Class, USN
William C. Ramsey, Photographer's Mate First Class, USN
Lawrence W. Raymond, Lieutenant, Medical Corps, USN
N. Terrel Robinson, Civilian, Naval Oceanographic Office

Team Three

Frederick W. Armstrong, Hospital Corpsman, First Class, USN
Derek J. Clark, Petty Officer First Class, Royal Navy
Wilbur H. Eaton, Gunner's Mate First Class, USN
Phillipe Cousteau, Civilian Photographer
Lawrence W. Hallanger, Civilian, Naval Civil Engineering Laboratory
Duane N. Jenson, Engineman First Class, USN
James E. McDole, Lieutenant, USN, **Team Leader**
James H. Osborn, Lieutenant Commander, Civil Engineer Corps, USN
William J. Schleigh, Chief Builder, USN
Donald J. Schmitt, Chief Machinist's Mate, USN

Team Four

Mark E. Bradley, Lieutenant Commander, Medical Corps, USN
William J. Bunton, Civilian, Naval Undersea Warfare Center
Lawrence T. Bussey, Lieutenant, USN
Wallace Jenkins, Civilian, Navy Mine Defense Laboratory
Cyril F. Lafferty, Lieutenant Royal Navy, **Team Leader**
William P. Lukeman, Leading Seaman, Royal Canadian Navy
Keith H. Moore, Machinist's Mate Second Class, USN
Richard R.Sutton, Lieutenant, Royal Australian Navy
William W. Winters, Engineman First Class, USN

Team Five

Robert A. Bornholdt, Lieutenant, USN, **Team Leader**
Kenneth J. Conda, Torpedoman's Mate First Class, USN
Leo C. Gies, Lieutenant Commander, USN
David M. Harrell, Civilian, Deep Submergence Systems Project
John C. Kleckner, Hospital Corpsman First Class, USN
Lawrence M. LaFontaine, Lieutenant Commander Royal Canadian Navy
Fernando Lugo, Machinist Mate First Class, USN
Jack W. Morey, Electrician's Mate First Class, USN
Andres Pruna, Lieutenant Junior Grade, USNR
Paul A. Wells, Senior Chief Torpedoman's Mate, USN

Alternates

Van T. Bell, Chief Damage Controlman, USN
Roger C. Burgess, Engineman First Class, USN
Billie L. Coffman, Torpedoman's Mate First Class, USN
Charles M. Coggeshall, Senior Chief Gunner's Mate, USN
Paul J. Heckert, Senior Chief Hospital Corpsman, USN
L. Chips Hurley, Mater Dhief Damage Controlman, USN
Martin W. Krepp, Engineman Second Class, USN
Paul A. Linaweaver, Jr., Commander, Medical Corps, USN
Joseph P.MacInnis, Civilian physician
James M. Melder, Chief Construction Mechanic, USN
Don C. Risk, Boatswain's Mate Second Class, USN
Irwin C. Rudin, Boatswain's Mate First Class, USN
Allen Storie, Electronics Technician Second Class, USN
Joe P. Stubbs, Shipfitter Second Class, USN
Cyril J. Tuckfield, Senior Chief Engineman, USN
Richard A. Waller, Civilian, Bureau of Commercial Fisheries
Gary E. Zyph, Electrician's Mate First Class, USN

These lists could not have been developed without the help of many people who were involved with the various programs and Navy Press releases, but Robert A. Barth, fondly known as "Sweet Old Bob", was the person who contributed the most.

SEALAB II Aquanauts (Official photograph, U.S. Navy)

SEALAB II Tech Specs

Adapted from

"Project SEALAB Report: An Experimental 45-day Undersea Saturation Dive at 205 feet,"

SEALAB II project group, edited by D.C. Pauli and G.P. Clapper, U.S. Navy (ONR Report ACR-124)*

INTRODUCTION

The SEALAB II habitat served as an undersea habitat (250-ft maximum depth) for 28 aquanauts for a period of 45 days. It was equipped with the necessary life-support equipment such as breathing-gas systems, air-conditioning systems, berthing, food-stowage and preparation facilities, sanitary facilities, work space, and communication, and electrical power, and lighting systems. It is capable of maintaining positive buoyancy adequate for surface tow. Water ballast is used to provide necessary negative buoyancy for lowering and to increase negative buoyancy for stability once it is placed on the sea bottom.

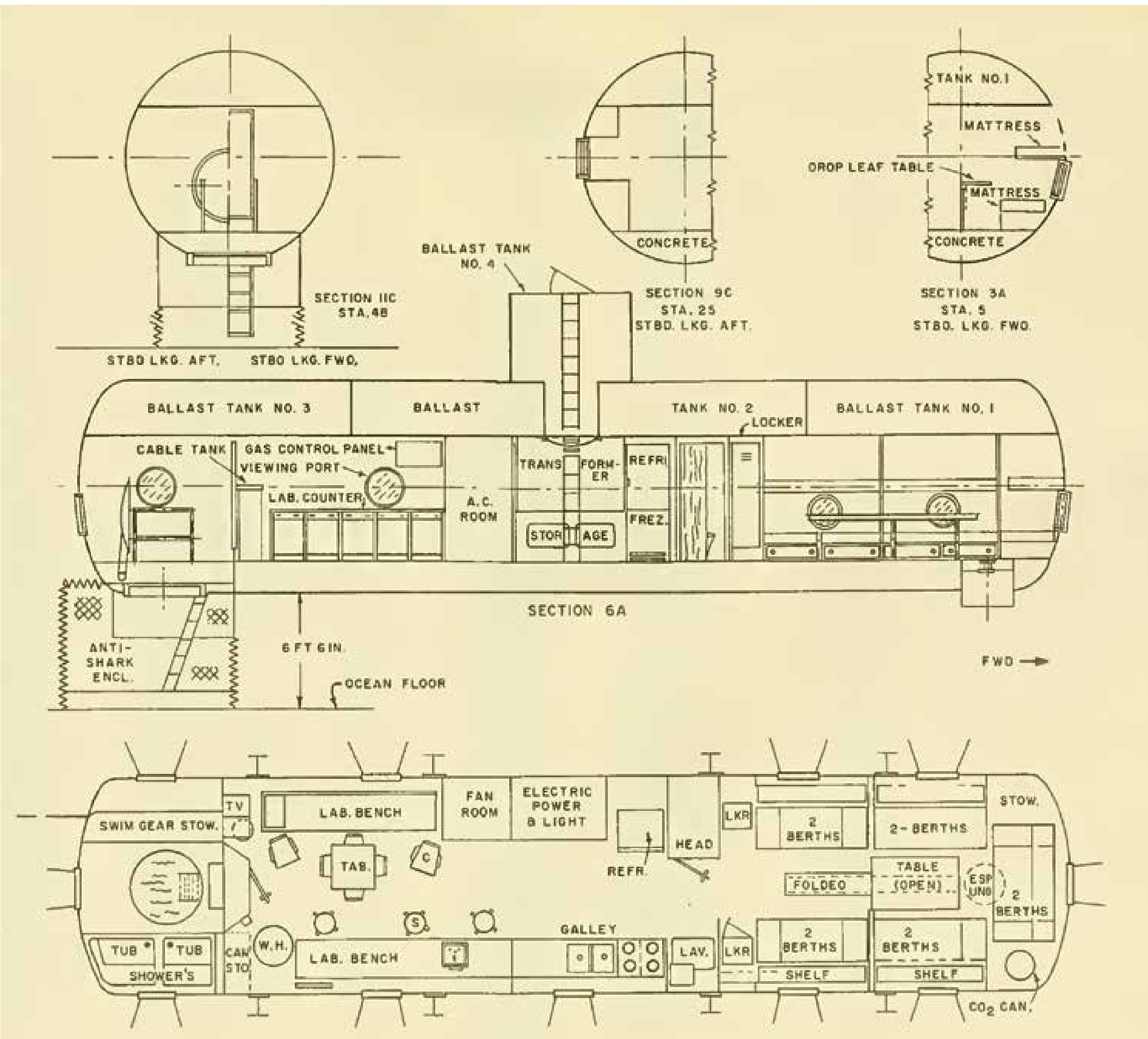


Fig. 1: SEALAB II Interior Arrangement (Official photograph, U.S. Navy)

General

The **hull** for the SEALAB II habitat was 12-ft OD, and 57-ft long with a semi-elliptical head at either end (Fig. 1). The hull was designed and fabricated in accordance with the ASME boiler code for unfired pressure vessels and is capable of withstanding an internal working pressure of 125 psig.

The hull is provided with eleven (11) **viewing ports** 2-ft in diameter.

The hull is provided with three **access openings:** the main bottom entry hatch is 4-ft in diameter and located near the stern in the entry trunk (Fig. 4), a bottom emergency escape hatch is 27-in. in diameter and located forward near the bow. A surface access hatch is 27-in. in diameter and located in the top of the hull amidships.

The **entry trunk** is 8-ft by 8-ft and extends 2-1/2-ft below the hull bottom. This trunk provides a displacement volume to compensate for the expected bottom-pressure variations due to tidal action, wave action, in addition to normal internal pressure changes.

The **shark cage** with a flexible extension extends from the entry trunk down to the sea bottom. (Fig. 1, upper left)

Hull penetrations for all gas lines, water lines, and sanitary drains are located as low on the hull as possible to minimize flooding or atmosphere loss in the event a line may carry away.

There are three internal **ballast tanks** and one external ballast tank. (Fig. 1) The three internal ballast tanks are arranged fore and aft and contain the full length, upper portion of the hull volume to a maximum depth of three feet. These tanks are designed to withstand a 15-psi minimum pressure differential across the flat bottoms. The external ballast tank is approximately 8-ft in diameter x 7-ft high and located amidships on top of the hull so as to provide a breakwater around the upper access hatch while the craft is on surface.

Fig. 2: Anode grade zinc plates are added for corrosion control. (Official photograph, U.S. Navy)

A water **ballasting system** is designed to provide the following characteristics:

a. Surface Tow 26 tons positive buoyancy
b. Surface (Prior to lowering) 7 tons positive buoyancy
c. Lowering (Raising) 4 tons negative buoyancy
d. On bottom 12 tons negative buoyancy

A **support structure** provides 6-ft of clearance beneath the hull for ease of entry to the SEALAB II hull on the ocean floor.

A concrete deck is installed inside SEALAB II from the entryway forward to provide a portion of the fixed ballast. (Fig. 1, upper right.) The remainder of the **fixed ballast** is placed in trays underneath the hull.

All **mechanical equipment** to be installed in SEALAB II (Fig. 1) was checked and certified for use in the ambient operational environment. Particular emphasis was placed on eliminating any materials that may introduce toxic fumes into the closed atmosphere. All equipment cavities or enclosures are vented for pressure equalization or are tested to prove a capability of withstanding the pressure of or permeation by the SEALAB II atmosphere. Particularly all "aneroid type" sensing elements were eliminated, since they are designed to operate only in standard (air) at barometric pressures. All equipment was performance tested in the SEALAB II environment and design capacities adjusted where necessary to compensate for the peculiar characteristics of the new environment, such as hyperbaric pressures, increased density, higher specific heat, increased thermal conductivity, etc. These include the water closet, lavatory, sinks, water heater, emergency freshwater tank, showers, hookah pumps, refrigerator-freezer, plumbing and sanitary facilities, and air conditioning system.

The **air-conditioning system** provides the following functions and capabilities: Dehumidification (Fig. 3), ventilation, heat, CO_2 Scrubbers, Charcoal Filter, gas sampling and lost gas make-up.

Fig. 3: SEALAB II dehumidifiers (Official photograph, U.S. Navy)

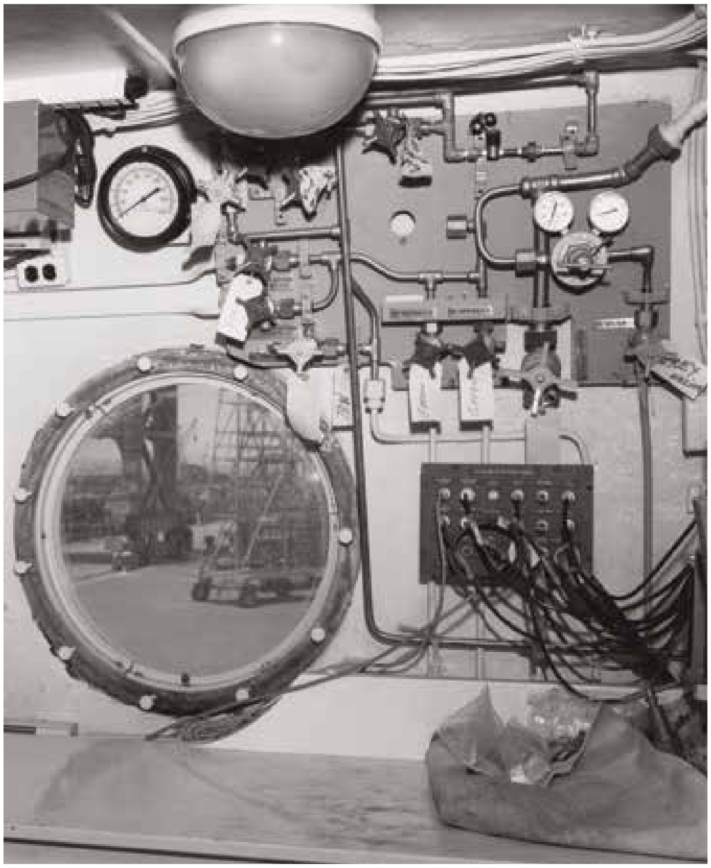


Fig 4. SEALAB II Gas Control panel upper right, SEALAB Communication Center sensor patch panel lower right, and depth gauge directly over the porthole (Official photograph, U.S. Navy)

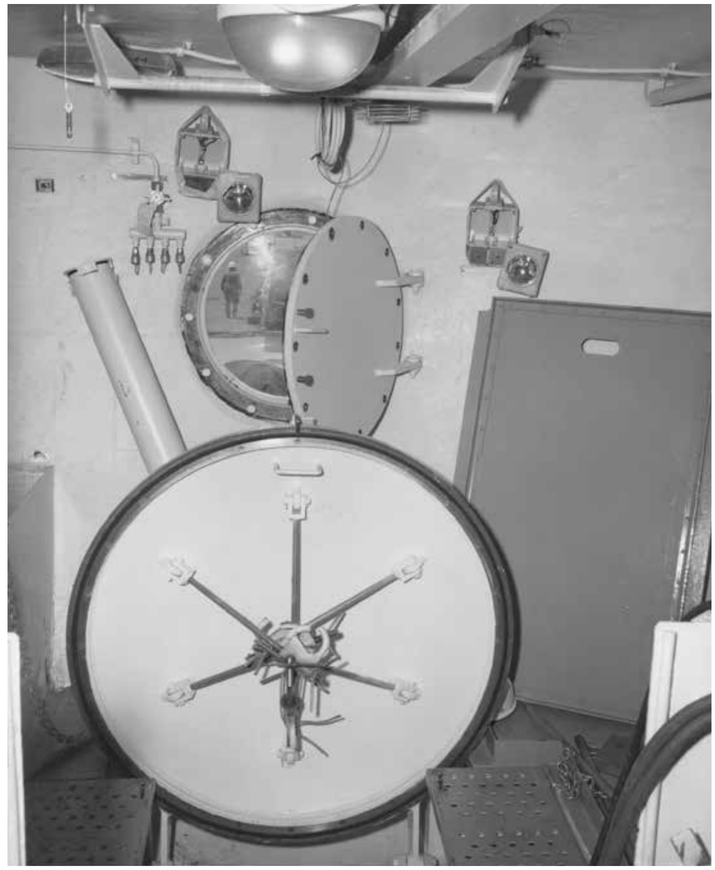


Fig 5. SEALAB II Main entry hatch open. Note tile shower to left, diagonal stuffing tube, 4 emergency air hose bibs, 2 emergency lanterns, and humidity sensor in ceiling. (Official photograph, U.S. Navy)

The **breathing gases** to be used to make up the SEALAB II atmosphere are stored externally in 1,300-cu-ft cylinders (approximately 21-ft long and 9-5/8 in. OD). Storage pressures are nominally 2400 psi and all high-pressure lines are designed for 3000-psi service. Gases for the emergency make-up systems are supplied through the umbilical cord at a maximum pressure of 400 psi.

The **oxygen systems** are designed for either automatic or manual operation (Fig. 4). Normal operation is automatic utilizing a PO_2 sensor and servo valve. Provisions are made for bypassing the servo valve by manual operation. In case of failure upstream of the gas control panel, a backup supply may be selected immediately inside SEALAB II.

Helium System

The Helium system provides any make-up required in SEALAB II and is designed for manual operation (Fig. 4).

Three external storage bottles piped to a common Bibb manifold system supply **emergency breathing gases.** (Fig. 5) Ten "Calypso" single-hose scuba second-stage regulators are provided for use with the Bibb system. This system is designed to provide emergency breathing gases (premixed) in the event the SEALAB II atmosphere becomes contaminated. It will provide approximately 43 minutes breathing time for ten aquanauts.

Ten 38-cu-ft scuba bottles with first-stage regulators and quick-connective fittings identical with Bibb system fittings installed in SEALAB II are provided and stored inside the entry trunk. These bottles may be utilized by the aquanauts to swim to the PTC in the event of emergency evacuation of SEALAB II.

An **emergency helium and air system** can provide helium or air from the surface in the event of failure or exhaustion of the self-contained helium supply. This system is also used for the surface charging of SEALAB. Gases are supplied through the gas-supply hose of the umbilical cord at 400-psig maximum pressure. This system is used as a gas-sampling system for surface monitoring of the SEALAB atmosphere.

ELECTRICAL AND ELECTRONIC SYSTEMS FOR THE SEALAB II HABITAT

The specifications for the electrical and electronic systems were divided into three sets of specifications: Electrical, Communications, and Data Recording. A fourth specification closely related to the electrical system was prepared for the electrical equipment to be used in the SEALAB II habitat. In general the material and equipment specified were standard Navy items normally used in shipboard electrical systems. The use of commercial items was permitted and in some cases specified. The short lead-time available precluded the design, development, and testing of any special items or equipment.

The **supply voltage** will be 450-volt, 60-cycle, three-phase supplied from the staging vessel or from shore through an underwater transformer bank and junction box installed at the test site by Scripps Institution of Oceanography. A maximum of 75kva will be available.

The **umbilical cord** from the support vessel will be a composite bundle of air, gas, and gas-sampling hoses, and power and communication cables. In addition to the power cable in the umbilical cord, a shore power cable shall be provided.

The cables shall be permanently connected and shall enter the hull through pressure-proof stuffing tubes near the bottom of SEALAB II. The cable ends terminating inside SEALAB shall be sealed to prevent the SEALAB II atmosphere from escaping through the cable jacket and around the conductors.

Lighting: Fluorescent fixtures shall not be used. Commercial 40-watt appliance lamps and 50, 75, and 100-watt rough-service lamps have been tested and have been found to be suitable for the proposed operating depth. The number and location of the lighting fixtures for general and detail illumination shall be that required to provide the initial average foot-candle values specified for Ships of the Navy. (Note: 50 and 75-watt bulbs may be used in 40-watt fixtures since the He atmosphere is a better heat conductor than air.)

Hand lanterns without relay shall be installed throughout the interior of SEALAB II to provide a limited amount of illumination in the event of a power failure.

The **exterior lighting** shall consist of six (6) semi-portable Standard Navy diving lights. Suitable mounting brackets shall be provided at locations to permit the lights to be installed after SEALAB II is on the ocean floor, or to permit movement to temporary locations. Connectors capable of being plugged or unplugged underwater may be used. Cables shall not be run through the entrance trunk. A switch shall be provided inside SEALAB II for each exterior light. Each switch shall be clearly labeled.

The equipment and material for the electrical system not specifically listed shall be Navy or commercial items best suited for the application.

Transformers — The transformers shall be dry. All transformers shall be enclosed in a gastight compartment to prevent contamination of the SEALAB atmosphere in case of overheating. Standard Navy stuffing tubes shall be used for all cables entering the compartment.

Interior Receptacle — The double receptacles installed throughout the vessel shall be grounded type (commercial). Commercial plugmold or similar may be used in the lab space.

Waterproof Connectors — Waterproof connectors shall be any suitable commercial or Navy type.

Communication between the SEALAB and the Communications Command Center (CCC) on the support vessel will be via a communications cable in the umbilical cord. The modes of communication include:

1. Helium Speech Unscrambler
2. Television
   a. Closed Circuit Monitors
   b. Entertainment
3. Audio, CCC to SEALAB (commercial intercom system)
4. Audio, CCC to shore via SEALAB (commercial intercom system)
5. FM Music

In addition to the communication modes, the following information will also be transmitted via the communication cable:

1. Wedge Spirometer Output *(Editor's note: an apparatus for measuring the volume of air inspired and expired by the lungs.)*
2. Trunk Water Level
3. O_2 Partial Pressure

SEALAB Communication Center — A section of the lab bench adjacent to the fan cabinet shall be used for the SEALAB II communication center. A patch panel shall have multi-pin receptacles for all multi-conductor circuits and coax receptacles for the TV circuits. Each receptacle shall be labeled. Plugs shall be provided for each receptacle. (Fig. 4)

The **Data-Recording** for engineering and the environmental data will be recorded either in SEALAB II proper or on shore through the facilities of the Scripps Benthic Laboratory.

The following data is to be recorded:

1. Power Usage;
2. Equipment Usage: (a) Water heater (1);
   (b) Dehumidifiers (4);
   (c) Electric heaters: Baseboard banks (3), Deck (1), Radiant (4);
   (d) Refrigerator (1); (e) Freezer (1)
3. Temperature, Interior (a) Trunk area , (b) Lab area, (c) Galley, (d) Berthing area
4. Temperature, Equipment, (a) Refrigerator, interior, (b) Freezer, interior
5. Humidity, Interior, (a) Trunk area, (b) Lab area, (c) Galley, (d) Berthing
6. O_2 Partial Pressure (PO_2)
7. Trunk H_2O Level

**Editor's Note: Readers interested in more detail may download the entire U.S. Navy Project SEALAB Report (ONR Report ACR-124) "Project SEALAB Report: An Experimental 45-day Undersea Saturation Dive at 205 feet / SEALAB II project group, edited by D.C. Pauli and G.P. Clapper," through the MBL/WHOI library at <https://archive.org/details/projectsealabrep00paul>.*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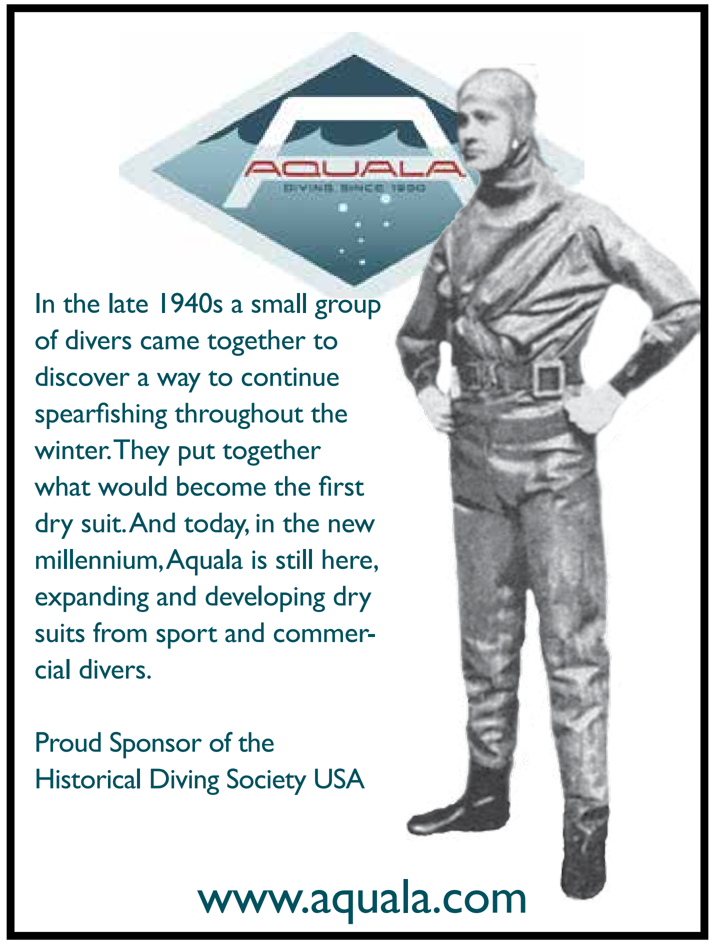
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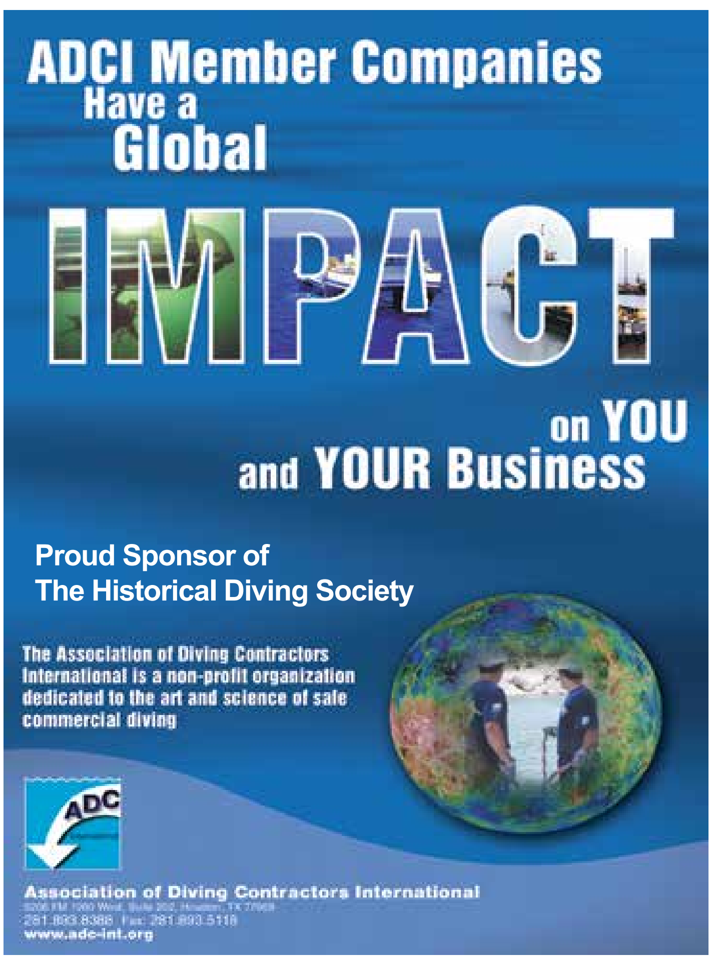
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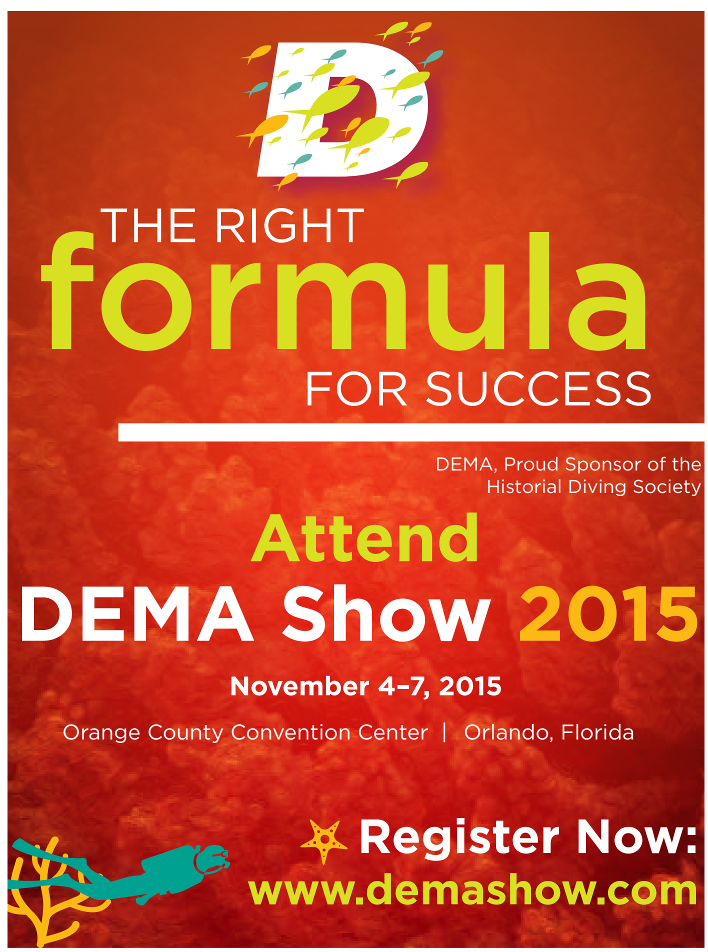
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Introduction

Capt. George Bond helped establish the Man-In-The-Sea Museum (MISM) in 1977 with a goal to preserve the history of manned undersea exploration. SEALAB I is now on display while undergoing modifications to allow visitors the ability to walk through and see the Spartan interior of this first USN undersea dwelling.

Kevin Hardy
Guest Editor

SEALAB II 50th Anniversary - Who Cares!

By Craig Cooper, Director

Institute of Diving/Man-in-the-Sea Museum
Panama City, FL

Well for one, I certainly care a great deal, but maybe the title should read "WHO SHOULD CARE?" For me the rationale is easy, even though I was only a junior in high school during SEALAB II's historic 45-day mission in the fall of 1965. Less than a decade later I would start an eleven year career with Taylor Diving and Salvage, much of it using saturation diving techniques developed by the U.S. Navy, starting with Dr. George F. Bond's Projects Genesis and SEALAB. Most of my diving supervisors were former Navy divers who were previously involved during the early days of Capt. Bond's Man-in-the-Sea Program. One of those whom I greatly respected, Sanders "Tiger" Manning, was one of the first humans subjected to saturation testing, as well as one of the four "aquanauts" on SEALAB I, America's first underwater "house" or habitat in 1964.

Never in all our discussions did Sandy ever boast of his part in those pioneering efforts, a humbleness I have also seen throughout my long friendship with Sandy's fellow Genesis and SEALAB I diver Bob Barth. Not only did those guys have the guts to be the first to go down that path previously untraveled, but to this day they still consider their efforts merely one of the many steps towards the saturation diving of today, and no more important than anyone else's.

So back to who should care about SEALAB II and its historical milestone, well I would say no less than all those who have made, or still make a living off saturation diving, certainly numbering in the thousands. Yet in July 2014, on the 50th anniversary of SEALAB I's eleven-day dive to 192 fsw off Bermuda, possibly one hundred people attended and the event passed with little notice, certainly a missed opportunity for all those who should care about this huge first leap in saturation diving history. Just like the Wright brothers' first flight at Kitty Hawk, NC, this was America's first underwater house, using saturation technology based on seven years of hyperbaric physiological research during the various phases of Project Genesis. It started with rats, then goats and monkeys, the steps required before the Navy would let humans become test subjects to develop this theory that a diver's tissues at depth would become "saturated" and an unlimited stay would only require a single decompression at the dive's completion.

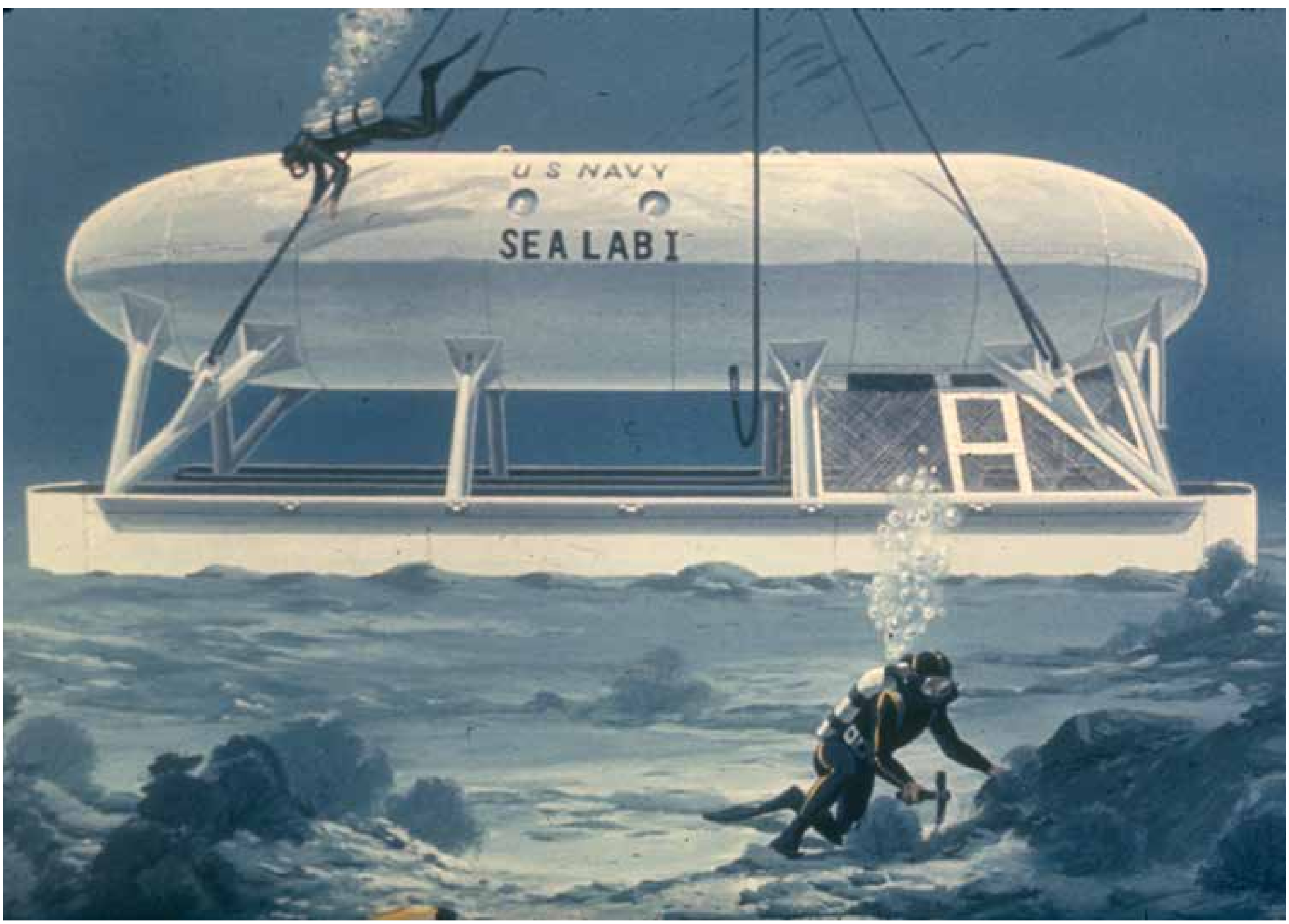
Just as SEALAB I deserved better acknowledgement on its anniversary, so goes the recognition of SEALAB II on its 50th celebration in 2015. Whereas SEALAB I proved the physiological theories of Project Genesis in an at-sea saturation, SEALAB II showed man could use saturation diving to do useful salvage, construction, and scientific work at depth for extended periods. I thoroughly recognize that the career I was able to pursue at TD&S was made possible on the backs of these diving pioneers, and so should all those Navy saturation divers who followed SEALAB's Man-in-the-Sea Program, working in saturation systems from ASR's and in special projects. Thousands of commercial oilfield divers can also trace their industry's roots back to Dr. Bond's SEALAB projects in the 60's. In the early 70's saturation diving systems in the oilfields became the tool of choice for most diving in excess of 200 fsw, but by the mid-80's we were using it even as shallow as 90 fsw because of the efficiency it afforded for round-the-clock operations.

There's even a saturation connection to space exploration today, just as there was with the SEALAB program and astronaut Scott Carpenter; Scott set a record of 30 days on bottom on the first two legs of SEALAB II's 45 day dive to 205 fsw off La Jolla. Today NASA astronauts use saturation diving to train for spaceflight and International Space Station (ISS) missions. Conducting saturation diving from the George F. Bond underwater habitat (AKA "*Aquarius*"), astronauts, engineers, and scientists in the NEEMO program (NASA Extreme Environment Mission Operations) have an analog to space exploration training unmatched anywhere. I was fortunate to have been on the NOAA team and part of those saturation operations for nearly twenty years and one hundred plus missions before my retirement, another debt I owe to my SEALAB forefathers. One of my fellow NEEMO 8 Mission aquanauts, aviator and Navy CAPT Scott Kelly, also commanded the NEEMO 4 Mission, and is currently spending the next year aboard the ISS, following in the footsteps of astronaut/aquanaut CDR Scott Carpenter. NASA continues to use the GFB/*Aquarius* underwater habitat and saturation diving facility in the Florida Keys for their space analogs, and is about to conduct their 20th NEEMO mission in July 2015. Numerous times during my days at GFB/*Aquarius* we were visited by SEALAB

II veterans Carpenter and Barth. I cannot tell you how much it meant to our team to hear those two pioneers telling us that we had the best jobs in the world and that they wished they were doing what we were doing; these were guys who had been places we only dreamed of. I can also remember the feeling I had in 2004 when astronaut and NEEMO 2 Commander Mike "Spanky" Fincke told me over a cell phone conversation from the ISS to our underwater habitat that he wished he was out there with me on my dive. I was out on a six-hour excursion during the NEEMO 6 Mission, tasked with habitat husbandry and maintenance, and he was circling the earth on his six-month duty as part of ISS Expedition 9. For the remainder of that dive, I wasn't outside an underwater habitat; I was on the spacewalk I had always dreamed about, and I would have traded places with Spanky in a minute! It's the ability to stay and "camp out" in space or underwater without the clock ticking that makes both these explorations such great analogs and so rewarding.

In Panama City Beach, FL at the Institute of Diving/Man-in-the-Sea Museum, volunteers are currently restoring the SEALAB I habitat to preserve its place in history, especially important since the SEALAB II/III habitat(s) no longer exist. After sitting mostly untouched for over 30 years, the quiet recognition on its 50th anniversary awakened the urge to make sure this important part of saturation and U.S. Navy diving history receives the attention it deserves. Funding for refurbishment has been limited to donations from individuals who recognize SEALAB I's importance to where saturation diving is today, volunteers willing to work on its restoration are even scarcer. The habitat is on long-term loan to the Museum from the Navy, but it has not been on their radar since it was recovered from the Stage II test site off Panama City in 1981. Restoration continues on however, and hopefully when completed within the next year, SEALAB I will offer a glimpse into the past and the men who took that big step that has allowed the rest of us to enjoy the rewards of their forays deeper and longer than before.

So again, who should care about SEALAB II? We all should, divers or not, for the economy we derive from oil exploration, for our military and national security, and up to outer space for all its scientific discoveries and advances. But most of all, any diver, whether Navy, commercial, NASA, or scientific, who reaped the benefits of saturation diving's "endless bottom time", should salute those pioneers from the SEALAB Program and thank them for being the first to try.



SEALAB I depiction (Official photograph, U.S. Navy)

SEALAB II Endbell Honors Aquanauts

By Lindy Dosher, Director, and Mary Ryan, Curator,
Naval Undersea Museum, Keyport, WA

SEALAB II is remembered for successfully demonstrating the efficiency and potential applications of saturation diving to Navy underwater operations. But the project also holds significance from a technological and engineering perspective — an aspect of the story that is often forgotten.

In 1964, the SEALAB II habitat, under the watchful eye of then LCDR Mal MacKinnon, began taking shape at San Francisco Bay Naval Shipyard, Hunters Point Division, in California. As the next step after the U.S. Navy's successful SEALAB I project, which established the viability of the concept of saturation diving, SEALAB II extended length of the aquanauts' time underwater and expanded the type of work they performed. CAPT George Bond, known affectionately as "Papa Topside," spearheaded the SEALAB projects, having brought them from their infancy as Project Genesis. Around the world at this time, a number of government, military, and civilian groups were pushing the envelope of man in the sea. Working to achieve greater depths of performance by humans, studies were conducted in ever deepening water, over increasingly extended times.

Early in the construction phase of the SEALAB II habitat, LCDR MacKinnon realized that the two ends caps needed to seal off SEALAB II's central cylinder body would not be completed in time — the tight production scheduled allowed only 30–45 days for this step. The intended fabricator, selected because it already supplied dish heads for Navy submarines, was on strike. The Navy considered welding the pieces as an alternate solution, but MacKinnon recognized this labor- and time-intensive method would also have caused delivery delays. The earliest possible delivery under either of these options was five to six months — after SEALAB II was scheduled to begin.

As the proverb says, necessity is the mother of invention, and LCDR MacKinnon conceived a new approach in an attempt to preserve the project schedule. His gutsy plan required doing something that had never been done on such a scale before — using explosive charges to form a 12-foot plate of steel into a precise dome shape. (Before this point, ashtrays were the largest item manufactured using explosive metal shaping.) MacKinnon enlisted the help of the West Coast Naval Shock Test Center, located at Hunters Point, to execute his idea. With their help, the two needed end bells were successfully created.

To produce each cap, a one-inch thick plate of steel was secured to the concave side of a large, dome-shaped die. Workmen exactingly attached 100 pounds of concentric C-4 charges to the steel and lowered the whole 60-ton assembly 30 feet into San Francisco Bay. To reduce venting during the molding process, and to minimize distortion of the end bell, a vacuum was drawn under the steel plate inside the mold. The explosion caused by detonating the C-4 formed each end bell almost instantaneously — in just 0.004 seconds. LCDR MacKinnon, writing about the experience in the official SEALAB II project report, described the complexity and precision of the calculations that had to be made regarding charge placement, size, standoff distance, and underwater depth to produce the bells. Adding to the pressure of adapting the technique was the high cost of explosive forming. Fortunately, the engineers calculated well, as MacKinnon also described the successful outcome:

> *"The results were phenomenally good, and only minor straightening in certain areas was required. The heads checked dimensionally within 1/16 in. on the diameter and within 1/4 in. on the contour, well within specifications. The metal did not thin at all, and thickening by approximately 0.075 in. occurred at the rim where stresses were highest."*

As a result of this engineering experiment, large-scale explosive metal shaping became a specialized technique for forming sizeable metal piecework and is still used today.

SEALAB II end bell immediately after being removed from shaping die. (Official U.S. Navy photograph.)

Aquanauts perched on the outside of the SEALAB III habitat. (Official U.S. Navy photograph.)

Thanks to LCDR MacKinnon's efforts, SEALAB II was lowered on time to the sea floor off La Jolla, California in late summer 1965. Between August 28 and October 14, three teams of ten divers spent 15 days each living in the habitat, carrying out over forty planned programs to show how saturation diving facilitated greater efficiency of underwater work. Aquanauts tested underwater tools, raised a sunken fighter jet, conducted geological studies, set up a weather station, and worked with a porpoise named Tuffy trained to carry tools and messages between the habitat and the surface.

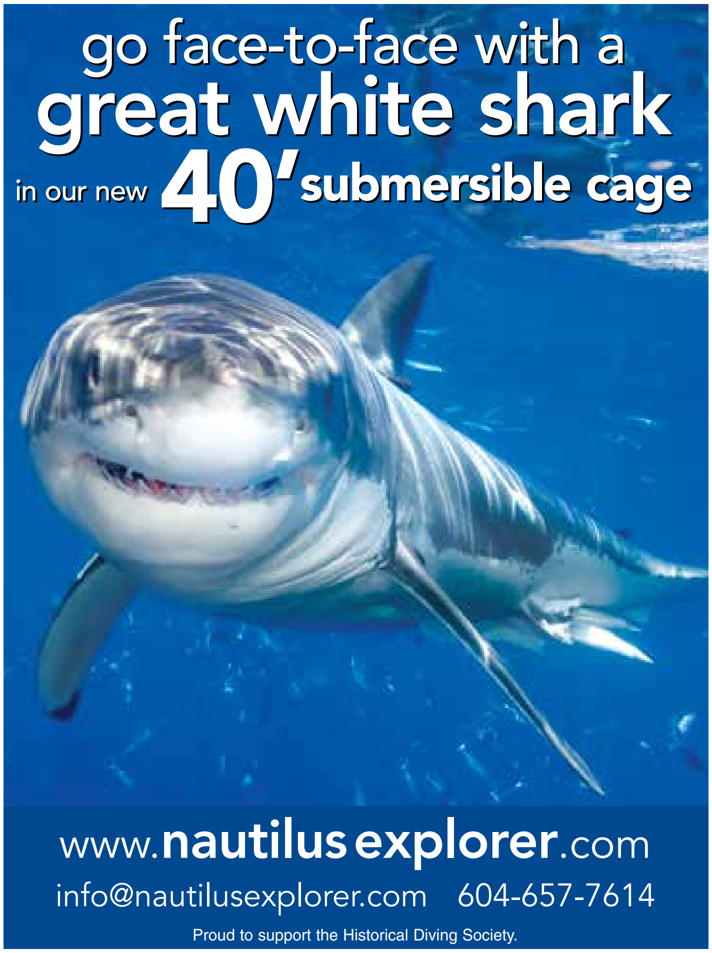
The SEALAB program came to an end in 1969 after almost a decade of successes and advancements. The SEALAB II habitat, having been converted for use with SEALAB III, was placed into storage. Decades later, as museum staff reviewed personal photographs with Master Diver and SEALAB II aquanaut Robert Sheats, something caught the attention of a sharp-eyed staff member. A more recent photo showed two large, distinctively-shaped metal caps sitting forgotten in a storage yard — the two SEALAB end bells, the only remaining pieces of the SEALAB II/III habitat. Better yet, they were right here in our backyard, in a laydown yard in Seattle's Discovery Park. Several calls and a visit later, one bell was found to have significant metal damage that was prohibitively expensive to restore. Happily, however, the other bell was salvageable. Museum staff hurriedly arranged its acquisition — just in time, as the park had been about to scrap both bells.

In 1998, following a successful restoration project, the end bell was placed on permanent exhibit at the Naval Undersea Museum, where it stands as an ongoing monument to the ingenuity and accomplishments of the SEALAB projects.

In 2010, a rare 1968 Aurora plastic model of SEALAB III was expertly assembled and painted by San Diego master modeler Jerome McAuliffe and his artist wife, Loralee. It was placed in a custom plastic case, hand carried on an aircraft, and presented to museum staff. Under the base is a wooden plaque signed by Aquanauts at the 2009 Aquanauts Reunion in San Diego.

The SEALAB III model on display at the Naval Undersea Museum (photo by Kevin Hardy)

We are proud and honored to be the Navy's official museum dedicated to interpreting deep submergence history and technology like the SEALABs.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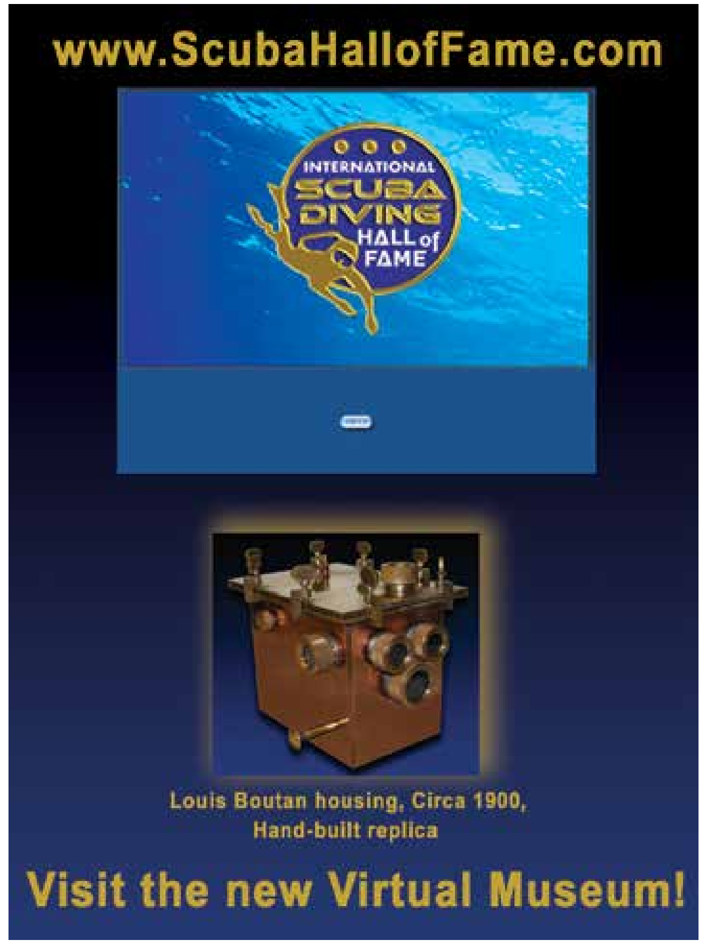
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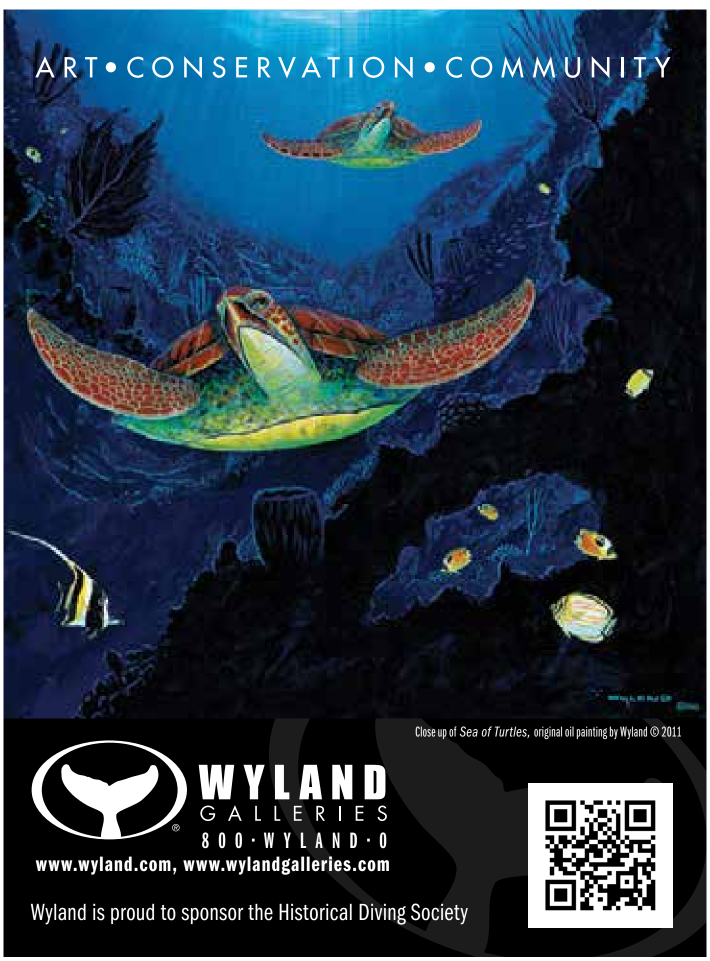
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BENEATH THE SEA
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Days of Future Passed, 1965-1969

By Kevin Hardy, Guest Editor

The heady days between SEALAB II and SEALAB III were full of free-reeling imagination of all things possible. In every quarter, the words of the technology prophets were taken as future events seen. We could imagine the harvesting of every marine resource of importance, the rescue of downed submarines in deep blue water, and the eventual human colonization of the seafloor. Our techno-driven evolution proceeded at a breathtaking pace, as wizards of science nulled long believed boundaries, while artists ignored laws of physics in their depictions of life below the surface. Wiser men argued for caution against a mind set that Astronaut Wally Schirra once ascribed to the galloping U.S. Space Program as "Go Fever."

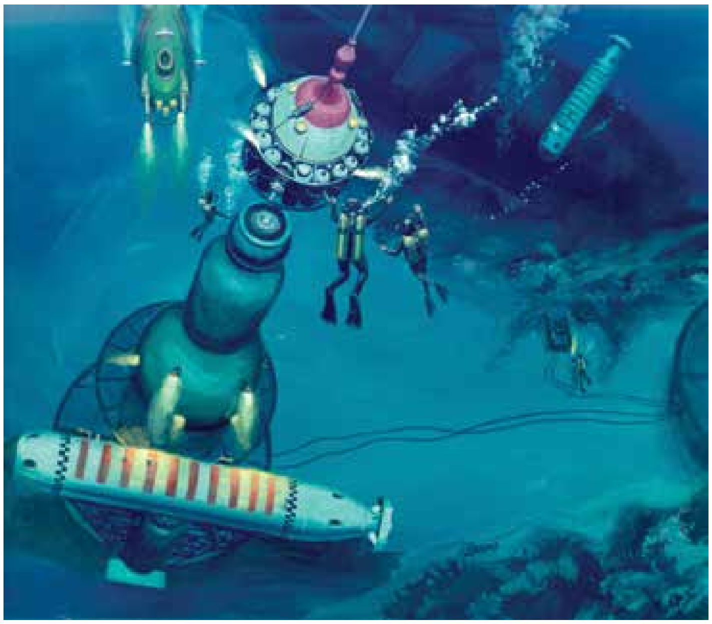


Figure 1: The future of Man-in-the-Sea as seen in 1968. Artists imagined Aquanauts moving freely in the 3D world of the ocean's volume, like birds soaring from mountain peak to valley.

Herewith a sampling of what lay ahead as seen in the years 1965-1969.

Astronautics & Aeronautics
July 1967
DEEP SUBMERGENCE
The Navy's Opening Projects
(Excerpt)

In the lead article of *Astronautics & Aeronautics,* July 1967, John Craven speculated that, "Major bottom installations, major mobile installations or surface ships that employ saturated divers will require small transport vehicles. A diver transport vehicle, piloted by men in a compartment at atmospheric pressure and transporting divers in a compartment at the saturation pressure, is under procurement by the Navy. This vehicle will be employed for development evaluation. The lessons learned in its use will probably form the basis for the design of an operational transport vehicle for versatile use with sea laboratories, submarines, the ASR submarine rescue fleet, standard decompression chambers, etc."

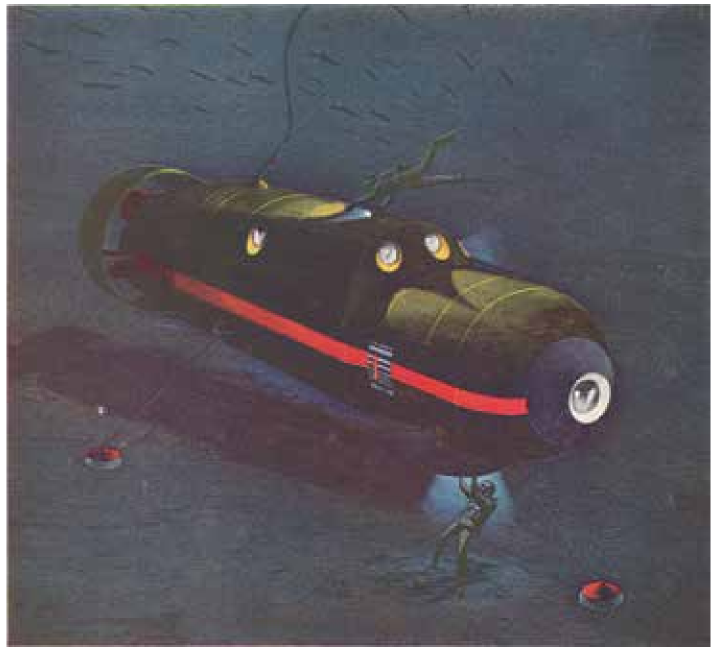


Figure 2: A saturation diver transport vehicle is moored to a location on the seafloor, deploying divers to perform a task. Note the Man-in-the-Sea logo on the forward fuselage.

THE OCEAN ENGINEERING PROGRAM OF THE U.S. NAVY
Accomplishments and Prospects
Office of the Oceanographer of the Navy
September 1967
(Excerpt)

UNDERSEA INSTALLATIONS

Prototype underwater manned installations are planned to develop construction techniques, equipment and methods. Submerged military support bases have application with submersibles requiring replenishment and exchange of personnel, where access of submersibles to traditional surface support craft cannot be reliably guaranteed because of sea state disturbance or where the distance to weather-independent harbors is too great for submersible endurance capabilities. Other potential uses of submerged military manned installations are as command centers, weapon sites, and surveillance network headquarters. Further, where work is taking place on the ocean floor, temporary habitats near the work site can have real value as personnel support installations.

Two characteristics of bottom and sub-bottom structures give them a great utility: (a) they are separated from the sea state disturbances at the air-sea interface, and (b) they are situated in the sea environment. Manned habitats placed on or near the bottom can provide an opportunity to put to advantage these two characteristics. Potential types of manned habitats include laboratories, military support facilities, recreational facilities, and industrial installations.

The construction of a manned underwater station could be accomplished in several ways, such as excavation under the sea floor, or a structure prefabricated on land and submerged to the ocean bottom. A third way would be to develop underwater construction techniques.

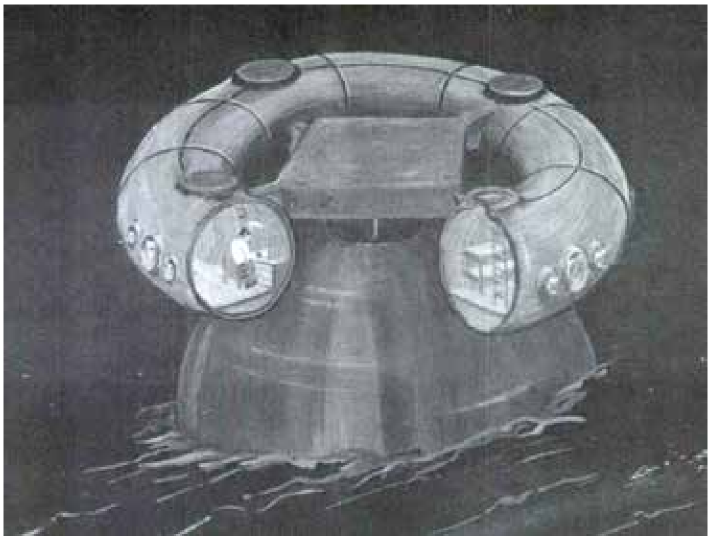


Figure 3: Concept for a manned underwater station using a toroid-shaped hull. The toroid would have a 40-ft overall diameter and a 10-ft annular diameter. The habitat would rest on a conidial foundation, allowing it to adjust to any bottom with a slope of 15 degrees or less.

SUB-BOTTOM INSTALLATIONS

A sub-bottom installation could consist of a room or a series of rooms, excavated within the bedrock beneath the sea floor, using the natural bedrock for the basic structure. Once the sea floor has been entered, and a working atmosphere established, the use of available boring machines can be used to extend such a base. These boring machines are capable of forming tunnels of 15 to 20-ft in diameter in most types of rock.

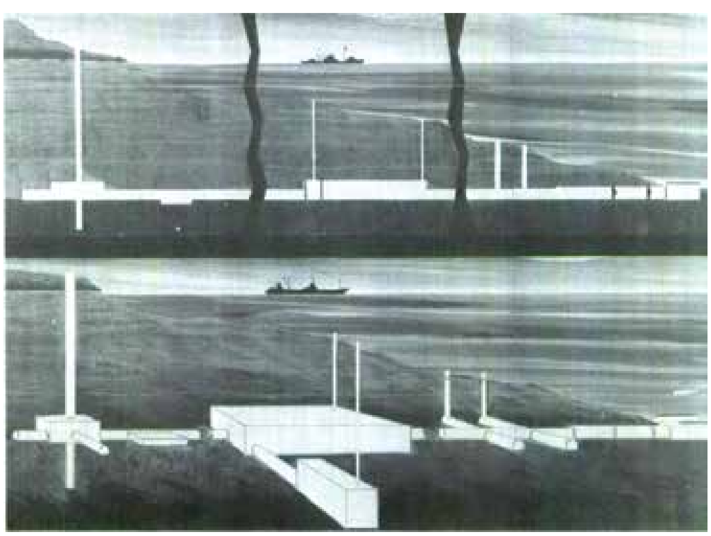


Figure 4: An undersea experimental laboratory tunneled into bedrock with a land access.

The station would be a relatively self-sustaining installation, possessing a power plant, possibly nuclear, as well as work facilities and maintenance capabilities. Access to sub-bottom installations near land can be achieved through tunnels and shafts to the land surface. For shallow continental shelf installations, access can be achieved through a tube to the surface. Access to deeper installations, which are isolated from land, can be made by means of a lock system passing through the seafloor-water interface. Lock systems could also allow direct entry of a submersible into the installation. An alternative lock system would be one that permits temporary mating of the submersible to the installation.

BOTTOM STATIONS

Concepts for a manned underwater station, which would allow the Navy to establish fixed habitats on the sea floor on the continental slope at depths down to 6000-ft, have been developed. The initial criteria defined a station capable of supporting five-man crews at a pressure of one atmosphere in a shirtsleeve environment for an indefinite period of time. The station would have a self-contained power source and a self-contained life-support system that would make it independent of the surface. Resupply of the station would be on the sea floor. Upon completion of its missions, the station could be recovered and moved to other locations. Studies to develop the one-atmosphere manned underwater station have revealed several feasible approaches.

Structural shapes feasible with today's technology are the sphere, the cylinder, and the toroid.

Foundation requirements for each structural shape are different in design, concept, and materials. The toroid will rest on the bottom on a cone-shaped foundation that adjusts to a bottom slope. Tripod legs that adjust to bottom irregularities support the cylindrical or spherical station.

Life support and power requirements are a function of station mission and duration. Power systems considered for use include nuclear reactors, radioisotopes, silver zinc batteries, and surface conventional power with a surface buoy and umbilical. Using today's technology life support systems for a 30 day, five-man mission require approximately 500 gallons of potable water, 330 cubic feet of compressed oxygen, 560 pounds of lithium hydroxide for CO_2 removal, and 200 pounds of dehydrated precooked food.

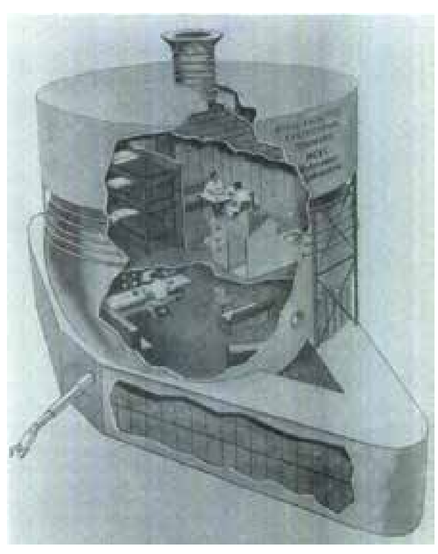


Figure 5: Concept for a manned underwater station using a 20-ft-diameter spherical hull. The station would use silver zinc batteries and would be placed on the sea floor using a winch-down mode. Overall height of the station is 50 ft.

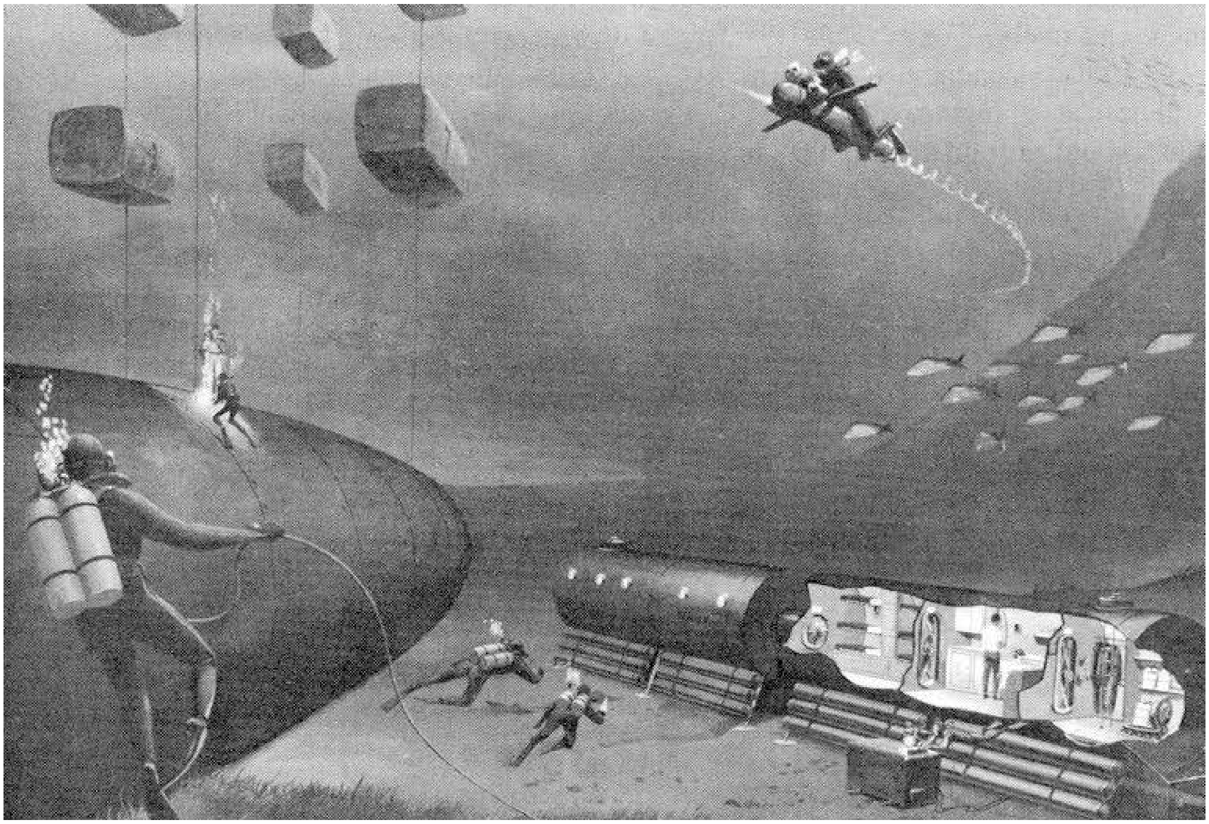


Figure 6: Artist's concept of a major U.S. Navy salvage operation in the 1970s: saturated divers are salvaging the disabled submarine at left; at right is a seafloor habitat totally independent of surface support once emplaced on the bottom.

THE FUTURE OF MAN-IN-THE-SEA

PRESS HANDBOOK
SEALAB III EXPERIMENT
THE U.S. NAVY'S MAN-IN-THE-SEA PROGRAM
September 1968

The Navy's operational requirements to provide a capability for extended swimmer operations at continental-shelf depths have led to the current goal of 850 feet for an operational saturation diving system.

Technologies and equipment will undoubtedly be developed to enable man to perform useful work at greater depths unless (1) definite and insurmountable physiological or behavioral phenomena limit the Aquanaut's ability to go deeper, or (2) there is a clear prediction of persistently unfavorable cost effectiveness in comparison with the other concepts for accomplishing required missions at advanced depths.

Ultimately, hardware being developed in the Man-in-the-Sea program will produce operational seafloor habitats that are totally independent of surface support once placed on the ocean bottom. This capability will provide for all weather, even under-ice, operations on the ocean floor. There will also be "semi-mobile" habitats--crawler or submarine-like vehicles--which will enable Aquanauts to range over a relatively wide area of the ocean floor, to pass through a hatch into the ambient water, perform useful work, and return to the habitat without decompression. During the mobile habitat's return to surface atmosphere or its base the entire crew would be decompressed.

Below 1,500 feet helium can probably no longer be used as the inert gas in the Aquanaut's breathing mix since it too becomes narcotic at this depth. The only other inert gas that could then be used is hydrogen, since this gas is theoretically less narcotic than any known inert gas. If such a breathing gas can be developed for practical use the physical properties of hydrogen might also lead to reduced decompression time for saturation diving. There would be no danger of explosion from the hydrogen in such a breathing gas because of the extremely low oxygen content.

Beyond these depths some contend that it is possible, although not necessarily probable, that man may dive freely to 10,000 feet and deeper for brief periods. Man swimming at these depths would breathe an oxygenated liquid, which would be pumped directly into his windpipe and lungs. Although the practicality of man walking the abyssal plains is a matter for discussion, man's traditional drive to discover and explore new worlds will unquestionably take him farther and farther into Inner Space.

THE FUTURE ARRIVES

Behind the scenes and below the surface, the world was already changing. Offshore oil was intently developing its own purpose-driven saturation diving capability based on the new techniques and technology of SEALAB, hiring freshly discharged USN dive medical officers and former Aquanauts. Jacques Cousteau popularized living in a "World Without Sun" with the Conshelf II habitat in the clear and colorful shallow waters of the Red Sea. Meanwhile, the highest levels of U.S. Naval intelligence were seeing unique applications of sat diving to best serve national interests. All were extrapolations of the careful and meticulous research George Bond and Walter Mazzone had used to validate the theory of saturation diving and its potential uses. Like the fire from Prometheus, the new knowledge was disseminated, assimilated and rapidly applied. If we guessed incorrectly back then what the future held, it didn't matter. Without question, mankind's ability to work in the sea was profoundly enhanced.

Home Made Housings

By Sid Macken

A very simple housing built by Wade Meeker of Corvallis, Oregon. Ca. 1953.

The era of the do-it-yourselfer and the home craftsman has nearly disappeared. There was a time when almost every household had a woodshop, auto, or machine shop in the basement or garage. In the formative years of recreational diving, craftsmen often lent their skills to the fabrication of diving equipment and, in due course, underwater camera housings. Some of these folks went on to become famous underwater photographers and in several cases, manufacturers of underwater photo equipment. Names like Henri Broussard, Karl Schaefer, Jerry Greenberg, Al Giddings, Leroy French, and Bob Hollis come to mind.

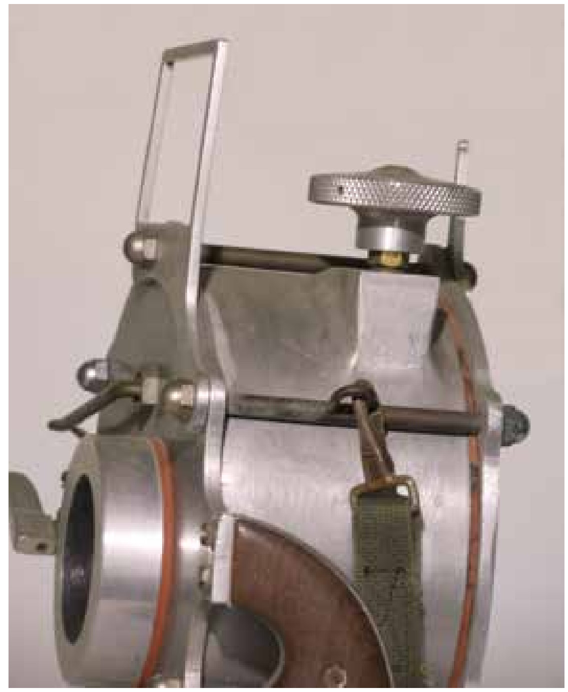
This issue's column is dedicated to those fledgling divers who built their own camera housings. Their skill is exemplified by their work and the following are samples of what they were capable of creating. Some housings were as simple as they possibly could be, while others displayed a high level of skill and ingenuity (See Ivor Howitt's Viewfinder, Submarine Lens, JoDH #67, Spring 2011).

First is a very compact housing built by a fisheries student at, then, Oregon Agricultural College in Corvallis, Oregon, circa 1953. Wade Meeker was looking for ways to study fish in the local ponds and rivers. As for many other diving enthusiasts of the time, both money and equipment were scarce, so Wade built his own scuba unit, swim fins, drysuit, and camera housing. The housing itself is made from a brass canister, and fitted with a film advance control and shutter release. It incorporates a valve for pressurising the housing, which would have been necessary due to the thin walls of the canister. A wire frame finder helped to compose the pictures. Although very basic and simply constructed, Wade's housing was functional and he used it to record aquatic life throughout Oregon's Willamette Valley. At 85 years of age, when I met him, the camera Wade used was lost to memory.

The second homemade housing was purchased from an online auction and nothing is known about the owner/maker, but whoever built it did an elegant job. The housing fits the Argus C-3 camera which was manufactured between 1939 and 1966 and was very popular with underwater photographers in the 1950s and early '60s. The cylindrical design shows that the maker understood the physics of pressure. The workmanship is superb, from neatly filleted welds, to graceful wooden scales on the handgrips. All in all, a very fine housing, with a touch of mystery about it. The brass bolts holding the cover to the housing, have the name of a British aircraft manufacturing firm, Airco, stamped in them. That along with the quality of work suggests that an aeronautical engineer or machinist may have built the housing.

The do-it-yourself era of diving equipment is mostly a thing of the past, however there was a time when home made equipment was the mainstay of underwater photography, and many of the early commercial manufacturers of underwater photographic equipment and professional underwater photographers got their feet wet while building and using homemade gear.

Photo Credits
All photos by the author



Note the fine work around the film advance knob, the loop for the neckstrap, and the wooden scales on the handle.

An interior shot showing the Argus C3 camera in place.

This housing displays much more sophisticated construction.

Helmets displayed by Global Diving & Salvage at the Maritime Events Center, Seattle, Washington

By Leslie Leaney

In 2016 the HDS Conference will return to Seattle, Washington, in an area known for its rich commercial, recreational and military diving heritage. During the last three years HDS sponsor company Global Diving & Salvage of Seattle, exhibited a display of diving equipment associated with the region at the Maritime Events Center. The display, which featured some of the distinctive Pacific North West style helmets, recently closed and in this column we show some of the helmets from the exhibit for members who were unable to visit it.

One of Leiter Hockett's personal diving helmets featuring the breastplate mounted air control valve that famed Seattle diver Hockett designed in 1943. The helmet is an A.J. Morse & Sons Inc. of Boston, Mass. 3 light commercial helmet serial number 1372, manufactured circa 1910.

USN Mark V Helium diving helmet by Schrader of New York, serial number H617. This helmet was manufactured as a standard USN Mark V air helmet in 1919 and later retro fitted with components for diving with mixed gas.

USN Mark V air helmet by DESCO of Milwaukee, Wisconsin. The Mark V was the US Navy's primary diving helmet from 1916 through to the early 1980's. This model, serial number 1296, was manufactured on June 6, 1944. With others manufactured on that date it is known as a D-Day Mark V, in recognition of the Allied invasion of Europe during WWII, which was launched on that day.

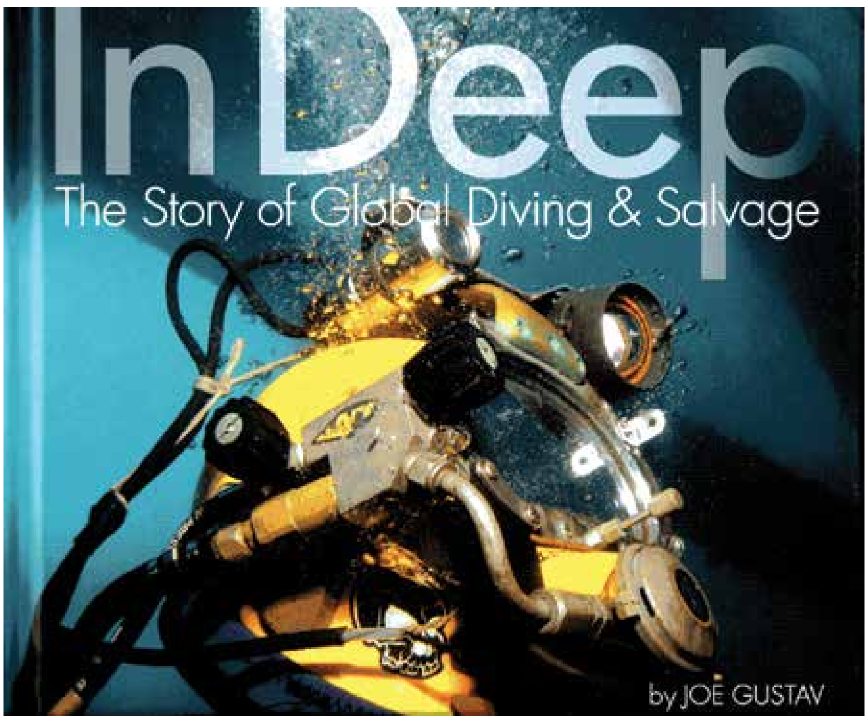
USN Mark XII helmet by Morse Diving Equipment Co. Inc. of Boston, Mass. This fiberglass helmet replaced the famed USN Mark V helmet as the primary USN helmet in the early 1980's.

Art McCray style diving helmet with small bonnet on DESCO USN Mark V breastplate. The air control and communications are attached to the front of the breastplate which was a common modification by divers in the Pacific northwest area of the country.

McCray style small volume bonnet helmet serial number 5825 manufactured by Morse Diving Equipment Co. Inc. of Boston, Mass. This helmet does not feature the Hockett breastplate air control valve but shows the scalloped form of the view port frames which was another distinctive feature of Pacific North West helmet design.

In Deep:
The Story of Global Diving & Salvage

Written by by ***Joe Gustav***
Reviewed by ***Christopher Swann***



In 1979, six young divers at Crowley Maritime in Seattle decided to set up on their own. The business of the Environmental Services division where they worked was salvage and cleaning up oil spills. Given that salvage usually requires diving, the division doubled as Crowley's in-house diving service, with the divers running what amounted to an independent unit: a situation that continued until a dictatorial ex-Navy diver was brought in to manage the group, leading to the exodus.

In Deep: The Story of Global Diving & Salvage tells the story of how what started as a bare bones company operating from the front room of a former World War II barracks grew to become the largest commercial diving concern on the West Coast of the United States.

Initially, work was hard to find. Fortunately, a boom in naval shipbuilding was around the corner and thanks to a dockmaster at Todd Pacific Shipyard who knew them from Crowley, the divers obtained work at Todd and then at the Lockheed shipyard. A further contract at a Texaco refinery encasing deteriorated pilings in concrete led to three more such projects, which together brought in enough money to buy a brand-new truck.

The owners of Global had of course cut their teeth doing salvage and oil spill cleanup, and this work became the major part of the company's business. It would remain so until the passage of the Oil Pollution Act of 1990 in response to the *Exxon Valdez* disaster—on which Global was a sub-contractor—reduced the number of oil spills. The result was more competition for less work; but, on the other hand, the formation of the Marine Spill Response Corporation and Environmental Quality Management opened the door to Global as a contractor to both organizations.

In 1991, Tim Beaver, who had been part of the cohort at Crowley, became the president of Global. One of the first things he did was to use part of the profits from the *Exxon Valdez* cleanup to buy a bell system that was on offer from a company in Alaska. The asking price was $200,000; short of cash, the sellers settled for $28,000.

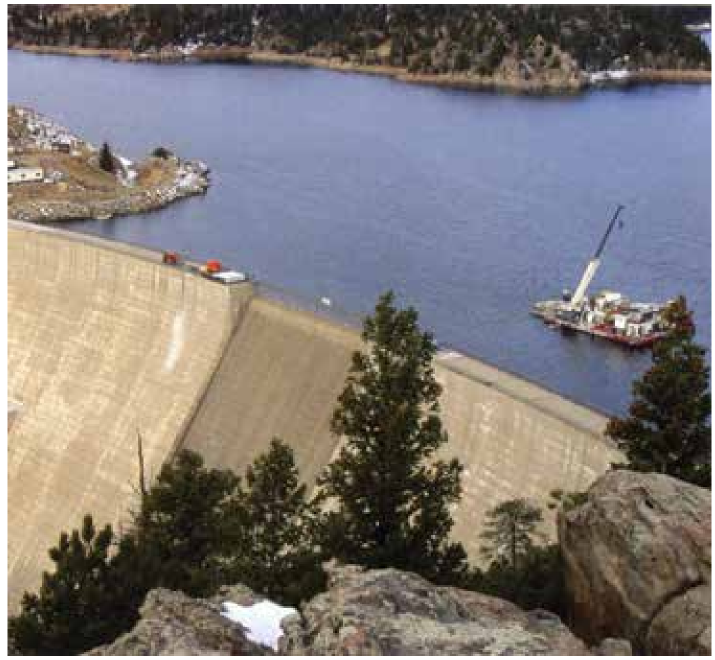
Less than a year later, the Army Corps of Engineers went out to bid on a contract to attach a large copper plate to the face of a gravity dam in Idaho, at a depth of 225 feet. Being the only bidder with a bell system, which meant the elimination of untold hours of decompression in the water, Global got the job—the first of many it would be awarded in the inland diving market.

In 1997 Global was contacted by Harvey Harrington of Deep Sea Research (DSR) in California. DSR had located the wreck of the long sought-after *Brother Jonathan*, which had sunk in a storm off Crescent City in 1865 carrying a large number of newly minted gold coins from the San Francisco mint. Technical divers hired by the company had already investigated the wreck and recovered a small number of coins, but given the depth—285 feet—salvaging the rest was going to require the services of a commercial diving company.

Global, who could not afford to work on the usual basis of a percentage of the treasure recovered, persuaded Harrington to agree to a day-rate, and then retrofitted the bell-bounce chamber for saturation diving. On the first operation, two divers, in punishingly cramped quarters, were in saturation for 18 days; on the second, in 2000, with a larger chamber rented from a company in New Orleans, one diver was under pressure for 40 days, with Tim Beaver replacing the second diver for the last 23 days. In total, 1,207 coins were salvaged—one of which, minted with an inverted date, fetched $115,000 at auction.

The experience gained on the *Brother Jonathan* put Global in a position to use saturation diving on two further contracts: one,

Global first bell bounce system.



Global barge at Gross Dam.

with the US Coast Guard and NOAA, recovering 80,000 gallons of bunker oil from a leaking freighter that had gone down in 1953 off the Farallon Islands; and a second, at Gross Dam in the Rocky Mountains, installing a hydraulically-actuated gate valve.

In 2004, Global was called to the Gulf of Mexico to salvage the legs of a jack-up drilling rig battered by Hurricane Ivan, a job for which the saturation system was upgraded. The depth was 300 feet. A contract to recover the wreckage of three destroyed platforms followed in 2005. Before work could be completed on the second platform, however, Hurricanes Katrina and Rita swept into the Gulf, destroying a total of 115 platforms.

With a boom clearly ahead, Global bought a 1970s-era saturation system in Norway and shipped it to the company's new workshop in Seattle, where at a cost of several million dollars it was rebuilt and put to work in the Gulf. In 2007, the company assembled a third saturation system for the biggest and most complex project it had yet undertaken: repairing a leaking shaft 720 feet down in the New York water supply system. A fourth saturation system was acquired in 2010 when Global opened an office in Houston. Today, Global offers marine construction, casualty response, and offshore operations services in Alaska, California, the Gulf Coast and the Northwest.

In Deep is a well-produced, well-illustrated book, with considerable additional material interspersed on separate pages throughout. It will undoubtedly be of interest to current and former divers, especially those in the Seattle area.

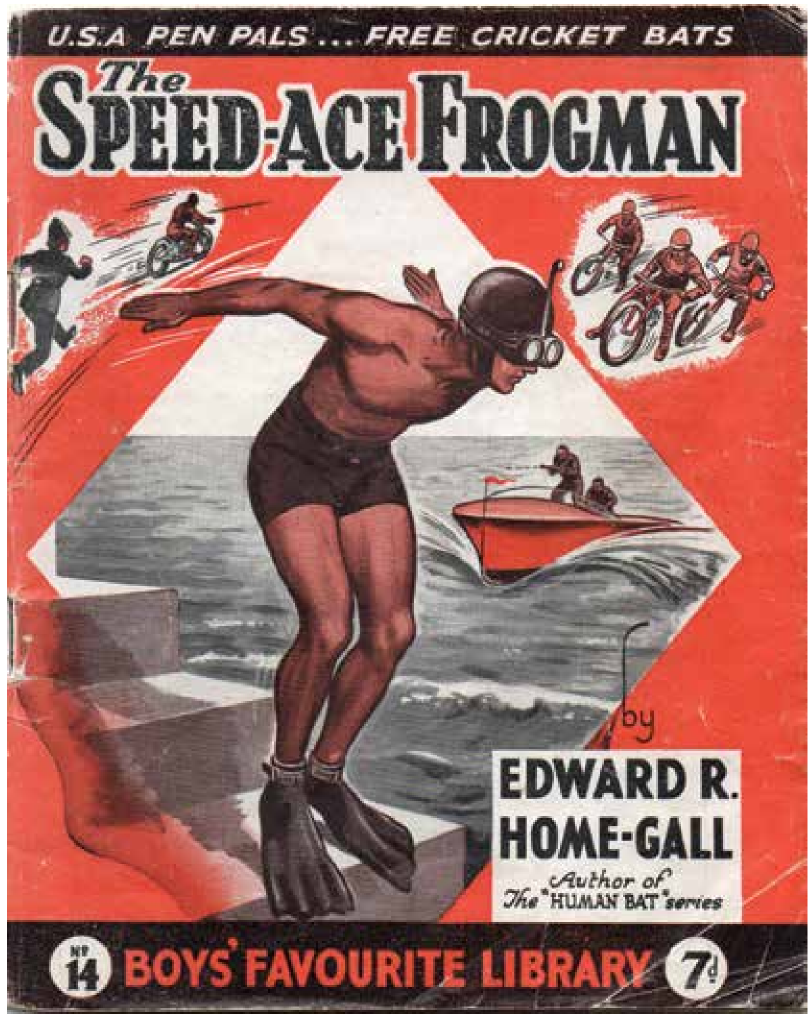
Documentary Media, Seattle, Washington
ISBN: 978-1-933245-36-2
Hardcover, 9 x 10 inches, 156 pages, full color

Paper Covers

By Peter Jackson

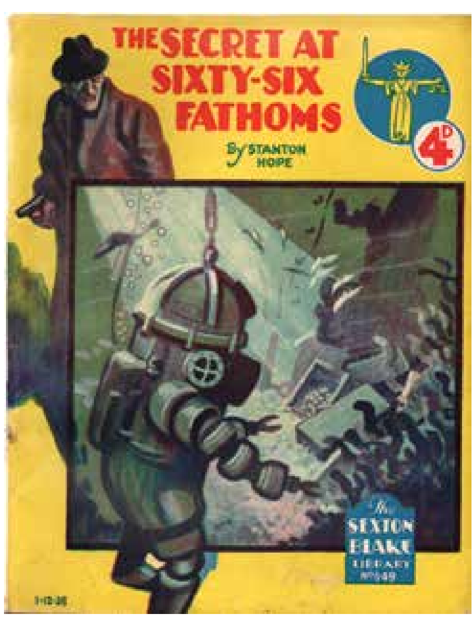
In this issue of Cover Story, we find ourselves cheating a little as the covers we show belong to what many might class as comics rather than books. They are some of those little juvenile adventure stories in flimsy paper wrappers, held together with staples – perhaps what you would call pulp fiction in the USA. There were thousands and thousands of such publications, often issued weekly as part of a seemingly everlasting series, such as the *Sexton Blake* ones we have shown. Sexton Blake was a very well known fictional detective, rather like a latter day Sherlock Holmes. Blake's adventures, written by various authors, were very popular in the 1930's.

As always, there will be more to follow. I hope you like them.

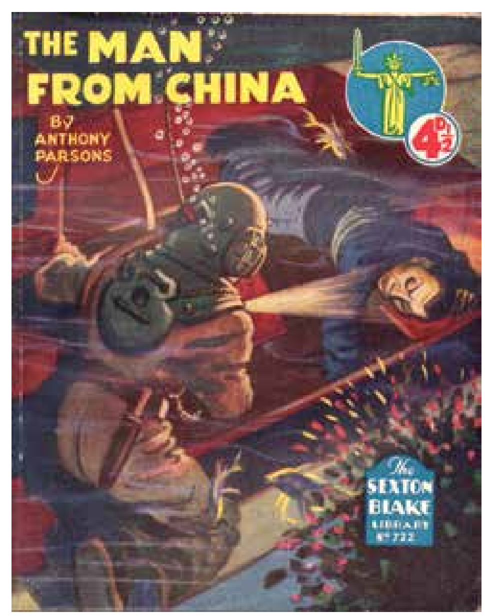


THE SPEED-ACE FROGMAN by Edward R. Home-Gall
Perry Colour Books Ltd. London 1950

THE SECRET UNDER THE SEA
by Sheila Austin
the Amalgamated Press, Ltd.
London 1958



THE SECRET AT SIXTY-SIX FATHOMS
by Stanton Hope
the Amalgamated Press Ltd.
London 1938



THE MAN FROM CHINA
by Anthony Parsons
the Amalgamated Press Ltd.
London c.1941

Images in History

Tritonia Diving Armor Photograph

By Gary Pilecki

This paper press photograph measures approximately 7 x 9 inches and is dated 5/26/33. On the reverse is an explanation about the diving apparatus being tested by the British Admiralty in the English Channel with the idea of adopting it for navy use.

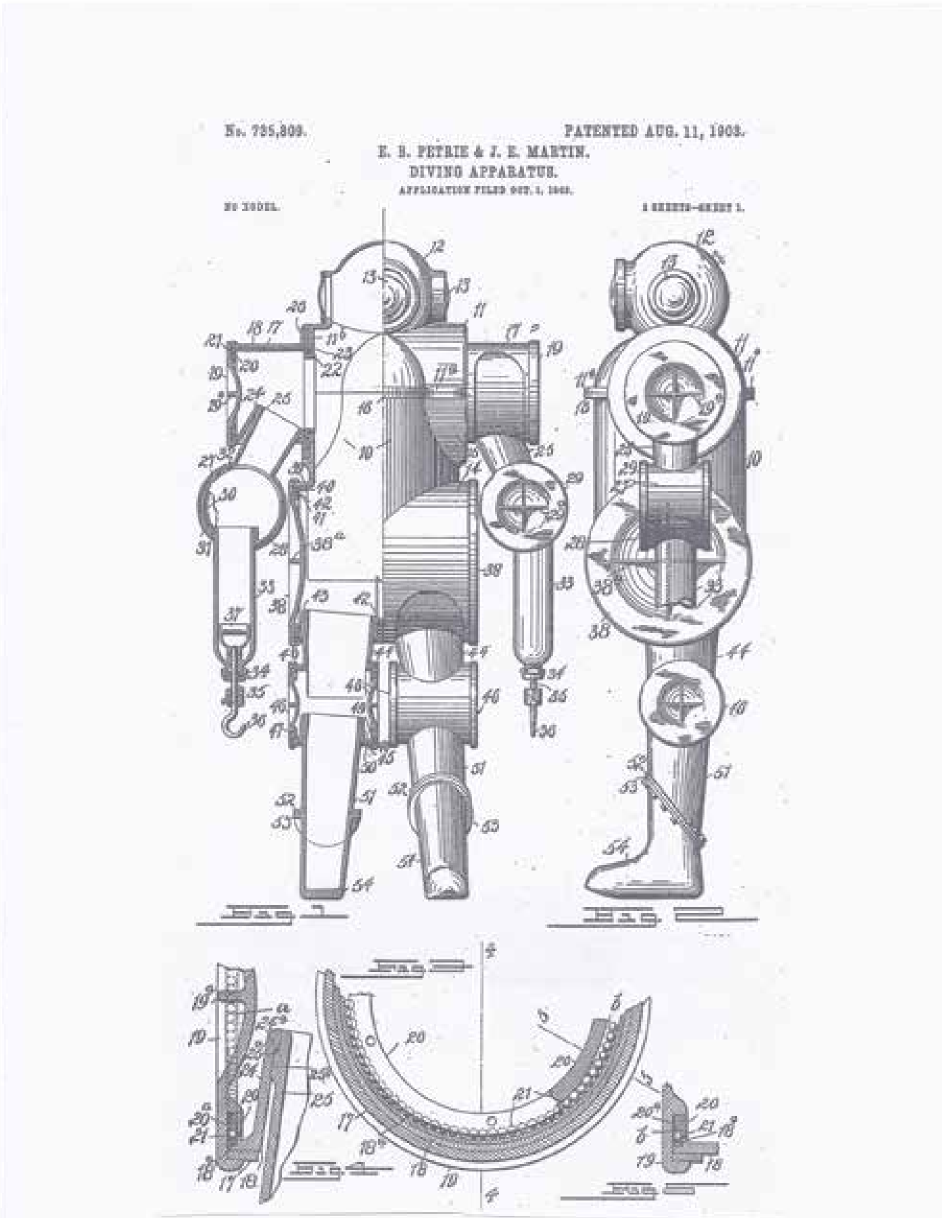
The diving armor is an atmospheric diving suit (ADS), which is a one-person submersible suit of armor that maintains an internal pressure of one atmosphere, thus eliminating the need for decompression. Divers can use this type of suit for many hours in deep water and have their own breathing gas supply, eliminating the need for surface supplied hoses.

Over the years, various attempts were made to construct ADS's, but two problems were never solved; the suits were too heavy and the joints were never able to work properly at depth. British engineer Joseph Peress managed to solve both of these problems when he constructed the Tritonia. First he used cast magnesium instead of steel, which was much lighter so that the diver could handle the suit. Secondly he found that using oil in the suit's joints made them non-compressible which allowed the joints to move freely, even at great depths.

Various tests of Peress' Tritonia armor suit were done in Loch Ness, in the English Channel, and on the shipwreck of the *Lusitania.* Although all tests were successful, the suit was retired due to lack of interest. Years later, the Tritonia suit was found in storage and the technology was copied into the Jim suit along with other modern day ADS's, used mostly in the offshore oil industry. Where this Tritonia suit is now, I don't know. Hopefully it still exists.

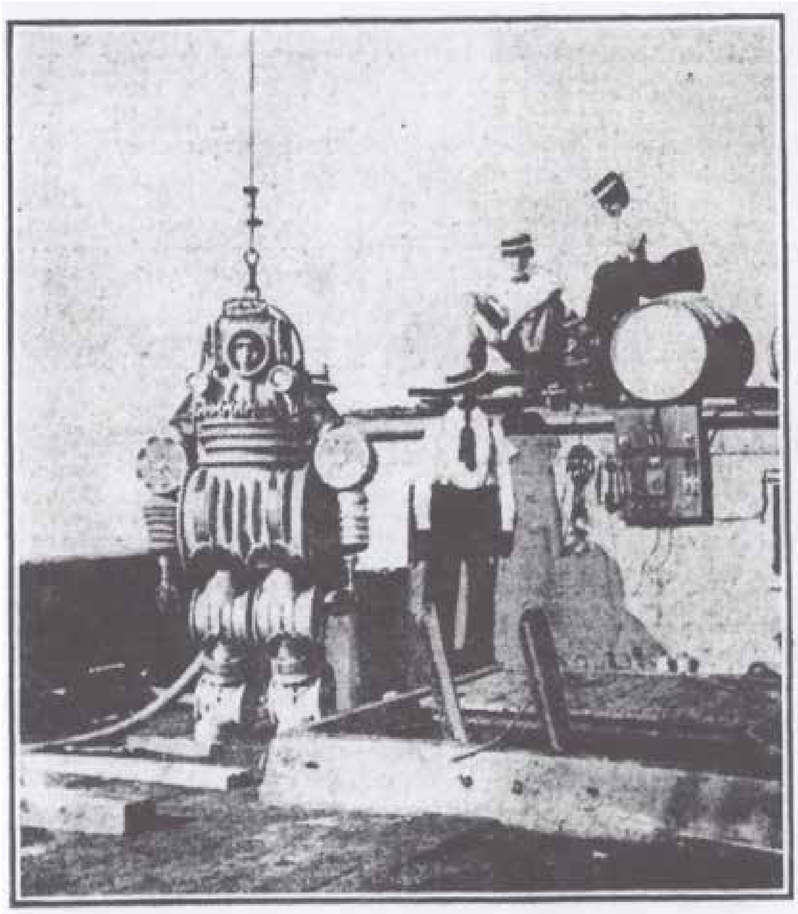
Petrie-Martin 1 ATA Diving Apparatus

By James Vorosmarti, MD



On 11 August 1903 Enos B. Petrie and Joseph E. Martin received Patent 735,809 for a Diving Apparatus, which had been applied for on 1 October 1902. This was a follow-on from the 1ATA diving suit from Petrie's first patent, Number 711, 342 of 14 October 1902, and was a different design for this same type of suit. The first patent used joints which were ball and socket in type, with the "ball" section sandwiched between two sections of the sockets. There was no method for controlling water leakage so the suit was to be covered by a rubber or other waterproof flexible suit. There is no information that this suit was ever built and used. One thing is obvious and that is, if the joints were tight enough to stop more than tiny leaks, the friction between the large globes of metal would have made it difficult for the diver to move his limbs, particularly at depth when the metal would have contracted because of the pressure. Petrie then teamed with Martin to design the suit in the patent described here. The patent rights were assigned to the Petrie Deep Sea Diving Company of Newark, N.J. This company was not mentioned in Petrie's first patent.

This suit, while looking very complex, is actually fairly simple. It is constructed of cylinders of heavy metal and fitted with large joints at the shoulders, elbows, hips and knees. It is the joints which are special in the design. Figures 1 and 2 show that the main body of the suit is an upright cylinder at the top of which is a flange (16) to which is bolted a one piece shoulder and helmet assembly (11). The design to allow movement of the joints is shown in Figures 3-5. The joints consist of two cylinders which sit inside each other. The outer cylinder is cut away to allow movement of the limb in one direction. The ends of the inner cylinders are



Diver Gaudy in His Suit.

threaded to accept a ring containing a raceway with ball bearings. The ends of the outer cylinders are threaded to accept the caps which close the joints and make a supposedly water-proof moveable joint. There is no mention of any gaskets in the joint mechanisms and I can envision leakage taking place between the inner and outer cylinders where the cut-away is. The end of each arm had a stuffing box through which a shaft with a tool on the outer end could be run and operated by the diver.

To enter the suit the diver climbs into it through the opening left when the chest-helmet section, shoulder sections and foot sections are removed. The helmet section is put on and the flanges (11a &16) are bolted together. After he has placed his arms through the openings for them, the entire shoulder sections are slipped onto the body section and secured in place by the spanner ring (26). Lastly the foot sections are bolted to the lower legs. The suit weighed 540 pounds.

A suit to this design was built and on 22 August 1907 the diver E. Gandy (or Gaudy -it was spelled both ways in the article) made a dive to 230 feet about 6 miles off Eaton Point, Long Island. He said it felt "light and airy" in the suit according to the *Brooklyn Daily Eagle* of 23 August 1907. The article also stated that an expedition would be sent to Cumana, Venezuela to find the wreck of the San Pedro de Alcantara, sunk in 1815 with a reported $3 millions in gold and jewels aboard. I have found no evidence that such an expedition took place. The photograph is from that article.

On can assume that the lack of any seals or gaskets in the joints did result in leakage of water into the suit because on 2 August 1904 Petrie and Martin were awarded Patent 766,465 for a "Means of Forcing Water from Diving Suits or Apparatus". This was a small pump carried on the apparatus and powered by high pressure air from the surface. The patent shows it attached to the back of the suit or one of the legs.

Petrie, himself, was granted Patent 984,104 on 14 February 1911 for a "Diving Suit Attachment". This was for a system to provide air to the suit and had a telephone line integrated into the single hose. There was no mention of the Petrie Deep Sea Diving Company on this patent. It would seem that Petrie was active in diving for the years cited above, but I have been able to find only one mention of him or his company in a newspaper search. This was in the *Trenton Evening Times* of 1 January 1910 and lists his company as being delinquent in taxes for 1907. Not a good beginning to the New Year.

HELMET AUCTIONS

By Leslie Leaney

A review of recent internet auction results. While every effort is made to accurately describe the lots, vendors' opinions of what the items are, and what their condition is, are not consistent. These results are published in good faith for the interest of members, and the HDS and JoDH are not responsible for any errors in descriptions, listings, or realized prices.

An antique Heinke Pearler helmet missing various parts. This model was from circa late 1800's very early 1900's with a copper breastplate and an exhaust valve in the breastplate. It had the narrower breastplate from the period and retained only the back strap, which has a distinctive reinforced ridge. As seen, it was what collectors and restorers deem a "project," as it was missing several breastplate bolts and wing nuts, three of the straps, the retaining ring and chain from the faceplate, the two turning knobs on the face plate. The bonnet showed a lot of denting with maybe a crimp or split in the shell behind the left view port. The bonnet was hand formed and the brazing line could be made out down the rear of the bonnet. Heinke's are generally accepted as being very collectible and retain a healthy following amongst collectors and historians. Although this one was stripped down to the bare metal and was missing several parts, it's scarcity as a genuine antique ensured it sold for the requested opening bid of $6,500. The winning bidder placed thee bids indicating that they were prepared to bid higher that $6,500.

Miller Dunn US Navy Mark V diving helmet serial number 1008, dated 3-1-44. Stated as all matching numbers. The helmet had been stripped down to copper and brass and appeared to have an older lacquer coating on it. A center section of the side port guards had been removed and the manufacturer's plaque was worn down. There were a few working dings in the bonnet but overall it appeared to be a good example. It came listed with an illuminated stand made from an antique English telegraph base and the shipping for the pair was listed at $500, which would seem a hindrance to anyone wishing solely for the helmet. It was listed several times with a But It Now price of $15,000. It was shown as selling for $7,907, but re-appeared again shortly thereafter requesting an opening bid of $4,000, and for Pick Up only, no shipping. That listing ended as the item was no longer available.

Morse Diving Equipment Co. Inc. US Navy Standard Diving Air Pump Mark III, number 38, dated 6/19/42. Edited from the listing: “This is an outstanding all original US Navy Mark III divers air pump from WWII. This pump is in excellent original condition and never restored. Dated on the front of the brass Morse Diving plaque 1942. Marked USN on the crank assembly. Everything appears to function as it should, wheels turn, and pistons pump. This pump is intended for two-diver operation, one diver deep or two divers shallow. I believe this is the largest hand operated pump that was made for the US Navy in WWII, manufactured by Morse Diving Equipment Company, Boston, Mass. I purchased this pump from 89-year-old Jack (JW) Franks who owned and operated The Marine Salvage Divers Construction Co. in Memphis, TN. His work was mainly diving in The Mighty Mississippi River around the 1950s-1960s. The pump box is made of solid ash wood with no cracks noted, heavy solid brass protected corners and bottom pieces. The box is strong and holds the complete pump and frame assembly inside as intended. The pump is all complete and included extra tools and parts in the storage compartment, gaskets, brass hardware etc. The pump box measures 43” tall x 25” x 25”. The iron wheels measure 36” in diameter and weigh 147 lbs. each. The total weight of the pump and wheels, I’m estimating, 800 lbs.” Pick up only, located in California. No bid on requested opening bid of $6,500.

By Ed LaRochelle

Sportsways Waterlung "DUAL-AIR" serial number D-10371 circa 1961-62. The serial number indicates it to be manufactured in 1962 nearing the end for the Dual-Air model. Research of serial numbers indicates that approximately 10,000 Dual-Air models were manufactured. The auctioned regulator was in all original excellent condition in original box (fair condition). Sold $695.

US Divers DA model military specification non-magnetic regulator, serial number 237526, circa 1963-1966, (phase one regulators). The serial number indicates it was manufactured near the end of 1966. US Divers would make three significant changes during the 12+ years run of non-magnetic regulators. This auctioned regulator falls in the first phase with nine + parts yellow gold plated in brass case painted black. This restored regulator complete with original and correct parts is a beautiful example of the first phase non-mag. Auction included a photocopy of 1963 government manual for the non-magnetic regulator. Sold $750.

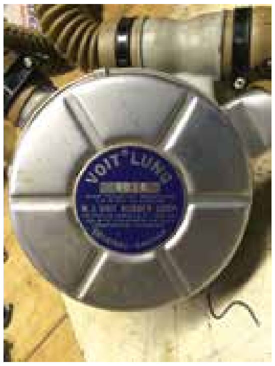
Phase two interior

US Divers DA model military specifications non-magnetic regulator serial number 240793, circa 1968. This auctioned regulator is a phase two non-magnetic model. The changes made from original phase one are the gold parts are now some yellow gold, some white gold, and fewer in number. The case is now thinner brass, plated in zinc, and then painted black. I have provided a photo of interior (not the actual auctioned regulator) for what this phase two model would look like. The auctioned regulator was new old stock still with original packaging dated 1968 from government surplus. Sold $713.67

Another US Divers DA model military specification non-magnetic regulator, serial number 241215, from the same seller, in the same unused new-old-stock, with original 1968 packaging from military surplus. Sold $700.

US Divers twin aluminum 90 cubic foot cylinders, non-magnetic, dated 6-1967. Auctioned by the same seller of the new-old-stock non-magnetic regulators, so is this cylinder set is also new-old-stock military surplus. A beautiful example of a UDT issued diving cylinder set. Sold $787.77

US Navy manual scuba



Voit-Lung VR-1 “Sportsman” blue label Over Pressure Breather, serial number 8834, circa 1959 (only). Verified serial numbers to date indicate 500 or less VR-1 blue label regulators were manufactured, making this one a very sought after model Voit. This auctioned regulator was in very good condition in every respect, label, chrome, hoses and mouthpiece, all correct for the 1959 model. The only incorrect item was the plastic clamps that are incorrect for this regulator. Those clamps did not appear until 1961. The regulator should be fitted with chrome plated Tinnerman clamps; the first year Voit did so. The 1959 VCR-1 50 Fathom also had the chrome clamps for its two-year run. See Lloyd Bridges as Mike Nelson comic cover with 1959 VR-1 Sportsman. Sold $787.77

Mike Nelson sporting the VR-1 blue label.

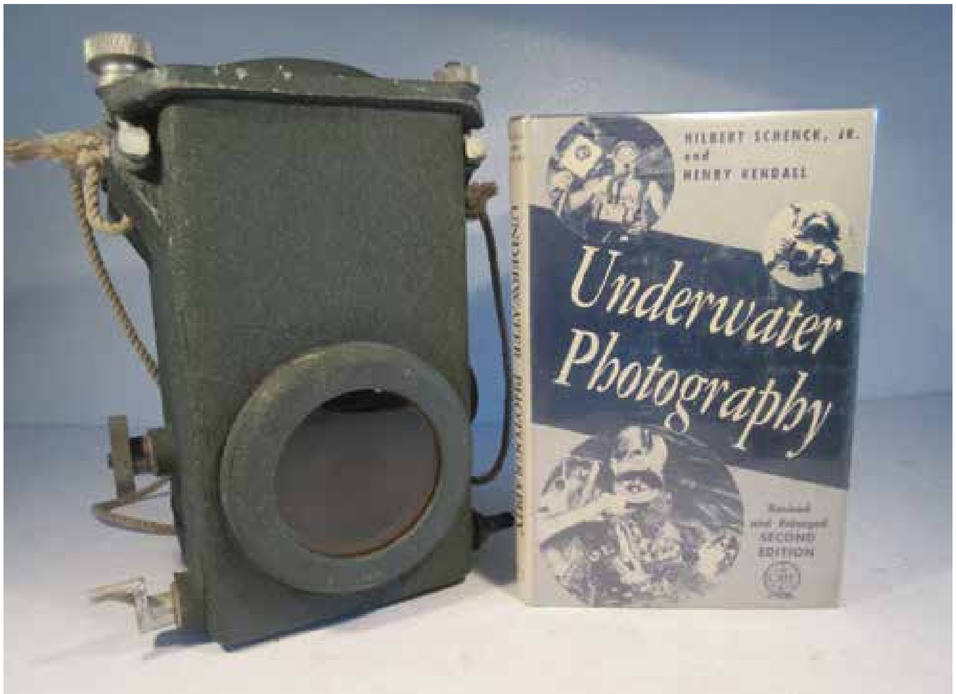
VOIT-LUNG “VR-1 Sportsman” green label, Over Pressure Breather, serial number 7856 circa, 1956-58. Serial number indicates it was manufactured during the latter part of the three-year production run. To date verified serial numbers reveal approximately 3,000 VR-1 green label regulators were produced. Auctioned regulator has a good condition label, and good chrome, the rotted hoses and mouthpiece auctioned with regulator are from a later model and not correct for this regulator. Sold $323.

1957 catalog cover

US Divers “VIGO” tank harness and regulator set, circa 1959-61. The 18 cubic foot cylinder with Aqua Matic regulator was cataloged for three years. In 1962 the VIGO came with the new design regulator Aqua-Div. The auctioned set was complete and in nice condition over all. Sold $100.

CAMERA AUCTIONS

By Sid Macken



French Ondiphot housing for Rolleiflex camera, included a copy of Schenck and Kendall's *Underwater Photography,* 1957, 2nd edition, sold $2291.

Green Aqua-Cam camera with flash and rope neck strap, sold $428.

Cast aluminum Wessman housing, unusual design would fit a variety of cameras, sold $976.

Black Aqua-Cam camera, with homemade neck strap, missing reflector for flash attachment, $175

Calypso camera, with correct frame finder, shoulder strap, and lens cap, sold $784.

Calypso camera, with Nikonos frame finder, cosmetically rough condition, sold $587.

A unique brass housing for a 16mm movie camera, weighs over 30 pounds and is 14 inches long, nearly identical to William Beebe's camera housing as shown in *Beneath Tropic Seas*, G.P. Putnam's Sons, 1928, p. 164, although this claim not made in item description, sold $150.

Rolleimarin housing for Rolleiflex cameras, sold $1200. A second Rolleimarin housing, sold $338, no photo.

La Spirotechnique Aquamatic camera with flash attachment, owner's manual, and carry case, sold $350.

Ikelite housing for Polaroid Model 600 series or similar cameras, including flash attachment, sold $759.

Seahawk MK III housing for Argus C4 and C44 cameras, controls for film advance and shutter release, sold $182.

By Sid Macken, President

Long Beach Scuba Show

Our last show before summer set in was the Long Beach Scuba Show, held in the Long Beach Convention Center, California. The booth was staffed by myself along with volunteers Larry Breazeale and Leslie Leaney. The show was well attended with many old friends stopping by the booth to visit. It appears this momentum will carry through into 2016, and we will be there.

The Long Beach Convention Center and Aquarium location for the Scuba Show and evening events.

Willy Wilson Retirement Ceremony.

On July 2nd, the Divers Institute of Technology (DIT) in Seattle, Washington, celebrated the retirement of Sylvester "Willy" Wilson. Willy retired after 40 years - and a day - as an instructor at the school. Coming to DIT after his retirement as a highly decorated navy diver, Willy is credited with instructing over 8,000 commercial diving students. Willy's impact on DIT was evidenced by the large turn out of former students and testimonials given by visiting dignitaries. His long time dedication to diver education and safety earned him two awards, which were presented at his retirement ceremony. The HDS Leonard Greenstone Award was presented to Willy by HDS President, Sid Macken, and the ADC-I Lifetime Achievement Award was presented by ADC-I Executive Director, Phil Newsum, himself a DIT graduate and one of Willy's students. Both awards were well deserved. Willy's ceremony was attended by family, friends, colleagues, and a host of DIT students who then adjourned to the pier outside the school where a barbecue buffet was set up next to the school's dive boat.

Willy Wilson with the Leonard Greenstone Award.

Willy Wilson is first in line at the barbecue following his retirement ceremony at Diver's Institute of Technology.

The Annual HDS Helmet Raffle

The annual HDS raffle drawing was conducted at the Santa Barbara Maritime Museum on August 15th, and the winners names are posted on the HDS website. Thirteen prizes were awarded. Due to California gaming laws, we can no longer conduct the drawing at DEMA as in the past. The raffle must be drawn in California, and the Museum will be the location of all future drawings. There will likely be changes to how we conduct our raffles in the future and so keep watch on the HDS website for announcements.

Look for the HDS booth at Oceans 15 in Washington D.C, October 19-22, and at DEMA in Orlando, November 4-7.

Safe Diving,

Photo credits by author

A Stillson Prototype Commemorative Helmet by DESCO. This is helmet #3 of 10 built, and will be the fundraiser helmet for the HDS in 2016. This limited edition series of helmets by DESCO are built to the specifications in Gunners Mate George Stillson's 1915 report to the Navy.

Santa Barbara City College Honors Bob Christensen with Scholarship Program

Diver education is a vital component to improving working conditions and safety in the field for all diving career fields. Bob Christensen, former instructor and director at Santa Barbara City College's Marine Diving Technology Program, exemplified the type of educator who can affect the lives and careers of divers in the most positive way. Prior to coming to SBCC, Bob was involved in much of the pioneering research work done in the field of deep diving, worked in the commercial industry, and served his country as an officer in the Navy's Underwater Demolition Teams (UDT) during the Korean War. He continued to work in the commercial diving field and was employed for many years at Kirby Morgan Diving Systems International.

With this tremendous background, Bob remained a very quiet and humble person. His influence over students was presented in subtle encouragement, personal example, and support for the efforts of his students. He was one of the original instructors at the SBCC Marine Tech Program, later becoming the program's Director. His mentorship and teaching style brought out the best in his students and reached divers in commercial, recreational, scientific, and other professional diving career fields. He remained an advocate for the diver in the field and diving safety until his death in 2013.

In honor of this quiet man's dedication to diver education, SBCC has established an endowment to provide scholarships for Marine Tech students. It is a fitting memorial which will allow Bob's mentorship and influence to continue to promote diver education and safety far into the future.

To contribute to The Bob Christensen Memorial Scholarship, or for additional information, contact Lucille Ramirez at the SBCC Foundation, (805) 730-4406, or go on line at www.sbccfoundation.org

Donations can be sent to:

SBCC Foundation
Christensen Memorial Scholarship
721 Cliff Drive
Santa Barbara, CA 93109

HDS USA's Helmets in History
Limited Edition Challenge Coin Series

Subscriptions available for $60 per year - four coins, one released every three months

Fourth Quarter 2015

U.S. Navy Mark III

After the publication of Gunner G.D. Stillson's "Report on Deep Diving Tests-1915" The U.S. Navy followed through on the recommendations contained and the famous Mark V was introduced into service, it became necessary to designate different styles of earlier helmets. From the U.S. Navy's 1916 Diving Manual; Interrupted screw type; otherwise the same as Mark I.

The HDS Founder's Coin

HDS Helmets in History Challenge coins are the perfect gift for the diver in your life, or as presentation gifts for achievement, speakers, or notable visitors to your company or organization. Available as single coins or annual-release sets. Some coins are now in limited supply so contact products@hds.org for availability.

2013 and 2014 still available in limited quantities as four-coin sets or individually

Individual Coins - $15
Four Coin Series - $60
Walnut Presentation Box - $25
Boxed Set - $75
Prices include US shipping. For international orders, email products@hds.org

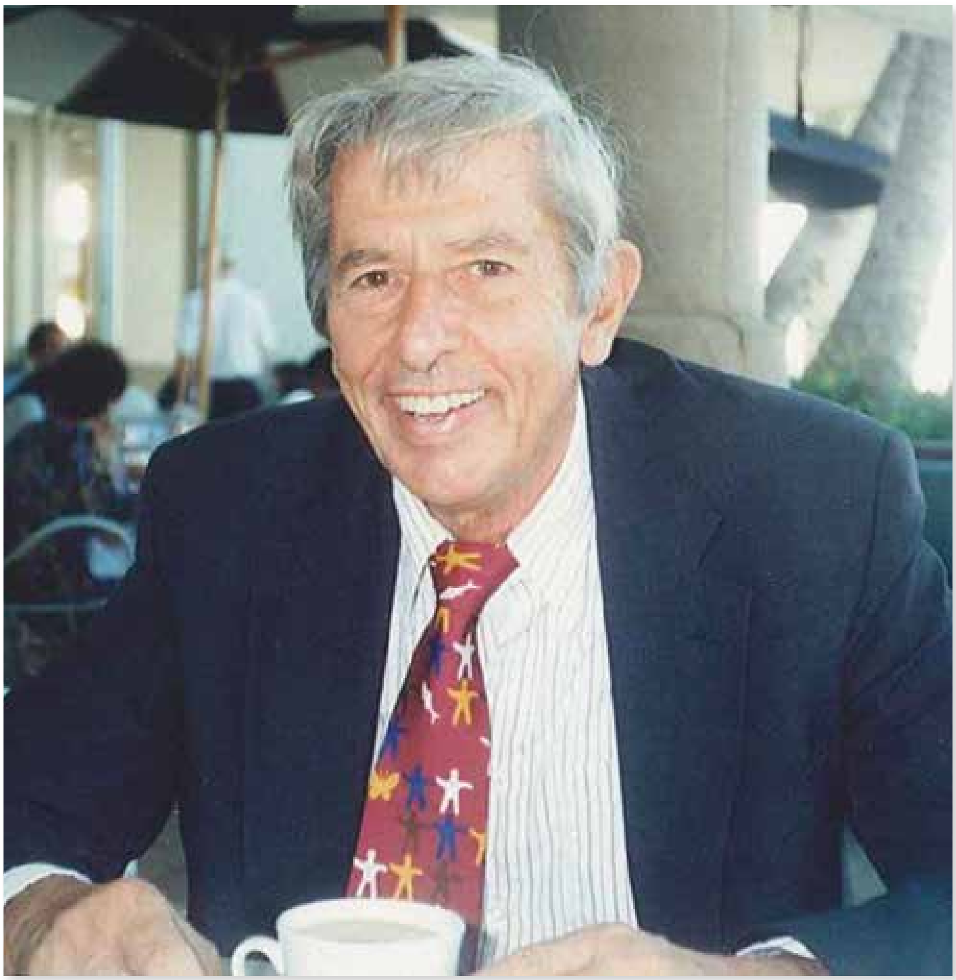
www.hds.org • www.facebook.com/historicaldivingsociety

John Piña Craven

American Treasure

October 30, 1924 – February 12, 2015

By Diann Karin Lynn, CAPT, CEC, USN (ret)



To me it's fitting to begin any narrative about John Craven with a quotation of some sort, since he was so prone to pop a phrase or verse (or burst into song) whenever we met. Thus he penned his version of Psalm 107 (which he called "a song of the sea") in a book dedication to me in 1997.

"We who go down to the sea
Who do business in great waters
We see the wonders of the Lord
And his works in the mighty deep
From
The old man of the sea
JPC"

This story is a personal account about John Craven, The Man, through my eyes. To paraphrase astronaut Scott Carpenter, a good friend and compatriot of his in the SeaLab endeavors: some men have courage, some have vision, and some have curiosity, but few are endowed with all three.[1] Craven, surely, was one of the exceptions.

John Craven was "Marine Technology" personified. Well known to Marine Technology Society members as a Lockheed award winner and Society President from 1971-72, among other credits, his life story was aptly chronicled in the obituary carried in the March/April 2015 issue of the MTS newsletter *Currents*. How to separate any one area of endeavor from the plethora of arrows in his quiver? As described in the June 2005 *Wired* magazine article about him and his cold-water agriculture pursuits at the time,[2] he was, indeed, a "polymath"– a person whose expertise spans a large number of diverse subject areas, who is also known to draw on complex bodies of knowledge to solve specific problems. How à propos for Craven.

As that article continued, "Craven may sound like a brilliant psychotic, but he's got plenty of credentials," and went on to enumerate his impressive qualifications (BSCE from Cornell, MS from Cal Tech, PhD in hydrodynamics from the University of Iowa, JD from George Washington University, Chief Scientist for Poseidon/Polaris, Chair of the Law of the Sea Institute, and so on…) – the list alone could fill this essay. His accomplishments – application of those credentials – are equally if not more impressive.

As I culled various notebooks and articles and web pages for this piece, I came across an especially comprehensive and inclusive blog (the title of which was borrowed with permission for this article) by another friend and colleague of Craven's, Nicholas Johnson. It summarizes better than most the spectrum of his contributions; I strongly commend that commentary to the reader for its humor, completeness, and many fine references (including a video of a typical Craven Tutorial about cold water agriculture).[3] It is a most splendid tribute to a most amazing man, whom I was deeply honored to call Friend.

I initially started writing this article as a chronicle of Craven's involvement in SeaLab II, although it morphed into more of a tribute. To at least fulfill the premise of my task, the short story of Craven's involvement with SeaLab II can be pieced together from his own book, The Silent War.[4] Starting his long career with the US Navy in 1949 as a hydrodynamicist at the David Taylor Model Basin, by 1959, at a mere 35 years old, he had been named Chief Scientist of the Special Projects Office (SPO), which was charged with development and acquisition of the Polaris/Poseidon Fleet Ballistic Missile System. Peripherally, some of his scientists were working on tests for *USS Thresher*, and in the wake of the early and tragic loss of that submarine, suddenly SPO's "offspring" became the Deep Submergence Rescue Vehicle, the Man-in-the-Sea (MITS) Program – which included SeaLabs – and several other associated systems. Luckily for Craven, these projects involved research and development of the capability for humans to be deployed in the deep ocean for unlimited time, embodying a concept he recited almost every time I saw him: *man as a marine mammal.* The program was transferred to him just as SeaLab I was completing and SeaLab II was about to begin. As conceived and developed by Navy medical captains George Bond, Walt Mazzone and Robert Workman, the objective of the MITS program was to develop a capability and push the envelope for saturation diving, to enable humans "to live in the sea as though they were marine mammals."[5] Craven's association with and top-level direction of the program continued through the successful culmination of SeaLab II and its many resulting offshoots in November 1965, and the unfortunate and fateful end of the program with the cancellation of SeaLab III in 1969.

Craven's life continued to weave many threads after parting ways with the Navy, as a professor at the Massachusetts Institute of Technology and a marine educator at the University of Hawaii; dabbling in politics, with a close brush with election to Congress; and fulfilling Hawaii Governor John Burns' vision for Hawaii as an Ocean State by being named Hawaii's ocean czar as the State's Marine Affairs Coordinator, Dean of Marine Programs at UH, and Director of the Law of the Sea Institute. On a related and topical note, considering Hawaii's recent 100% renewable energy goal, Craven established the Natural Energy Laboratory of Hawaii Authority (NELHA) to integrate research in agriculture and energy, overseeing the first successful demonstration of ocean thermal energy conversion.[6,7]

I close with a personal vignette. I first met Dr. Craven in 1983 when he was acting Chair of the Department of Ocean Engineering at University of Hawaii (then part of the engineering department). Typically not content to sit in his office, one day he dragged all of the masters and PhD students to Ke`ahole Point on the Big Island on a field trip to the Natural Energy Lab and to see the prototype OTEC plant and cold water agriculture in action. I got to sit next to him on the plane. This was the first time (of many) I heard his life history, starting as a less-than-stellar high school student in Brooklyn, through his career with the Navy up through the current time. He lamented that he did not fulfill his family's expectations of following in many footsteps as a Naval Academy graduate and esteemed Naval Officer. But even during that first acquaintance, I sensed that the Navy, ocean science, the United States and probably the world at large benefitted far more by his service to country unfettered by the uniform and its many constraints as a brilliant contributor to the global equation both in and out of government.

In the end, however, one of his deepest and most enduring passions – outside of family, of course – was the United States Navy. How appropriate, then, that his Navy saw fit to honor him in the deepest possible way by an official, private ceremony conducted by the captain and crew of the *USS Hawaii* (SSN 776) at the Pearl Harbor submarine piers. The traditional 3-volley gun salute was fired by a rifle party of sailors following committal to sea of his ashes in the harbor – a truly fitting culmination of life for the old man of the sea.

Man's capacity for sea stories should exceed his reality
or what's a legend for?
~ John Piña Craven

(Endnotes)

1 *Carpenter, M. Scott, "Exploring Space and Sea," Edwin A. Link Lecture Series, Smithsonian Institution Press, Washington DC 1967*

2 *Hoffman, Carl, "The Mad Genius from the Bottom of the Sea." Wired magazine, http://tinyurl.com/wired-mad-genius, June 2005*

3 *Johnson, Nicholas, "John Piña Craven, American Treasure" blog, http://tinyurl.com/http-NJ-JPC-com, 15 February 2015*

4 *Craven, John, The Silent War: The Cold War Battle Beneath the Sea, New York: Simon & Schuster, 2001*

5 *ibid, p. 147*

6 *Karl,David UH and the Sea, "Chapter 6, "Enter John Piña Craven: Founding UH Dean of Marine Programs and State of Hawaii Marine Affairs Coordinator," 2004*

7 *State house bill H.B. 623, signed 8 June 2015 . http://governor.hawaii.gov/newsroom/press-release-governor-ige-signs-bill-setting-100-percent-renewable-energy-goal-in-power-sector/*

John P. Craven Marine Education Fund

A Fund in Craven's Honor

When former dean of marine programs at University of Hawaii Mānoa Dr. John Piña Craven died in February 2015 at age 90, his family and friends started a fund in his honor. The **John P. Craven Marine Education Fund** will provide the Marine Option Program with resources to support student scholarships, student awards, student research projects, and student travel reimbursements to conferences and symposiums – all with the aim of supporting the next generation of ocean leaders. - See more at: http://www.uhfoundation.org/giving-opportunity/celebrate-marine-research-pioneer

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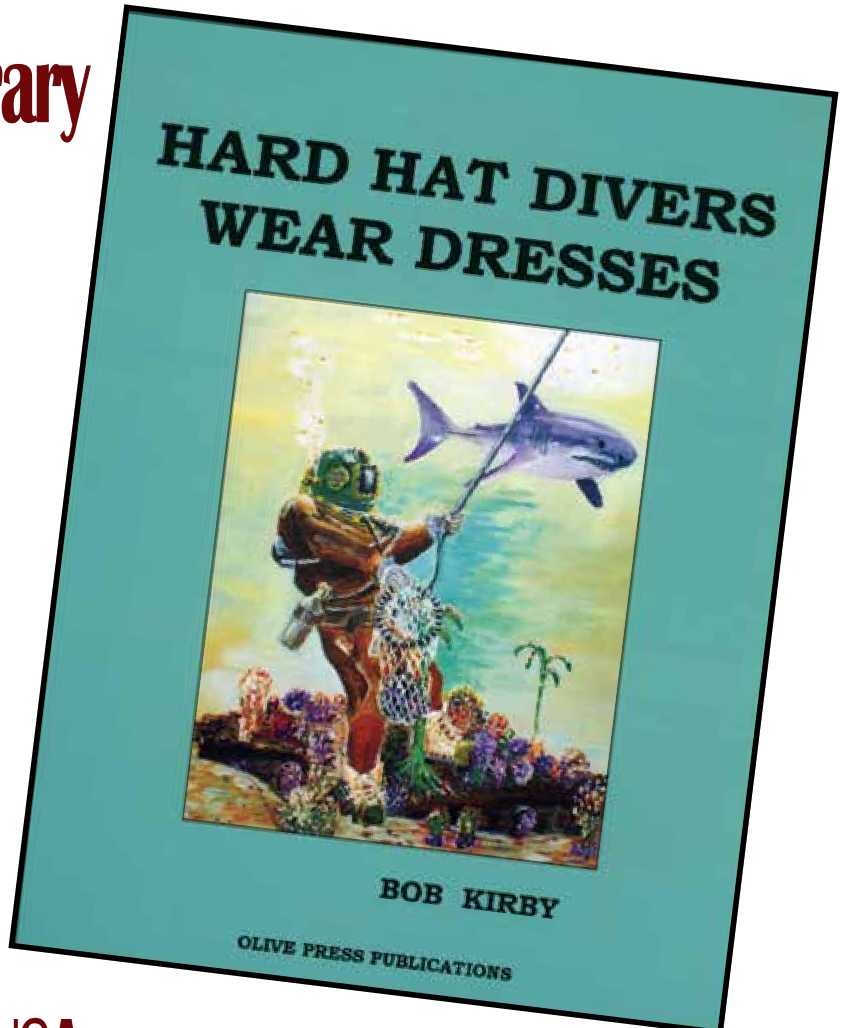

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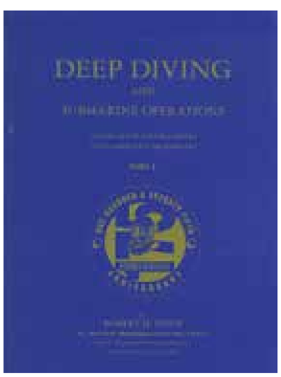
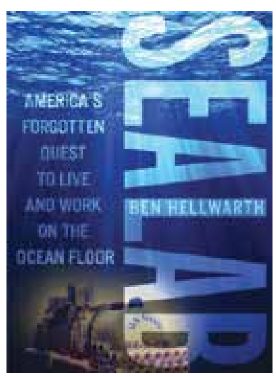


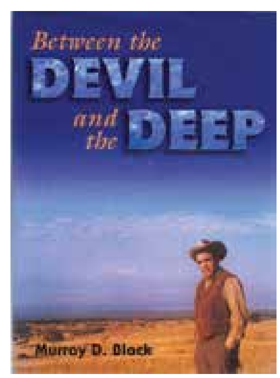
DEEP DIVING AND SUBMARINE OPERATIONS BY SIR ROBERT H. DAVIS

Referred to during last century as "The Bible of Diving," the first edition of this book appeared in 1909, as was gradually revised and expanded through the 20th century. This ninth edition celebrates the 175th Anniversary of Siebe Gorman. Part One is essentially a diving manual and covers all aspects of diving technology, physics, physiology. Part Two contains accounts of notable diving operations and a history of all forms of diving apparatus. Two-volume set in a reflex blue presentation slip case. Probably the most famous diving book ever printed. "The best book on diving I have ever read," says Bev Morgan. Reviewed in HDM #6. 712 pages, over 650 b&w photographs, line drawings and illustrations, index. $115 plus plus $18 domestic p&p ($60 international).



SEALAB: AMERICA'S FORGOTTEN QUEST TO LIVE AND WORK ON THE OCEAN FLOOR BY BEN HELLWARTH

An extensive and detailed record of the triumphs and tragedies of the SEALAB program, based upon Hellwarth's painstaking research. Hellwarth, a veteran journalist, interviewed many surviving participants from the SEALAB experiments and conducted extensive documentary research to write the first comprehensive account of one of the most important and least known experiments in US history. His compelling narrative covers the story from its scrappy origins in Dr. Bond's Navy laboratory, through harrowing close calls, historic triumphs, and the mysterious tragedy that brought about the end of SEALAB. Hardbound in dust jacket, 2012, 388 pages b&w photos, index, 19 pages of reference notes. $28 plus $7.50 domestic p&p.



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As one of the early pioneers of commercial oilfield diving, Murray black was an industry leader with an abundance of natural bravery. After graduating from E.R. Cross' Sparling School of Deep Sea Diving, Black progressed through the colorful ranks of the abalone diving and eventually founder DIVCON. History was made with DIVCON, with surface bounce dives past 500 feet as Black consistently pushed the envelope. The book also contains details of Blacks post diving career with friends like John Wayne and other characters. nd, 189 pages with b&w photos. $25, plus $5 domestic p&p.

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UNLIMITED AIR: Stan takes us back to the Caymans but this time we travel and dive with Our World Underwater scholarship winner Lisa Truitt.

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FINS TO THE RIGHT, FINS TO THE LEFT: Return to Cocos Island for a thorough shark-fest. Together the films offer nearly an hour of Stan's delightful images and eloquent narration.

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MORA WHEELS: This is the story of the Moray Wheels a Boston-based Scuba club for divers with disabilities. Produced in the 1970's, Stan follows two students as they undergo their initial dive training in the pool at M. I. T., then make check out dives at the New England Aquarium in Boston. The students face the challenges of diving in open water at Bonaire, Netherland Antilles.

GENESIS 1-27: "So God created man in his own image, in the image of God he created him; male and female he created them." Stan's underwater imagery set to a haunting musical score won a Gold Medal at the inaugural United Kingdom Film Festival.

A BITING KIND OF SHARK: Eighteen years after filming *Blue Water, White Death*, Stan returns to Dangerous Reef, South Australia, with famed Australian shark expert Rodney Fox to once again film the Great White Shark. They are accompanied by underwater photographers and scientists from Canada, Saudi Arabia, and the United States.

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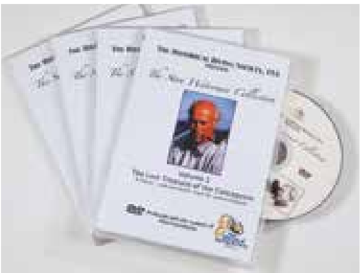
THE WAR REEFS: In 1942, the small, South Pacific Island of Guadalcanal became the scene of a decisive, World War II, air-sea battle between the United States and Japan. It was a turning point in te war for the US and its allies, but a resounding defeat for the Japanese. The terrible cost of the battle can be found enumerated on the sea floor in what is now called Iron Bottom Sound for the scores of ships and aircraft that lie there. Stan and his companions visit the waters surrounding Guadalcanal, and as they explore Japan's sunken fleet, they discover that the debris of war has, over time, been changed, softened by the sea, and is now the home of a fantastic array of marine animals.



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PETER AND THE SHARK: Stan, Peter Benchley, and crew travel to Australia to dive with Great White Sharks. Along the way, they encounter Manta Rays, sea turtles, Bronze Whalers, Tiger Sharks on the Great Barrier Reef, and then, at Dangerous Reef, the big guys showed up. Originally aired on the American Sportsmen Show

THE CALL OF THE RUNNING TIDE: Edited for U. S. Divers from Stan's original lecture film, Call of the Running Tide documents a year that Stan and the Waterman clan spent living in the South Pacific, diving Tahiti and Bora Bora, and learning the South Pacific Islanders.

THE LAST OF THE RIGHT WHALES: Stan travels to Patagonia to search for and dive with Right Whales. These amazing, gentle creatures were hunted nearly to extinction because they were the "right" whale to bring large profits to early whalers. Stan also looks at the other creatures living along this lonely, desolate coastline.

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THE BEST OF CAYMANS: Stan visits the Cayman Islands aboard Wayne Hasson's Aggressor Fleet liveaboard dive boats. Along on the trip are Stan's good friend Peter Benchley and his family. They dive the wreck of the Ore Verde; visit Jew Fish, Barracuda, and Grouper; dive reefs, walls, and visit a shallow sand patch filled with sting rays.

THE SINAI REEFS: The best of the Red Sea, aboard the live aboard dive boat, SUN BOAT. Stan and mixed group of divers from the US visit reefs along the Sinai Peninsula, the Gulf of Eilat, Ras Muhhamad, and the Straits of Tehran. The beautiful colors of reef fish and corals endure in this film.

BELIZE - A DIVING HOLIDAY: An Aggressor Fleet trip, this time to the reefs of Belize. Day or night, the reefs are ablaze with color and the photographers on board take full advantage of the scene.

CORTEZ - THE HAMMERHEAD: Stan and Peter Benchley travel to the Espiritu Santo Seamount in the Sea of Cortez to film the massive schools of Hammerhead Sharks known to congregate there. Accompanied by shark researcher, Dr. Ted Rulison, Peter and Stan learn about the enigmatic Hammerheads and research in shark behavior.

STELLA MARIS: In another American Sportsmen episode, Stan films author Peter Benchley and Dr. Sylvia Earle as they dive with sharks at Stella Maris in the Caribbean. First dives include encounters with a large Manta Ray, and individual sharks, then the large school arrives and the dives get interesting.

Volume 9 $15
JACKI'S WORLD:The Island is Virgin Gorda, in the British Virgin islands. The subject is jacki Kilbride. Her love of the sea and devotion to protecting and sharing it make Jacki's World a very special place.

THERE'S AN EEL IN MY BC: Bonaire, diving mecca of the Caribbean, is the location for this adventure. Peter Hughes, Dee Scarr, Geri Murphy, and Paul Tzimoulis make appearances along with Stan in a comedic cameo.

A PEOPLE'S TRUST: The Bahama's National Trust, dedicated to the preservation of the Bahama's invaluable natural resources, brings education to Bahamian children and protects the island's environment through a series of parks.

CURACAO, DIVING PLUS: The Caribbean Island of Curacao, in the Netherland Antilles, is as much a delight above water as it is below. Stan takes us on a tour of this beautiful island and shows us the attractions which make it a must-dive location.

Volume 10 $15
A SIXTIETH AT ƒ EIGHT: Underwater photography is all the rage, and Stan takes us to class on the Bahama Island of San Salvador at the Paul Tzimoulis Underwater Photography College. Look for appearances by Paul, Geri Murphy, Peter Benchley and his family. Includes a dolphin sequence filmed by Jack McKenney.

SCUBA: A lesson in diving history, with Stan as our professor, traces the advance of man's efforts underwater from Leonardo da Vinci to Cousteau. Includes a visit to the Dacor Company and film sequences by Al Giddings and John Ernest Williamson.

SHARKS: A glimpse into the world of sharks and their relationship with humans. Incudes interviews with Dr. Don Nelson, Dr. Eugenie Clark, and Rodney Fox, plus film from of Ron and Valerie Taylor. Produced by Stan and Howard Hall as part of a World of Audobon television special.

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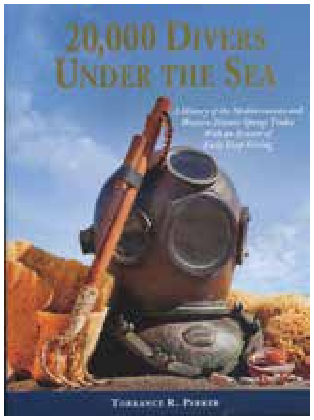

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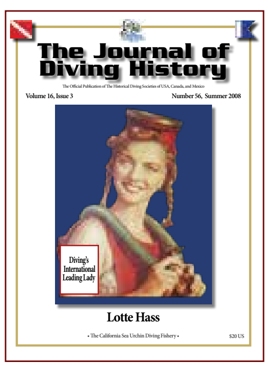

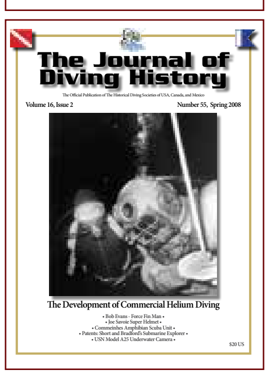

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