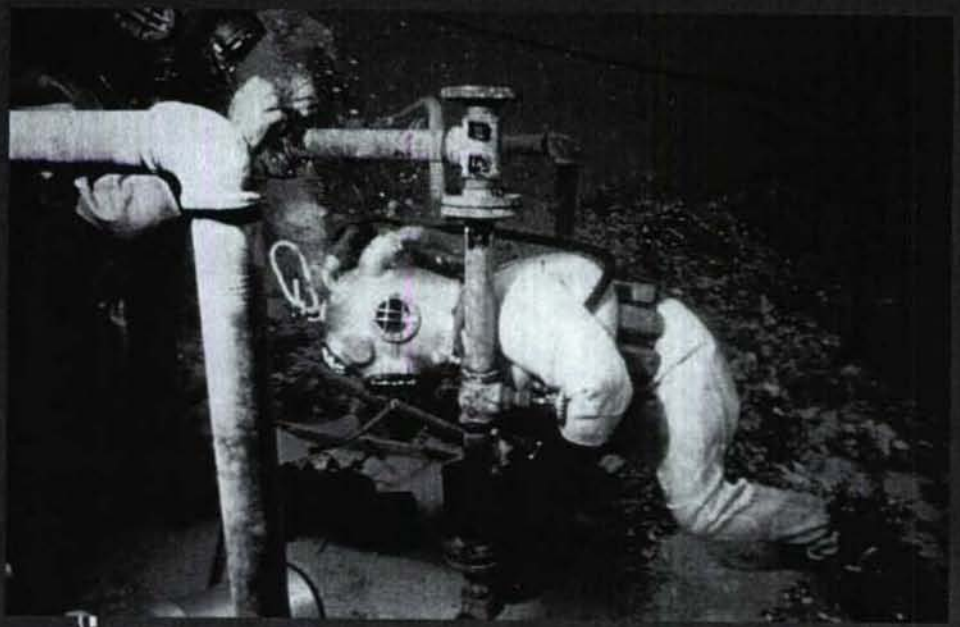
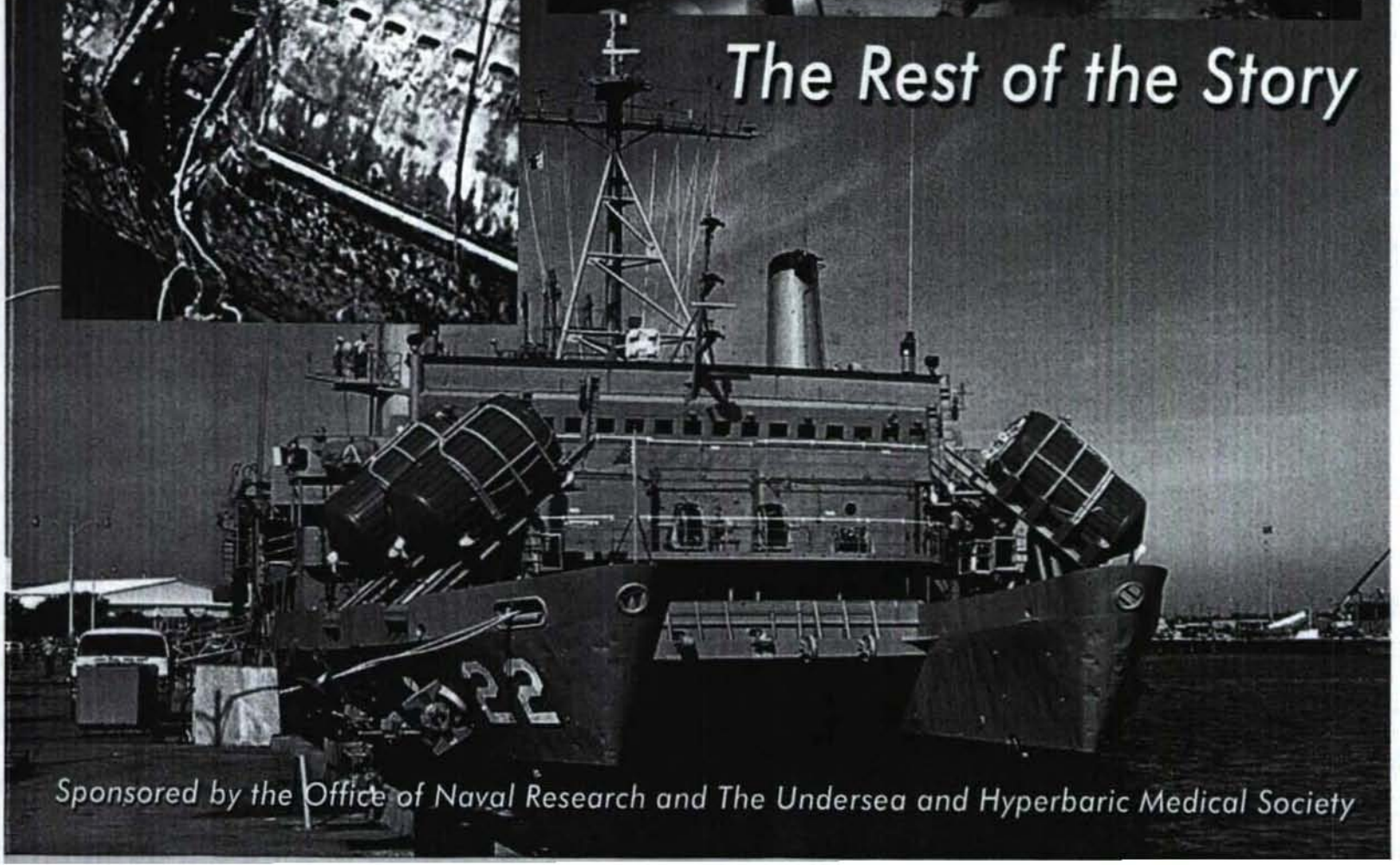
Naval Forces Under the Sea





The Rest of the Story



Sponsored by the Office of Naval Research and The Undersea and Hyperbaric Medical Society

REPORT DOCUMENTATION PAGE

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This book is a collection of information and oral histories of the U. S. Navy undersea technology during the 20th century. The oral histories are of those considered among the leaders in advancing U. S. Navy undersea technology.

15. SUBJECT TERMS

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Naval Forces Under the Sea

THE REST OF THE STORY

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1908
(RN) ADMIRALTY report on deep diving (John Scott Haldane)





25 March 1915
The first US submarine sank, USS F–4 (SS-23), just 1½ miles off Honolulu in over 300 feet. All 21 crew members drowned.

April–August 1915
Salvage of USS F–4 with record setting air dives.





12 October 1900
First USN submarine USS Holland (SS–1)

1912
Chief Gunner George Stillson began experimental diving program at Brooklyn Navy Yard to test Haldane's diving tables and stage decompression



25 September 1925
USS S–51 sank off Block Island after a collision with the steamship City of Rome. Three survivors escaped before S-51 settled on bottom at 132 feet with 33 casualties.



1924
US Navy and Bureau of Mines began study of helium-oxygen mixtures for diving in Pittsburgh, PA

1916
Navy diving school established in Newport, RI

1900 1905 1910 1915 1920 1925



1927
Driven by the need for more divers, Navy Deep Sea Diving School established at the Washington Navy Yard



17 December 1927
After being rammed by USCG Paulding, USS S–4 (SS–109) sank off Provincetown, MA in 104 feet with the loss of 34 officers and crew



25 February 1928
LT Charles B. Momsen demonstrated the escape "lung" at the Washington Navy Yard



ca. 1930
McCann Submarine Rescue Chamber developed.



1937
NEDU conducted record setting dive in chamber to 500 feet with helium-oxygen. Later completed open water dive to 420 feet using MK V Mod 1 Mixed Gas Diving Suit



23 May 1939
USS Squalus (SS-192) sank off Portsmouth, NH in 243 feet. Submarine rescue chamber successfully used in the rescue of 33 crewmembers. Salvage began three days later.



7 December 1941
Japan attacked Pearl Harbor. Massive operation to raise and salvage Pacific fleet.



OSS Maritime established during WWII; began a force of combat swimmers—predeccessors to UDT/SEALs



1942
USS Normandie sank at New York Harbor, Pier 98. Navy salvage school established

1925 1930 1935 1940 1945 1950

January 1960
Bathyscaph TRIESTE reached the deepest ocean's depth; Challenger Deep



1975
Navy Experimental Diving Unit moves to Panama City, FL





1963
USS Thresher (USS 593) sank. All crew lost.

1957
Project Genesis began to investigate the possibility that man could live for extended periods of time at depths under the sea

1963
US Navy's Deep Submergence System Project started to improve submarine search, rescue, and salvage



1964-1969
Project SEALAB

1950 **1955** **1960** **1965** **1970** **1975**



28 January 1986
Space Shuttle Challenger crashed during takeoff. Massive salvage operation followed to investigate cause of accident.

17 July 1996
TWA 800 crash. Massive salvage operation investigated cause.



13 January 1982
Air Florida Flight 90 crashed during takeoff from Washington National Airport

1975 1980 1985 1990 1995 2000

Naval Forces Under the Sea

THE REST OF THE STORY

United States Navy



The publication of this collection of oral histories from individuals who made significant contributions to the advancement of undersea naval technology during the 20th century was funded in part by a grant from the Office of Naval Research. Grant No. N00014-02-1-0992

Disclaimer:
The views, opinions, and findings contained herein are those of the contributors and should not be construed as the official government position, policy, or decision unless so designated by other official documentation.

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TABLE OF CONTENTS

Message from the Planning Committee x

Planning Committee xi

Introduction xii

Participants & Contributors xiii

The Early Years 1

Special Warfare and EOD Operations 37

Genesis and SEALAB 93

Ship Salvage 167

Deep Submergence Operations 195

Naval Research 237

Harbor Clearance Unit 247

NEDU Celebrates 75 Years 257

Other Saturation Diving Related Topics 265

Submarine Rescue and Escape 295

US Navy and Royal Navy Cooperation/Exchange 347

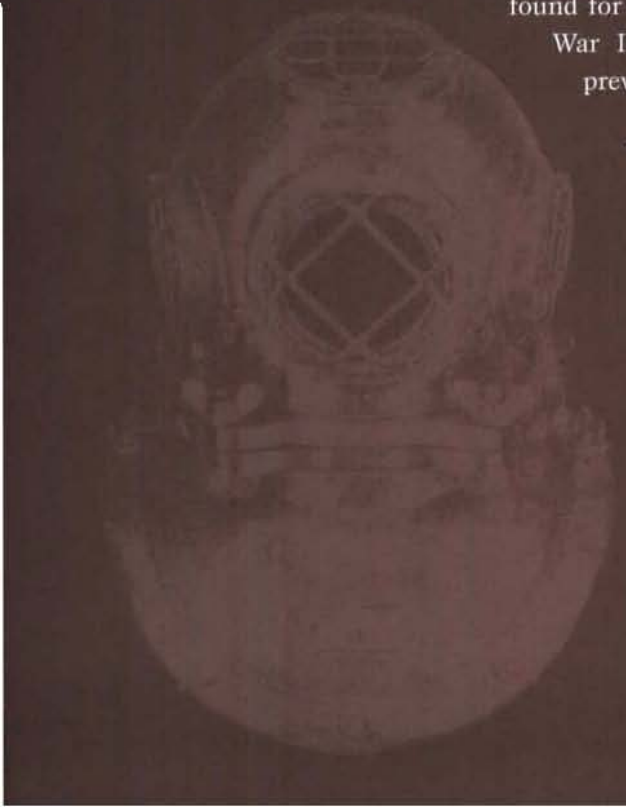
Marine Mammal Research 363

Indices 389

Message from The Planning Committee

It is hard to believe that over five years have passed since the US Navy held the "Naval Forces Under the Sea" symposium at the United States Naval Academy in Annapolis, MD. In addition to literally bringing together a "who's who" in undersea warfare, this three-day event, held from 27-29 March, 2001, allowed the retelling of many historical events in submarine rescue, special warfare, and diving and salvage, told first hand by many of the heroes who were involved. The symposium proceedings, *Naval Forces Under the Sea: A Look Back, A Look Ahead*, and special video recordings of several oral histories made concurrently with the symposium, helped to record many untold stories and detail a large block of previously undocumented naval history. By all feedback from the over 700 participants at this event, "Naval Forces Under the Sea" was a huge success. Yet, even before the symposium closure, it became obvious that a large part of the history could not be recorded in the limited time available—the rest of the story remained untold.

Since "Naval Forces Under the Sea," and with the continued support of the Office of Naval Research, 15 individuals comprising the Planning Committee volunteered their time in an attempt to fill in many of the gaps left by the symposium in the history of undersea warfare from 1900 to the present. The Committee went about this labor of love by conducting over 66 personal interviews across the country, consisting of over 1,000 hours of oral recordings, many with individuals who either did not have the opportunity to tell their stories at the symposium, or who, for health or personal reasons, were unable to attend. We felt a certain sense of urgency as we undertook this task since we realized that several of the initial participants from the 200l symposium had already passed from this life, or because of poor health were no longer able to tell their stories. Where no survivors could be found for interviews, particularly to document the early years before World War II, we painstakingly researched available publications, including previously recorded oral histories.



What at times seemed to be an insurmountable task, *Naval Forces Under the Sea: The Rest of the Story* has been well worth the effort. It tells the history of naval undersea warfare since the introduction of the first US submarine, USS *Holland* (SS-1), on 12 October 1900. But it is more than just a history book. By using literal excerpts from the numerous interviews, much of the book consists of a living history, told in story fashion by those who made this history. *The Rest of the Story* preserves this history to be retold again and again to future generations.

M. Lew Nuckols, PhD, PE
Planning Committee Co-Chairman

The Planning Committee

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Introduction

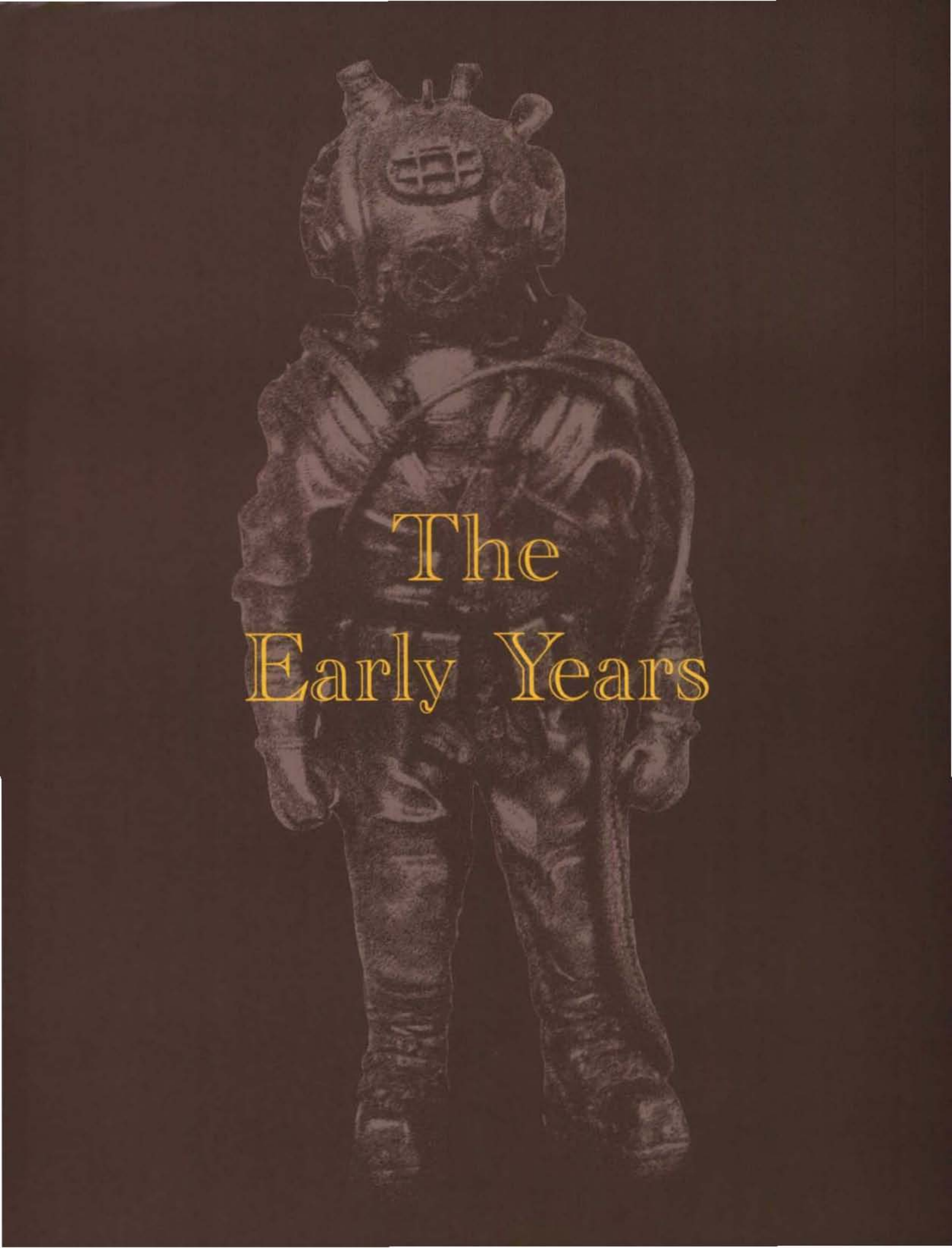
Naval Forces Under the Sea: The Rest of the Story is a continuation of the symposium of the same name that was held at the US Naval Academy, Annapolis, MD, USA, from the 27th through the 29th of March, 2001. The symposium was heralded by many as the greatest underwater meeting and can never be duplicated. Many, if not most, of the "giants" of underwater activity during the past half-century were invited speakers and, while they did an exceptional job of condensing their very colorful and eventful careers into 20–30 minute presentations, it was clear that most of their stories remained untold. It is the intent of this book to record the portions of the US Navy's undersea story that were left untold, and to give details of the whole story to include how man, through the US Navy, challenged the oceans' depths–how they sometimes lost and how they sometimes won.

Much of this text includes information collected from these outstanding figures' oral histories and checked for accuracy to the best of the editorial committees ability, with the highest standards in mind. However, some information is solely based on oral history qualitative research, and may be arbitrary in some instances. Also, the choice to include some interviewees and exclude others is solely the responsibility of the US Navy and does not reflect any preference on the part of the editors. Interviewees may have been chosen for a variety of reasons, which included but not limited to: availability, merit, and for their interest and importance. The US Navy has incorporated as many key figures as possible and assures readers their mission is to thoroughly convey the rest of the story of US Naval undersea history.



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The Early Years

The early history of diving in the US Navy is closely associated with the development of the submarine for undersea warfare. Although some diving was required in the US Navy prior to 1900, mostly ship husbandry and shallow salvage operations, a new mission emerged for divers after the delivery of the first US submarine, USS *Holland* (SS-1), 12 October, 1900.

In the early 1900s, Navy divers were qualified by the hundreds at the Naval Torpedo Station at Newport, RI, to support the practice of torpedo[1] firing during submarine training exercises. These torpedoes were designed to make a buoyant ascent at the completion of their run; however, it was not uncommon for errant torpedoes to sink, necessitating divers to locate and recover them. In some cases, the divers had to excavate torpedoes buried in mud on the sea bottom. One faulty torpedo was reported to have buried itself in 22 feet of mud, creating severely hazardous diving conditions with frequent cave-ins.[2] Divers gained valuable experience in excavating the torpedoes using water hoses and nozzles. This experience later helped out with tunneling operations to attach lifting pontoons beneath sunken submarines.

A manual for diver training at the Naval Torpedo Station, dated 1905, described the qualifications the Navy was looking for in their divers, including men who were:

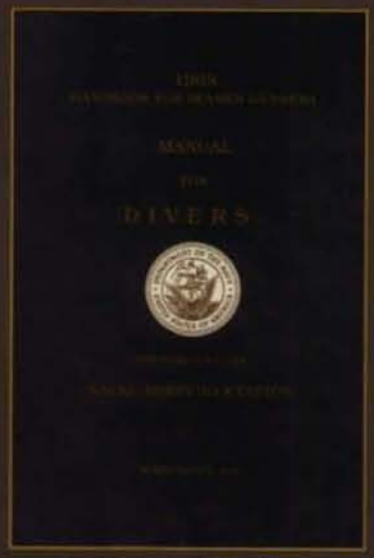
a) Cool-headed, calm, and of a phlegmatic temperament.
b) In good health, have a strong constitution, and the action of the lungs to be normal.
c) Not short-necked, full-blooded, or with a tendency to nosebleed.
d) Not to have bloodshot eyes, or a high color on the cheeks, caused by the interlacement of numerous small but distinct blood vessels.
e) Not to be very pale, nor have lips more blue than red, nor be subject to cold hands or feet.
f) Not to perspire freely.
g) Not to be affected with cough, asthma, or catarrh.
h) Not to be subject to headaches or dizziness, or affected with deafness.
i) Not to be hard drinkers, nor have suffered frequently or severely from venereal disease, or have had sunstroke or rheumatism.
j) Not to have been subject to palpitations of the heart or fainting spells.
k) Not at any time to have spat or coughed up blood.[3]



12 October 1900. First USN submarine, USS Holland *(SS-1).*



At work on the USS Holland



1905 Manual for Divers

The manual went on to say that "men who have long trunks with well developed chests and loins generally make good divers."

A prerequisite for taking the diving course at the Torpedo School was enrollment in seaman gunner's class. Other than the two weeks of diver training, most of the eight-month school was spent learning torpedoes, air compressors and mines.

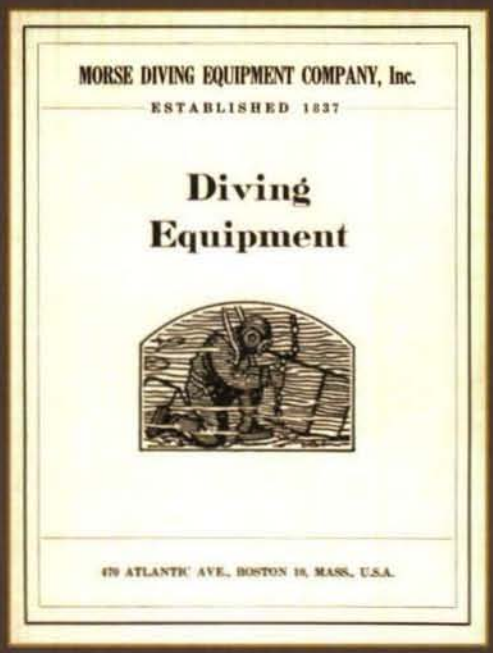
The diving course in Newport was taught by Chief Gunner's Mate Jacob Anderson while he was in the Navy, and later as a civilian instructor. The two weeks of diver training consisted of in-dressing, undressing, and diver tending, followed by a minimal number of dives to 60 feet. If the diver could stay down twenty to thirty minutes at a depth of 60 feet he was marked as a "qualified diver."

Little training was given at the time to perform an actual task on the bottom with tools, and rarely were dives made below 60 feet. This school was closed at the start of World War I, since all available divers were needed in the fleet.

The early diver training in the Navy used commercial diving equipment made by either A. J. Morse & Sons in Boston or A. Schrader in New York. The diving suits had changed little since Augustus Siebe introduced his "closed" diving dress in 1837. The suit consisted of vulcanized rubber surrounded on each side with cotton twill, reinforced at heavy wear regions with chafing patches. The neck of the dress was fitted with a rubber collar, which had holes punched to connect it to a breastplate by studs. In addition, elastic rubber cuffs were attached to the sleeves of the suit to provide watertight wrist seals, leaving the hands exposed to the water.[2]

The helmet and breastplate were constructed from tinned copper. Although the earliest helmets were bolted to the breastplate, they were later attached by means of an interrupted screw to speed up the dressing process. The first official Navy dive manual, published in July, 1916, described five different helmets in general use by the Navy at that time, including:[3]

a) Mark I—a bolt type helmet with a wide breastplate manufactured by A. J. Morse & Sons, Inc. of Boston, MA. Its faceplate was screwed into the front of the helmet with oval windows positioned in the top and two sides. It had a "Morse" type regulating escape valve, a telephone, and safety check valve.





Mark I helmet with bolt connection breastplate

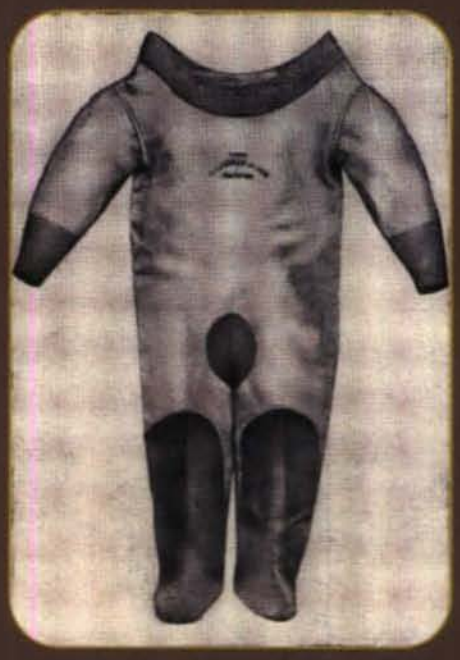
b) Mark II—the Mark II was manufactured by A. Schrader's Son, Inc. of Brooklyn, NY. It replicated the Mark I except that the top and side windows were round rather than oval.
c) Mark III—the Mark III was exactly like the Mark I, except that Morse & Sons replaced the bolt type helmet with an interrupted screw connector.
d) Mark IV—was the same as the Mark II except that Schrader also replaced the bolt type helmet with an interrupted screw connector.
e) Mark V—By 1916, the Navy Bureau of Construction and Repair adopted as standard what would become the icon for deep sea diving. The Mark V Deep Sea Diving helmet consisted of an interrupted screw type connector, and, for the first time, a hinged faceplate. It also had a narrow breastplate, an improved regulating escape valve, an oval top window and two round side windows, and an improved telephone connection.

Air was delivered to the diver's helmet through an umbilical connected to a hand powered pump on the surface.

The amount of air that could be supplied by the surface pump restricted diving to maximum depths of approximately 80 feet. This relatively shallow depth capability, coupled with short bottom times, generally avoided the need for decompression. All communications between the diver and the surface tender were made by pull signals on the air hose and life line.

In a 1931 article in the *Naval Institute Proceedings*, Lt. Henry Hartley, then the Commanding Officer of the Deepsea Diving School in Washington, DC, described a typical diving operation in the early 1900s as follows: "Twenty-five years ago the diver climbed over the side of a launch and hung on to a ladder, the attendants helping him, lifting his legs over the gunwale.

"His diving dress was bolted rigidly to the breastplate. The helmet was off. His belt was placed and the straps buckled. One tender held the life line, a 2.5-inch cable-laid manila secured about the body under the arms; a second tender held the air hose. The faceplate was moistened with vinegar, to prevent fogging, and the helmet was screwed in place.



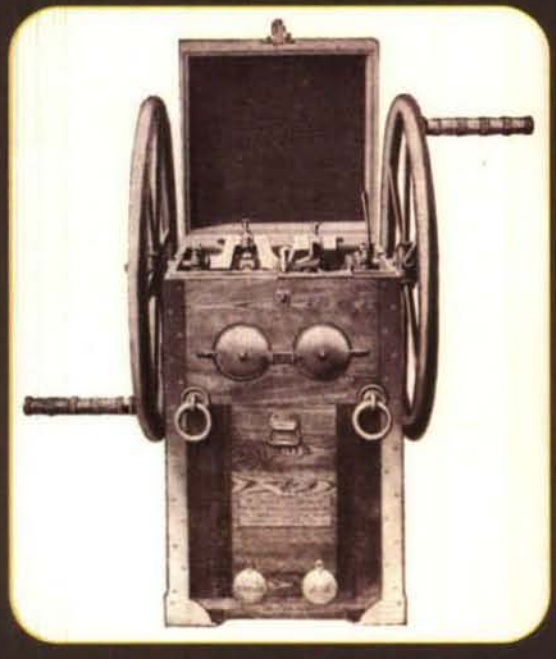
Morse Style 101 Dress



Hard hat diver with life line, hose, pump, and suit.



Shallow Water Air Pump



Air Pump limited to 80 feet

"The diver climbed down the ladder and slid down his descending line. Reaching the bottom, he gave one jerk on his lifeline, meaning 'On the bottom.' All communication on the bottom and until his return to the surface was carried on by pull signals on his air hose and life line.

"The usual purpose of the dive was to search for lost objects in water up to about 80 feet (though his qualifying depth attained in the gunnery school was 60 feet) or he might be clearing a strainer or cleaning a propeller."[6]

Between 1905 and 1907, John Scott Haldane, a British physiologist, was commissioned by the Royal Navy to extend the practical operating depth limits for divers and to establish a method of decompressing divers in stages. In 1908, the landmark paper published by Haldane and his colleagues, Arthur E. Boycott and Guybon C. Damant, entitled "The Prevention of Compressed-Air Illness," laid the foundation for air diving to depths beyond 200 feet.

In 1912, the US Navy began an experimental program at the Brooklyn Navy Yard to test Haldane's diving tables and stage decompression methods. Over the next three years, a small group of hand-picked, experienced divers, under the direction of Chief Gunner George D. Stillson,[7] gradually increased the maximum depths of diving operations. Eventually, they exceeded 270 feet in open water dives in Long Island Sound. It was during this experimental program that Stillson's divers made gradual improvements to the Morse and Schrader diving suits and helmets (Mark I, II, III, and IV), including the addition of a telephone communications system between the diver and tender, a supplementary air relief valve, called a spitcock, to allow better control of air volume in the suit, and a safety lock to ensure that the helmet would not detach from the breastplate while submerged. This modified rig was officially designated as the Navy Mark V Deep-Sea Diving helmet in 1913, although it was continually improved upon over the next 10–15 years.[8] Most importantly, a more efficient means of providing air to the diver's helmet was achieved.

Lt. Hartley stated in his 1931 assessment of Navy diving, "The most important stride that has been made during the past quarter century (1906–1931) in furthering diving is the substitution of high-pressure compressed air carried in special containers or torpedo air flasks, and using of power-driven compressors for furnishing the diver air supply. The amount of air that could be furnished by the hand powered pump restricted diving to depths of about 80 feet."[9]

NAVY STANDARD DECOMPRESSION TABLE
(using Compressed air)

Depth of dive (Feet)	Time from leaving surface to beginning of ascent for regular decompression or to reaching first stop for surface decompression. (Minutes)	Stops at different depths in minutes: Feet 60	Feet 50	Feet 40	Feet 30	Feet 20	Feet 10	Total time of decompression: sum of times at various stops. (Minutes)	Approximate total time for ascent; column 4 plus time between stops. (Minutes)
40	120	.....	.....	.....	.....	.....	0	0	1
40	180	.....	.....	.....	.....	.....	2	2	3
40	Opt.* 240	.....	.....	.....	.....	.....	4	4	5
40	300	.....	.....	.....	.....	.....	6	6	7
50	78	.....	.....	.....	.....	.....	0	0	2
50	120	.....	.....	.....	.....	.....	2	2	4
50	150	.....	.....	.....	.....	.....	5	5	7
50	Opt.* 190	.....	.....	.....	.....	.....	9	9	11
50	300	.....	.....	.....	.....	.....	12	12	14
60	55	.....	.....	.....	.....	.....	0	0	2
60	75	.....	.....	.....	.....	.....	2	2	4
60	110	.....	.....	.....	.....	.....	13	13	15
60	Opt.* 150	.....	.....	.....	.....	5	15	20	22
60	180	.....	.....	.....	.....	7	16	23	25
60	210	.....	.....	.....	.....	8	18	26	28
70	42	.....	.....	.....	.....	.....	0	0	3
70	60	.....	.....	.....	.....	.....	4	4	7
70	75	.....	.....	.....	.....	.....	13	13	16
70	90	.....	.....	.....	.....	4	16	20	23
70	Opt.* 120	.....	.....	.....	.....	13	16	29	32
70	150	.....	.....	.....	.....	18	21	39	42
70	180	.....	.....	.....	.....	21	32	53	56
80	35	.....	.....	.....	.....	.....	0	0	3
80	50	.....	.....	.....	.....	.....	6	6	9
80	70	.....	.....	.....	.....	16	14	30	33
80	100	.....	.....	.....	.....	20	16	36	39
80	Opt.* 115	.....	.....	.....	.....	22	26	48	51
80	150	.....	.....	.....	.....	28	29	57	60
90	30	.....	.....	.....	.....	.....	0	0	3
90	45	.....	.....	.....	.....	.....	6	6	9
90	60	.....	.....	.....	.....	4	16	20	24
90	75	.....	.....	.....	.....	18	14	32	36
90	Opt.* 95	.....	.....	.....	2	27	21	50	53

The US Navy's first standard decompression table by Haldane, used in early 1912. Note the difference in depth and time with the present US Navy Standard Air Table:

40 feet 200 minutes
50 feet 100 minutes
60 feet 60 minutes
70 feet 50 minutes
80 feet 40 minutes
90 feet 30 minutes



Amplifier Type Telephone



Amplifier and tender's reproducer



Helmet Relief Spitcock



Helmet Safety Lock



Portable 9DM Air Compressor



Medal of Honor citation of Chief Gunner's Mate Frank W. Crilley

"For display of extraordinary heroism in the line of his profession above and beyond the call of duty during the diving operations in connection with the sinking in a depth of water 304 feet, of the USS *F-4* with all on board, as a result of loss of depth control, which occurred off Honolulu, T.H., on 25 March 1915. On 17 April 1915, William F. Loughman, chief gunner's mate, US Navy, who had descended to the wreck and had examined one of the wire hawsers attached to it, upon starting his ascent, and when at a depth of 250 feet beneath the surface of the water, had his lifeline and air hose so badly fouled by this hawser that he was unable to free himself; he could neither ascend nor descend. On account of the length of time that Loughman had already been subjected to the great pressure due to the depth of water, and of the uncertainty of the additional time he would have to be subjected to this pressure before he could be brought to the surface, it was imperative that steps be taken at once to clear him.

Instantly, realizing the desperate case of his comrade, Crilley volunteered to go to his aid, immediately donned a diving suit and descended. After a lapse of time of 2 hours and 11 minutes, Crilley was brought to the surface, having by a superb exhibition of skill, coolness, endurance, and fortitude, untangled the snarl of lines and cleared his imperiled comrade, so that he was brought, still alive, to the surface."

Frank William Crilley was born in Trenton, New Jersey, on 13 September 1883. Following enlistment in the Navy in March 1900, he became a gunner's mate and received additional training as a diver. In 1915, while a chief gunner's mate, he made dives to over 300 feet during salvage operations on the sunken submarine *F-4* (SS-23) off Honolulu, Hawaii. On 17 April 1915 he rescued a fellow diver who had become entangled at a depth of 250 feet. For his heroism on this occasion, he was awarded the Medal of Honor in 1929. In 1917, Crilley was appointed to the rank of gunner (T), and in February, 1918, became an ensign in the Naval Reserve. He commanded USS *Salvor* in 1919 and left active duty in July of that year. In the mid-1920s, he was involved with salvaging USS *S-51* (SS-162), and returned to active Naval service in 1927-28 to work on the recovery of USS *S-4* (SS-109). He was awarded the Navy Cross for his actions as a diver during that operation. In 1931, Frank Crilley served as second officer and master diver during the Arctic expedition of the civilian submarine *Nautilus*. Also in 1931, he assisted with the salvage of USS *Mayflower* (PY-1). Transferred to the Retired List in May 1932, he was again employed on Navy work in 1939, during the salvage of USS *Squalus* (SS-192). Ensign Frank W. Crilley died at the Naval Hospital, Brooklyn, NY, on 23 November 1947. USS *Crilley* (YHLC-1), 1967–1993, was named in honor of Ensign Frank W. Crilley.[18]

THE FIRST US SUBMARINE DISASTER

The first 15 years of the US submarine force were relatively uneventful. In contrast to the multi-day operations of today's nuclear fleet, space limitations on these relatively small boats, and the short operational range of early submarines, dictated short daily training exercises lasting only a few hours. Few of these early submarines had galleys, bunks, or even toilet facilities.[10] The Navy gave little attention to rescue methods in the event of accidental sinkings during these early years. After all, the submarine was relatively new and unique, and only 17 had ever been lost worldwide, none in the United States.

This all changed dramatically on March 25, 1915 when the USS *F-4* (SS-23) became the first US submarine to sink. It was just 1½ miles off the coast of Honolulu, in over 300 feet of water, with a crew of 21 men, including its commanding officer, Lt. Alfred Louis Ede. The US Navy was faced with a rescue operation for which it had practically no experience. It readily became apparent that the only chance for rescuing the *F-4* crew was for divers to attach heavy lifting cables to the hull to raise it to the surface. Unfortunately, the *F-4* sat at a depth never before reached by divers. Although the Navy quickly realized that rescue would be impossible, it decided to spare no time or expense to salvage the *F-4* to learn the cause of the sinking.



USS F-4 was the first US submarine sinking, off Honolulu, Hawaii, in March, 1915.

Chief Gunner Stillson's crew was sent as a unit to Honolulu, along with eight specially designed salvage pontoons built at the Mare Island Navy Yard, north of San Francisco. The experience gained from Chief Stillson's three-year experimental diving program, still in progress at the Brooklyn Navy Yard, was instrumental in successfully raising the *F-4* after five grueling months.

During the salvage operation, Chief Gunner's Mate Frank Crilley became the first diver to reach a depth of 306 feet on air; two other divers also matched this feat later in the salvage operation. The severe exposures that these divers faced were highlighted on 17 April when Chief Gunner's Mate William F. Loughman became fouled at 250 feet and suffered severe decompression sickness and oxygen poisoning.[11] The heroic acts of Frank Crilley to clear Loughman after 2 hours and 11 minutes and bring him unconscious back to the surface were recognized with the first Congressional Medal of Honor for a Navy diver.

This unprecedented salvage operation provided the US Navy experience in several new salvage techniques, such as the use of lifting pontoons to float sunken objects. Most remarkable, however, is the success of salvaging the *F-4* in over 300 feet of water using air as a breathing medium; this feat still stands as the US Navy's deepest air diving salvage operation. A Navy investigating board later attributed the *F-4* sinking to seawater seeping into a battery compartment caused by corrosion of rivets in the tank's lead lining.

"As the sea valves of the ballast tank were opened as usual, additional water entered the hull, probably to the extent of several tons. This caused the boat to sink to a bottom depth of 288 feet within two to four minutes, where the water pressure was so enormous as to open her seams."[12]

The aftermath of Stillson's experimental diving program and the *F-4* salvage led to the publication of the first US Navy Diving Manual and the establishment of a Navy Diving School at Newport in 1916.

Even though the US Navy began to recognize the importance of divers to complete these difficult salvage operations, it would take more tragedy before the Navy gave serious consideration to establishing rescue methods from a sunken submarine. "Until (LCDR Swede) Momsen's advent [development of the escape lung and rescue chamber in 1928], scant



Chief Gunner George Stillson began an experiemental diving program in 1912 to test Haldane's tables.



Escape lung training on the USS V-5 (USS NARWHAL) in July 1930.



Vice Admiral Charles B. Momsen, USN (Retired), (1896–1967)

Charles Bowers Momsen was born in Flushing, Long Island, NY, on 21 June 1896. He attended the US Naval Academy, graduating with the Class of 1920 in June, 1919. Following initial service in battleships, he was trained as a submarine officer and commanded three submarines in 1923–27. Following those commands, Momsen was assigned to the Bureau of Construction and Repair. In 1929–32 he was actively engaged in the development of a submarine escape breathing apparatus that came to be known as the "Momsen Lung."

During the remainder of the 1930s, he held positions in submarines and surface ships and was in charge of Navy Experimental Diving. In 1939, Commander Momsen was involved in the salvage of the sunken submarine USS *Squalus* (SS-192). During World War II, he led two submarine squadrons, including service at sea as a "wolf pack" commander, and held other important staff and training positions. Captain Momsen was commanding officer of the battleship USS *South Dakota* in December 1944–July 1945.

During 1945–51, Rear Admiral Momsen administered the Japanese merchant marine, was commandant of the Naval Operating Base at Guam, served on the Navy's General Board and was Assistant Chief of Naval Operations for Undersea Warfare. In May 1951, he took command of the Submarine Force, Pacific Fleet, holding that position until June 1953, when he became Commandant of the First Naval District. He was Commander, Joint Task Force Seven from April 1954 until September 1955, when he retired with an increased rank on the basis of combat awards. Vice Admiral Charles B. Momsen died on 25 May 1967.[65]

attention was paid to the question of saving submariners. They simply took their chances. If their boats sank, as they did with nerve-racking regularity, the fortunate ones died quickly, by drowning."[13]

Nevertheless, changes continued to be made to the deep sea diving suits to improve safety as a result of the *F-4* salvage. "Flaps with lacings were fitted to the rear side of the legs, and so arranged that they permit lacing the legs up tight, to prevent the accumulation of air in the lower portion of the suit; this was a very valuable addition, as it not only lessens the danger of blowing up, but also prevents the diver from capsizing, decreasing the chances of drowning the diver in case of blowing up."[14]



US Navy Dress (Front)



US Navy Dress (Back)



"Swede" Momsen demonstrating an early escape lung (Courtesy of Helen Hart Momsen).

About this time, the extreme depths to which divers were now going on air caused an unexplained malady to appear. For example, during the salvage of the *F-4,* divers would appear to become intoxicated as they traveled to the bottom. Often referred to as "oxygen intoxication," the narcotic effects of nitrogen would not be fully understood until the 1930s.[15] However, the experience gained in the deep *F-4* salvage highlighted the extreme physiological limitations of breathing air.

In 1924, the US Navy partnered with the Bureau of Mines in Pittsburgh, PA, to conduct a series of experiments using helium-oxygen mixtures to replace air as a breathing gas supply for deep diving. These initial studies, led by Chief Gunner Clarence L. Tibbals, clearly showed significant advantages of breathing helium-oxygen mixtures rather than air in deep diving. Not only were these mixtures found to eliminate the intoxicating effects experienced when breathing air, but they also appeared to shorten decompression times.

Despite these favorable results, diving with helium-oxygen mixtures did not see wide acceptance in the US Navy until the late 1930s.[16] Lt. Henry Hartley expressed the prevailing opinion of most divers during this era: "The use of synthetic gases (helium) has been more or less experimented with since 1924, and has not given any satisfactory results."[17]

In fact, the predominant attitude of the submarine community following the *F-4* tragedy was still apathy toward using diving as a means for rescue in future submarine sinkings. "We don't need you. If anything happens to us, we'll take care of ourselves or we'll stay there."[19] This was not an uncommon response when the role of Navy diving was discussed as a potential escape tool with submariners. This attitude is perhaps understandable, because in the 10 years immediately following the *F-4* sinking, there were at least nine submarine accidents, only one in which the crew members benefited from diving.[20]

- On January 15, 1916, an explosion occurred aboard the USS *E-2* (SS-25) while undergoing a scheduled overhaul at the New York Navy Yard.[21] Four crewmen were killed and seven others injured when hydrogen gas released during battery charging was ignited by a spark. The submarine remained afloat, and divers were not required.
- Nearly two years later, on 17 December 1917, the USS *F-1* (SS-20), a sister ship of the ill-fated *F-4*, collided with another sister ship, USS *F-3* (SS-22), while making surface runs off San Clemente Island, CA, during a heavy fog.[22] A large hole forward of the engine room caused the *F-1* to sink in about 10 seconds in 600 feet of water with 19 of the 22 crewmembers onboard going to the bottom. Because of the extreme depth, far beyond the capability of divers at that time, no attempt was made to raise the *F-1*. The potential for such a tragedy occurring in the future was viewed as the risk that submariners had to take, and that diving would be of little help. Incidentally, a short time after this disaster the US Navy declared all of the F-class submarines defective and dangerous, and they were decommissioned.
- The USS *H-1* (SS-28) went aground during surface operations on 12 March 1920 off Magdalena Bay, Mexico.[23] Four men, including the commanding officer, were killed in an attempt to swim to shore. The remaining 21 crewmembers were rescued on the surface before the *H-1* sank during attempts to pull it from the shoal. No attempts were ever made to salvage the *H-1*.

- The first submarine accident that occurred after the *F-4* where divers could have possibly made an impact occurred on 1 September 1920.[24] While on maneuvers, 55 miles off the Delaware Capes, the USS *S-5* (SS-110) sank because of flooding through the main induction valve when the man responsible for closing the valve during a practice "crash dive" was momentarily distracted. After considerable difficulty, all compartment valves were closed except for the valve to the forward torpedo room, making the boat bow heavy. The water from the initial flooding in the motor room and the forward torpedo room caused the *S-5* to settle on the bottom at 194 feet. The situation initially appeared hopeless because the crew had little hope of being located in time for divers to be of any assistance. After blowing the aft ballast and fuel tanks, however, the stern became buoyant enough to rise 17 feet above the surface while the bow rested on the bottom. The SS *Alanthus*, a steam-powered liberty ship, spotted the stern of the *S-5* and summoned assistance from the steamship SS *General Goethals*. Remarkably, after being trapped for 51 hours, all crewmembers were able to exit safely through the hole in the hull! This successful rescue only further fueled the opinion that divers were not necessary for submarine safety. During an attempt to tow the crippled submarine to shore, it sank in deep water. No salvage attempts were made.
- A similar success story occurred on 7 December 1921, when the USS *S-48* (SS-159) sank in Long Island Sound while conducting sea trials prior to being commissioned.[25] During a test dive off Penfield Reef, a manhole plate in one of the aft ballast tanks was left unsecured, and the *S-48* sank in 60 feet of water. The crew successfully blew the forward ballast tanks and brought the bow to the surface. All personnel were able to escape through a torpedo tube and returned safely to shore! Again, the role of the diver in submarine rescue was not apparent. Incidentally, the *S-48* holds the distinction as being the only US submarine to have been involved in two major accidents. Nearly 3 years after being raised from the first accident, and eventually commissioned, the ill-fated *S-48* ran aground off the New Hampshire coast during a heavy snowstorm. The entire crew was again successfully rescued, this time by Coast Guard lifeboats.
- Three major accidents occurred on US submarines in 1923. Two of these occurred on the surface while in port. On 17 July 1923, the engine room of the USS *S-38* (SS-143) was flooded in port in Anchorage, AK, when a crew member accidentally removed a valve cover below the waterline while performing routine maintenance.[26] Fortunately, all crewmembers were able to safely escape.
- In another harbor accident, on 10 October 1923, the sister submarine USS *S-37* (SS-142) suffered a severe explosion in the after battery compartment while recharging batteries at port in San Pedro, CA.[27] Three crewmembers were killed and two others were seriously injured during the explosion.
- Just a couple weeks later, on 28 October 1923, the USS *O-5* (SS-66) was rammed by the merchant steamer SS *Abangarez* in Limon Bay outside the entrance to the Panama Canal. It settled to the bottom 30 feet below the surface in less than a minute, with the loss of three men killed outright in the sinking while sixteen others escaped.[28] Two other crewmembers spent many hours trapped in the forward torpedo room of the sunken *O-5* until divers were able to connect lifting lines to the bow to allow it to be raised above the surface using two of the Panama Canal's giant floating cranes.[29] At that time the two crewmembers were able to exit to safety through a forward hatch.



USS O-5 off Provincetown, MA, during sea trials.

Finally, the *O-5* incident demonstrated that divers could be of some benefit to submarine rescue. Unfortunately, funds were scarce during the post WWI years, and diving resources in the US Navy were few. In 1924, "the only diving at that time to amount to anything was located around Newport, where divers' main job was recovering lost torpedoes from the practice range, typically at depths less than 100 feet."[30]

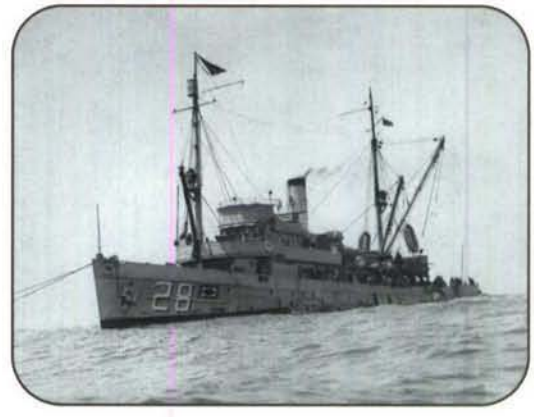
The primary resource for submarine rescue and salvage was a converted minesweeper, the USS *Falcon*, stationed at the Brooklyn Navy Yard. When Lt. Henry Hartley reported as commanding officer in 1924, the *Falcon* was in a bad state: "dirty, torn apart for repair, crew was helter-skelter bunch."[31] More importantly, there were only a few divers onboard.

The state of Navy submarine rescue and salvage capabilities was clearly demonstrated to the public eye in the fall of 1925. On the evening of September 25, 1925, the USS *S-51* (SS-162) was struck in Long Island Sound, approximately 15 miles east of Block Island, by the steamship *City of Rome*, opening a large hole on the port side of the battery compartment forward of the conning tower. Three survivors were able to escape from the conning tower before the *S-51* sank to the bottom in 132 feet of water in a matter of seconds with 33 crewmembers aboard.[32] The USS *S-1*, commanded at that time by Lt. Charles "Swede" Momsen, located the *S-51* two miles from the buoy dropped by the *City of Rome*.[33] The impression that this experience left with Momsen would have dramatic impact on submarine rescue in the coming years.

The first divers on site arrived by noon the next day from the Newport Torpedo Station. They were able to attach air hoses to the salvage connections on the side of the *S-51* to pump air from the sister sub *S-50*. Unfortunately, the USS *Falcon* was undergoing an overhaul at the New York Navy Yard, and was not able to get underway until the next morning, 26 September, with only two divers onboard. By the time the *Falcon* arrived at 10:00 that evening, it was apparent that there was little hope for rescuing the *S-51*.

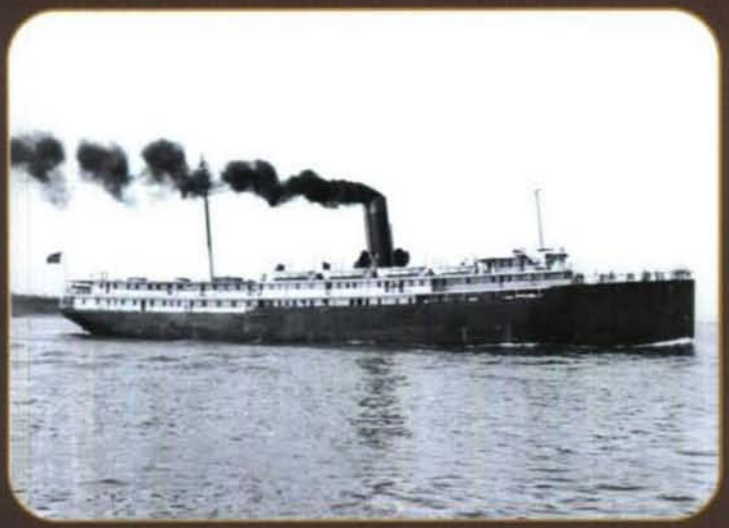
Although the Navy hired a commercial wrecking company to send two 150-ton derrick barges to attempt to lift the *S-51* to the surface, the derrick barges were not able to come to the site until five days after the sinking because of heavy seas. The two derrick barges could not budge the *S-51*; it was obviously flooded. All thoughts for rescue were dashed.

The atmosphere in the country was one of public outrage over the failure of the Navy to be able to rescue the *S-51* crew. Despite the fact that the crew had most likely drowned immediately during the initial sinking, the failure to make a prompt rescue attempt was a political embarrassment for the Navy. The nation's press demanded that the *S-51* be salvaged so that her crew could be given proper burials by their families.



USS Falcon (ARS-2), a minesweeper converted for submarine rescue and salvage.

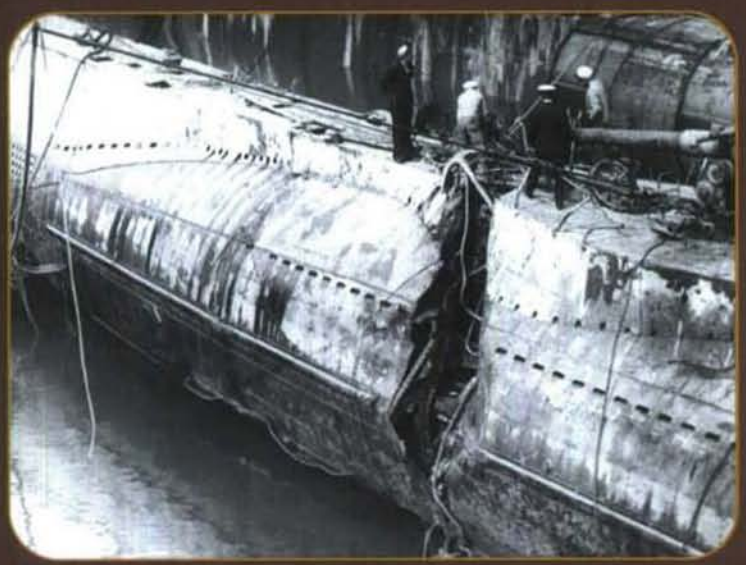
The Sinking of the *USS S-51*



Steamship City of Rome



Two derrick barges conducting operations during recovery of USS S-51



Large hole in port side of USS S-51 *caused by a direct hit by the bow of the steamship* City of Rome



USS S-50, *sister ship to the S-51*



Coming up from a dive, the diver grasped the stage bails and the tenders swung him aboard.



Salvage hatch of USS S-51 in dry dock



Salvage crew



The diver fired a hollow bolt into the hull of the submarine with a cox gun.

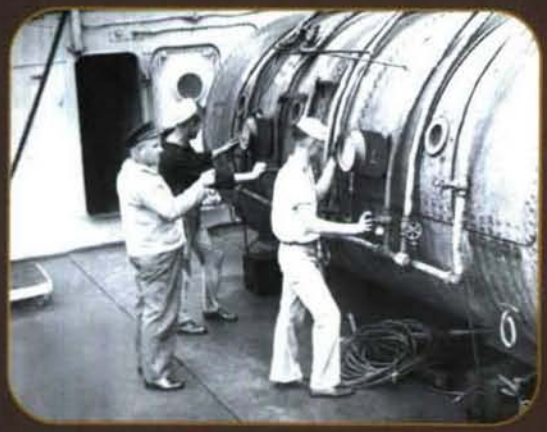
The Navy knew that neither they nor private wrecking companies had the means to raise the *S-51*. No large submarine had ever been raised in deep water in the open sea (the *F-4* salvaged in 1915 had a displacement of 330 tons compared to over 1000 tons displacement for the *S-51*).

Initially, the Navy began to negotiate a salvage contract with a private wrecking company in a very lucrative arrangement for the private company. The Navy was to provide all needed equipment and divers, plus pay the company a considerable sum of money whether the salvage was successful or not. However, the commandant of the New York Navy Yard, Admiral Plunkett, objected. "This is a Navy job! If we can't take care of our own ships, we ought to get out and let some one run the Navy who can!"[34]

To save some level of credibility, the US Navy decided to direct major resources to raise the *S-51* on its own. A salvage fleet was assembled under the command of Capt Ernest King, commandant of New London Submarine Base, including:

- The USS *Falcon*: an ocean-going tug used as a minesweeper during WWI before being converted to the Navy's primary salvage ship. It carried special air compressors for diving, wrecking pumps, a recompression chamber, and special salvage tools.
- The USS *S-50*: sister ship to the *S-51*, was used by the divers to learn the physical layout of the *S-51* and provide high pressure air banks for blowing ballasts tanks.
- The USS *Vestal*: a repair ship with a machine shop, foundry, carpenter shop, and large staterooms to provide berthing space for the salvage crew.
- Two seagoing tugs, USS *Iuka* and USS *Sagamore*, used to help with mooring the *Falcon*.
- The USS *Penobscot*, a small tug, was used to make daily trips to New London, 50 miles away, to ferry supplies and salvage personnel.

Captain Edward Ellsberg, USNR, with the technical assistance of draftsman John Niedermair, was given responsibility to come up with a plan to salvage the *S-51* and tow it 150 miles to the nearest harbor with a suitable drydock, the New York Navy Yard.[35] Unfortunately, there were only a few qualified commercial or Navy divers on the Atlantic coast at that time (practically all of these qualified divers



Exterior view of the "Iron Doctor," the divers' recompression "tank."



Captain Edward Ellsberg with S-51 bell

had received instruction at the Torpedo School in Newport). Of these, only a handful had any deep—beyond 60 feet—wrecking job experience.

When salvage operations were initiated on 14 October 1925, the enormity of the job soon became apparent. With a limited number of divers and inadequate salvage equipment, it became clear that they were in for a long, dangerous, and physically demanding operation. However, the words of Navy Master Diver Robert Sheats, many years later, best sums up how the divers on the *S-51* overcame many of their obstacles: "strength is born through adversity."[36]

Initially, the Westinghouse "sub-mersible" lights kept burning out whenever the divers attempted to enter the sub to close all valves for cabin dewatering because of the pressure on the bottom at 132 feet. The divers modified the design of the lights by adding a vulcanized water-tight sleeve at the site of cable penetration at the base of the light; no further problems occurred with the lights.



Robert C. Sheats,
US Navy Master Diver



The diving lamps illustrated above represent developments in electric lamps for submarine work. Each lamp was furnished with rubber-covered cable, bulbs of 250, 500, or 1000 watts power, and a strong wire reinforced rubber loop so that they could be carried on the diver's arm. Lamps were constructed of spun copper and brass casting with a highly polished chrome finish.







Furthermore, the divers found the salvage pontoons—14-foot diameter cylinders, 32 feet long—unmanageable during raising and lowering attempts to the bottom. No one had ever had any pontoons in deep water. Ellsberg described the initial operations thus: "A somewhat analogous problem would be to lower a heavy Pullman car from the top of a fifteen story building which was swaying violently, due to an earthquake, to the street, in the middle of a black night when you couldn't see the street, nor the car either after you started lowering; and then land the Pullman car in a vacant space in the middle of a train standing on a track in the dark street below without dropping the car on the diner ahead or the car just behind the vacant space."[17]

Even though these heavily reinforced pontoons had flood valves, relief valves, air inflation valves, and vent valves to control the amount of air inside, the divers found that any water in a partially flooded pontoon, with only a single bulkhead, would run to one end and sink the pontoon end first rather than horizontally. Later, the pontoons were modified with two bulkheads; this created a central ballast tank in the center that could be flooded to allow the pontoon to submerge horizontally in a controllable manner.



Similarly, improvements in salvage tools were required to be completed prior to lifting the *S-51* from the sea bottom. The American torch for burning metal underwater was found to be ineffective for clearing cables and debris. Ellsberg invented a hydrogen-oxygen cutting torch that greatly improved the *S-51* salvage operation. In addition, Ellsberg and Niedermair experimented with a method to plug hard to seal ventilation valves in the *S-51* by injecting various cement mixtures into the valves from the surface. They eventually settled on a special quick-setting cement called Lumnite to seal off the valves in the control room prior to dewatering.

Initial attempts were made to dig a tunnel under the keel of the *S-51* amidships using a water nozzle. Although many of the divers had benefited from their earlier experiences with excavating practice torpedoes from the mud bottom with water nozzles at the Torpedo Test Range in Newport, the initial nozzle design was largely ineffective at tunneling in the more dense bottom in Long Island Sound. The reactive forces from the nozzle, when held by the divers, limited the allowable water pressures that could be used during these initial tunneling efforts. This made the tunneling agonizingly slow—only 16 feet of tunneling were achieved after two weeks of diving operations. Later, Machinist's Mate Waldren redesigned the water nozzle to provide a number of smaller ports which discharged water at an angle astern. This minimized the load on the diver and allowed him to work with higher water pressures; with the modified nozzle he could accomplish in one day what had taken weeks before.[38]

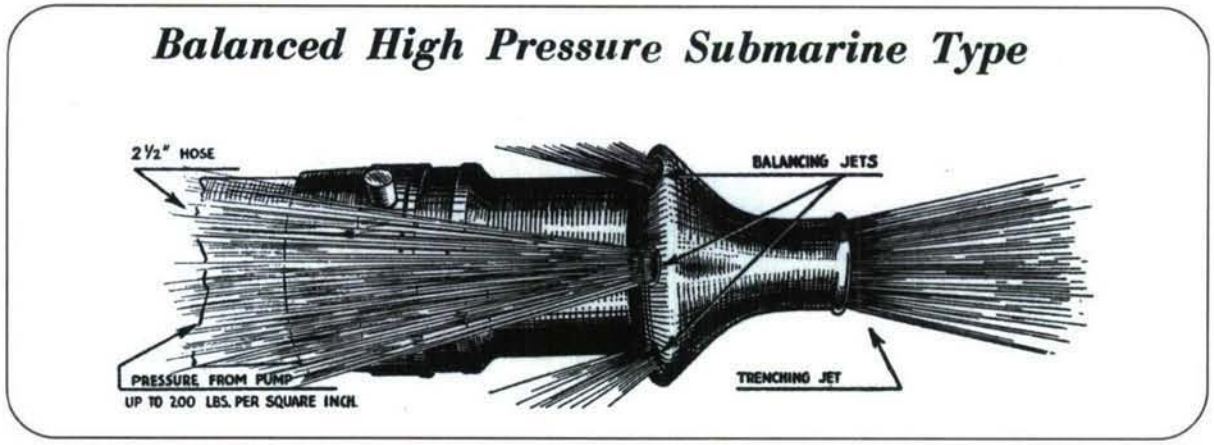
Despite all of these salvage innovations, the operation was still severely hindered by rough seas and intensively cold water. Heavy seas typically allowed only one day of diving operations out of three. "During the *S-51* operation a new type of molded threestall glove with stockenet-cloth gauntlet was devised; this glove was cemented direct to the sleeve of the dress in lieu of the cuff, and gave excellent results."[39] Even with the new gloves, the cold water still made hands numb and useless for tasks requiring any level of manual dexterity. Finally, diving operations were secured for the winter on 30 November 1925, after interruptions of air flow to the divers' helmets became a common occurrence as a result of freeze-ups due to condensation in the air hoses.



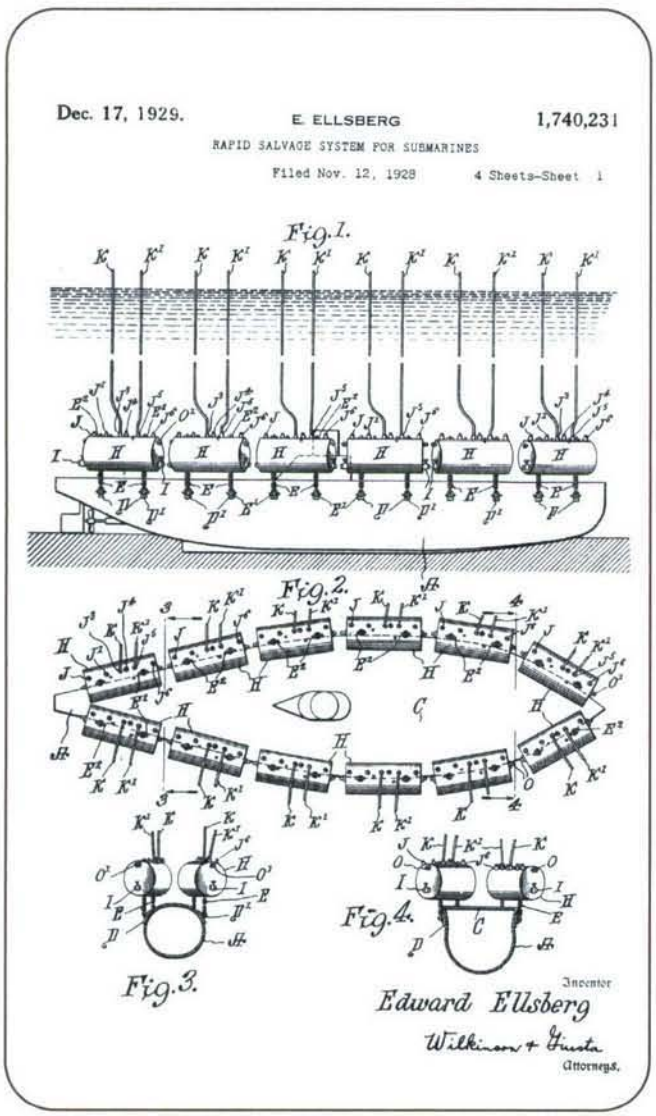
Diver ready to descend



Standard diving dress with gloves attached



Ellsberg's Jetting Nozzle.
Made of cast brass, the nozzle is used for jetting under hulls and other embedded objects. The vents in the back spray were tapped for iron pipe plugs, which could be inserted to adjust and control front nozzle pressure.



Ellsberg's application and patent for his rapid salvage system for submarines.





During the winter, most of the Navy and commercial divers went back to their normal jobs. Ellsberg recognized that more deep sea divers would be necessary when salvage operations resumed in the spring. Ellsberg used the down time wisely by setting up a dive school at the New York Navy Yard between December 1925 and late April 1926, with Chief Torpedoman John Kelley, one of the *S-51* divers during the fall operations, as his instructor. During this time, Ellsberg and Kelley were able to train 20 of the dressers, tenders, and repairmen who had been on the *Falcon* during the fall operations to become deep sea divers. These new divers became proficient in the operation of air drills, chipping hammers, and in the safe operation of their diving equipment. In addition, Ellsberg was able to perfect his new hydrogen-oxygen cutting torch prior to the resumption of salvage operations on the *S-51* on 23 April 1926, now with 24 divers and 40 additional tenders.[40]

This additional manpower and training paid big dividends during the spring operations. After one failed attempt to raise the *S-51* on 22 June, when the lift pontoons connected to the *S-51* surfaced in heavy seas while the stern remained planted on the bottom, the *S-51* was successfully lifted on 5 July and towed to the New York Navy Yard. It arrived at the approaches to the East River during the early morning of 7 July, but only one mile from the Navy Yard, the *S-51* went aground on Man-of-War Rock. As a result of heroic actions by the divers to readjust the pontoons in severe tidal currents, the *S-51* was refloated and completed the tow into the Navy basin at 11:00 that evening. "The diving performed during the salvage operations of the USS *S-51* totaled 556 dives to a depth of 136 feet; the average time on bottom was set at one hour during the second period, that is, during the spring and summer of 1926. Tables approximating those of the diving manual were used, and only minor cases of the bends occurred."[41]

To add further embarrassment to the US Navy, a district court inquiry, and a later appeal in the Circuit Court of Appeals, found the *S-51* at fault for not having proper navigation lights on the night of the disaster.[42] The Navy argued unsuccessfully that it was "not practicable to have submarines of this class comply with the literal provisions of the law in regards to lights." The court went on to say, "Thus, even though this accident was a tragedy, and many men lost



USS S-51 successfully towed to the New York Navy Yard for dry docking, July, 1926



USS S-51 in dry dock



Medal of Honor citation of Chief Machinist's Mate William Badders (as printed in the official publication *"Medal of Honor, 1861-1949, The Navy"*)

"For extraordinary heroism in the line of his profession during the rescue and salvage operations following the sinking of the USS *Squalus* on 23 May 1939. During the rescue operations, Badders, as senior member of the rescue chamber crew, made the last extremely hazardous trip of the rescue chamber to attempt to rescue any possible survivors in the flooded after portion of the *Squalus*. He was fully aware of the great danger involved, in that if he and his assistant became incapacitated, there was no way in which either could be rescued. During the salvage operations, Badders made important and difficult dives under the most hazardous conditions. His outstanding performance of duty contributed much to the success of the operations and characterizes conduct far above and beyond the ordinary call of duty."

William Badders was born in Harrisburg, Illinois, on 15 September 1901. He enrolled in the Naval Reserve in August, 1918 and transferred to the regular Navy in December, 1919. Later trained as a diver, Badders was awarded the Navy Cross for "extraordinary heroism and devotion to duty" during the salvage of USS *S-51* (SS-162) in 1926. He was designated a master diver in April 1931 and received commendations for his diving work in salvaging USS *S-4* (SS-109) in 1928 and the Japanese steamship *Kaku Maru* in 1932, and for clearing the propeller of USS *Bittern* (AM-36) at sea in 1933. Chief Machinist's Mate Badders was awarded the Medal of Honor for heroism during the rescue of survivors of USS *Squalus* (SS-192) and subsequent salvage of that submarine in 1939. He transferred to the Fleet Reserve in March 1940.[44]

their lives on the *S-51*, the court felt that the records show that the greatest blame for the accident must lay with the *S-51*, but especially with the Navy, for allowing a manifestly unsafe submarine to be operated. While the *City of Rome* shares some blame, the design of the S-class was, in many respects, an accident waiting to happen."[43]

While a great deal of attention and blame was being directed toward the Navy submarine community as a result of the *S-51* disaster, at that time little energy was being expended toward developing equipment and methods for future rescue efforts. Despite the fact that Lt. Momsen had sent plans for a rescue chamber design to the Bureau of Construction and Repair in Washington, DC, shortly after the *S-51* sinking, no action was taken on the plans until Momsen reported for duty in that office over a year later. In fact, few changes were implemented as a result of this disaster. Chief Machinist's Mate William Badders would later express the attitude of the Navy immediately following the *S-51* salvage when he said, "Diving and salvage are related to emergencies; the further apart the emergencies come up, the less interest is shown toward that type of work."[44]



Lt. Momsen rescue chamber

Unfortunately, it would not be long before disaster struck again. At 3:37 pm on Saturday, 17 December 1927, the USS *S-4* was impacted while submerged off Provincetown, MA, by the US Coast Guard destroyer *Paulding*. Unlike the *S-51*, in which all crew members still onboard after the initial sinking had drowned, six crew members from an initial contingent of forty were discovered alive in the forward torpedo room of the *S-4* when it sank to the bottom in 102 feet of water; they had no means to get out. Chief Gunner's Mate Thomas Eadie, one of the original divers on the *S-51*, was the first diver down around 11:00 am the next morning; he confirmed that at least six crew were still alive. Their only chance of rescue was for divers from the USS *Falcon* to blow the ballast tanks using air hoses from the surface. From the beginning, the divers' efforts were plagued with rough seas and extremely cold water temperatures, making connections with the salvage couplings extremely difficult. The shortage of available divers became evident when Eadie was forced to make a second dive on 18 December to rescue a fellow diver, Chief Torpedoman Fred Michels, who had become severely fouled on the *S-4*. Rough seas made further attempts to blow the *S-4* ballast tanks on the 18th impossible; this forced the decision to abandon further rescue attempts and transport the critically injured Michels aboard the USS *Falcon* to Boston for treatment. This all but doomed the fate of the six *S-4* crewmembers.[45]

While Thomas Eadie later won the Congressional Medal of Honor for his rescue of Michels, the public outcry over the perceived abandonment of the still alive *S-4* crew was extreme. After further attempts at rescue failed when the *Falcon* returned to the *S-4* site the next day, the divers were forced to switch operations from one of rescue to salvage on 22 December. Despite the extremely cold temperatures (34°F water and much colder surface air temperatures), the US Navy decided to continue salvage operations during the winter in an attempt to ward off further criticism.



Medal of Honor citation of Chief Gunner's Mate Thomas Eadie (as printed in the official publication *"Medal of Honor, 1861-1949, The Navy"*)

"For display of extraordinary heroism in the line of his profession above and beyond the call of duty on 18 December 1927, during the diving operations in connection with the sinking of the USS *S-4* with all on board, as a result of a collision off Provincetown, MA. On this occasion when Michels, Chief Torpedoman, United States Navy, while attempting to connect an air line to the submarine at a depth of 102 feet became seriously fouled, Eadie, under the most adverse diving conditions, deliberately, knowingly, and willingly took his own life in his hands by promptly descending to the rescue in response to the desperate need of his companion diver. After two hours of extremely dangerous and heartbreaking work, by his cool, calculating and skillful labors, he succeeded in his mission and brought Michels safely to the surface."

Thomas Eadie was born on 8 April 1887 in Scotland. He enlisted in the Navy in 1909, became a gunner's mate and was also trained as a diver. While serving as a chief gunner's mate in the 1920s, he assisted in salvage work on the sunken submarines *S-51* (SS-162) and *S-4* (SS-109), receiving the Navy Cross for each operation, and the Medal of Honor for extraordinary heroism in rescuing a fellow diver on the *S-4* on 18 December 1927. Eadie retired from active duty in 1939, but returned to service during World War II, receiving appointment as chief gunner (warrant officer). He later became a commissioned officer and retired in the rank of lieutenant.[49]

Undoubtedly, the salvage experiences that the divers had gained on the *S-51* helped tremendously with the *S-4*. Many of the same techniques used on the *S-51* were repeated on the *S-4*, with some major improvements in their equipment, as pointed out in an article in the 1931 Naval Institute Proceedings by Lt. Henry Hartley, commanding officer of the *Falcon* during both salvage operations: "During the salvage operations on the *S-4*, a new type of batteryless telephone was used, and while its acoustical properties were somewhat weaker than the battery phone, its freedom from the effects of moisture more than compensated for this difference...The next item of importance to be added during the past quarter century to broaden the art of diving is the system that was installed on board the USS *Falcon* during the salvage operations of the *S-4*, which permitted controlling the moisture and temperature of the compressed air supplied to the divers through mechanical process. This permitted carrying on diving operations in air temperatures as low as 8°F and water temperatures as low as 31°F." [46]

The salvage operation took 90 days to complete, in which diving was possible only 56 days because of poor weather and high seas. Hartley further reported that, "During the salvaging of the *S-4*, 564 dives were made; the maximum depth at high water was 114 feet; decompression tables used were Bureau of Construction and Repair, lengthened out due to the very cold weather. About nine cases of minor bends occurred, but always in cases where the diver had been working hard over a period of one hour."[47] Most damning of all, however, was Hartley's assessment of diving personnel at that time: "During the salvage operations of both *S-51* and *S-4*, we experienced no difficulty in having a sufficient number of divers whom we could send to those depths, but the number of divers who could go down and actually accomplish work was surprisingly small."[48]

Not surprising, immediately after the *S-4* sinking and salvage, Congress approved major funding initiatives to improve equipment and diver training to establish a real salvage and rescue organization in the US Navy. First, the Navy School of Diving and Salvage was established at the Washington Navy Yard in 1927 under the charge of Lt. Henry Hartley, former commanding officer of the *Falcon* during the salvages of the *S-4* and the *S-51*. Also in 1927, the early experimental diving program previously located in Pittsburgh, PA, primarily to study helium as a diving gas medium, was moved adjacent to the dive school at the Washington Navy Yard to ensure that advances in diving technology could be rapidly incorporated into diver training. This unit, commanded by Chief Gunner Clarence Tibbals, became known as the Navy Experimental Diving Unit (NEDU). Hartley quickly established a 26-week curriculum, with class sizes of approximately 20, to emphasize diver training with a proficiency in accomplishing tasks underwater with a variety of underwater tools. In 1931, Hartley contrasted the new curriculum with the training divers received in the early 1900s in the following way.[50]

"We have qualified divers by the hundreds in the Torpedo School at Newport, but not one of them was ever given a task to perform on the bottom requiring the use of tools; in fact, the practice has been continued along the lines followed when I went through the Gunnery School—the time allotted to diving being just sufficient to give the students some practice at dressing, undressing, and tending the diver, and to make a few dives, walking about the bottom up to the qualifying depth, 60 feet, later advanced to 90 feet. When the depth was 60 feet, if the diver could stay down 20 to 30 minutes he was marked as a 'qualified diver.' Later the 60-foot man was designated 'diver second class,' and the 90-foot man 'diver first class.' Their ability to use tools underwater did not enter into the question..."

CURRICULUM AT DEEP-SEA DIVING SCHOOL IN 1931

"The [new] qualifying depth is set at 150 feet; after he has made the qualifying depth of 150 feet and has been taught to use hand and power tools underwater, we then find out what pressures the individual can safely make, up to 300 feet, and mark his record accordingly. His proficiency in the use of tools determines whether he is rated diver 2nd or 1st class."

Navy divers also had to maintain their diving proficiency by completing four dives every 6 months, 1st class and master divers to 150 feet and 2nd class divers to 90 feet.[51] In the late 1920s, the design of the Navy's Mark V Deep-Sea Diving Suit stabilized with few changes to follow. In 1931, Lt. Henry Hartley described the principal improvements in the deep sea dress as:

"The helmet and breastplate, made of tinned copper, have undergone several changes during the past 25 years, principally in changing the manner of securing to the collar of the breastplate, from the four-lug swing-bolt style, to the interrupted-screw thread; the faceplate, from the screw type to hinge type; the same exhaust valve is in use now as then, but it has been placed more accessible to the diver's reach, and the helmet has been somewhat enlarged, so that it now has about two-thirds of a cubic foot capacity.

"The most important change in the helmet is the installation of a telephone transmitter and jack plug for the receiving microphones which the diver wears fitting over his ears. Much difficulty has been experienced with the telephone due to dampness and air noises. The diver must shut off his air and close his exhaust valve in order to hear over the telephone, and even then it is difficult for him to understand other than words spoken very clearly, slowly, and distinctly."[52]

A typical diving operation in the early 1930s was described accordingly:[53] "Today the diver is dressed sitting on a small bench....







"...he wears a skull cap to support the microphones held over the ears by a chin strap...

"The telephone cable passes from its connection at the back of the helmet under the right arm and is made fast to a lug on the front part of the breastplate, and has sufficient strength to be used as the life line; the air hose was taped to the cable forming one line, the first 100 feet being sewed up in canvas to minimize fouling. His faceplate butterfly nut has been set up tight and wired in place. The faceplate glass is not treated with vinegar to prevent fogging, as it was later discovered that this fogging is the diver's first warning of carbon-dioxide accumulation.

"Fogging of the faceplate glass is the first indication of an insufficient flow of air through the helmet.

"At the word, 'Phone OK,' the helmet is lowered in place and given a twist to cause the interrupted-screw segment to engage, the safety bolt is dropped into its slot, the diver rises and steps on the stage, assisted by two dressers...

"When the helmet is just under the surface, lowering ceases, and the diver adjusts his air valves, sees that his suit is tight, again tries his telephone, steps off the stage when told to go down.

"...he locks his legs about the descending line, grasps it with the right hand, and with his left hand on his air control valve, slides down to his work. If he is to use power tools, they have been sent down ahead of him."

Congress approved six additional salvage ships and new arrays of pontoons to be located in key Navy submarine bases around the world, including the USS *Falcon* in New London, CT; USS *Mallard* at Coco Solo in the Panama Canal Zone; USS *Ortolan* in San Diego, CA; USS *Widgeon* in Pearl Harbor, HI; USS *Pigeon* at Cavite in the Philippines; and the USS *Chewink*. Each was equipped with an air pressure system, recompression chamber, and diving and salvage equipment.[54]

Attention was also directed toward developing equipment and methods to rescue submariners from a sunken vessel. The Navy was quick to implement Lt. Swede Momsen's plans for an escape apparatus, or escape lung, and his original plans for a rescue chamber. Nearly two months after the *S-4* sinking, Momsen and Chief Gunner Clarence Tibbals, officer-in-charge of the Experimental Diving Unit, built the first prototype of the escape lung from an old inner tube and demonstrated it on February 25, 1928, at the model boat basin at the Washington Navy Yard.[55]

Also, in 1928, the resurrected hull of the salvaged *S-4* was converted into a test boat for submarine escape and rescue developments. A steel skirt was installed around a hatch in the motor room of the *S-4* which extended approximately four feet down into the compartment.

The following year, the modified *S-4* hull was transported to Key West, FL. On February 6, 1929, Momsen and Chief Torpedoman Ed Kalinoski made the first realistic submarine escape from the motor room of the *S-4* sitting on the bottom at a depth of 40 feet off Key West using the "Momsen" lung. They would later increase their lockout depths to a maximum of 207 feet in subsequent testing.[56]

During this same time, Momsen also tested his first rescue bell prototype on the *S-4* hull off Key West. He and Chief Torpedoman Charles Hagner made the first submarine escape using the bell from a depth of 75 feet of water. After these first tests, Momsen made several improvements in the design to improve safety and operational capability:[57]

- Used only a single down-haul cable rather than two to avoid cables crossing
- Added portable ballast that could be dumped to compensate for added weight of rescued submariners
- Constructed new chamber with two compartments divided by a horizontal bulkhead equipped with an access hatch
- Added telephone, lights, and fast-action valves for admitting and releasing compressed air

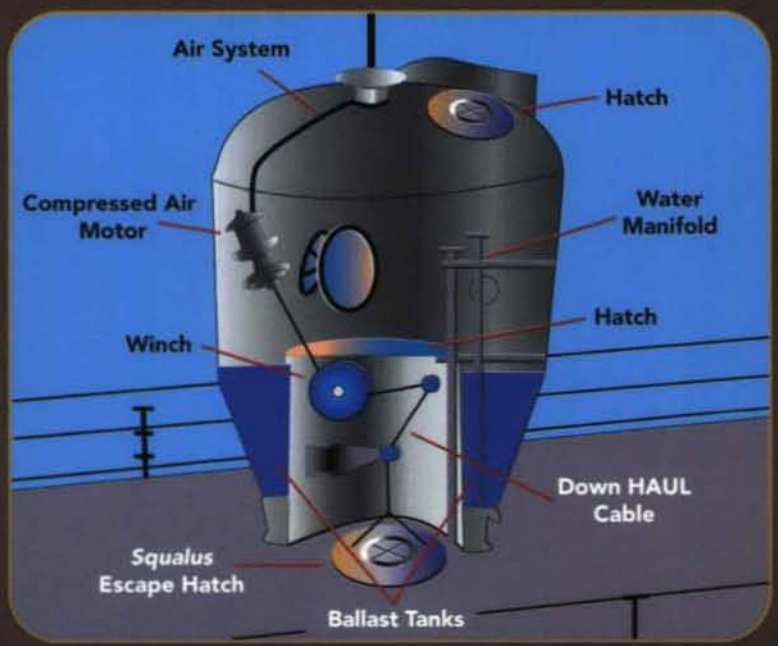


Early rescue chamber trials
(Courtesy of Helen Hart Momsen)

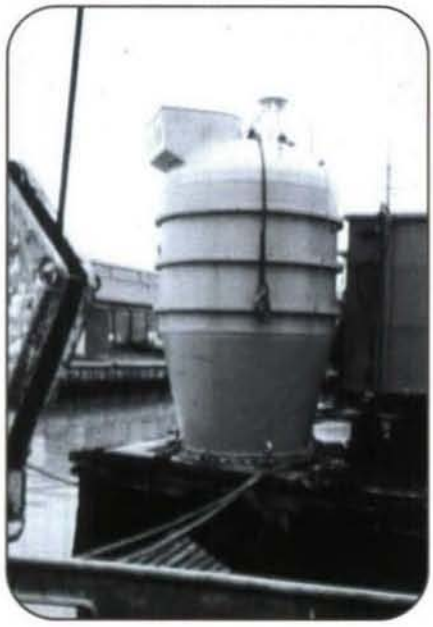
The success of these escape trials prompted the Navy to contract for 7,000 lungs and introduce escape hatches on all new submarine construction as well as to retro-fit existing submarines with escape hatches and telephone buoys, which would allow crews trapped inside a submarine to communicate with rescue ships on the surface. Momsen was detached from the Bureau of Construction and Repair prior to the completion of the bell modifications to set up a submarine escape training program to be completed by all submarine crew members. When the improved submarine escape bell was completed in the fall of 1930, the Navy ordered one for each submarine command around the world. When delivered to the fleet, the modified bell was officially designated the "McCann Rescue Chamber," after LCDR Allen McCann, the officer who was assigned to replace Momsen in Key West to complete the follow-through with the bell testing after Momsen's detachment.

The response of the submarine community was less than enthusiastic to all of these initiatives in escape and rescue. Although the Navy Diving School attempted to run simulated submarine escape drills with the fleet, the submarine community was not keen on this training. "We don't need you. If anything happens to us, we'll take care of ourselves or we'll stay there."[55] The US Navy could have easily slipped back into complacency, because 12 years separate the sinking of the *S-4* from the next US submarine disaster.

Fortunately, the decision to co-locate the dive school with the Navy Experimental Diving Unit helped to maintain a critical mass for continuing diving research and developments. During the early 1930s, NEDU conducted research in perfecting underwater salvage techniques, including underwater cutting tools, both gas and electric arc, and underwater welding. They also perfected the velocity power tool that drove steel projectiles into steel plates for



McCann Rescue Chamber resting over the Squalus escape hatch.



McCann rescue chamber

bolting up plates over holes and hollows. This tool, developed by the Mine Safety Appliance Corporation in Pittsburgh, could be used to drive threaded studs into steel plates, or drive hollow studs through a steel hull to connect an air hose, or fire a rivet expander into the center of a loose rivet to tighten a faulty joint.[59]

The physiological concerns for deep sea diving in the early 1930s were summarized by Lt. Hartley:[60]

"...we are first concerned in maintaining him there, the retarding agent being, first, carbon dioxide poisoning. Six percent carbon dioxide causes very great distress; 10% brings about a tendency to unconsciousness.

"Second in importance in retarding deep diving is the effect of oxygen breathed under pressures... There is no appreciable danger of oxygen poisoning at nine atmospheres excess pressure, as the body will only absorb the amount necessary to support life, but the partial pressure, or driving force of the oxygen breathed, appears to have a peculiar effect somewhat similar to an intoxicant, and referred to in the diving manual as oxygen exhilaration. A diver suffering from this cause is far from normal, and not capable to thinking clearly...

"Numerous occasions occurred during the diving operations on the *S-51*, depth 136 feet, where the diver was carefully instructed in his task, and could clearly explain it in detail, but once on the bottom he appeared to have but a hazy idea of what he was supposed to do. We attributed these conditions to oxygen exhilaration, and found it necessary to select divers carefully for certain work, even though they appeared in all respects equal when not under pressure." [Nitrogen narcosis was poorly understood at this time.]

"Oxygen breathed under pressure has an irritating effect on the lungs; the greater the partial pressure, the more marked this effect becomes; at above ten atmospheres, oxygen poisoning will take place. It is the exposure of the central nervous system to a high partial pressure of oxygen that causes convulsions...

"...and third (in importance in retarding deep diving) is the rapid increase in the rate of saturation of the body tissues with nitrogen. The blood passing through the lungs picks up this nitrogen; when this blood reaches the systemic capillaries, the nitrogen will diffuse out, and the blood will return for a fresh charge, this process being repeated until at length the tissues are fully charged with nitrogen. Those parts receiving less blood supply take longer to saturate; on the other hand, they require more time to desaturate.

"Safe decompression, or safe desaturation, is that which will so decrease the pressure of the air breathed by the diver as to permit the nitrogen to come out of solution, but not to expand in such large bubbles that it cannot pass through the capillaries, and back out of the system, in the reverse order to that in which it entered."

In 1937, LCDR Charles B. "Swede" Momsen took command of NEDU; he immediately revived the earlier investigations in deep diving with helium-oxygen (heliox) mixtures that had fizzled out after 1925. Two medical diving officers under Momsen's command, Lt. Oscar D. Yarbrough and Lt. Albert R. Behnke, developed improvements in both

decompression tables and treatment tables for heliox diving. They also investigated the benefits of switching from air to heliox to minimize decompression and investigated accelerating decompression schedules by shifting divers to pure oxygen upon ascending to 50 feet.[61]

These studies culminated with a record setting dive in 1937 by Chief Machinist's Mate William Badders and Chief Metalsmith Jim McDonald, to 500 feet on heliox in the NEDU chamber. Badders later did an open water dive to 420 feet from the *Falcon* off New London. Under Momsen's leadership, NEDU continued to improve the equipment used in diving. NEDU worked with a New York manufacturer in the late 1930s to develop electrically-heated underwear to be worn under the MK V suit for diving in extreme cold water. Additionally, NEDU developed a mixed gas version of the MK V helmet that recirculated the heliox mixtures to conserve gas. This MK V Mod 1 Mixed-Gas Diving Suit reduced the amount of helium and oxygen required for deep diving operations by 80 percent.[62]



MK V MOD 1 Mixed-Gas Diving Outfit developed in the 1930s



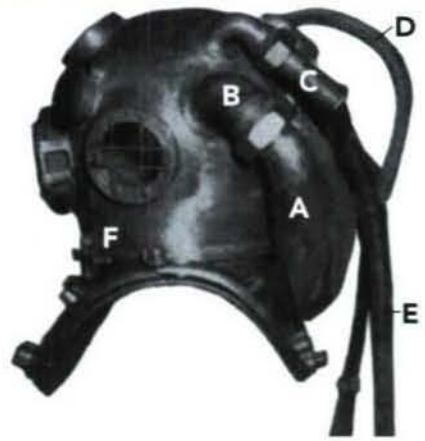
Medal of Honor citation of
Chief Machinist's Mate James Harper McDonald
(as printed in the official publication
***"Medal of Honor, 1861- 1949, The Navy"*)**

"For extraordinary heroism in the line of his profession as a Master Diver throughout the rescue and salvage operations following the sinking of the USS *Squalus* on 23 May 1939. His leadership, masterly skill, general efficiency, and untiring devotion to duty in directing diving operations, and in making important and difficult dives under the most hazardous conditions, characterize conduct far above and beyond the ordinary call of duty."

James Harper McDonald was born at New Mand, Scotland on 15 July 1902. He enlisted in the US Navy in October, 1920, was discharged three years later, and reenlisted in February, 1926. Trained as a metalsmith, and later as a diver, he was commended in 1928 and 1930 for his excellent diving work. McDonald was designated a Master Diver in October 1934. In May–September 1939, he was heavily involved in rescue and salvage efforts on the sunken submarine USS *Squalus* (SS-192). For his heroism and leadership during that operation, Chief Metalsmith McDonald was awarded the Medal of Honor. Continuing his Naval service into World War II, McDonald became a commissioned officer. He retired after the war with the rank of lieutenant.[63]



Side



A. Canister for Shell-Natron (CO_2 absorbent)
B. Outlet end of canister
C. Coupling for life line and telephone cable
D. Helium-oxygen supply hose to venturi
E. Air hose
F. Safety lock

Left side

MK V MOD 1 Mixed-Gas/Helium Diving Helmet



Back



A. Canister for Shell-Natron (CO_2 absorbent)
B. Inlet end of canister
C. Venturi
D. Helium-oxygen supply to helmet
E. Air inlet and nonreturn safety valve
F. Air hose
G. Electric cable for electric heated underwear
H. Life line and telephone cable
I. Exhaust valve
J. Exhaust channel
K. Face plate

Right side

The welfare of Navy diving and submarine rescue was in its best shape when at 8:35 am on the morning of 23 May 1939, the USS *Squalus* (SS-192), 310 feet long with a displacement of 1450 tons, took on water through the main induction valve during a practice dive in sea trials off the coast of Portsmouth, NH. The engine room and the aft torpedo room flooded immediately, drowning 26 crewmembers before the *Squalus* sank to the bottom southeast of the Isle of Shoals in 243 feet of seawater with 33 men alive in the forward cabins. Despite the fact that the forward cabins were nearly dry following the sinking, the cabin pressure had risen to that of a depth of 27 feet, nearly twice normal cabin pressure. Although the *Squalus* was equipped with Momsen escape lungs and an escape hatch, commanding officer Lt. Oliver Naquin decided to wait for surface rescue because of the the cold water temperatures and the extreme depth (the deepest the lung had ever been used previously was 207 feet during trials off Key West in clear, warm waters). What followed was a rescue and salvage operation that is unsurpassed in the history of undersea warfare.

Within hours, a missing sub alert was issued at the Portsmouth submarine base, and *Squalus'* sister submarine, USS *Sculpin,* was ordered to conduct a search in the last reported location of the *Squalus*. Because of an apparent miscommunication between the *Squalus* and the shore base prior to the fateful dive, the initial search was conducted many miles from the dive site. This resulted in a delay before the *Sculpin* located the surface telephone buoy that had been released from the *Squalus* (the emergency telephone buoy was another piece of standard equipment installed on modern subs after the *S-4*). Only momentary communication was established between the *Squalus* and *Sculpin* before the telephone cable broke when it was overstressed during a large surface swell.

In the meantime, LCDR Momsen and his NEDU staff were summoned from Washington, arriving at 11:30 that evening. At the same time, the USS *Falcon* was steaming from New London equipped with the McCann Rescue Chamber; it arrived at 4:00 am on May 24th. While the divers from NEDU and the *Falcon* had been in transit, the *Sculpin* and a small surface vessel, the *Penacook*, searched the area to re-locate the *Squalus* by towing grappling hooks. Fortunately, the *Penacook* succeeded in hooking onto the port railing of the *Squalus* less than 10 feet from the escape hatch.



USS Squalus

The next morning, Boatswain's Mate Martin Savitsky, one of the *Falcon* divers, wearing a suit of electrically heated underwear that was controlled by a storage battery on the *Falcon*, was able to descend to the *Squalus* and attach a down haul cable from the escape chamber to the escape hatch. A procedure that had been exercised time and time again during practice trials would now have to be implemented in a real emergency.

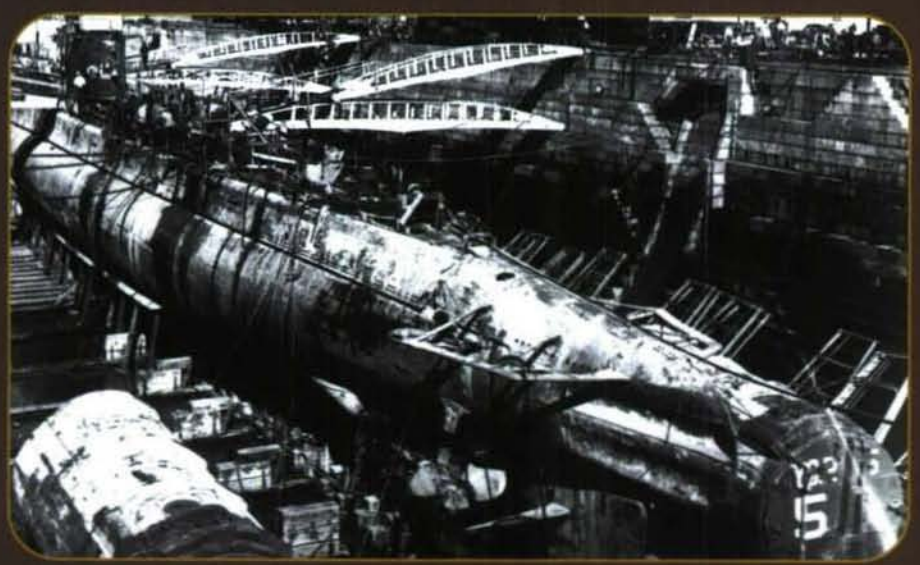
Two chamber operators were able to winch the rescue chamber down to the Squalus escape hatch using a compressed air motor, while controlling its buoyancy by blowing or flooding ballast tanks. Once the rescue chamber sat securely on rubber gaskets over the *Squalus* escape hatch, the chamber operators blew the water from the area between the two hatches. Next, they descended through the lower chamber hatch and secured the chamber to the submarine hull with attaching rods. They could then open the outer hatch of the submarine to allow partial transfer of the crew before removing the attaching rods, closing the hatches, and making a controlled ascent with the compressed air motor.

During three successive journeys via the escape chamber, 25 men from the *Squalus* were

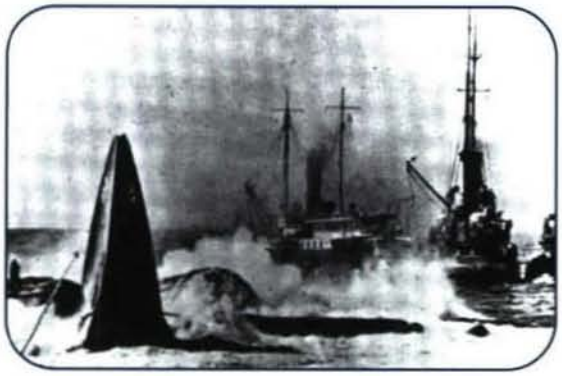


Escape chamber used in USS Squalus *rescue*

safely returned to the surface. By 7:51 pm (approximately 35 hours after the initial sinking), the remaining 8 men, including Lt. Oliver Naquin, were transferred into the escape chamber to complete the final journey to the surface. As fate would have it, the down



Salvaged USS Squalus *in dry dock (Portsmouth, NH)*



13 July 1939
Bow of the Squalus raising above the surface during the initial lift attempt.

haul cable jammed during this final ascent, forcing the chamber operators to flood the ballast tanks and sink back to the bottom. Working with poor visibility and cold conditions, divers were able to cut the down haul cable to allow the chamber to be pulled to the surface. In a delicate balancing act, the chamber operators were able to blow just enough water ballast to make the chamber only slightly negatively buoyant. Removing too little ballast would have placed excessive strain on the surface line; removing too much ballast would have caused the chamber to ascend uncontrollably and risk impact with the bottom of the *Falcon*. At 38 minutes after midnight on the 25th of May, approximately 39 hours after the initial sinking, the final eight men reached the surface. This completed an unprecedented rescue mission that has remained unmatched.

Following a repair of the chamber down haul cable, one final descent was made the next day to the aft escape hatch to confirm that there were no survivors in the aft torpedo room. As anticipated, the aft cabin was completely flooded; this removed any hope of additional survivors.

Immediately following the conclusion of the rescue phase, Momsen and his divers turned their attention to salvaging the *Squalus*. They were faced with a submarine that had nearly 50 % greater submerged displacement than the *S-51* and *S-4*, and was in water over 100 feet greater than the *S-51* and nearly 140 feet greater than the *S-4*. Rather than lift the submarine completely to the surface, Momsen decided to do staged lifts with pontoons to progressively bring the *Squalus* into shallower water. Tunneling under the hull to cradle the *Squalus* with lifting chains, similar to what was done with the *S-51* and *S-4*, was considered excessively dangerous at this depth.



Salvaged USS Squalus—Forward Torpedo Room



Medal of Honor citation of
Chief Torpedoman John Mihalowski
(as printed in the official publication
"Medal of Honor, 1861-1949, The Navy")

"For extraordinary heroism in the line of his profession during the rescue and salvage operations following the sinking of the USS *Squalus* on 23 May 1939. Mihalowski, as a member of the rescue chamber crew, made the last extremely hazardous trip of the rescue chamber to attempt to rescue any possible survivors in the flooded after portion of the *Squalus*. He was fully aware of the great danger involved, in that, if he and the other member of the crew became incapacitated, there was no way in which either could be rescued. During the salvage operations, Mihalowski made important and difficult dives under the most hazardous conditions. His outstanding performance of duty contributed much to the success of the operations and characterizes conduct far above and beyond the ordinary call of duty."

John Mihalowski was born in Worcester, Massachusetts, on 12 August 1910. He enlisted in the Navy in December 1927, rising to the rank of chief torpedoman during the next decade. Trained as a diver in 1932–33, he served with the Experimental Diving Unit in 1933–37 and then as a member of the crew of USS *Falcon* (ASR-2) into 1941. While serving on *Falcon*, he played an important role in the rescue of survivors of USS *Squalus* (SS-192) and the subsequent salvage of that submarine in 1939. For his heroism during that effort, Chief Torpedoman Mihalowski was awarded the Medal of Honor. In 1942, Mihalowski was appointed a warrant officer and became a commissioned officer later in the war. He participated in rescue and salvage operations on six LSTs that had exploded in Pearl Harbor in 1944, and, while executive officer of USS *Shackle* (ARS-9), on damaged ships during the Okinawa campaign in 1945. Following the war, he took part in the harbor clearance in Japan and in salvage efforts during the 1946 "Crossroads" atomic bomb tests at Bikini. He was executive officer of USS *Gypsy* (ARSD-1) in 1947–48, before transferring to the Fleet Reserve in January 1948. Recalled to active duty in September, 1950, as a chief torpedoman, Mihalowski was reinstated as a lieutenant the following year. He was assigned to the Naval Gun Factory, Washington, D.C., in 1952 and was promoted to the rank of lieutenant commander in February 1954. LCdr. John Mihalowski retired from active Naval service in about 1958.[68]

Instead, Momsen designed a special nozzle that was connected to 6-foot lengths of pipe bent to the curvature of the hull. As the nozzle progressed beneath the hull, additional lengths of bent pipe were added until the nozzle reached the other side. Lifting chain could then be pulled beneath the sub to be connected to the lift pontoons.

In all, 640 dives were made during the salvage operation, nearly half in 240 feet of water. Although tested in laboratory conditions at NEDU, these deep dives provided the first operational use of the MK V Mod 1 Mixed-Gas Diving Suit. Several modifications were made to improve the gas flow and communications performance of the helium hat during these dives, including:[63]

- The sodalime in the carbon dioxide scrubber was replaced by caustic potash (Shell Natron), which was a good absorber of moisture. This reduced clogging of recirculating gas system
- A new vacuum tube telephone system developed by RCA was added to the hat to improve communications
- A special muffler system developed at Harvard was added to the recirculating gas system to quiet hat noise

As in the cases of the *S-51* and the *S-4*, the operation of the lifting pontoons continued to provide major obstacles in the *Squalus* salvage operation. The first attempt to lift the *Squalus* off the bottom on 13 July resulted in a demoralizing blow for the entire salvage crew as the bow raised 30 feet above the surface in heavy seas while the stern continued to rest on the bottom. Severely damaged, the bow pontoons re-flooded, causing the *Squalus* to settle back to the bottom, and wiping away weeks of effort by the divers. The damaged pontoons had to be re-surfaced for repairs before repeating the jetting of the lift lines under the hull and re-attachment of the lift pontoons.

The second lift attempt on 12 August was successful, allowing the *Squalus* to be towed toward shallower water, eventually bottoming out again at a depth of 160 feet.

After readjusting the lift lines attached to the pontoons, the *Squalus* was towed further toward shallower water on 17 August, eventually bottoming out for a second time at 95 feet. The final lift and return to the Portsmouth Navy Yard drydock occurred on 13 September, 113 days after the sinking, completing an unprecedented show of innovation, heroism, and the will of the human spirit.

Although the Official Court of Inquiry that was convened after the sinking never explained how the main induction valve had accidentally opened to cause the engine room to flood, it did recommend that a protective shield be placed around the main induction operating lever to isolate it from adjacent levers to prevent opening by mistake.

In addition, in every new submarine construction, the lever position was changed and given a distinctive grip to further avoid confusion.[64] The official record further stated, "This was a period of the greatest diving effort in the world's history. That in 640 dives, under the most severe conditions, there was not a single loss of life or a serious personal injury speaks for the eternal vigilance, professional skill, technical knowledge, and responsibility of Commander Charles Bowers Momsen."

In addition to Momsen, four of Momsen's divers were singled out to receive Congressional Medals of Honor for extraordinary acts of heroism during the *Squalus;* rescue and salvage operations. This included Chief Machinist's Mate William Badders and Chief Torpedoman John Mihalowski, two of the rescue chamber operators who brought 33 trapped men safely back from the stricken *Squalus* and Chief Boatswain's Mate Orson L. Crandall and Chief Machinist's Mate James Harper McDonald, two of the Master Divers on the *Falcon* responsible for the success of the rescue and salvage operations.



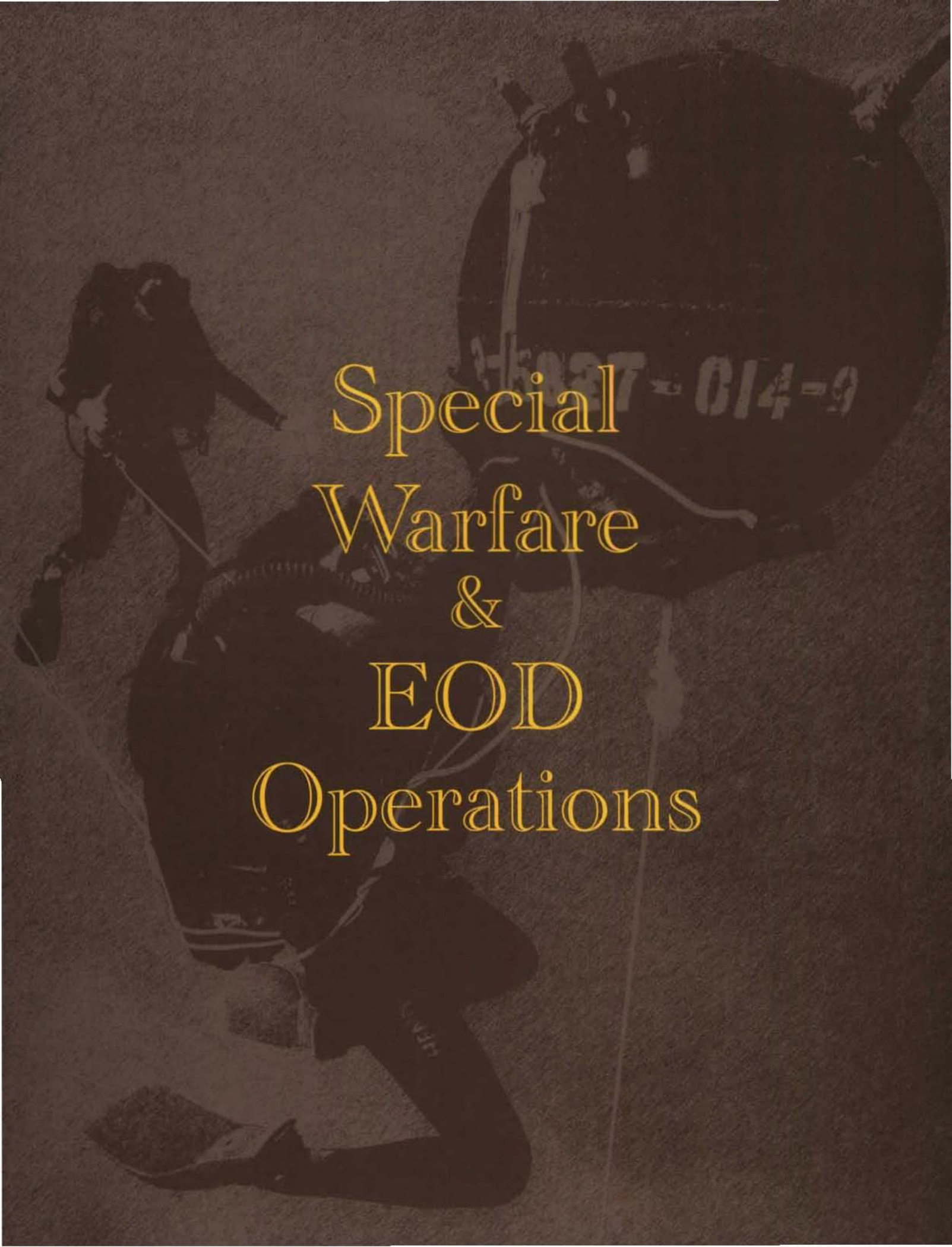
Medal of Honor citation of
Chief Boatswain's Mate Orson L. Crandall
(as printed in the official publication
"Medal of Honor, 1861-1949, The Navy")

"For extraordinary heroism in the line of his profession as a Master Diver throughout the rescue and salvage operations following the sinking of the USS *Squalus* on 23 May 1939. His leadership and devotion to duty in directing diving operations and in making important and difficult dives under the most hazardous conditions characterize conduct far above and beyond the ordinary call of duty."

Orson Leon Crandall was born on 2 February 1903 in St. Joseph, Missouri. He enlisted in the Navy in June 1922, serving on several ships over the next decade. Trained as a diver in 1932–33 and designated a master diver in March 1939, he was serving on USS *Falcon* (ASR-2) when she supported the rescue and salvage effort on the sunken submarine *Squalus* (SS-192) in May–September 1939. Chief Boatswain's Mate Crandall was awarded the Medal of Honor for heroism as master diver during that operation. During World War II, Crandall became a commissioned officer and served in a variety of salvage and diving-related positions. He transferred to the Fleet Reserve in June, 1946 and retired in December, 1952. Lieutenant Orson L. Crandall died in May, 1960. USS *Crandall* (YHLC-2), 1967–1993, was named in honor of Lieutenant Crandall.[65]

REFERENCES

1 Hartley, Henry, Lt., USN, *Some Historical Facts on Diving*, Naval Institute Proceedings, March 1931, pp 341–349.
2 Eadie, Thomas, *I Like Diving: A Professional's Story*, Boston, Houghton Miffin Co., 1929.
3 *Handbook for Seaman Gunners: Manual for Divers*, Naval Torpedo Station, Newport, RI, 1905.
4 Eadie, Thomas, *I Like Diving: A Professional's Story*
5 Diving Manual, Navy Department, published by Government Printing Office, Washington, DC, July 1916, p 33.
6 Hartley, *Some Historical Facts on Diving*
7 Diving Manual, Navy Department
8 Lonsdale, Mark, *Evolution of US Navy Diving*, http://www.navydiver.org/history/default.html.
9 Hartley, *Some Historical Facts on Diving*, p 344.
10 White, Sondra, *The Sinking of the USS F-4: Part 1*, http://www.sid-ss.net/history/f4-hist1.htm.
11 Hartley, *Some Historical Facts on Diving*, p 348.
12 US Naval Institute Proceedings. US Naval Institute, Annapolis, MD. Nov–Dec 1915. Vol 41, No 6, p 2059.
13 Maas, Peter, *The Terrible Hours*. New York, Harper Collins Publishers, 1999, p 53.
14 Hartley, *Some Historical Facts on Diving*, p 343.
15 Ellsberg, Edward, CAPT, USNR, *On The Bottom*, New York, Dodd, Mead & Company, 1928, p 108.
16 Badders, William, Chief Machinist's Mate, *The Reminiscences of Chief Machinist's Mate William Badders*. US Naval Institute, Annapolis, MD, 1986.
17 Hartley, *Some Historical Facts on Diving*, p 348.
18 US People—Crilley, Frank W., Ensign, USNR, www.history.navy.mil/photos/pers-us/uspers-c/fcrilly.htm.
19 Badders, *The Reminiscences of Chief Machinist's Mate William Badders*
20 Early Submarine Accidents, http://www.lostsubs.com/Early.htm.
21 http://www.subvets.org/Requiem/025.htm.
22 http://www.csp.navy.mil/othboats/f-1.htm.
23 ibid. /h-1.htm
24 ibid. /s-5.htm
25 http://thesaltysailor.com/s-boats/s48.htm
26 ibid. /s38.htm
27 ibid. /s37.htm
28 http://www.history.navy.mil/photos/sh-usn/usnsh-o/ss66.htm
29 Maas, Peter, *The Terrible Hours*, p 53.
30 Badders,*The Reminiscences of Chief Machinist's Mate William Badders*
31 Badders, *The Reminiscences of Chief Machinist's Mate William Badders*, p 14.
32 Ellsberg, *On The Bottom*
33 Maas, Peter, *The Terrible Hours*, p 62.
34 Ellsberg, *On The Bottom*
35 ibid.
36 Robert C. Sheats, *One Man's War: Diving as a Guest of the Emperor 1942*, Flagstaff, AZ, Best Publishing Company, 1998.
37 Ellsberg, *On The Bottom*
38 ibid.
39 Hartley, *Some Historical Facts on Diving*, p 343.
40 Ellsberg, *On The Bottom*
41 Hartley, "Some Historical Facts on Diving," p 348.
42 The loss of the *S-51* – The Aftermath, http://www.lostsubs.com/SS-162_Aftermath.htm.
43 ibid.
44 Badders, *The Reminiscences of Chief Machinist's Mate William Badders*
45 Eadie, Thomas, *I Like Diving: A Professional's Story*
46 Hartley, *Some Historical Facts on Diving*, p 344.
47 ibid. p 348.
48 ibid. p 348.
49 US People—Eadie, Thomas, Lieutenant, USN, www.history.navy.mil/photos/pers-us/uspers-e/teadie.htm.
50 Hartley, *Some Historical Facts on Diving*, p 349.
51 Badders,*The Reminiscences of Chief Machinist's Mate William Badders*
52 Hartley, *Some Historical Facts on Diving*, p 343-344.
53 ibid. p 345.
54 Maas, Peter, *The Terrible Hours*, p 119.
55 ibid. p 101.
56 ibid. p 109.
57 ibid. p 135.
58 Badders, *The Reminiscences of Chief Machinist's Mate William Badders*
59 ibid.
60 Hartley, *Some Historical Facts on Diving*, pp 346-348.
61 Maas, Peter, *The Terrible Hours*, p 189
62 ibid. p 195
63 ibid. p 209
64 ibid. p 236.
65 US People—Momsen, Charles B., VADM, USN, www.history.navy.mil/photos/pers-us/uspersm/cb-momsn.htm
66 US People—Badders, William, Chief Machinist's Mate, USN, www.history.navy.mil/photos/persus/uspers-b/w-baddrs.htm
67 US People—McDonald, James H., Lieutenant, USN, www.history.navy.mil/phoos/pers-us/uspers-m/jmcdnld.htm
68 US People—Mihalowski, John, Lieutenant Commander, USN, www.history.navy.mil/photos/persus/ uspers-m/j-mihlsk.htm
69 US People—Crandall, Orson L., Lieutenant, USN, www.history.navy.mil/photos/pers-us/uspers-c/ocrandl.htm



Special Warfare & EOD Operations

Special Undersea Warfare and Explosive Ordnance Disposal was born from the genius of such Navy greats as Draper Kauffman, Frank Kaine, Phil Bucklew, Chris Lambertsen, "Red Dog" Fane, Milton "Mary" Miles, Bill Donovan, and others too numerous to name. First known to the general public as "frogmen," these intrepid divers risked life and limb to put together a force of underwater swimmers who learned about sub-surface demolition and clandestine underwater operations as developments happened.

Without any formal training, dire circumstances forced these heroes to resolve hairpin operations in unconventional warfare on the job. Conducting any operation never done before is not easy in any environment, but when that environment is hostile and underwater, it is nearly impossible. Yet, these early pioneers of undersea warfare prevailed and, achieving the impossible, a new form of Naval warfare gave birth to Sleeping Beauty, X-Craft, Chariots, LARU, OSS MU and the Aqualung.

After World War II ended, this form of special warfare was dissolved and almost became extinct, but because of the prudence of a few visionaries who wouldn't give up, the US Navy kept unconventional undersea warfare alive. Now Special Operations Forces is part of a multi-service command, with its own career path headquartered at McDill Air Force Base in Tampa, FL, dubbed the US Special Operations Command (USSOCOM).

The following portions of individual oral histories are the recollections of some of the people who made all of this happen. We begin with Dr. Christian Lambertsen, believed to be the most notable and influential icon of them all. Dr. Christian Lambertsen coined the acronym SCUBA used by underwater swimmers for some of the best known and most spectacular war actions.

DR. CHRISTIAN LAMBERTSEN

I went to medical school beginning in 1939 and through the next four years, which was the tail end of the depression. At that time, a very fine situation occurred in the country; the Works Progress Administration (WPA) evolved. There were dozens of tiny jobs at 25 cents an hour, and I was able to get a half dozen of those jobs. That helped me get through the first part of medical school. I then got the one scholarship that existed at the medical school, and then the whole situation was under control.

From the very beginning, I was interested in human breathing and why people breathe like they do. This piqued my interest in medical research. A Dr. Bazet was most encouraging in this research. An Englishman, he was not only a great citizen of the United States at that time, but also his connections back to Europe were strong. He was aware of what was happening in England.

Can you picture France in 1940? France was finished, and the Battle of Dunkirk had just happened. Because that was the situation and Europe was really overrun across the board, and the regions around the Mediterranean were also being overrun, Bazet knew, as I did, that Britain was really in a severe difficulty.

Radio was our source for what was going on every day, here and across the ocean. I don't know whether Dr. Bazet influenced me or not. I don't think he did, but radio did.

I'm sure that as I began to put my first breathing system together, I didn't think that it might have a military application.

That was the beginning. I built and tested my initial breathing system at my base of operations, a summer job with the Ohio Chemical and Manufacturing Company. That was the same company where Bazet had obtained parts. He had told the president about me, and the president wrote back and said to send me out. He said that they would give me a job for the summer. Once the system worked, it became obvious that it could have military application.

The breathing system I built that summer was a re-breathing system that provided pure oxygen and removed the carbon dioxide in a small canister. This allowed an individual to do rather severe exercise for about half an hour underwater and swim neutrally buoyant. That means a diver wasn't walking on the bottom, but was a free-swimming diver. It worked like a charm from the very beginning.

The breathing unit was pretty flimsy, because I had to make it happen in such a short time. I had only a few weeks to construct a good, working system that summer and try to improve upon it.

Imagine two breathing bags, one behind each shoulder, connected by tubing used in anesthesia machines. That tubing led to a container that had sodalime in it, an alkali material that removed carbon dioxide, and a single tube from that canister up to a mask. The mask I used was one of the first aviation masks ever built.

Before my breathing system, aviators used to simply stick a wooden pipe stem in the mouth and take oxygen through it while flying at high altitudes. A full-face mask was not used, just one that covered only the nose and mouth. In diving, goggles were made with a welding system that allowed the diver to seal the goggles against the water outside, and they had a bit of lead to counter-balance it so that it was neutrally balanced. There were no swim fins, only those goggles.

I was heavily influenced by the USS *Squalus* event, and the fact that there was a submarine escape apparatus that seemed sensible. It was a system that was useable to come up from the depths, but not to go down into them. It was not a diving system, but an escape unit. I was also stimulated by some of the more popular books like *Danger Is My Business* by John Craig. It was the sort of thing I read because I had a great interest in diving.

From the beginning, it was obvious that the system I had designed and built was a different situation from the big hard hat diving suits and the 200 pounds of weight, with hoses connected to the surface. With my system, you were a free agent, and that was very different.

My first thought for using the system was that it could be used as a life saving apparatus to be put on quickly by lifeguards if someone went down in the water. I thought because it was to be able to be put on within approximately two minutes, a lifeguard would get in the water and be able to stay there to recover the person. That was its initial purpose. Once it worked well, with the unfolding events in the world, the concept evolved toward having a military use.

I don't even recall whether there was any reimbursement for that summer job at the Ohio Chemical and Manufacturing Company, but that job allowed me to do what I wanted to do with their materials.

After the first year of medical school, I was connected with the Office of Strategic Services (OSS), which was evolving. In 1940, I built and tested an apparatus and demonstrated it to the Navy. After having demonstrated it to the Navy, they concluded that there was no sensible application for it in the Navy's system. It was 1941 and Pearl Harbor hadn't happened yet. We weren't yet at war, and we weren't really doing a lot to help on the other side because there was a bit of resistance in our country to getting involved in the conflict.

The OSS had its start-up seed planted by General Donovan's mission to Britain to learn how likely it was that Britain would be able to sustain itself against imminent invasion. Paris was gone, and the British forces were driven out of Europe so there was an extreme situation in the world.

On that basis, I made another visit to the Navy. This time the fledgling OSS personnel, the few that existed, caught on quickly and decided that we would join forces. I became an unofficial component of the OSS as a sophomore in medical school. They were interested in the concept of having men who were able to do what the OSS felt was needed, namely, unconventional warfare that include sabotage.

After joining the OSS, I met General Donovan, but it was a very simple kind of meeting. He didn't come to the demonstrations because he was much too occupied for that. I don't recall much about the meeting; it would have been in an office.

The commitment to form the OSS was not really acted upon until 1941, until the months before Pearl Harbor. The OSS was officially formed by then, though, and that meant that once Pearl Harbor happened, the US was in the war. My role began to accelerate in terms of training people, because the OSS had recruited individuals into teams of swimmers and trained them to be capable of handling almost anything in the water.

These men were trained as operatives in all but the final training section on underwater activity, and I conducted that. I carried that out as a civilian initially for the first group. Because I was by then only a reserve army officer, I was forced to continue medical school, because the medical department would not allow students to do anything but finish medical school. I had to work with the OSS while I was completing medical school.



LARU

I went to school, but my dean wrote a letter to the faculty directing them that I had his permission to do whatever I felt like doing, when I wanted to. The OSS was a top secret operation. When my obligations to the medical department of the Army were finished, my orders were already cut to go to the OSS. I reported into Washington, D.C., as soon as medical school was completed and immediately went on with an OSS assignment.

I went first into the headquarters of the OSS, which had a maritime unit with a unit head who was the former mayor of Providence, RI, and a Navy lieutenant.

Men had been recruited and had their primary training during the year before I reported to OSS. As I reported to that office, I asked the head of the maritime unit what he would like me to do. He replied that I ought to tell them what I wanted to do. We agreed that I should go out to the Ohio Chemical Company for a couple of weeks and put the advanced equipment into production. At that time, there was only the one prototype underwater breathing unit and fifty units were needed. As the number of men recruited as underwater operatives grew, the total number of underwater breathing units totaled about 250. My main point is that the first task I had to do was to convert a prototype that I had made by hand into a production system. In three weeks it was in production.

During production the quality of the materials for the system improved as well as construction of the mask. We couldn't make new things. We had to adapt to the existing things. There wasn't time to do what is done now. We could not spend ten years designing a mask. I took a sand blaster's mask and rebuilt it in order to give it better vision and mounted valves, allowing the diver to choose whether to breathe air while the mask was on. It also allowed the diver to drain water from it if he got water in the mask and to shut it off. Thus, if the mask came off or the diver took it off, he didn't sink, but could float on the breathing bag. All those things were done within a three-week

period with good machinists and people in the anesthesia company who were not diving equipment manufacturers.

There was no monetary arrangement. In fact, payment was never even considered. The first purchase of equipment was four units of the pre-final apparatus. The OSS couldn't afford it because they had no budget. The cost was split with the British. The British paid for two and the OSS paid for two, at something like $150 each. That's why finances were not something that got in the way.

In the fall of 1940, one of my medical professors wrote a letter to a person whom I think was called the "Director of Scientific Research and Experiment," at the British Admiralty. That letter presented our message to the British, who were hungry for everything because they had needs of the same nature. The message the British had received from me, and then from the OSS, was that there was something they would be interested in.

The Admiralty sent a couple of British medical officers to the US by boat to talk about shallow water blackout. They were losing men with their primitive diving systems. The reason was determined to be inadequate training, not the equipment proper. The problem was caused by the lack of oxygen when their divers did not remove the nitrogen from the breathing system as a routine task.

General Donovan knew that entering by air was a one way street but entering by sea was a two-way situation. His doctrine, and the reason for ultimately establishing a maritime unit, was that he wanted full use of that sea entry for delivering agents, for recovering agents, and for sabotage.

Therefore, in the beginning of 1944, we had sent a team of swimmers using the primitive equipment to an OSS maritime station in England. That was before the final model was sent over to England. The team had a total of only four units to prepare for missions on submarines, which they never got to do.

But the philosophy of underwater attacks had been established. The underwater breathing unit was a needed tool. It was such a strong part of the maritime concept that it became almost a focal point for building other kinds of concepts around it. That was why, when it became sensible to think in terms of longer-range activity than a swimmer could do on his own, there was a rapid acceptance of the concept of incorporating the British submersible canoe that they had developed with the swimmers with whom I had developed the tools. Brought together, under the maritime unit, it allowed us to have a swimmer delivery capability by which individuals could go for long distances, become swimmers, come back as swimmers and come back the long distance via the submersible canoe. Later, we expanded the concept into flight. It all happened in months.

From that point on, I had absolute influence over what happened with the activity we called "operational swimmer activity training." As we reached the point where the equipment was committed, I came back from Ohio Chemical after those first few weeks and went down to the Caribbean. On the way down, I very rapidly wrote a manual so that I'd leave something behind if I disappeared. By the time I got there, the first big OSS group was in training with the prior equipment, which was not, in my judgment, suitable for military operations.

The equipment they were using was my second model. This was the one I had changed from the life saving system into what the OSS could see was useable for several hours in the water. It didn't have resistance against corrosion. It didn't have all the life saving features or floatation features that you would need in case of emergencies, but it was the first functioning, true, underwater closed-circuit-breathing apparatus. That was what it had as its mark, as opposed to breathing in and out of bags. It was a system that let a diver breathe out through the canister, leaving the CO_2 to be absorbed, breathe the next breath out and have that absorbed.

The men who were there were all Navy men, and as I came in, they went out. They had gotten their training through a couple of their people, and, subsequently, they became trainers. That was the breathing system training.

This was 1944, and they had already completed their ranger training and all of the small boat training. Therefore, they were assigned to the Navy. The Navy requested them and assigned them to their new underwater demolition teams. They were assigned to Team 10 and became the nucleus for that. When I arrived in the Carribean, it was after the first group had gone through what I considered less than thorough training, but there was no choice. I had to make the new system come into being.

These new underwater demolition teams were doing a great job, all of them, via the Navy's system. In 1943, when we were beginning the OSS, the Navy was starting its program, so we tried working together. The OSS people went to the head of the Navy system in Fort Pierce. The head of that was Draper Kauffman, who was a very famous Navy person.

It was soon obvious to the OSS people that there was no way that the Navy personnel could be saddled with having to learn how to breathe underwater at the same time as the OSS personnel. The Navy was going to have to use massive numbers of people who would work in daylight.

The Navy training was at Fort Pierce, and the OSS training was on a very small island, called Treasure Island, about three miles long and one half mile wide, off Nassau. At that time, it was under British jurisdiction, but the British were not even allowed to fly over the islands because of the security of the training. We took over that island and used it as a training base, while we lived on the shore and came to the island each morning, back and forth. There were no special facilities.

The second group was now under a different training system, and I was named as the trainer. I was both the medical officer and the trainer, and I had to become the demolition trainer as well, because we had no adequate demolitions. We had to design and build the kinds of things we needed to use. We were working in water with systems that needed to behave and go off when they were supposed to go off and not just blow things up. As a result, we had to design and build some of the kinds of equipment with time delays that would not be ruined by an accident of moisture.

I think the important thing about this training was that the second group of OSS people had the chance to train on the final apparatus. That meant their skills were very far above those of the previous groups. They not only had to be trained as swimmers, but also to use the new mask. That was not hard to do, because they were all water oriented and had volunteered for some task that had to do with water. That was all they did know. They didn't know what it was going to be. The training was very specific in terms of what you learned to avoid getting killed in the process. Therefore, the group started off with great confidence and had no difficulties.

Out of necessity, in the wartime situation, I was a physician who became a demolitions expert. I had to do this because it was imagination that was needed. I had to ask myself, "How do you put these things together? How do you make all of this fall into place?"

To allow the men to work at night and learn how to go from one place to another and not be seen meant we had to devise the navigation system. We needed something that would attach to the breathing system so as to be there, visible, as the men were swimming. We snapped it up in front so that it would come under our faceplates as we were swimming and could hold a course, and we could find the course back.

They now use an equivalent, but they hold it in their hands instead. They call it an "operations board." The Navy SEALs also use an equivalent, which they use as a hand held device.

We made things in place in the field to expand the operational capability. We ended up being able to talk to each other underwater. To make the underwater communication system

work, I got earphones from the British air station and took them apart, and made them into mouthpieces to mount in the mask. The diaphragm of that earphone became a transmitter that took the sound waves of voices into the water. The ears themselves were the receivers, and for about 75 feet or more, we could talk to each other. That concept was lost right after the war, and never came back.

During the early months of the OSS, it was evolving. One of the things that evolved was called a "research division." It was there to devise things that were needed. When I devised the speaking system and sent the details of it to the OSS, they did not even know that they had it because we were not talking to each other. We were off doing training, and, when they learned about it, they immediately provided enough good earphones to go around.

To administer what we needed in the OSS, we had someone who was at a base, even though the base was nothing but a house. Whatever was needed, he got. He was a reserve naval lieutenant commander and had no connection to, or functions with, the training. Another person, named Sullivan, was called the "training officer." He was a Marine captain who had been hurt badly in Guadalcanal, and was appointed the training officer, but he was not the training officer, he was just named that. He was really the authority over some young characters who were these brand new, young guys from the Coast Guard, the Navy, the Marines, and the Army who were the swimmers. He was what you would call the "head of troops," but there were only about thirty troops.

Sullivan was a Marine. He had a natural ability, but he didn't need it for that. He needed to be a figurehead, and he was. He never took his shoes off, never got them wet, and he never went near the water, but he was respected by the guys.

The total of about thirty people were divided into three platoons such as they may have in the SEALs at this point. The platoons were not divided in accordance with whether they were Army, Navy, or Coast Guard; there were Army, Navy, and Coast Guard all together in the same group. Whereas the previous group was all Navy, that one was a mix. Each of them had a lieutenant (junior grade) as a head. One had a Marine second lieutenant, one a Coast Guard lieutenant (junior grade) and one was Army.

Men of different backgrounds headed the three platoons within this group, but it didn't matter. They were all there because of what they were doing. It had no relevance as to whether they were from the Coast Guard or whatever. They all had heavy water experience beforehand.

My roles were multiple but without anyone saying what they were. I was there to make something of the system. I was also medical, so I was also there to take care of any medical problems.

I had no boss. When the head of the base began to intrude in the training and interfere with what I thought needed doing, all it took was a telephone call and he got the word from headquarters to get out of the way. That was the way it was. I never thought of it that way. There was no officiousness on my part. I was brand new. I was just doing it, and it worked.

That kind of loose organization wouldn't work at all today. While the organization was loose, it was purposeful and dedicated on the part of everybody. Security was so high that I didn't even know what was going on the other side of the world. I didn't even know what the Italians had been doing. I didn't know that, despite the fact that we were generating an equivalent.

The men with whom I worked were very security conscious, and I was very security conscious. Once we had a big storm, and it washed the whole bloody bunch of us away from land. We were scattered out there, but wearing the underwater breathing apparatus. Those people had trained with it and had the equipment that could float them, but only if they used it so that it would allow them to float. During the storm, one of the men got scared and took off his equipment because he knew he could handle himself in the water. Actually, he

was just plain scared. He decided to ditch his equipment, whereas the others did what they had been trained to do, namely turn the valve off and float on the breathing bag, which became a life jacket. I raised so much grief with those characters at the end of that experience that they all went out and found the equipment the one fellow had ditched.

My concern wasn't the cost, it was just that I didn't want it to be picked up by somebody because the security was so tight. I gave that guy so much grief that he thought I was the worst guy in the world. He told me he should have drowned himself. You know how it was there. It was a hard wartime situation that caught up everybody.

There was no administrative interference from the OSS. There was absolute commitment from them. However, the real question was when would a group of this sort really be ready? One had been sent out and absorbed in such a way that it was obvious it probably wasn't going to be used, even though the best equipment was sent right off after it. They took the equipment they used for training and had it delivered to Pearl Harbor. This was the advanced equipment that I had finished getting produced.

With the unit that went into the UDT, we assumed that everything was going to be fine, but it was not. They did a great job in bringing swimming into UDTs. I mean real swimming, because originally the UDTs did not have much swimming training or guaranteed swimming capability, because they were just generating people so fast.

We had some of the world's best swimmers in that first group, Olympics-type swimmers, candidate swimmers. One was called the "fastest swimmer in the world." They were in the teams out there and doing so well that the head of the Pacific fleet wrote to Donovan to thank him for providing the opportunity to upgrade the swimming in the UDTs. That was a great thing. The first group brought swim fins into the UDT system, which they hadn't had before.

How do you work when there seems to be nobody in charge? One of the things that had to be decided was when those groups would be ready to go. Roberts came down with the headquarters staff of the maritime unit to appraise the situation, more or less. It was not an officious bunch coming down. They were coming down with full confidence that things were okay. I did the obvious thing. I set up a nighttime operation for them and let them be the targets.

Everybody agreed that there would be a live attack, because there was no point in doing something if it was not real. At that point, it was not a peacetime situation and the need was to get as many people involved as possible, even though ultimately one person may have done a task.

The 80-foot boat, the only boat we had, with everybody on it as observers, team members and the people visiting from Washington, became the target. The rubber boats were called LCRs then, or landing craft rubber, and were paddled by inflatable boats. We paddled about 300 or 400 yards from the 80-footer.

I chose the youngest swimmer in the team to join me as a partner in making this run on the boat. I was going to do it because I surely didn't want it to fail. We stuck together on the way from the rubber boat and hit right on the anchor line of the boat. Our targeting was using compass and having, not an anchor line, but the heavy chain anchor. We hit the anchor chain; using the communications we had so I could talk to my partner, I told him to just stay put while I took one half pound of TNT. It wasn't big, but it was big enough that it had time delay. What we called "time pencils" at the time were delay detonators set at a half an hour.

The boat had a big, five-gallon bucket over the side with a rope, and everybody was looking for action. They saw nothing of what we did. Time passed, so they assumed our experiment had failed and began to pay little attention until someone pulled up the bucket and found the charge in it.

That meant that my partner was sitting on the anchor, waiting for me to come back. It was all moving quickly at that point. I had to get out of the way of the anchor. There we were; the

anchor came up, the bucket came down, and the boat took off like a shot. Now there were two people under the water in the dark, not in connection with each other, with the rubber boat out there somewhere. "Darn it," the fine young fellow just kept calling through the water; "Oh doctor, where are you?" over and over and over again. I honed in on his voice, and we swam back, and that was the end of that. Roberts decided we were okay.

Finally, we were ready. That was readiness. It was a live charge that went off. We swam far enough away to get out of the way of the blast. That solved the problem of readiness, so we were immediately able to wrap up and proceed.

Following the demonstration, we went back, quickly back. We broke up into two teams. I knew that our primary task was to go to Guantanamo Bay to very carefully arrange things between the head of the OSS and the Navy to use our trained swimmers to help judge the security of the bay's defenses. It was a well-planned Navy operation in which we joined the Navy, and that meant joining them at Guantanamo.

But the techniques of what was done were techniques that we decided upon together. I was delayed only a bit in getting there, because I had gotten a hand infection. We got some of the first penicillin that had been made to cure that infection, so I was able to join them at the beginning of the Guantanamo operation.

That was when I thought that it would be wise to point out two separate things. One was a full-scale attack on the harbor as though it was an operation similar to what we did with the eighty-foot boat. It was done. That time, we had the benefit of a submarine, but I don't remember its name.

They approached within about a mile or two of a secondary submarine and offloaded the rubber boats. The swimmers, in their rubber boats, were able to get over and through the nets with those boats. They then entered the harbor. It's a big harbor, of course. They had designated targets within it. They were derelict targets, so they could actually make limpet attacks on the targets. They did that successfully.

That was kind of an all night mission. There were boats, Navy and otherwise, observing other boats. The second part of it was a multi-day thing that went on for almost two weeks. During this time the swimmers were demonstrating what they could do as individuals to the net defenses themselves, as opposed to planting charges on shipping vessels.

It was astounding what could be done because of the way in which we were able to use charges. It usually involved linking charges using primacord, which is an explosive cord that's set off by a cap. The explosion instantly travels down that cord, no matter where it is and how it's laid.

We were able to drop torpedo nets right out of existence simply by having swimmers put lumps of plastic explosive, like composition C, which was an original plastic explosive, in the shackle-like fittings. After running primacord through them so that the primacord flashed through in a fraction of a second, each explosion went off, and the torpedo nets disappeared. It was a mess getting them up off the bottom afterward. Nevertheless, that was one example of the kinds of things that our operation did.

They even went so far as to try to prevent the gate from opening by rigging systems that linked the two giant gate systems so that they, at least, would not do what they were supposed to do. I don't know whether they could have been broken open or not, but nevertheless, the trials were made. It could be done. Torpedo nets could be raised from the bottom by a sort of block and tackle. They could raise whole sections so that you could take people underneath the nets if you couldn't get through them. I think it was that kind of multiple task that made the ordnance that the senior Navy group was involved with.

I have a good story about their security, which was beautifully documented and put away so tightly that it didn't come out until about four years ago. I did not see it until it was finally released. The operation showed the

offensive capabilities of this new system. It was designed to show defensive faults as well, but it didn't. This, at the beginning and middle of a war, is not the sort of thing that anybody wants floating around. The Navy did a beautiful job of managing that effort, backing it up, and the OSS people came in to be actors in the scene. I consider that one a Navy operation.

The people we trained were ready to go to war. You have to realize how ignorant a first lieutenant in the Army was when the world was geared around secrecy. The OSS had to make things happen, and they let you know what was sensible to let you know. As a first lieutenant, even if I had to make the whole system work, all I knew was that we were going to be going over to what was called the "Southeast Asia Command." The word was that it was a base in what was not a war zone. It turned out that Donovan had come to an agreement that we could use this group. That was the key element. We were going to join the system. I never knew anything about that.

We split. The men were put in their pathway for being sent over. I had to stay put for a couple of weeks to get some more documentation into the system so as to not just walk away and leave things out of control. I have a hunch that some of my team may have gone by ship. I don't know how they went, because I was delayed in getting over there, because ultimately I had to pack up the equivalent of what I would need for almost two years to create their medical support.

I was on another track. I generated containers that were tough containers, field-like containers full of whatever I thought I would need medically, in a remote region, to back up the people when there was no one else to help in any way. I went so far as to pack sterilizing equipment, instruments, things that you would not think of in terms of ordinary medical backup for something. I packed drug supplies and tropical medicine. I had to invent what would be needed by myself.

There was no one in the OSS who said, "Well, here's the stuff you ought to take." I had to create not only the equipment requirements for the swimmers, but also the medical support requirement at the same time. That was where the block came. I was off on my own without anything I needed because it had gone with the swimmers.

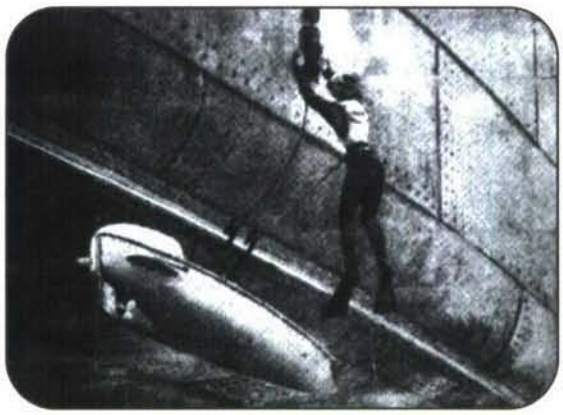
I traveled from Washington and had to wait for transport, which took some weeks. That was the disconnect that I mentioned. I left New York and flew to the Azores and then on my own across Africa and India to get to Calcutta. Then I kept on moving down into Burma.

I flew on a very fine aircraft called a C-47, which was a two-engine plane with bucket seats. That was what you did in those days. The air transport command existed, but these were the kinds of planes that flew the hump over Burma and China at the time. I was disconnected; I had to find my own way to where the system was. As the medical back-up for the swimmer group, I had to be there; that was it.

In the final stages, my travel was with troops who were going down the coast on foot and by jeep to get to a point where we took off for an amphibious landing, for which my crews were already loaded up. I joined those people in their landing, and we ended up as backup in the last part of this campaign.

When that was under control, I left. I came back and picked up the training of the swimmers and submersibles, training the teams into swimmer submersibles, or what we called "swimmer delivery techniques and tactics." It was what the British called the "Sleeping Beauty."

The *Sleeping Beauty* was a one-man submersible that was, indeed, like a steel canoe. It had buoyancy chambers fore and aft so that you could let those chambers be filled with air and float, or with water to sink, or become neutrally buoyant. There were something like four batteries of the sort that we'd put in an automobile, a motor to drive a propeller, and the planes on the stern would allow you to go up or down. As you sat in it, you wore a breathing apparatus. The British used that system. They had planned



Sleeping Beauty

to use it heavily in that whole southeast Asia region against the Japanese. They had it all. They didn't have the chance to do it, because, once again, they had problems with losing people in training.

That same early process that I had to go through with British officers was showing them how to avoid hypoxia. I had to do it all over, again, in Southeast Asia when the SRS finally knew we were over there. Together we made contact with the head of that system. I then had a proper liaison with their *Sleeping Beauty* efforts.

The British turned over a couple of the submersible units to us, and I used them to teach our swimmers how to become their pilots. At the same time, our men were already expert swimmers. For that reason, we had almost immediate swimmer delivery capability. The SRS retained their *Sleeping Beauty* non-swimmer capability, because they did not have the ability to truly swim outside.

The British had the concept that the submersible and the pilot were a unit resistance factor. Of course, I knew nothing about that. We were considered part of the OSS. It was something that existed without my understanding what it was when my first contacts began. They were just direct contacts with people; a Marine captain or a Navy lieutenant at a swimming pool, for example. That was the OSS as far as I was then concerned. I later learned that there was an office behind it, meaning some people were there. It was a secretary and a Navy lieutenant who seemed to be in charge. As a medical student, I thought they were perfectly fine people. They kept in close touch with me.

Then, as it opened up, I don't believe I saw any real change in the way they acted over the following several years. They kept that personal communication approach and never seemed to be in a hurry. I'm sure they had a lot going on. It got to be touchy only when we were in a remote place in another part of the world. When I showed up at the Southeast Asia Command, I discovered that people there lived a different, disconnected life.

The medical officer at the OSS headquarters, in a town called Candy, had decided that there was a medical officer in the area and this officer was now on his staff. He was a medical officer, and I had to disconnect myself from the clutches of the OSS medical department that was so pleased to finally have another medical officer.

At this point in time, I was still absolutely inexperienced in terms of what was going on in the background, because I was focused on what we were making happen. To extricate took a little bit of time, but it was done. I just wasn't going to do it.

The British had a different concept of the relationship between swimmer and submersible, and that difference was very sharp. I think Britain never developed real underwater swimmers because they developed great divers for going up and down. The British had the big explosive ordnance disposal, and therefore, if you couldn't swim with their equipment, it didn't make any difference, because you were going to be going down and walking around on the bottom.

Their concept, when you were in the *Sleeping Beauty*, was that you were in it until you reached your target, and, then, if you had to get out, you got out. You had a lanyard connecting back to the *Sleeping Beauty*, so that you were never really a free agent. Conversely, the OSS groups began as long range underwater swimmers who could find their way and do things, and then find their way back without that transport.

Once we got to use the *Sleeping Beauty*, we had the advantage of being able to go without wearing the swimmer out and still have additional reserves of swimmers.

When the war ended, the OSS ceased. When the atomic bomb was dropped and we won victory over Japan, it was the fall of 1945. On September 20th, Truman wrote a letter to Donovan, thanked him for his service, and terminated the OSS. It was obvious that if you were the president, you were not going to want an OSS laundering around inside the country with the kinds of situations that it had built into itself, and therefore, it was not too surprising to me.

What was necessary was to somehow keep from losing what we had done, and so I made some contacts with the Navy. I was hopeful that the swimmer delivery concept would be made a part of its own activities.

The whole aim was to salvage the concept by broadcasting it. When I got to the office of the maritime unit, the true physical office in Washington, it was tearing itself apart, packing up its papers, throwing them away, burning them, and doing whatever.

I had just come in from a long trip back from the West Coast to discover at that point that the OSS was finished.

I was able to get the Navy lieutenant administrator of that maritime unit office, John Moran, to simply type and sign a secret clearance to open the underwater apparatus and use it. Right then and there, in an office, with nobody else there but Moran and myself, we made that possible. There may have been some background instructions that this Moran fellow had, general instructions about declassifying equipment, but it was a really catastrophic circumstance for the OSS to close in this manner, and we had to save time, save our equipment, and close and preserve. Consequently, he and I just did it. That meant I could go and, for the first time, discuss it and talk to someone about it.

I chose to go to the head of the Army engineers, a Lieutenant General Wheeler, I believe, and to the commandant of the Coast Guard, and to the head of a few ships that still had a diving section. Going there, I left equipment with each one.

I managed to obtain the equipment from Washington storehouses. I had simply gotten a sergeant and a truck. I went and loaded the equipment onto the truck and went to each of the headquarters and deposited two sets of equipment with each one, along with the manuals that I had generated before going overseas, which Moran had. As I delivered the equipment to the Army, Coast Guard and the Navy, I simply got a paper receipt. I've still got the receipt I got from the Navy. It reads, "Ships written, received two Lambertsen units from Captain Lambertsen, signed somebody."

Then I had to report for duty as an Army medical officer, because I was no longer part of the OSS. So I reported back into the medical system.

It took nearly two years before the Navy picked up on the fact that they had been given the open equipment, unclassified, and the fact that they could have any of it filtered through to anyone in the Navy, such as the amphibious forces who might have been interested in it. I didn't know that there was such a point of contact.

All I knew was that the men were gone and that meant there was no system at all, and unless something was done, there would be no equipment. About all I knew was that there was a storehouse in which we had kept the supplies for the OSS.

While the Navy didn't pick up on the importance of what I had done right away, it was different with the Coast Guard. The Coast Guard commandant was so fascinated by what happened, he had the equipment delivered right to his office. He then took me home and I had dinner with him. His son was out, so he said, "I've got a bed for you. We'll just talk some more." Instantly I was asked, as an officer, to go to the Coast Guard station and set up a training program for the air/sea rescue system at Mayport, FL.

With the Army, it took a little more time, the better part of a year, and then a system existed.

The Army engineer research and development command got the word from Lieutenant General Wheeler's office, "Let's see what you can do to evaluate the potential for this system." As I said, the Navy was the last one to pick up any interest. It got that word from the Army. The Army informed the Navy, and that led to the head of the amphibious forces, Atlantic, and a Lieutenant Commander Fane. He was the recent head of two underwater demolition teams, classical underwater beach reconnaissance teams. He was quick. Once he got notice that there was something going on, he and the Army talked. The end result of that was that I got an invitation to come down and train the Navy UDTs in underwater swimming.

The breathing units were the same stored, original batch. Only one batch had been made, and they were exactly the same ones that we used during the war; they had lasted for almost 15 years.

At that stage, I was a civilian. I had to stay with the Army medical department for about another year because I was a physician and people were hurt. Thus, medical officers stayed on. I managed to get an occasional leave of a month or so to go and train the Coast Guard. That training was very fast moving.

Then, in 1946, I was discharged from the Army and joined The University of Pennsylvania. It was only a year from the time the atomic bomb had been dropped. Within a month or so, I went down and dealt with the Army, and in 1948, the Navy. I stayed with them for ten or more years.

The Navy used the apparatus for a number of years and then two things happened. Leaders changed, and, therefore, direct communication changed. Just picture what would happen if something was made and went through some several years and then some ten more years of working in the field with the Navy. It wears out; parts wear out. The Navy never bothered to follow up with spare parts and things like that.

Also, the budget began to get a little lean and the leadership changed. This meant Commander Fane, who was very keen on the whole thing, moved out and began doing other things on the West Coast. No more equipment was being manufactured and the Navy switched to other equipment.

At that time, there was no such thing as civilian self-contained diving or self-contained civilian divers. I didn't push it because I knew they would get hurt. I purposefully never pushed closed-circuit breathing for civilians, and I still don't. What the Navy began to do was scrounge around to try to find what it could use. The aqualung came along; it was obviously an attractive thing, but it was not useful, and it took several years for the Navy to admit it.

It's my opinion that the aqualung was not useful for the Navy because of the weight and the inability to use extremely heavy equipment. The Navy men were used to picking up something with one hand, slapping it on, jumping off the dock, taking off, and that sort of thing. The aqualung only had a duration of a half an hour or so in the course of an ordinary depth run. If you left the bubbles out of it, you dumped every breath as it expanded in the water.

Furthermore, it was not useful for submerged activity, such as working in and out of a submarine. You couldn't crawl in and out of a submarine lock escape trunk with it. You could get two people in, with difficulty, instead of four people in with ease. It just didn't adapt to any of the things that the closed circuit oxygen breathing adapted. Next, the Navy began to just reach out and try to find what they could get. They got some old Italian equipment that had been good for the torpedo men, meaning the charioteers. It worked beautifully for them because they were sitting quietly and steering a torpedo. They didn't do any exercise. They were not working. Therefore, its ability to handle the carbon dioxide absorption was not adequate for underwater swimming. Its positioning and its buoyancy characteristics were not geared for it either.

The Draeger was a foreign unit that emerged, but it was designed as a submarine escape apparatus, quickly modified to meet a

possible new market. It became a commercial kind of thing, but was poorly made. As a result, there was no source of equipment. So, the Navy played around and ended up, more or less, just using the aqualung for a good number of years. They lost a lot of capability when this happened.

The Army had taken a different approach. As we finished an evaluation of all existing equipment, it was obvious that it was sensible to go ahead and try to use new materials that were emerging and reconstruct the capability of building an improved, better self-contained diving apparatus. We did it, and I found a manufacturer that would help build it. It was the Emerson Company, which made polio resuscitation equipment.

The Emerson Company made iron lungs and those kinds of apparatus. They knew breathing and knew how to put tubing together. They became a partner with me. We were partners, because I needed someone who could make what I wanted to make. We made a good, new Army apparatus, but, by that time, the Navy had begun to try to establish what it would do.

Somehow those in the Navy would not connect with the Army. The correspondence that went back and forth was beautiful. It consisted of individual naval officers trying to crack problems with the Navy to try to get communication going about equipment that they knew existed. Finally, we just turned the thing around when I said, "Let's call this new



Draeger LAR-6



Emerson—Lambertson self-contained apparatus



Emerson—Lambertson self-contained apparatus



Draeger LAR-5

apparatus the 'Emerson equipment.'" It solved a lot of the problem with those people who were thinking, "It's just the Lambertsen apparatus again." When we changed the name, it opened a pathway that had a long, long run.

It took nearly ten years to go from that immediate reconstruction in the Army to getting the Emerson, what's now called the "Emerson—Lambertsen," or the "Lambertsen—Emerson," but then called the "Emerson," into the fleet. That ten years was a very poor time, because it was a time when the SEAL system hadn't emerged in full and the amphibious forces had no picture of how they would use the UDTs with swimming equipment.

We had a limbo situation. The UDTs had poor equipment and were struggling to get some equipment that would work. The Emerson became that unit in the Navy. The Army and Navy tried to work together temporarily, but then it wasn't worth it. So the Army went through extreme evaluations and put it aside as something that was just not going to meet its evolving purposes. That kind of equipment couldn't stand the heavy power-shoot operations and that kind of thing. As a result, the Army development was documented in full and put aside.

The Navy evolution occurred through the Emerson into other forms of equipment and finally into the Draeger, which is now called a LAR-5. The conventional Navy oxygen re-breather now used by the SEALs is the Draeger LAR-5. It's been in operation for almost 15 years now. It's a long period of time we're talking about.

The LAR-5 began as a submarine escape apparatus, but it had a manufacturer who knew how to make that kind of equipment, so it kept going. Finally, the Navy slid over, and we stopped worrying about whether our source of supply would exist if there were another war. We decided it didn't matter what the source was. We took the best we could get, where we could get it, and that's what happened; the LAR-5 was the best, and was good.

I was to make the green UDTs, those good surface swimmers who had never dived, into good underwater breathing apparatus swimmers and self-contained divers. That was done in Little Creek. Then, to make them more operational, we had the submarine service provide the USS *Grouper* to train the swimmers in locking in and out of submarines on the bottom and underway. That was where the *Grouper* came in.

It was in January of 1948 that they got underwater training and had their diver training. Immediately, we put it to work. It was always Fane and me doing it together. It was not something in which he was just an administrator. He was right in there with them as a swimmer. He was the first trainee and the first everything else. The *Grouper* taught them the lock-in, lock-out sort of activity. There was also the need to try to have them learn how to work with the *Sleeping Beauty*. That happened in the fall of 1948.

By that time they had been through a lot of things in the Navy. They were taken up to the Submarine Base New London at Groton, CT, for training at the submarine escape tank. They were learning how to lock-in and lock-out and practicing so that we didn't have to have a whole submarine on our base. You could run people through the procedure again and again until they got so used to it and it became so easy and it was natural.

They then went to the USS *Quillback*. With the *Quillback*, the task was to have them do heavy work on the deck of that submarine. We used it first on the bottom and then had them go through handling the *Sleeping Beauty*, learning how to secure it and getting used to the thought of it. Some of them trained a little bit in the use of it as pilots. Some of them trained to become the trainers of the pilots, the maintenance, and such things.

Having done that, we had the opportunity to go back and do a long run. At about the same time as with the *Quillback*, we did a long run on a straight course to demonstrate coming down on the submarine and landing on it. We had a small two-man deck crew positioned to help

secure that submersible and demonstrate that, and then have it take off and demonstrate that. But the key to it was taking two people. Fane was one; we taught him to be an underwater cameraman, because we had one of the few underwater cameras in existence at the time. The inventor of the underwater camera was Fenamar Johnson, a neighbor of mine, who had been taught to use the scuba equipment for the first time while he was down with the submarine.

Fane and Johnson sat in the gun chairs of the *Quillback*, with the cradle for the *Sleeping Beauty* up forward. Both men had cameras and fifty feet of film, with a single shot with a line from the bow to a buoy, about a submarine length away. The requirement was to have the *Quillback* come up and the *Sleeping Beauty*, which I piloted, come in from the side as the submarine approached. We then had to thread a bowline through a loop in the buoy and hang on for dear life to that bowline while the tanks were vented. We used the diving planes to go down and sweep over the bow of the craft. We also had to have the help of one of the crew members pulling on the snared line and into the cradle, tying it up quickly, and then untying it and taking off again. That was the *Quillback*. The point I'm making is that the deck crew were who made it work because even coming over the rail, I lost a stern plane. It hooked on the rail and ripped off.

The main point of all of that was that it demonstrated in one shot, with two good guys on the cameras, that it had happened. Once that had been done, the film became the message that was sent by Fane and me with reports up into the system. They then acknowledged that it existed and that something could be done.

The key guy in that whole thing was Admiral Fife. Through all that kind of an operation, with people outside that submarine and all those things happening, that was hard work going on there, and hard work meant more oxygen pulling and more of everything. It was touch and go.

He, on occasion, rode that submarine when things of that sort were happening. He did it with his neck out so far because there was no communication between the inside of the submarine and the outside of the submarine. Nobody inside knew what was going on outside. They only knew that the periscope had signaled an okay. The submarines came in from the side; if they swung around, they wouldn't see it. That was all the information they had. Men could have been swept over, had convulsions, passed out, or had equipment troubles. There was just no way to communicate. Those people, the skipper of the submarine and the admiral, who stuck their necks out, I think, were real characters.

People like Fane were doing that as though it were nothing. We were just doing it. By that time Fane was a good expert, confident swimmer like the rest of them. He had his neck out, too, because, after all, he was the skipper of the team. The only one who didn't have his neck out, I guess, was me because I didn't belong to anybody.

REAR ADMIRAL RICHARD LYON

Very briefly, here's a fast history of how I wound up in Navy special warfare. Right out of Columbia Midshipmen School in 1944, I saw an interesting notice on the bulletin board: "Wanted: Volunteers for extra-hazardous duty involving explosive disposal, and must be strong swimmer." That had my name on it. So I volunteered and went right into Navy Scouts & Raiders. I went to Ft. Pierce, FL, for my training in 1944.

Interestingly, I don't recall any of our UDT frogmen who were involved in the action at either Omaha or Utah Beach during World War II. However, we certainly did have those when I was going through the training with Phil Bucklew and Ensign J.J. Bell at Ft. Pierce. They were the ones who were running the Scouts & Raiders training in 1944.

We went to Advanced Naval Intelligence School right from Ft. Pierce, FL, which was held

at the Henry Hudson Hotel in New York City, right on Columbus Circle. From the jungle of the Indian River at Ft. Pierce to New York City was quite a transition. We were there at the intelligence school where, very candidly, (I think it's totally been declassified at this point) our briefings and all of the classwork that we had was focused on Taiwan. Of course, as it turned out that was misdirected, but we then went right from Henry Hudson Hotel, Advanced Naval Intelligence School, to Administrative Command Amphibious Forces, Pacific (AdComPhibPac), with a brief stop in Coronado.

AdComPhibPac was headquartered at Pearl Harbor. So we would be in Pearl Harbor and at the disposal of ComPhibPac for such work as needed to be done, primarily in beach reconnaissance. We were first in the South Pacific, in the Philippines. I wound up doing a reconnoiter on a beach in Mindanao.

It was anticipated the next amphibious assault would take place there, but that never happened because the bomb was dropped.

The Naval Combat Demolition Units, which were all Seabees right out of Camp Perry in 1942, transitioned down to Ft. Pierce, FL, in 1943, and then were folded into Naval Combat Demolition Units (NCDU), underwater demolition. At that time, it was a kind of "feeling your way with what was going to work best and how to do this most effectively" daily routine. Of course, Draper Kauffman was right at the forefront. He was the patriarch of Navy Special Warfare as it ultimately evolved right from NCDUs, Scouts & Raiders, Underwater Demolition, and Navy SEALs. I'm sure Draper is looking down at what's being done now and saying, "Oh my gosh!"

Things were different in the Pacific than in the Atlantic theater, because Phil Bucklew was one of the most well-known for doing recons. He did recon on Omaha Beach, but that didn't happen for us in the South Pacific as it turned out.

I got out when the war ended and I had the opportunity for extended duty. Being a bachelor at the time, I volunteered to go on to the staff of the Commander, Seventh Fleet, where I became known as a Scout Intelligence Officer. In 1945, I wound up in Northern China as a Scout Intelligence Officer for nearly a year.

There, I met Phil Bucklew, who had been my instructor at Ft. Pierce, FL. One of the members of my class was his assistant, Ensign Vin Adams. They were running the Shanghai Shore Patrol, which was kind of interesting.

I subsequently got out of the Navy in the summer of 1946, and then began to pursue my studies at Stanford. Then the Korean War broke out. Being an active Reservist, I was ordered back to the Naval Beach Jumpers in Coronado, CA.

When I reported in there in June of 1951, I found that some of the former acquaintances and friends I had made during World War II were getting ready to establish a new Underwater Demolition Team (UDT). On the first day that I reported, I volunteered out of the Beach Jumpers. Eventually, we went on to commission UDT-5 and take them to Korea.

I had done my Scouts & Raiders training at Ft. Pierce. Because I was the only one who had been through the training, I went personally to see LCDR Louis States, who was the commanding officer of UDT 5. I said, "Captain, I know that this training is somewhat rigorous; maybe I could be used in another way, because I've already done this down in Ft. Pierce." He was a southerner and he looked me right in the eye and he said, "Lieutenant Lyon, there is not going to be anybody on my Underwater Demolition Team who doesn't go through this training, with one exception, and that's me." So, I've gone through that training twice. It was quite an experience.

As I think about it, there was very little difference in the training of the Scouts and Raiders and the UDT. The Scouts & Raiders were decommissioned immediately following cessation of hostilities in World War II; anybody who wanted to stay in the service was phased into the UDTs. My case was somewhat different, because I had the opportunity of going from

Scouts & Raiders to Commander, Seventh Fleet as a Scout intelligence officer, which was great.

Admiral Richmond J. Turner was the one who saw the similarity of the missions of the Scouts and Raiders and the UDTs. He was the one that really was the strong advocate for both the UDTs and the Scouts & Raiders, but then he scratched his head and said, "I don't think we need the Scouts & Raiders. We'll just have that function performed by the UDTs."

Phil Bucklew in Scouts & Raiders did the reconnaissance in Normandy, North Africa, and the beaches in Sicily, which also were done by the Scouts & Raiders.

The UDTs really did their operations in the campaigns in the Pacific. The Scouts & Raiders were, interestingly enough, less involved there, with some notable exceptions. As I said, I wound up in the Philippines doing it.

I think the most related experience to diving was when Captain States detailed me because of my background in competitive swimming while I was an undergraduate at Yale. He said, "I need a strong swimmer to go on up to Wonsan Harbor on independent duty. You'll probably be up there a couple of months. We have reports of a new anti-amphibious assault mine, which has been found inside Wonsan Harbor. The harbor itself is enormous, at least a good 10 miles across. The entrance to the harbor is rather well-formed; it's somewhat like a reverse of San Francisco Harbor."

So I went up to Wonsan Harbor and that's where I became involved in mine recovery. It was during the winter. While I knew what my physical capabilities were, when I was in 34°F water in a dry suit, I found that I just couldn't physically function effectively and efficiently. For me, that was a big surprise. I could stay in the water only for 20 minutes and then I had to be pulled out.

We had a two-man rubber boat and these were anti-amphibious mines. Upon occasion, we were being shot at from the shore. Lieutenant Dick Edwards would stay in the boat while I would be in the water with a pair of 24-inch bolt cutters. I would dive under the mines, which we had previously spotted by a helicopter that was on board the LST 799 in Wonsan Harbor where our base was.

I dove nearly every day when we were able to find the mines. We had a lot of not-so-good weather, because we were there during the winter time and into the spring.

We found one of the RMKYM, which was the Russian-made mine, the small one. Also, there were impact mines and several other types that turned out to be all manufactured by the Russians.

I had no kind of gear on, neither clothes nor open circuit gear. I was just skinning it, as the saying goes. I would dive down to about 10 feet. That's no big deal, but as I said, you just don't work as efficiently in cold as you do in warm water.

I took the 24-inch bolt cutters and put them on the cable under the mine and then cut the mooring cable; the mine would bob up to the surface. Sometimes we did that in another fashion. I would go down and tie a recovery line around the mine, and then we pulled up the mine anchor mechanism from the bottom, which turned out to be like a little cart on which the mine rested.

They would take those mines out on sampans and push them over the fantail; this would sink the mines in what we thought were cleared channels. Incidentally, that is what happened to both the *Pirate* and the *Pledge*—they thought they were in clear channels, but it turned out not to be.

I would make as many as four dives in one day, and then I would get back into the little two-man rubber boat. We would go out to the MSB, the mine sweeping boat, which was a converted LCVP. Then we would go to the next spot where we had previously located a mine. We would again launch the two-man boat, and over we would go. I'd get in the water and do the same routine.

We didn't use either open or closed scuba gear at the time; it was just coming in. When the

team came back from Korea in 1952, the gear got issued and we had it. That is, UDT-5 had it in our dive locker, and we used it both in the bay and in the ocean.

Doug Fane was there at the time and we had the three teams—teams 1, 3, and 5; all were skippers of course. Then they established the unit command, UDU. Doug Fane had the unit command as a senior lieutenant commander. He stayed on over the next years and really kept Underwater Demolition on the front burners.

Our instructors were enlisted guys who had gotten previous instruction from somewhere, plus the guys who were in the dive locker who took care of the gear after the dives and made sure everything was working right. It was easy for me to tell that they didn't know a hell of a lot more than I did. So it was kind of a learn as you go evolution. For me, it was a great experience because it was really new at that time. There was not a lot of this kind of equipment around, and just going along the bottom of San Diego Bay with a dive partner was, for me, very interesting. Eventually, they changed the numbers, and teams 1, 3, and 5 became 11, 12, and 13. When team 13 was decommissioned, the members of 13 went into 11 and 12.

In 1952 I came off active duty and went right back up to Stanford and finished my MBA.

I had the pleasure of meeting Draper Kauffman, patriarch of Navy Special Warfare, one time when he was on his last tour of active duty as Commandant of the 9th Naval District, in Great Lakes. We had a wonderful talk. He was a rear admiral, and I was a fresh-caught rear admiral. We had a great single meeting.

I guess one of the most exciting things that can happen to any naval officer is hearing about getting promoted. As a captain having spent all the time that I did in Navy Special Warfare, I figured that was the end of the line for me until I got a phone call from the Pentagon in 1974. It started out "Admiral Lyon?" I said, "No, this is Captain Dick Lyon. And who have I the pleasure of speaking to?" "Well, this is Vice Admiral Pierre Charbonnet, and I just wanted to let you know that you can just forget that captain stuff. Congratulations."

And so as of 1 July 1974, having previously gone to Lakehurst, NJ, in the dead of winter in 1969, I got my jump call and became fully qualified. I also got my designator as an 1135 officer. And so I became the first flag from the SEAL community on 1 July 1974.

MR. TOM ODUM

In 1954, I left Harley Davidson to work for Hayes Aircraft in Birmingham, AL. My job was designing components and subsystems for the YKB50 in-flight refueling tanker. In this capacity, I was on a design table eight hours a day, five days a week. I soon discovered that I was not compatible with a job consisting of a life with nothing more than a design table.

While at Hayes, however, I bought a surplus B4 oxygen diluter demand regulator, waterproofed the inside with rubber cement, and started diving in the quarries in the Birmingham area. I had no knowledge of decompression or embolisms, but somehow I managed to survive. I was diving to depths up to 85 feet, but fortunately a 38-cubic-foot fire extinguisher bottle has a very limited air supply, especially when used with a regulator with high inhalation pressures.

It was early in the scuba program, and when I used my rig, which had a large brass bellows as part of the pressure regulator, in salt water there was considerable electrolysis between the brass and the aluminum. One day at about 20 feet in the Panama City jetties, the brass bellows failed and released the full supply pressure to my bit. Fortunately, I did not have a strong grip on the bit, and it blew out of my mouth. Again, blind luck was on my side.

I next applied for an engineering position with the Navy Mine Countermeasures Station (NMCS) in Panama City, FL, and reported for work there in June of 1955. The NMCS had numerous name changes through the years and, when I retired in 1992, it was the Naval Coastal

Systems Center. I really enjoyed my work at the Center and had tremendous opportunities.

My first program was to design a remotely operated vehicle (ROV) for Mine Countermeasures. Components of this concept were used in the first ROV in Mine Countermeasures and maybe even by the Navy.

At that time, the NMCS had three civilians, qualified by the Navy for diving, who were working on a program to support EOD divers in Mine Countermeasures. Neither of the three were really interested in continuing the diving program. I was in the fortunate position ofk being a new employee with great enthusiasm for diving, so I requested the program. The objective of the first program (Project MANFISH) was to develop an underwater TV for the divers in the MCM program.

TV cameras were very big at that time but required constant adjustments of several functions. We installed the camera in a brass canister 14 inches in diameter and three feet long. They had to be pretty heavy to make it negatively buoyant. It was not much fun lugging that thing around, but it worked, and it worked very well. It did its job within limitations. While it was not considered feasible for fleet uses, it did have the beginnings of a useful tool in MCM, for salvage, and other uses underwater.

The next program we had, in 1956, was to develop a low influence scuba for EOD divers. We made a sintered metal filter for the exhaust, and we were able to break exhaust air into bubbles one-sixteenth of an inch in diameter and reduce the noise to an acceptable level. The filter worked fairly well; the EOD divers accepted it because it didn't add much volume to the breathing system.

In about the 1958 timeframe, we started a program to develop fiberglass air flasks. The bottles were approximately four inches in diameter and 20 inches long. At first, we had seepage through the fiberglass, so we tried different liners. We mounted the bottles in banks on a manifold that incorporated a quick disconnect valve so the banks could be plugged



Early version of PQS 2A swimmer sonar



Small Area Navigation System (SANS)



Small Area Navigation System (SANS)



Mark VI Semi-closed breathing apparatus

together to tailor the air supply to the dive. Each bank was enclosed in a neat fiberglass shell. We were not able to introduce these fiberglass bottles into the fleet because of the unpredictability of fiberglass at that time. However, it did start the process of using fiberglass bottles under water.

The MK VI semi-closed circuit breathing apparatus was approved for fleet use, but after testing it, there were a lot of changes that needed to be made. NAVSEA let a contract for the system and tasked us to evaluate it. A fleet team consisting of divers from EOD, Special Warfare and Mixed Gas School, Key West, came to Panama City for the evaluation.

During testing, the team found several discrepancies with the unit. For example, the MK VI is based on a constant mass flow control regulator that injects a constant mass of gas to the breathing bags regardless of depth. The most interesting problem was that the unit changed mass flow of gas as it descended.

In testing, we found that the regulator would reduce mass flow with increase of ambient pressure. We eventually discovered that the orifice adjusting screw was sealed with an "O" ring and that this "O" ring was the only retainer for the adjusting screw. As ambient pressure increased, the "O" ring allowed the screw to move to the extent of the clearance of the threads, thus reducing the flow rate. A jam nut was installed on the screw, eliminating the problem.

I don't know of any fatality with the MK VI, but we did have some near misses because of the CO_2 canisters. We all thought they were six-hour canisters, but we did not realize how much loss of efficiency we had with cold water. We didn't discover this until we had the Hydrospace Lab functioning, where we could actually analyze the gas under changes of temperature and flow rates. While we were able to find the canister problems with the Hydrospace Lab, we did not have the means to correct the problems. We did, however, inform everybody about how much efficiency dropped off with temperature.

We were trying to work out a system so that the MK V (the Navy's deepsea diving system) could approach an acoustic mine. We also did some experiments with the MK V hard-hat to reduce exhaust noise. We thought if we had a flexible hose from the exhaust to the surface, we could eliminate a lot of the noise from the MK V so the diver could approach acoustic mines.



Mark V

This was in the days when the divers were having a hard time adjusting to scuba. In fact, some of them actually transferred out of the diving program rather than adjust to scuba. When we put a flexible hose on the exhaust of the MK V, it vented the gas from the MK V very well. But as a slug of gas moved up the hose, the hose would collapse behind the gas. When it collapsed, it actually amplified the noise of the MK V quite severely. That was, of course, an effort that failed.

This story is a sideline from the work I did, but it is a good example of the type of problems we had to solve. When we were testing the MK VI semi-closed mixed gas unit against the instrumented mine apparatus, Wilber Eaton, as so many people knew, made a dive on an instrumented mine. Ten minutes later, he was floating on the surface, unconscious. We pulled him on board and got him all squared away. We could not find anything wrong with the MK VI, so I took it and went down below the boat and swam on the bottom with no problem.

Later, I asked Wilbur how late had he been out the night before. He said he had been out a while with a bunch of the visiting teams. I asked Wilbur to get a good night's sleep. The next morning, 10 minutes after Wilbur went into the water, he was on the surface unconscious. So, we stopped everything.



EX 19 sensor controlled mixed gas breathing apparatus with lithium hydroxide absorbent canister

I entered the recompression chamber with the MK VI and worked real hard—nothing happened. We went to 80 feet, and still nothing happened. So we decided to take every screw off the MK VI to find out what was going on. It turned out that the hoses were delivered from the factory with no check valves in the mouth bit. Wilbur's lung capacity was such that he was breathing shallow and was chasing the gas back and forth in the hoses and bags without going through the scrubber. On the other hand, I was breathing deep and pushing it through the scrubber enough to keep me going. It was just one of those things that you come across that you don't think about.

The MK VI was very successful and it lasted for about eight to ten years in service. There are still a few of them around, but I doubt they are used any more.

I started into the program working on the three projects mentioned earlier. Bill Quigley came into the program next, and then Roger Johnson. For several years, it was just the three of us. Then we got Bill Culpepper and Bob Porter involved, and it gradually grew. At that time, the Department had all the engineering labs, the test ranges, the Special Warfare Program, and the Diving and Salvage Program. So, of the 300 people we had in the Department, I'd say 200 of them were dedicated to diving when I retired in 1992.

One of the interesting projects we worked on was the cryogenic breathing system. The theory was that we could freeze the CO_2 out, using the liquid helium as a cooling agent for the CO_2 canister. It worked fine; however, the absorbent canister, the freeze out canister, was made of flimsy material, probably a clear, flexible plastic. It withstood the temperature well, but at that temperature, it was very fragile. But worse than that, CO_2 would freeze out and chunks of CO_2 ice would start breaking off and

going through the system. All of a sudden, you would get a slug of dry ice.

I think that could have been improved because it still has merit in a firefighter's breathing apparatus where you are in a protective suit. In an environmental suit where you are in a totally enclosed atmosphere, with no way to get the heat out of the system, using a cryogenic breathing system would have done a good job.

For thermal protection, we tried a blubber suit, which was micro-balloons in a gel of castor oil. It provided good thermal protection and was non-compressive so you did not lose buoyancy as you descended. Of course, it probably took 75 pounds to make it neutrally buoyant, but then you still used the same 75 pounds at 200 feet as you used on the surface. We did that in an attempt to eliminate the buoyancy change and to increase thermal protection. Unfortunately, it worked well in theory, but not very well in application.

In thermal protection, we also tried a device that burned magnesium chips in a pure oxygen environment. We circulated water through the combustion chamber into a tube suit to provide heat to the diver. The water temperature was controlled, plus or minus a degree, by controlling the amount of oxygen going into a combustion chamber. It worked well, but once you snuffed it out, it would not restart. So if you had a flame-out, you were exposed to the cold. We used a device similar to a flashbulb to ignite the magnesium chips in the combustion chamber, and it burned fairly well. We got good combustion of the whole charge and it produced a good heat supply. It had several practical problems; for example, the concept of burning magnesium in a pure oxygen environment kind of shook up some people. It was dropped fairly early in the game, so we did not really get a chance to perfect it. But to me, it was a good heat source. It was a small canister, and it didn't take all that much oxygen to feed it.

I think that if we could solve three problems, we would have unlimited capability in diving. Of course, the first one is the physiology to 2,000 feet—if it is possible. The second is the thermal protection problem. I think the system of putting hydrogen into the breathing medium is really a breakthrough. Once we get that accepted, I think the thermal protection problem is essentially gone. If you can heat the torso and transmit the heated blood to the extremities, you no longer have a thermal problem. The third problem to solve is the need for a life support system that is truly closed circuit, and is truly a long-duration breathing system.

We tried lithium hydroxide as a CO_2 absorbent; it proved to be an outstanding absorbent with very little degradation in low temperatures. With lithium hydroxide, we can get a 20-hour duration out of a standard sized canister without any problem at all. It is, however, very caustic, and until we can develop a canister that guarantees no lithium hydroxide coming into the breathing intake system, it is prohibited.

If we can solve these three problems—the physiology, the thermal protection, and the unlimited life support—we can do anything we want to underwater. Without the solving of these three problems, we are limited to 1,000 feet and a few hours of duration because of thermal protection. We need to put research money into the program and into the resolution of these problems to accomplish what is really needed.

Things came apart after Berry Cannon's death. The resulting investigations and all that went on with it killed the initiative in saturation diving in bottom-mounted habitats. There is still some interest in Europe in the bottom-mounted habitats, but in our country, it is very limited. The little interest in the US is mostly by the universities and not by the Navy. We are essentially out of that business as far as the Navy is concerned.

I am convinced that even with the advancements in underwater vehicles,we will never eliminate the need for a diver. You will always have to have a human brain on site. The dexterity and the thinking ability of a person on site is just non-replaceable. It may not be to the extent that we have today; it may be limited to a few construction jobs, inspection jobs, and military jobs.

I agree that vehicles, such as remotely operated vehicles (ROVs) and similar undersea vehicles are a thing of the future, but they will never eliminate the diver as far as I'm concerned.

Speaking of underwater vehicles, in about the 1959–60 timeframe, we started evaluating the MK I and MK II vehicles. The MK I was what they call a SPU (swimmer propulsion unit). It was one of the units that you rode on the backside of and controlled it with body English. It had silver zinc batteries. The Navy decided there would never be an application where they would need individual swimmers, and the idea was dropped. Up until that time, the Navy was interested in the *Pegasus*, a French-designed and built unit that worked very well. It had three axes of freedom and was very controllable. You could roll it, you could flip it, or do just about anything you wanted to do with the craft.

The *Pegasus* used lead acid batteries and, of course, had a limited duration. But like I said, it was very agile—it did about every acrobatic that could be done with a performance aircraft. Not having the stress of gravity on it and not having the velocities that an aircraft had, it was very capable.

One interesting sideline on the French PR77—it was advertised to have watertight bulkheads and watertight compartments throughout. But here again, they did not gas block the cables, and hydrogen leaked into the main switch. Don Patterson was performing a pre-dive test, and when he hit the switch, an explosion skinned the whole vehicle and the inspection cover went through the roof of the machine shop. Don could not hear for about three days, but it was amazing that he survived because of the size of the explosion. It was our only experience with a SDV battery explosion and, at that point, we realized we had to hydrogen-block everything. We installed hydrogen catalyst in all the battery compartments, evacuated all the oxygen out of the system, and then back-filled with nitrogen to reduce the possibility of a hydrogen explosion in the future.



Mark II swimmer delivery vehicle

Some batteries do off-gas oxygen, as well as hydrogen, on charge and discharge. So to have a completely safe system, all switches and ignition sources must be taken out of the battery compartments and located in totally watertight compartments elsewhere. Hydrogen-blocked cables must be used throughout the battery compartment. We should have learned from the submarine people early on, but we didn't.

The MK II was the Navy's first attempt at sophistication. It had a fluxgate compass, a gyro, and a series of thrusters on it so you could rotate it or move it up and down with fairly good control at slow speeds. The company that did the original study felt that all divers would be claustrophobic in a closed vehicle under water and decided to make it look like something that was an everyday occurrence. They chose a 1950 or '52 Ford pickup truck as their model. If you looked at it, it looked like a '52 pickup truck, and it also had the underwater stability of a pickup truck. We tried putting fins on it. In fact, we tried everything to stabilize it, but it



SDV MK VIII

never got to the point that you could fly hands off. You always had to nurse it full-time.

The MK VIII was originally designed and built by Aerojet Corporation. The Special Warfare Group I on the west coast developed it further. The Laboratory was tasked to add a program that gave it longer life, better navigation, better electronics, and made it into what is essentially in the fleet now. We continued to upgrade the MK VIII to the MK VIII MOD I. We looked at other vehicles and purchased a French PR77, which was a lead acid battery-driven boat that was a good, stable boat that worked very well.

These were all wet submersibles. The Navy's interest in dry submersibles was very limited. It is still limited to the Advanced Swimmer Delivery System (ASDS).

Our group tried all kinds of propulsion units that were being developed at that time. One of the most interesting was an Aqueon developed by Aerojet Corporation. It consisted of a series of hydrofoils that worked with your legs through the water; it was a fairly good propulsion system. In fact, you were hard-pressed to outrun it with your fins. It was a drastic increase in the efficiency of the application of your muscles in propulsion.

The first vehicle that we were involved with, as far as design and fabrication, was the MK VI. The MK VI had a streamlined body that was very stable. You could put it on a course, take your hands off, and it would fly itself along that course until you changed the settings. It was good for six knots and several hours, using silver zinc batteries. It had a very good trim system. As part of the frame, we had a large, donut-shaped tank in the front and in the rear. Those donuts were tied together with stainless steel tubing and had a pump so that you could pump water fore and aft. You could trim the boat out very nicely in just a few seconds.

The silver zinc batteries, of course, had the same problems as all other silver zinc batteries. It took a lot of maintenance to keep the batteries charged properly, but the vehicle was very good. It had forward and stern planes to control azimuth and elevation. It had a high meta-centric height so you had no problems with roll. It was a stable vehicle with a Doppler navigation system. It was designed so the hull could be separated and a center pod could be added so you could carry additional personnel, cargo, or sonar.

Much of the technology was transferred to the MK VIII. We did a test run in which we launched the MK VI from the deck of a submarine and made a five mile run into Stage 1 (a tower in the Gulf at that time). Then we made a five mile run in a different direction and rendezvoused with the submarine without ever exposing the vehicle from the time of launch to recovery.

We did use an acoustic marker for the final homing to get aboard the cradle on the deck. A deck crew locked out of the submarine and gripped the boat down into its cradle. As far as I know, that was one of the most successful early starts in the launch and recovery of a Swimmer Delivery Vehicle (SDV) from a submarine. That happened in 1965–66. There were other submarine launches and recoveries, but I do not think any of them made that kind of a range and recovery.

For propulsion, early in the game we tried an experiment using compressed air from the breathing medium, expanding it through a cylinder, and sending it to the diver for breathing. We used a long rubber fin, like a fishtail, for propulsion, and we got very good results. It was later installed into a vehicle, using an electrical drive instead of the gas drive. With the expanding gas drive, of course, you only had three-quarter horsepower in your tank at best. The fishtail concept was used for a couple of years as a quiet propulsion system in an experimental Mine Countermeasures vehicle.

We built six vehicles for use in Vietnam. We were given only two months to develop these boats and have them ready for use. We took the Italian Sea Horse, added silver zinc batteries and a bigger motor to increase performance. We also streamlined it and closed it so that we could get

more speed and endurance. It was shipped to Vietnam on time.

Next we built a four-man vehicle, using the Italian *Trasch* as a starting point. Again, we used silver zinc batteries, a larger motor, and enclosed the canopy. It was a good, small vehicle for use by the Vietnamese.

From the background of the MK III and the MK III MOD 1, we developed the MK VI.

For the past 11 years, I have been a consultant for Columbia Research Corporation (CRC) and a member of their Board of Directors. Presently, our primary effort is in support of the US Navy and the Navy's Special Warfare Program. Under contract with a friendly foreign Navy, we recently delivered the SDVX, which is the next generation SDV, with significant new approaches to design of both mechanical and electronic systems.

I have thoroughly enjoyed my work.

DR. EDWARD THALMANN

I served in a Fleet Ballistic Missile (FBM) submarine for two patrols, then in 1971 got orders to report to the Navy Experimental Diving Unit (NEDU).

When I arrived at NEDU, they were busy putting arterial catheters in divers as part of physiologically-based measurements to determine adequacy of underwater breathing apparatus. What they really wanted to know was the arterial CO_2 partial pressure. They asked me if I knew how to put catheters in. I said, "Yeah," because I had spent three months in the cardiovascular service, so I had some experience with arterial catheters.

Shortly after my arrival, I found myself on the bottom of the NEDU wetpot. This was a big fiberglass water tank called "the ark," in which a diver sat on a bicycle and extended his arm through a rubber sleeve so that his wrist was outside. The arterial catheter was placed in his arm before he got in the water; once he fit his arm through the sleeve, we hooked it up to a little sampling device.

Just before we had moved to Panama City, a couple of guys from the Naval Ocean System Center in Hawaii came by. They had this idea about putting an algorithm in a wristwatch and using it for a decompression computer. They came by to see if they could sell it. We said, "Yeah, it looks great." At that time, I had been learning to program the PDP-12 by trying to program the Navy dive tables. We were pretty much up on algorithms, or at least I was, that we could have used for the Navy air decompression tables. This would have been 1974.

The inception of the decompression computer was a long time coming. The bottom line was this: if you sent them off to NAVSEA and told them, "Look! Hardware," NEDU could provide you with the software to actually compute the dive tables. They did that, and the SpecWar community looked at it and bought off on it. At the same time, the Mark 15 Underwater Breathing Apparatus was coming down the pike, which really had no tables. I guess originally they were going to use equivalent air depths.

The details are fuzzy, but at the end of the project, NEDU was asked to develop a set of tables for the Mark 15, with the idea that this



Mark 15

would provide the software for these guys to put into their decompression computer. I reckoned the tables would be useful in and of themselves, even if the decompression computer never came to be.

In July, 1975, I went off to do a post-doc at State University of New York (SUNY), Buffalo, leaving behind the decompression computer work. At that time it was in the form of a bunch of software computer tables and printed tables and that was about it. Ian Buckingham was working with some computer contracts at the Naval Coastal Systems Center not only to run the program in the PDP-12, but in the control room they actually had an HP, I think it was a 1000.

My job was to set up the software so they could compute tables wherever they wanted. So we had a protocol to test the tables. It was known that I was going to be leaving for Buffalo before testing actually started and that somebody else would have to actually do the testing.

The guy who ended up in charge of this was a Canadian exchange officer, name of Ian Buckingham, who had managed to finagle a tour at NEDU because the Canadians were building the saturation chamber at the Defense and Civil Institute for Environmental Medicine (DCIEM) in Toronto, Canada. Ian had saturation experience, so he told them that the way to complete their project was to send him to Panama City for two years to learn everything about sat diving. They also had a line officer, an exchange line officer, and an exchange medical officer.

Ian was given charge of the development of the Mark 15 tables. Initially, he recognized that these were tables that were going to be used to lock in the submarines. Having no experience, he wanted to lock out as deep as possible. Somehow, 175 feet came up, and it was decided that this was a depth that would be used to lock in and lock out, and that the table should be tested to 175 feet.

Well, at that time, the only way to do it was to actually compute the tables, have the computer print them out, and then give them to the operators. It was the operator's job to follow them as closely as possible. Of course, when there were delays during descent, it made for some messy compromises.

The other problem was that the divers were so narced with nitrogen at 175 feet that they didn't know which way was up, because they were diving at a .7 ATA partial pressure of oxygen. One hundred and seventy-five feet is about five or six atmospheres with .7 atmosphere nitrogen on board. Nitrogen narcosis was pretty prevalent. Plus, they were having problems, as I mentioned, in compressing and accounting for delays and a whole bunch of other stuff. I was asked to make at least one visit from Buffalo to try to help out.

While I was in Buffalo, I was called only when NEDU absolutely needed help and there was nobody else to turn to. It became apparent to me that the problem in Panama was that they were using the handwritten tables, because we were actually using computed tables at Buffalo. We were doing 190-foot dives to do physiology experiments; some of these dives had the potential to go on for forty or fifty minutes. I think the schedules went from thirty minutes to an hour and then to an hour and a half. There were big jumps.

I computed a whole bunch of intermediate tables using my HP 65 calculator. We had to



Mobility test—NEDU

have a stand-by if we had to go over the thirty minutes allocated by the diving manual. It turned out that we only did that a couple times. We were using the calculation to some advantage to compute tables at Buffalo. It was obvious to me that one way to get around it would be to have the tables computed to real time. Therefore, besides doing the stuff I was up in Buffalo to do, I was also figuring out how to compute these tables in real time by using the PDP-12 computer.

When I got to Buffalo, Dr. Claes Lundgren was there. He was on sabbatical from Sweden because Ed Lanphier had left, and they were looking for somebody to run the hyperbaric lab. When I arrived, he was scheduled to go back to Sweden and was in negotiations with the university. He had a plan for doing some studies in the chamber involving looking at static lung loading and exercise. There was kind of an apparatus that was partially built.

When I got to Buffalo, I was essentially put in charge of the whole hyperbaric lab, even though I was only a fellow. They had nobody else with any experience. The chamber eventually fell directly under Herman Rahn, so Dr. Rahn was kind of my boss. He didn't mess around much except for really big picture stuff, such as writing a renewal grant.

Dr. Lundgren left within three weeks of my arrival and came back four or five weeks before I left. In the meantime, I found myself in charge of his lab, which had four full-time guys and a couple of part-time guys. Plus, there were peripheral investigators, for example Mary Ann Rokitka, from the nursing school. She was our part-time chamber operator and log keeper.

Since I was a Navy undersea medical officer, I was medically responsible for the whole operation. This was convenient, because other individuals at Buffalo would have to go out and beat the bushes at the VA hospital, which was across the street, or they would have to go to some other hospital to get a physician to be medically responsible for their studies. As I recall, I also began to assume medical responsibility for just about any study that went on in the lab, because they decided having an in-house MD was a good thing, at least a MD licensed in New York.

We treated the infrequent cases of decompression sickness. There wasn't a lot of diving up in the Niagara frontier, but I recall we had one or two cases of decompression sickness that we treated. From our experimental dives, we treated only one. He was the only guy to ever get bent in the profiles we did for the study.

I spent most of my time in a bathing suit in the water. Buffalo had this big, circular donut-shaped pool. It was eight feet by eight feet wide, but the diameter, the inside of the donut, must have been 60 feet. It was a pretty good size. As I said, the chamber, at that time, was funded by ONR. In order to keep the ONR grant going before Lundgren got there, they did this big study with putting mice in the chamber, doing behavioral studies at great depth, and writing it up in some behavioral magazine.

When I got there, we were actually progressing to manned studies. The ONR grant came up for renewal, and I remember Herman Rahn called me into his office where we sat down and wrote some stuff. It's all kind of blurry now, but, the bottom line is that because I was there and actually making progress, we got this apparatus built. We were almost ready to test subjects, and ONR continued funding it.

I was probably responsible for at least keeping that job slot open while Lundgren was negotiating. If that grant hadn't gotten renewed, I don't know if Dr. Claes Lundgren would have the same degree of expertise when he got back, because the hyperbaric team was composed of incredibly talented guys.

At any rate, we started doing tests on a regular basis. We used esophageal balloons. In conjunction with Claes, we investigated how to make them, how to optimize them, and what kinds of errors were made because they were too big or too small.

From all my leadership training, I knew that if you were going to get the troops to do something, you had to do it first. So I turned my back, went

into a corner, and vomited and made all kinds of unhealthy noises. I retched and convulsed, but in the end, when I turned around, there was an esophageal balloon catheter coming out of my nose. I had kind of persuaded everybody else to at least give it a try.

We commenced our exercise runs. We did runs at the surface, which were really 15 feet, because we needed 15 feet of pressure just to get the samples out of the chamber. Anytime we did a wet or dry run, we did them at 15 feet. Our other depths were 60, 120, and 190 feet. During the run, we would drain the wet pot and put in a seating arrangement so you could pedal a bicycle dry. The 190-foot runs were fun because the divers were narced out of their minds.

There was more than one time when the whole experiment just collapsed because somebody would not stop laughing. Once you started laughing at 190 feet, you couldn't stop it. The whole dive had to be aborted because everybody was so busy laughing and doing goofy things that there was no way that any useful work was going to get done.

Hugh Van Liew got interested in gas mixing, so we ginned up a couple of experiments for him with mixtures of gases with different densities, up to and including an SF-6 mixture. Everybody called it the "Van Liew strange gas," because SF-6 is incredibly narcotic in breathing these very dense gas mixes. Sometimes we'd breathe the "strange" gases at 190 feet.

We had some interesting out-of-body experiences breathing some of that gas. It was a good time. We had a free hand and could just do things that we dreamed up, and we would just try stuff.

While we were following a plan in this big research study that was funded to improve the operational capability of Special Warfare (e.g., SEALs), Explosive Ordnance Disposal, and saturation diving operations, we did a couple of studies on the side for some commercial companies who had some unexplained deaths on their underwater breathing apparatus (UBA). We did some studies just to determine whether the UBA was at fault. We never did find anything wrong with any of the UBAs.

When I got back to Panama City, I got up to my eyeballs in the Mark 15 dives. They had tried doing 175 footers, but it just didn't pan out, because the divers were so narcotized. They got into a bunch of dives where they just had a lot of bends, one right after the other. They had to stop because they didn't know why the bends were happening. It was especially frustrating at the time, because they were all trying to dive from tables using what we called "M values." There were M values 0, 1, 2, and 3. M value 0 was the one that computed the Navy tables.

M value 1 was a slight modification. When I plugged M value 0 into .7 PPO_2, in which you simply changed one line of Fortran instead of computing the oxygen partial pressure by multiplying the fraction of oxygen times the ambient, you just put in $P0_2$ equals 0.7 PPO_2 and that was it. You just changed that one line in the Fortran program, and whap, you went from air to 0.7 PPO_2.

Lo and behold, it began predicting some strange things. For example, you could do repetitive air dives at much, much shorter decompression times than called for in the Navy Dive Manual. I began reading all the reports and how they



Mark 15

computed through repetitive dive tables and figured out why that was true. It also turned out that getting bent on a repetitive dive was fairly rare. That was probably because the repetitive dives always assumed that the 120 minutes surface interval introduced a pretty healthy shot of conservatism into that second dive.

I had three sets of M value 1 computed tables. The first dive was all based on 190 feet for 30 minutes. Let's say it was a one-hour surface interval followed by another 190 foot dive; that was the basis of constructing M values 1, 2, and 3.

M value 1 was constructed such that the first 190 feet for 30 minutes was pretty close and actually slightly longer than what was in the dive manual. The second 190 feet for 30 was whatever the model predicted, which was pretty short. Instead of having a 30-minute residual nitrogen time, it was like having a five or ten-minute residual nitrogen time. M value 3 was constructed so that the M values were adjusted. You did the first 190 feet for 30 minutes and had a one-hour surface interval. The second 190 feet for 30 minutes was the same schedule that the dive manual predicted. The M values were adjusted to make that long enough, and as such, the first dive got a lot longer.

I left the surface interval as it was at 120 minutes. All I did was change the M value so that on the second dive the decompression schedule was that of a 190 feet for 60 minutes, which was what the tables called for. They called for a 30-minute residual nitrogen time. Then, I let the model predict what the first schedule was going to be, which, as you might imagine, was longer than what was in the dive tables by quite a bit. That was M value 3, and M value 2 was halfway in between. I made the first and second dives each a little bit longer. Basically, the way it worked was in going for M values 1, 2 and 3, I began shifting decompression time toward the first dive and making the second decompression dive longer. As I recall, we ended up with M value 3.

When I got back from Buffalo to NEDU, I said, "Well, the way to do this is to get the dives in real time." We spent a month or two getting the software to run in real time. Oddly, one of the problems we ran into was on the PDP-12. The digits were 24 bits long, whereas in the Hewlett Packard, they were only 16. This actually caused several ugly problems in several different ways in the software. We did a lot of iterations in which we counted iterations. I had assumed the digits were all going to always be 24 bits, but it wasn't that way. I spent a lot of time at the computers. We eventually ginned up a way to do the dives in real time, and we could actually have the computer monitoring depth. I'll go on record as saying I think those were the first digitally computed decompression dives ever done.

We actually had a digital depth gauge monitoring depth. It was a digital computer computing actual digital real time, not the fluid mechanical stuff that had been going on up in Canada for some time. In this case the schedules were computed as the dive was progressing. Once we did that, things went a lot more smoothly, but we did back off from 175 feet to 150 feet. We decided going below 150 feet was a non-starter. We finished up with the first phase, and lo and behold, we actually got a pretty decent set of tables down to 150 feet. Nowhere had we tested them, because we were told they weren't important.

When we printed the tables, I remember making a couple of computer runs and telling Bill Spaur there was a bit of a problem. He asked, "What do you mean?" I answered, "Well, the decompression for 60 feet is five minutes, and the 60 for 60 involves a 10-minute decompression stop at 10 feet." In the end, we said, "Well, shoot, they got their decompression, so having to stop 10 minutes at 10 feet is not a big deal. It turned out we were wrong. What we did was fit the tables to the 150 footers, 100 footers, and 75 foot multiple repeat dives that we had done. We adjusted the M values to fit those dives. Then, we let the chips fall where they may. Whatever the model computed was fine.

We sent those tables off. There was this great howl and wailing and gnashing of teeth

coming from downtown, because at the time the Navy had decided you couldn't do decompression diving. Somehow, it was inherently dangerous, and the only way you could do decompression diving was if the country itself was under attack.

Two things happened at that time. Bill Spaur went on a campaign, saying, "Well, if you're going to do this Mark 15 decompression computer stuff, decompression dives will become a way of life, and we shouldn't be afraid of them."

Then we said, "Gee, guys, if you give us another half a million bucks, we'll be happy to do another set of dive trials and concentrate on getting the no-D limits buffed up." They acquiesced and gave us the money. When we did the phase two testing, we concentrated very heavily on doing multiple, no-decompression repetitive dives. When we finished that up, those tables became the basis for the tables that are in the dive manual today.

We eventually went on to do a third dive series, which I promoted. I managed to produce the air algorithm, saying, "Oh, we have this algorithm that works on 0.7 PPO_2. Let's see if it works on air."

At the time, it gave predictions on air dives, which were much, much longer than those in the manual. We were under the naive assumption that the schedules in the dive manual were all okay, which we know now is not true. It was around that time that Paul Weathersby got together with Lou Homer up at the Naval Medical Research Institute (NMRI) in Bethesda, MD, and began looking at the probabilistic model.

As a part of the air algorithm, we went back and tested some standard air tables. The purported reason was to test some schedules out of the dive manual. The real reason was that the computer software wasn't yet ready, and we had dive subjects coming in. We had a little per diem identified, and we didn't want to give it up, because it might go away. So I suggested that we try some dives right out of the dive manual. We tried the infamous 60 minutes at 180 feet, and because the dive was cold, we came up on a 60 minutes at 200 feet schedule. That was for three out of the first ten guys we tried. Very rapidly, we found out that the 60 minutes at 180 feet using the dive manual gave guys a lot of decompression sickness. This surprised the heck out of us.

By then, we had gotten the software out. We moved on, but it turned out we increased the 60 minutes at 180 feet decompression time from 75 minutes to 225 minutes before we finally got a schedule that we thought was reasonably safe. The whole point of the air algorithm was to take the 0.7 PPO_2 algorithm and plug air back in to it to see if it would compute air dives.

It was during phase two that we went from M values to V values. We went to V values because the decompression model was loosely based on a gas phase that kept the over pressure of the gas phase constant. Then, we made some other changes to the model in which we actually looked at arterial-venous oxygen differences rather than keeping the venous oxygen the same. We said that the extraction rate was constant. In using the hemoglobin association curve, we actually computed what the venous oxygen tension would be given the arterial oxygen tension and tissue oxygen consumption. We ended up at V value of approximately 50-something for the air algorithm.

There were a lot of V values in between it. Every time I tried a new one, I just gave it a number. A lot of them never made it outside the computer lab. I tried them and discarded them. But then, the next time I made a new one, I just incremented the number by one. At the end of the series, I thought we had come up with a pretty decent air algorithm.

I guess under one scenario, I could have gotten NAVSEA to use that as the basis for a whole new set of air tables. There were a couple reasons why I did not do that. We had finished up the 0.7 PPO_2 table and we were happy with it. John Zumrick was coming on board, and I showed him how to use the software. When I went off to England in 1985, the whole thing stopped.

Nobody was interested in it, even though the Naval Medical Research Institute at the National Naval Medical Center, Bethesda, MD, was investigating probabilistic decompression.

When I went to England, I tried to garner some interest in getting a joint program going with the British and the Americans to come up with a single set of helium tables, but that didn't work out. Before I left for Alverstoke, we tested some helium oxygen tables for the Mark 16, which were all bounce dives. We eventually went down to 300 feet for 30 minutes.

We had finished up the 0.7 PPO_2 and CO_2 work, and those were published. Then, EOD came. They wanted a study, so I finished it, wrote the report, and those got published. Then it stopped because nobody else there was interested.

When we started testing the Mark 15, the thinking from the start was that we were designing it for a decompression computer. This was based on the two individuals from Naval Ocean Systems Center (NOSC) in Hawaii who had come by NEDU earlier in 1974 with a proposal to build a decompression computer. The Naval Sea Systems Command had given them the go-ahead to try to develop the hardware, with the EOD developing the software. The whole point of the effort from the beginning was to develop an algorithm that would go into a decompression computer.

It was recognized, however, that the computer hardware might take longer than the software, so we decided that in the event that the algorithm testing was finished before the computer, we would come up with a set of printed tables. We also needed a set of printed tables for emergencies, anyway, but the original proposal basically indicated that we were trying to man-test a computer algorithm, not a set of tables.

We completed the first phase of testing, concentrating on these deep dives, like 150 feet for 30 minutes and 120 feet for 30 minutes, because it was envisioned that the divers would be on submarines that had dry-deck shelters on the back. Those submarines also had SDVs in them, and it was thought that the divers would get into the SDVs and launch themselves from some depth. It would take about a half an hour to launch; that time would be spent at the deepest depth, which initially was going to be 120 to 150 feet. Then, they would ascend to some shallower depth, probably around 30 feet, and on the way back they would come back into the submarine.

We spent a lot of time concentrating on these deeper dives. When we were done, we thought we had a pretty good algorithm for doing the deeper dives. Then, we just extrapolated the algorithm to the shallower depths. But because we hadn't tested the shallower depths, the no-decompression limits were rather short, like a sixty-foot no-D limit. It was about ten minutes, and a 60 foot dive for 60 minutes required a five or ten-minute stop at ten feet. We thought that was a reasonable trade-off, and we didn't make much of it until we sent it out to the fleet. They were terribly upset. At the time, it was a "no-no" to do decompression dives unless you got dispensation from somebody.

Two things happened about that time. One, we got some money to go back and look at no-D limits. Two, Bill Spaur went out to convince the powers that be that if we were going to have a decompression computer, the decompression was obviously going to be the norm. There was no way that you could really avoid decompression diving unless you were so conservative that you planned to hamstring the operation.

In the second phase of the N_2/O_2 algorithm testing, we went back and concentrated heavily on the no-D limits. We got a set of no-D limits that were very reasonable and also fit in with the deeper decompression dives that we had done earlier. In the end, we thought it was looking pretty good.

We started out, as I said, with exponential uptake and off-gassing. Partway through the dive series, it became evident, especially for some of the repetitive dives, that in order to get longer decompression times, the no-D limits began to shrink. We thought that was necessary because we were having too much decompression sickness on repetitive dives. The no-D limits

began to shrink because of the way the M value matrix was set up. We couldn't reconcile with it. In other words, we couldn't keep the no-D limits, which we thought were safe, and make the repetitive dives long enough to make those safe. I had been fussing with an idea for some time about a decompression model in which, immediately upon any reduction of pressure, a gas phase formed. This idea came from the literature I was reading, which would lead you to believe this happens. It was not any great insight.

Apart from doing decompression studies, we came up with a very nice thermal garment. It was based on a rubberized outer garment, one that was fairly thin but very flexible, and a Thinsulate undergarment. I guess the main thing we did was a set of gloves. We used Thinsulate ski gloves underneath windsurfing gloves. We took very large windsurfing gloves and pulled them over the Thinsulate gloves. We made up a sealing arrangement at the wrists that didn't put any pressure on the wrists but kept the hands pretty warm. The Royal Marines were pretty happy with that garment and went out and had a whole bunch of them made up. I understand they used them for quite some time.

WARRANT OFFICER WILLIAM C. WOODWARD

For my first tour in Vietnam, I was sent to EOD Training Unit Team 82 as the element leader for the advisor to the Vietnamese EODs. My assignment was Can Gio, near Vung Tau. I was to relieve a young warrant officer. I had been in country exactly four days when we got word that a young SEAL, who had just made chief, had been killed the previous day. His name was Bomar.

I can't remember the name of the province but it was bad, bad country. The Viet Cong (VC) controlled it heavily. The SEAL team detachment there had requested EOD assistance because they knew the area was going to be booby-trapped fairly well. My element was elected to go.

The guy I was relieving had seven tours in Vietnam at the time, but it was my first. He was almost out the door when I said, "Wait a minute. I don't think I want you to go just yet. How about a little bit more turnover? How about you go on this last operation?" That turned to be a wise move, because, frankly, I don't know if I could have handled it myself.

We got there and reported to Lieutenant Mack Collins, who was later killed in an ambush. The deal was that we were going into the same area where they had just been wiped out and take care of this bunch of bad actors. There was a bunker right off the bank. It was just one of those bunkers with enough room to stick out the muzzle of an automatic weapon. They had wiped out the SEAL team from that bunker.

We inserted by fast boat, the Navy medium SEAL support craft that would run sixty knots. We eliminated any bad apples coming down the river. Nobody could live through that, but we came down the river firing away. We inserted and it was completely quiet. There were booby-traps, though. In fact, one of my guys hit one of the booby-traps.

The policy for tearing up bunkers was to put a haversack explosive charge in them. To keep them from being redone right away or ever again, we also put some "willie-peter" (white phosphorous) and CS gas in the haversack. The sun baked the mud out and it became hard as fired clay, like a brick.

The VC liked to re-dig those while they were still fresh and moist. Often, you could see a guy doing it. He was the friendly rice paddy worker waving at you all the time and smiling at you with his beetlenut-black teeth. In that particular area, the SEAL team told me they would see those guys. The next day, they'd see the same guy and his legs were all burned up because had gotten a little willie-peter during the night. So he was actually a VC. He was a rice paddy worker by day, but a VC by night. Anyway, they'd give him a zipper stitch with

a stone and take all the piss and vinegar out of him.

We had a haversack in a bunker, and just about the time we were going to go away and wait for the charge, which only had a short fuse, a tree line about a hundred yards away opened up on us. It was the bad guys. We were all diving for cover knowing that we had a really short fuse on the bunker and that it was going to go off at any minute.

Globs of heavy dirt the size of trash cans were going to be coming through the air any second. We were all hiding, and one of my guys stepped on one of their booby traps. I saw him in my peripheral vision going through the air, doing a couple of cartwheels, and then he landed. The guy's name was Len. Norm Garrin, whom I was there to relieve, came along and with just one swoop picked the guy up and threw him over his shoulder. Norm ran another twenty or thirty yards, counting, "A thousand two, a thousand three," and boom, it went off. Norm threw him down, covered him up, and waited for all the clods of dirt to hit.

When the smoke cleared, we were still being fired upon. The first class, Norm, said we were taking over. He radioed air support, told them blah, blah, blah, and fired a grenade over the smoke and said that the bad guys were in that tree line over there. The next thing I knew, OB-10s were coming in and the trees were going down. A five-inch zuni, and that tree line went away. It was really quiet. That was my first experience in Vietnam.

Our responsibility in Vietnam basically was port security. We had EOD teams from Da Nang, a place in Vietnam called "Solid Anchor." We had EOD teams at all those ports and elements as advisors.

I was on an advisor team, and we would just answer calls. We did port security every night at Vung Tau. We did swims around the ships. They had two huge generator ships anchored out of there supplying power; it was a highly sought after prize for the VC to mine one or both of them and sink them.

Every night we performed port security swims around the ships for mines and what have you, checking anchor chains and all that and responding to routine EOD calls. For example, one time, someone called and said there was a mine on a bridge. They had just finished building this bridge that would give us better access to Saigon, and it was a major artery between Vung Tau and Saigon. We went over, and sure enough, there was a mine the size of a Volkswagen tied to the bridge piers. The tide had gone out, and we were looking up at it from our boat.

It was made out of bamboo and stuff, but it was also made out of explosives. It was red, kind of a pinkish C-4. It wasn't nearly as good as our C-4, but it would have taken that bridge out. It didn't go off, though. It was a dud, as most of their crude, jungle-made VC ordnance was. We found it in a dud-fired condition. We gingerly arranged to support the thing, cut it away, and did everything we could, remotely of course, and lowered it away. It floated, so we floated it off to a safe area and blew it up.

There were other experiences in which we'd just get calls, as EOD did anywhere, and we responded to explosives, duds fired, or booby traps here and there. We'd just respond to whatever situation came up. Our area covered far south of Vung Tau to up north toward Can Gio. We were kind of roving circuit riders on my the second tour, where I had three Vietnamese EOD teams under my advisory.

They were five- or six-man teams. Each had a petty officer, officer in charge, or chief in charge, generally, and there were guys down to the rank of seaman. We were centrally located in one spot, but we went wherever was necessary, visited the team, and whenever they went on a mission, they could choose to have us go along or stay behind. Normally, they wanted us to go, but we were there mainly as advisors and were admonished to not take over. As badly as you wanted to take over, you had to bite your lip and say, "Huh?"

Some of the Vietnamese team members were darn good. In fact, most of them were good.

The type of guy who was in a Vietnamese counterpart underwater organization like SEALs, EOD, and diving, these were the kinds of guys you liked to have. They had to want to be in that program, just as we have to want to be in our Navy. They were a little bit above the average Vietnamese Navy person.

We actually made out pretty well in Vung Tau. We didn't have any problems with sappers there. We had security that really took it seriously and routinely, but not with a pattern that you could set your clock by. The security would run by and randomly throw out concussion grenades around the nests. The two ships were nested together. They were old Kaiser coffin-type liberty ships, but they also were like the USS *Luzon*. They were converted ships full of generators.

They were permanently anchored and chained to moorings there. Our security folks would keep the sappers away by throwing concussion grenades in the water out of a really fast boat that was circling around the ships. But there were several instances in which we had all of our supplies come into the country by contracted companies like Champion and Lykes Lines, and those were prized targets for the VC. They sunk the *Card* in Saigon Harbor with a mine, and that raised heck when it clogged up the harbor.

We would frequently find mines that had been placed on a ship or alongside a ship. It might have been a floating mine or another crudely made mine from the jungle with a bladder. It was quite common; a type of a limpet, but they would attach it to the ships. Actually they wouldn't even attach it themselves. They'd con some South Vietnamese friendly into doing it through intimidation, tell him how to work it, and he'd reluctantly swim down and do as he was told. Their fuse lighters weren't like ours; it was just a piece of string that you'd pull; there was some Quickmatch in there. Often, when they got wet, they were useless.

Sometimes, they'd tell a South Vietnamese farmer to swim down and put this on, or two of them would straddle the anchor chain and pull the two strings. Then, the thing would go alongside the ship on both sides. Someone would see a mine alongside a ship when the sun came up, that it had been tied to the anchor chain. Our naval intelligence folks would find that out and go interview the old rice paddy worker.

Sometimes we'd find the mines and the fuse hadn't even been pulled. As the Vietnamese farmer would say as he was floating down the river, "Now, look, these people didn't care about me. They don't give a darn about me. If I pull these strings, one of these things is going to go off, maybe. But if I don't, they're not going to come check, so I just won't do it and say that I did." Sometimes we'd find them and they weren't even pulled. That was how we knew that the bad guy hadn't put them on.

A lot of the farmers who were coerced or intimidated into doing this type of activity were pretty neutral. They didn't want to be involved with the war either way. They were the South Vietnamese. The South Vietnamese farmer wasn't a sympathizer. He was just arm-twisted into doing something with everybody taxing him. The North Vietnamese would come along and tax him, and then the South Vietnamese military got bad, and they started taxing them. The poor guy was getting taxed from everywhere.

One time, we collected explosives until we had enough to make up a decent-sized shot, and I obtained access to a Mike Boat ("M" size landing craft) because we lived right next door to the harbor clearance folks, and they had all kinds of boats. Knowing that I was going to have a clean up shot soon, the Army at Vung Tau called and said that they had a bunch of explosives to get rid of. We went over. Good Lord, they had explosives. We calculated it was 144 tons. We set off all 144 tons at one time. It was a 280,000 pound shot.

We did the shots from a mile and a half away. There were some guys at the Harbor Clearance Unit. One guy, who was playing volleyball and just about to serve, saw a mushroom cloud going up and said, "My God, they dropped it."

I shot 52 tons underwater once at Subic Bay, but that was out of necessity. There were a lot of explosives in that shot, too, because all sorts of rounds that had been captured. There were rocket-propelled grenades (RPG) and cases and cases of AK-47 ordnance, which made up much of the 144 tons. Anything the North Vietnamese had, we'd blow up, especially stuff that we found in caches that were meant to re-supply the north.

They'd have a guy on a bicycle bring a bullet or an RPG round all the way from the North Vietnamese down the Ho Chi Minh Trail and stash it in a cache. It might have been underwater or well-camouflaged some place. They'd say, "Thanks. Go back and get another one." Off he'd ride.

The caches were typically booby-trapped. Someone watching from a distance also guarded them, typically. He was camouflaged, as well. We wouldn't find them but the Navy Intelligence Liaison Officer (NILO) would give us word on those. We got to go blow them up. That was a rare enjoyment for us.

We liked to blow up stuff because you got a big boom out of it, and sometimes you got the bad guy, too. One time, we actually spent the night waiting. There was a curfew on the river at night in Vietnam. Anybody who was on the river at night was considered fair game. The VC would move at night, as we knew.

In those days, we did have night vision equipment. It wasn't nearly as advanced as it is today, but we could see. Once we had it all wired up and decided to wait; it got almost dark and we decided to spend the night because we had enough rations to do that. Sure enough, there was a little activity around the cache at night. We said, "Hey nutes, bye," and cranked it all off. That was great fun. (Editors note: "nute" was a nickname for the Viet Cong.)

As to Subic Bay: I wasn't even on the list to go to Subic, and it wasn't even on my list of the places I wanted to go. But the kid who was going there had made warrant the same year I had and he had his wife there who was a Filipino. He was all set to go, but was killed four days before he was supposed to report and relieve the officer in charge at Subic. I got a call from the commanding officer, Commander Dave Ussery, who said that he had a job for me. I was to go to replace the guy who was going to Subic. Subic Bay, as you might know, is the closest Navy base to Vietnam; two hours away by plane. All the retrograde ordnance that was coming out of Vietnam would be dropped at NAVMAG Subic.

The EOD officer before me hadn't done anything. He had let it stockpile. The team's morale was at the bottom of the bucket. They were not allowed to do anything but cumshaw work for things that he had going on. The guy before me never did anything during the rainy season. He kept giving his reasons for not working then. In the summertime, he came up with other reasons. On the pier was 1,900 tons of retrograde ordnance to be disposed of. There was no more room in the magazines to put another mortar round. You never saw so much ordnance in your life. It had several huge magazines; those three big three-door storage units. I forget the square footage, but they were full, clear up to the ceilings.

It was US ordnance coming out of Vietnam, ready for disposal. Master Chief Hannigan was there at the time. I re-enlisted him during a free-fall portion of a parachute jump. This was at the end of the Vietnam War, and in Vietnam, ordnance was still coming out daily. Every ammunition ship (AE or AOE) that came out of there brought retrograde ordnance. We were pecking away at it. Down at the range, we had three areas in which we could blow fifty pounds per shot; that was our range limit. We had 2,000 pound bombs. We couldn't get rid of those there.

One day, I finally got some help from Dave McNulty, who was a commodore then. I asked and asked for help and finally he sent me some. During the rainy season, we were blowing up ordnance by pumping out fifty pounds of shot. We'd prime up three holds and get back to the bunker. It would go boom, boom, boom, and we'd start all over again. We could burn up to fifty caliber rounds in my oven; we'd burn that.

I lived in Senior Officers Quarters (SOQ). Being the Officer In Charge (OIC), I rated that, and it came complete with a bar. The master chief and I were sitting at the bar one afternoon, having a beer and talking about how we were going to get from here to there. We did a little arithmetic and reckoned, at fifty pounds a shot, we'd be there until the year 2031 getting rid of what we already had on board, without any more coming.

We had to come up with some plan.

At that time, the commodore sent two more people to help us. I wrote him that if he didn't open his shirt, his heart was liable to fall out. The two guys were actually great guys. One was named Jim Ruttman and the other guy was the disbursing clerk (DK).

We started looking for ways we could blow the stuff up underwater. We started doing it underwater. There was a procedure for shooting off huge quantities of explosives underwater. You had to send a message to the world. The top info was the Chief of Naval Operations (CNO). Let's say that you were expected to shoot this off or blow that up at such and such latitude and longitude at so and so time on so and so day. We'd fire that information off to the world. If you got nothing back in five days, you could consider it approved and go do it, and we did.

We did two 2,000 pound bombs at first. We just strapped them onto the side of my own Mike Boat that I had there. We strapped them on the side and packed the nose and tail fusewells with C4. We went out and found the area we wanted, which was sixty feet deep. We cut the lines and let them fall to the bottom. Then, we put two guys in the water. They swam down and capped in, put in the electric, and blew them up. They backed off first, of course. It was great fun. Everybody got some good pictures.

We were all at my bar, congratulating ourselves and having a beer. One of the guys, Ruttman actually, asked, "Gunner, why can't we do all of it that way?" I said, "I don't know. Why can't we? Let's think about that." We brainstormed around the table. One of the magazines I had that was full of explosives for disposal was full of C3. That was the predecessor to C4, and it was bad, bad stuff. You could get a really bad headache from that stuff.

The stuff was so bad and we had so much of it that you could get a headache just driving by. Yes, it was bad stuff. We had to get rid of that. We lined a skip box, which was a box with metal sides, metal corners and wood flats in between with great big wire lifting slings to the four corners. We lined the walls and floor of the skip box with C3, filled it up with 81-millimeter mortars and a few other odds and ends and lined the top of it with old haversacks. We put a cherry-picker in the boat, took it out, lowered it to the bottom, swam down, and put a C4 charge on it, which we already had in there. We just capped in, ran the fuse to the surface, and capped it off. It was a non-electric. We ran the wire to the surface, and had a non-electric floating on a piece of styrofoam.

We pulled it and backed away. It was beautiful. We waited until the current cleared, and we went down. All we could find was some twisted-up metal from the skip box. Realizing that the commanding officer of the magazine would get really mad if I blew up all of his skip boxes, we decided we had to build some boxes, so we built boxes.

We built boxes out of the donuts that were used for shoring up the ships that came over. They were throwing the donuts out in the dump and burning them. We just went down and got it and built boxes. Then, I hired a 14-man stevedore, a Filipino stevedore crew, to build boxes for me. We got away from the cherry-picker; we got to where we could pick them up with a forklift.

We limited them to 5,000 pounds and stacked them because the forklift capacity was 6,000 pounds. We stacked them on the boat and then drove the forklift onto the boat, got underway, went over, sent a message, dutifully, and waited. Only once did I ever get a request to postpone, and that was from SUBLANT. I guess a submarine was going to be in the area. We postponed that one until they sent a message.

Then, we would put the boxes out and slowly make our hole on the bottom much, much deeper.

I'd moor the Mike Boat by the stern and put a zodiac up in the bow and just have it go in an arc. I'd have the forklift pick it up, take it to the rail, and just dump it overboard. We had holes cut in four sides and C4 crossed across the bottom, top, and all sides so no matter how the box hit the bottom, it was capped in two places.

Right after that, the master chief and I would go underwater with a spool full of detonation cord and a piece of pipe. We'd swim a circle around the whole lot, and the kids would come along behind with sensitized detonation cord, and that was the cap on the detonation cord. They'd cap in and tie it off to the ring main. You couldn't get a girth into the hole, so we used what we called "underwater tape" which was actually electrician's tape.

By then we had graduated from the non-electric because we didn't have any control over that. We almost blew a helicopter out of the air once. He was coming along the beach, and I had to inform the Quantity Verification (QV) tower and security that I had everything out there ready to explode. All the world knew it, except this helicopter pilot who didn't get the word. He was coming right along the beach just as a plume of water shot 3,000 feet in the air; he was screaming like a rat eating red onions.

Anyway, we got rid of a lot of ordnance that way, about 300-and-something tons. My biggest shot was 52 tons, but we did that routinely. Every two weeks, we'd shoot a shot off.

The commodore called out and sent a message that said I needed to come out and visit. During the visit, he said, "You're disposing of more ordnance every month than all of my other 16 detachments combined." I said, "Oh well, I reckon they ought to go to work. But commodore, remember, I've been asking you for help."

I was getting help from the Marines. A good friend of mine, a gunner, had been in charge of the Okinawa Marine Detachment. The Japanese wouldn't allow them to do any ordnance disposal. Instead, the Japanese would harass them. They would say, "You can blow up twenty pounds on Sunday at 2:00 p.m. That's it."

They came down one time to TAD. Just fooling around, I asked, "Do you all want help?" They said, "Yes. Man, we'd love help." I could send help because I was really fortunate. I had about ten of them. I'd send some to burn 18,000 pounds of powder in the morning.

Sometimes I would draw upon the underwater demolition teams (UDT) at Subic. Those guys would come out to watch. They knew we'd be blowing up stuff because I'd sent the message to the world. Dennis Baber, an ensign, and Master Chief Gallagher would come out with their cameras, just waiting, and they'd take pictures when the shot went off, then off they'd go.

I called over one day and said, "I want the UDT officer, Dennis, to come see me." I said, "I know what you're going to do. You're going to go back to Strand and say, 'Look here what we did in WESTPAC' (western pacific region). If you really want to do this, I need some help. Send me three or six or ten of your best guys and my master chief and first class will train them in what they need to do. In return, you can help us out, because I really need the help. I'm running out of bottom time here and we're doing this thing at sixty and seventy feet with a four-man detachment. You can figure it out. Run the numbers." I got him to send us some guys. Then, the rest of them would come and take pictures.

I was at Subic for two and a half years and we came pretty close to getting rid of all the ordnance. We got rid of over 300 tons. You have to remember that there was more coming every day and plenty in the magazine. I don't even know how much was in the magazine, but that was a good tour.

I did a lot of jumping. We did a lot of diving. We did a lot of diving on plane crashes, picking up the pieces, basically. Once in a while, we found a piece of a body. Once we got both bodies out of the plane. It just went off the end of the runway and right in the water for some reason, but we didn't know why. Parpinski, the old master diver, who now lives in Panama City, FL, called me. We went out with our hand-held sonar and found it right away. We went to the

aircraft and got the bodies, safety seat, and all the EOD stuff out.

We worked with a lot of the Vietnamese Navy. Of the ones I remember, the most colorful one was "Whisky" Tom. His name is Tom Nguyen. Tom was quite a character in EOD in his own right. He had been in several of my friends' teams prior to my entry into Vietnam, and I was fortunate enough to have him.

Tom was a seaman in the Vietnamese Navy. The way it worked in Vietnam was that when everybody got paid, someone had to go to Saigon to get the money for everybody, and that person would bring it back and pay everybody. When Tom got his money, he was just like a seaman second on liberty. He'd spend all his money that same day and wanted to take everybody out for dinner. We'd try to tell him, "No, Tom, you don't need to do that."

If we were traveling down the river on a boat, we got transportation any way we could, and more often than not, it would be in a swift boat that was going from point A to point B. We'd stop off wherever they would stop in our support base along the river and spend the night. We'd go out to a little town nearby and eat Chinese soup, or what Tom called Chinese soup. It was just noodles, a little meat, some green stuff, and boiling water. That was a meal in Vietnam. Tom would order Chinese soup for everybody like he was the admiral in charge.

The mama-san wanted to get paid but Tom would say, "No, mama-san. You don't understand. We keep the VC away from you. You pay for us." She said, "No, no. That's not the way it works." He had a .45 that someone had given him. The mama-san would have a Sanyo fan that she had paid dearly for, and that was her only prized possession. She'd have a light and a Sanyo fan and some really crude tables and chairs on a dirt floor. He'd say, "Mama-san, do you like your fan?" She would say, "Yes." Boom! Tom would blow the fan away. She would say, "Okay, you eat free."

Once, Tom did that in the wrong place. It was while I was between tours, and Tom, as the story goes, had pulled one of his tricks. The QC, the Vietnamese military's equivalent to the Military Police, was called and Tom was thrown in the monkey house, or jail. That particular jail was a Conex box, and in Vietnam, when you got thrown in jail, in the monkey house, that was where you were. You lived, ate, slept, and did everything in there. It got to be rather smelly after a while.

Everybody tried to get him out, even Commander Ronan. Our team leader and officer in charge in Saigon finally went down and were successful in getting him out. Whisky Tom was a real cocky son of a gun up until then, but the way Commander Ronan told it, Tom was humbled when he came out of that box after about five days.

At the end of the Vietnam War, "Whisky" Tom was back in our detachment.

LCDR WAYNE WRIGHT

In 1979, twenty-two years after I joined the Navy, I found myself back in Alaska with an EOD detachment. We did training dives just to maintain our training. The most exciting part of that tour was actually blowing up two fish processing vessels to burn the oil out. The first one was up off the Pribilof Islands, an island called St. Paul. One island belongs to the United States; the other island belongs to Russia, with the border split right between them. The fish-processing vessel ran aground there. The major industry there was seals. Have you heard the term "clubbing of the seals?" Well, that's where it starts, right up there on the Pribilofs.

The seals go to those islands and mate every spring, in March or so. There are upward of ten million seals that hit those islands every year. Alaska's Department of Fish and Game was fearful that the fuel on the ship was going to drift ashore and kill a lot of seals because it breaks down their insulation. They asked us if we could get rid of the oil in the ship before the seals started coming in.

When we got there, the seals had already started coming in. There were maybe 200 or 300 swimming around. We devised a method of blowing the ship, forcing the oil up inside and lighting the oil on fire. At 28°F below zero, we knew it would be hard to light diesel. We knew thermite would do it. We put 250 pounds of Mark 8 hose along each side, below the water line. We put satchel charges on all the tank tops to blow the tops. Then, we put thermite grenades on all the stanchions throughout the ship and tied it all in with deck cord. When it blew, the Mark 8 hose created a hole on the outside, with water going inside, forcing the fuel up. We punched holes through the tank tops, so that made a common area inside the ship for the fuel to go, and the thermite pushed it. She burned for four days. Out of 115,000 gallons of fuel on that ship, they estimated less than ten gallons went to sea.

That operation saved the state of Alaska $15 million. They had a commercial contract to soak up all the oil as it broke and went ashore. A company gave them a bid for $15 million, but we did it in 16 days at the cost of $3,000 in explosives. It was a good clean job.

A year later, we did another one off the north coast in the same time frame. After that, diving for EOD was pretty much in the MCM arena. I had a Personnel Exchange Program (PEP) tour in Canada. I was the EOD officer for the entire eastern part of Canada.

While I was on PEP duty, I was stationed in Halifax. Actually, Shearwater, Nova Scotia was where the fleet diving unit was. I was assigned as the commanding officer of one of the diving tenders when we were up there. I'd made lieutenant (junior grade) by then and I took over the diving tender. Then, the Canadian forces wanted to conduct a mine exercise in Canada. They asked me if I could write the plan and establish an annual training event up in Halifax.

I wrote the first plan, and we conducted a mine exercise up in Bedford Basin. We actually coordinated with the United States. A couple of the detachments down in the US had one parachute in with all their equipment. All we had to do was provide them a boat when they got there, and so it was a joint exercise at that point. Canadian Navy divers and US Navy divers were to clear the mines that we had laid for the exercise. We had the mines at a hundred feet.

The second mine exercise that we orchestrated was off the eastern coast of Nova Scotia. We actually brought up minesweepers to get involved in that one. All the Canadian Navy divers and the US Navy divers once again participated to go down and validate what the minesweepers had recognized.

We were diving with scuba then, with wet suits, in November. Of course, the water of Nova Scotia is always cold, I'll tell you what. The Canadian divers were a different breed. They were very serious about their diving.

We used the Draeger. Of course, you had different problems with the Draeger. It had pure oxygen, so you were depth limited, whereas if you were diving with helium or nitrogen in a Mark 6, you had a little more depth capability. If anything happened, you could last a while without freaking out or going into convulsions. Actually, it was better than the Draeger, but it was not as good as the 16 (MK 16 Closed Circuit Breathing Apparatus). With the 16, you basically look at the lights and the panel and you're all right.

Mines aren't always within reach. During the Red Sea mining incident in 1984, I was actually the staff officer assigned to the US Central Command (CENTCOM). That was the year that the British recovered the Soviet 995 mine.

You've got to be careful on this story and I don't know where I'm going with this one. Actually, I was ordered by radio to go and meet with a British diver, because they had all the diving down at the mouth of the Suez Canal. They said they had recovered a mine and they had the *Sea Owl* to videotape it. The admiral wanted me to go down and look at the video and try to determine whose mine it was. I went down there and was basically told that the Egyptians didn't want the US to know that there was a mine. The British

had already declared that it was a Central Intelligence Agency plant. I was not allowed to go into the Egyptian naval base. That night, they smuggled me in. I was in a British uniform, and I went aboard their mother ship.

It was the British ship that showed me the video. I had some publications with me. I said, "Here are all the identifying features of this mine. This mine is a new vintage Soviet mine. It's two bladed. The warhead is about a 1,500-pound warhead. It's magnetic acoustic by function." I actually wrote that down on a yellow-lined tablet.

The British kept asking, "Well, are you sure? Do you really know what you're talking about?" I handed them the notepad and said, "Here. Xerox this, because I'm taking a copy back with me and giving it to the ambassador." Our headquarters was in the embassy.

I took a taxi from Port Suez to Cairo and went straight up and told the admiral what I had found. I gave him my paper on it. He asked me if I was positive. I said, "I'm one hundred percent positive, without a doubt. This is what you've got." He said, "Okay, I'll get back to you later." I went over to the Hilton Hotel, where we were staying, and went down into the casino and started playing blackjack.

While we were there, we weren't allowed to be in uniform. There were still people out trying to kill American citizens. I was sitting there at about two in the morning, then a marine burst through the door with a radio in his hand. He was in uniform, and he hollered out, "Is there a Lieutenant Wright in here? The Ambassador wants you right now." I went over to see the ambassador.

Commodore Larry Kelly had Explosive Ordnance Disposal Group One. When I retired he was still there. He was an 0-4 at that time, at Chief of Naval Operation Code 372. When I walked into the ambassador's office, he said, "There's a little box over there with a phone inside of it." It was a soundproof box, and there was a red phone in it, a secure line. He said, "There's a Commodore Kelly who wants to talk to you on the phone."

I was on the phone with Commodore Kelly (at the time he was Commander Kelly) for about an hour and a half as I explained to him what I had seen on videotape and what the identifying features were. This was a big political football. After I left the ship, the British had radioed London again and told them that they still believed it was a CIA plant, but that I had been there and said that it was a Russian mine. I finally convinced Larry Kelly, who would have had to go over and brief the President the following morning on what that thing was about.

About three or four years later, I was the operations officer of a group for Larry Kelly, who was a commodore at that point. One of my former commanding officers, when I was an executive officer, Dave Resick, came into my office one day. He had a great big book with him. He said, "Here, I want you to take a look at this." It was the intelligence package on the 995 Soviet mine. It had my comments in the front of it. He said, "Everything that you said about this thing was precisely right, except you missed the explosive payload by fifty kilograms."

That wasn't too bad. It made me feel pretty good because it was a magnetic acoustic and a heck of a find. It was actually built in 1981. We had seen it in 1984. Before I left Cairo, I told the admiral and the ambassador, "Okay, I've told you that this mine is two bladed." The significance of that was when a ship came through the canal, it would just roll over the side. That thing could actually be launched from below the water line.

They said, "Well, there were no submarines that went through there." That was really immaterial.

I said, "Start looking for a ship that has a double bottom and looks very unsuspicious."

I guess they found the ship. I think it was the Liberian registry *Gatt* up in Marseilles. I think they found that it had a double bottom. But during that whole Red Sea mining incident, they brought in HM-14, a helicopter mine-hunting squadron, and that was when HM-14 was just getting started.

There were the old CH-53s, and they had brand new size. A captain came over there to orchestrate the whole Mine Countermeasures (MCM) effort in the Red Sea. He actually put the helos out there, running wire up and down the Red Sea. They had identified something like 450 targets.

I went down there again. Be careful of what you identify as a mine-like object, because you're going to have to verify every one of them before you leave the country. The depth of the water was anywhere from 200 feet to 350 feet. We were looking at a long, drawn out process. I told them I would suggest that you take your helicopters back to see if you can start pinpointing these things again, because what you have over here are 55-gallon drums going over the side on these ships all the time. These are the things rolling down the canal.

Well, sure enough, most of what they were finding were 55-gallon drums, too short to be mines. But we had brought over a detachment. If I'm not mistaken, they came over with Mark 6 rigs. That was Sue Fitzgerald's detachment, out of Sigonella, Italy. The Admiral made it kind of a joint concern. They wanted to train some Egyptian divers to dive for mines. That job was given to Sue to train the divers. They dove to quite a few of the mines.

The only mine found over there was that 995, and it was laid right at the entrance to the Suez Canal in Port Suez. The British actually found it, and that was a horror story in itself. They found it, went down, and put a cable to it. You've got to realize we're talking about an influence mine. They put a steel cable to it,and jerked it off the bottom. I think they said they raised it to within twenty feet of the surface. They were in contact with London the whole time. I guess London told them they didn't want to raise it. They actually just cut it and let it fall back to the bottom to find out that it would have functioned above 18 feet. By the way, they did this behind a steel tug.

They went down later and actually took their underwater x-ray. It was a lethal dose for anybody in the Pacific, because you had to put out so much power. They identified that there was a big control package in the end of it. Then, they went down there and put explosives around it to try to separate the instrument package from the warhead. They actually went too far into the instrument package and damaged some of the components. From what I gather, they got enough information out of it to tell them exactly what it was. They shipped the counters and everything.

It kind of turned me off quite a bit with Great Britain's MCM capability. They jerked that influence mine off the bottom, put it underneath the steel hull of a tug, and cut the cable and let it go back down, and then dove to it again.

I was there for three or four days. I talked to them, and it sounded like they knew what they were doing. But the way they treated the mine was a little cavalier, but nobody was killed. But they were actually allowed to take the mine out of Egypt and back to the United Kingdom to do all the intelligence work. I'm sure we had a big part in that.

The threat was all we needed. They had ships over there that were running into mines all the time, or at least that's what they were claiming. They said they were running into floating mines. We didn't find any floating mines, but there were ships that had great big holes in the bow from explosives. They couldn't explain it. We rode around on helicopters looking everywhere. The only things we could ever find were 55-gallon drums. There was always a theory that maybe there were explosives in the 55-gallon drums that floated just under the surface, but we never did find any more mines.

I had some experience diving in the Antarctic also. We'd dive off the ship rather than off the ice or from land. What happened was that we backed down into some ice, and the old man feared that we had sheared one of the blades. The blades on an icebreaker are replaceable. In fact, they're like the variable pitch blades on a minesweeper. We would dive down just to do routine checks to see if we had

damaged a propeller blade and sometimes, sure enough, we had.

The big thing about diving down there was that everybody was scared to death of orcas, the killer whales. Sometimes, we'd pull up on the ice. That's how an icebreaker does his job. They pull up and it crushes the ice. We'd pull up on the ice, settle down, put out ice anchors, and we would go out and have a party on the ice. We'd play ice football. But nobody was allowed within twenty feet of the edge of the ice because killer whales would come up. They would slide way up on the ice, grab a seal, and go back in the water. We used to witness that all the time.

When you were getting a lightweight diver to go in the water, you were always looking around. The water was absolutely crystal clear. You could see forever. It's the same way in the Arctic. It was always really clear.

I never did see a killer whale while I was in the water, but once when we were about 15 miles off Point Barrow, the captain wanted us to check the shafts, and there were walrus in the water, and we actually could see them. I had seals nip at me. I've been in the water with the white tip and black tip sharks.

My first experience in EOD work was in Kahoolawe, HI. In the early seventies, we would go over there with 200 or 300 pounds of explosives in a backpack. We'd set up camp and backpack all over the island and blow up anything we could find, be it bombs, projectiles, or whatever. It was excellent training. If you wanted to find out how to gain access to a 2,000-pound bomb without having to go high order, you could practice anything you wanted to, and we did.

We got to a point at which we could cut a bomb in half explosively, without making it go high order. Of course, you didn't get an opportunity to do that every day, but it was good training. Of course, diving over there was a treat. There was ordnance in the water all around it because it had been shelled for so many years.

There's a little island in between Maui and Kahoolawe called Molakeni Rock. From the surface, you can see the bombs and projectiles lying in the water. It's almost like flying over Viegas. You can see the munitions underwater.

Once while I was on Guam, we made a trip down to a place called Angaur, which is about eight or ten miles southwest of Palau. The Japanese had used that as a runway, and the island still had a long runway on it. We were sent over there to clear the sides of the runway because the vegetation was getting to the point that they couldn't land planes or anything. They would bring C-130s in there to the Coast Guard Loran Station. We went over to blow the trees, and the islanders had begged us to dive in this one lagoon and clear an old Japanese tank that was blocking the channel.

We went down there and found one of those old Japanese two-man tanks, sitting upright in the middle of the channel. We put a couple satchel charges underneath it, launched it, put it up on the quay wall, and it worked out really well. They were happy.

The kids were out there playing on their beaches and they found a number of different bombs. We just hurried everybody to the other side of the island because we could capture these bombs and get rid of them so that the kids didn't have a problem. It was a good trip. All those islands out there are just loaded with ordnance.

The islanders were kind of tricky. They live on fish and one of the best ways to get fish, of course, is underwater detonation. We would get a call, every once in a while, telling us that the islanders had found some munitions they wanted us to get rid of. Sure enough, we'd go out there. Actually, they'd taken all the munitions they could find down to the lagoon and piled them up. Then, they would sit back there with their boats and their nets. As soon as we'd crank it off, they were out there, getting all kinds of fish, turtle, and whatever they could find. There was a big feast that night to which we were invited. It was a lot of fun. I enjoyed that.

ADMIRAL "IRISH" FLYNN

To begin, let me give you just a synopsis of my time in the teams. I joined the United States Navy in 1960 and went through UDT training. I went through replacement training at Little Creek that same year, and I reported to UDT 11 in Coronado in October of 1960 as an ensign, USNR, and served in UDT 11 until 1963. I was in SEAL Team 1 from '63 to '65, staff duty in Washington from '65 to '67, and SEAL Team 1 and UDT 12 from '67 to '69. I then had various school and staff duties until I returned to Coronado as chief of staff of Group 1, in 1977. That lasted until 1979. Then, I had more duty in Washington, followed by command of Group 1 from '81 to '83.

It was in those times that I was in the Naval Sea Systems Command in Code OOC from 1970 to 1972 that I was involved in the acquisition of SDVs and the diving systems.

When I got to the teams, I hadn't had diving training on the East Coast. In those times, you went through UDT, reported to the team, and then the team sent their new people to Key West for diving training.

I came out to Coronado and was in the teams for some months before there was an underwater swimming course for team members. I did not do it with the trainees. On the West Coast, SCUBA training was part of UDT training. When the people came to the teams, they had already had scuba training.

Well, not having had that, I was in a pretty small class with just a few people. It was run by the UDT section of the amphibious school, with Kevin Murphy as the principal instructor. When Kevin retired, he went on to work for US Divers. He's a very accomplished guy and knew his diving physics and diving medicine very well. Various hospital corpsmen, and I could daresay the doctor, lectured in that course. What we learned to do was swim and dive with aqualungs. We did free ascents with a bell that was suspended from a Mark 6 LCM, which was used as a diving support by the UDT. It went out by the entrance of the bay out by Ballast Point. You free ascended from about 35 feet, rather than the 100 feet or so that East Coasters probably did at New London.

There was a doctor there who nobody had very much confidence in because there had been an accident on the strand. A guy was pulled out of the water; he died, and the doctor pronounced him dead, but the team members thought that not enough had been done to resuscitate this guy. I thought there was an awful lot of emotion in that, rather than science. Why would the doctor have said he was dead if there were any signs that he was still alive or capable of being resuscitated? Anyway, that was the knock on this doctor, and he wasn't there for a great deal before he left.

What was I trained in? We still had Pirellis in the team. That was not a circulation thing; they were phased out and there were just a very few of them left. The Pirelli was a pendulum system. People used to call them the 'black death' because you could have a problem of just rebreathing, literally, the same air without it going through the canister and getting oxygen depletion, combined with CO_2 build-up if people were working hard with them.

The Italians had used them principally for charioteers who were riding on, in effect, SDVs. The Americans used them while swimming horizontally with a very high work rate of underwater swimming. Maybe that was part of the problem with them. But all I recall is that there were a few of them still on the team. What I was trained in, in addition to the aqualung, was the original Draeger. I think that was the Mark V Draeger.

There was also the Lund Draeger, and it was an excellent diving rig. I enjoyed swimming it because it was super for getting in and out of boats and other things because it was lightweight. To my mind, the good reason for doing away with it was that they weren't able to get repair parts, particularly to repair the bags, which were inclined to leak because they didn't have clam shells over them, as the later Draeger had.

Occasionally, if you weren't careful, you could get sea water around your mouth while

diving the Lund. Some of them had pin prick holes in the bags, too, because they were wearing out. You could get water in that way. When you did, you got a caustic wash into your mouth. That only happened to me once or twice in a good bit of swimming, and I only got it into my mouth. I didn't get a good lung full of the stuff like some guys did.

The swimming that we did with it was typically off the strand in Coronado. You got a boat, loaded it through the surf, were taken off 1500 yards or a mile, and swam into the shore while being guided by the headlights of trucks on the beach. We also did that in the bay. Very occasionally, we would actually do attacks. We did do attacks with them out at sea off San Clemente. I remember doing that and doing a good deal of diving.

For example, when we did lock outs from submarines, I don't recall ever using the oxygen rig. We used aqualungs and hooka rigs for that. We did hooka rig ascents and occasionally free ascents, buoyant ascents. As I said, there were problems with the parts in them. Then, somebody got hurt with one somewhere; I think it was on the East Coast. There was somebody killed on it, and people said that it was an unsatisfactory piece of gear. NAVSEA designed something new to replace it, called the Emerson.

When I went to Vietnam in 1964, the CIA had bought many Emersons for the Vietnamese to use. They were pretty hopeless pieces of gear, but we trained the Vietnamese in the use of the full-scale Emerson. I must have gone through Emerson training perhaps as early as 1962, certainly by 1963.

The Emerson was clunky and noisy. You had the clam shell in the back and bags in the front. From the swimmer's point of view, once you were in the water, it was okay. But it was an engineer's design, rather than a war fighter's design.

Tactically, it was a bit of a mess. It looked like a mini Mark 6. Instead of being compact, like something that you could put into a kit bag, it was bigger and had the problems of noisiness and visibility.

We could come up to take a look with a Draeger. There was nothing particularly visible. Since it was very lightweight, you could go across a beach very handily with it. You could turn off the oxygen supply, close the mouthpiece, and run around with it because it was so light.

The Emerson wasn't all that heavy, but it was a noisy bugger with that plastic thing. If you banged into anything, it didn't make a great deal of noise, but it made some noise that you didn't want to have. Also, even though it was painted black, things would get scratched, and it was made of a more reflective surface. Again, it was perfectly okay to swim it. At the same time, I was introduced to the Mark V mixed-gas rig and trained in that. The Mark 6 followed.

As I recall the physics end, the calculation of your equivalent air depth, equivalent of the dive and repetitive dive tables, they were very similar for the Mark V and Mark VI. The Mark V may have had less flexibility in setting. I recall 60–40 as being a typical mix, and I think it may have been a little bit bubblier than the Mark VI. You got a larger stream of bubbles from it, and it was more cumbersome and heavy. But neither was a particularly good underwater combat swimmer apparatus. They just weren't made particularly for that. They could have been fairly decent in SDVs, but we didn't have an SDV worth anything at the time.

The Emerson was noisy, but the Draeger was all in front of you and you could protect it.



Mark VI

These rigs were good examples of different approaches. The difference of approach, if you want to know my understanding of it, was that we were never all that serious about going to war this way, because the United States didn't need it.

The United States had a huge Navy with lots and lots of submarines armed with torpedoes, and lots and lots of carriers with bomb-carrying planes. For example, if we screwed around with the Vietnamese, having them attack in North Vietnam, it was more a pin prick than a serious way of destroying the aircraft. But when the United States, after the Tonkin Gulf incident, really wanted to destroy them, they just bombed the heck out of them.

Now, the Italians, in the Second World War, needed to have something pretty slick to get at the British targets in the Mediterranean. They had the underwater swimmers and the establishment at La Spezia to do that.

When I, along with Gene Mitchell and Chuck Lemoyne, visited La Spezia in 1972, the Italians were still very seriously into that concept because the conventional Navy didn't have the reach to get to the Russians and other Russian surrogates. Where the targets were, I'm not sure, but perhaps they were in the Adriatic and maybe even going into the Black Sea.

On the other hand, when I joined the teams, part of the notion was to use scuba for taking the World War II beach reconnaissance and doing it under water. Teams put forth immense efforts, particularly with the Mark 6, into doing that on the East Coast, where we had nice, clean, clear water and a good environment to do it in at St. Thomas.

The underwater reconnaissance of beaches was essentially an attempt to do underwater what was done on the surface. From the surface, the attempt was to do a 50-yard grid from the three and a half fathom line into the water line, of taking soundings in depth and in the shallow gradient that was a very large area. Even in a medium gradient, it was a large area with a fair amount of surf breaking over it, with the surf effect reaching down to the bottom sometimes.

Swimmers were to establish this grid using great long flutter boards with lengths of line many hundreds of yards long. They were swimming with compasses to lay out a baseline. Then, other swimmers were swimming a baseline parallel to the beach. Swimmers were also swimming vertically from that with compasses into the waterline.

It involved an awful lot of swimmers, and it was fairly problematic about whether they were actually doing things on an accurate grid. With those parallel lines into the beach, perpendicular to the baseline, I dare say a lot of them crossed. But what you did get was a fairly good impression of what that beach area was. Were there any rocks, shells or really prominent sand bars in it? You could get that from this evolution, but you probably could get as much useful information by just two or three guys doing it.

When they really had it going well, after lots and lots of practice, you could get pretty good at it. But it involved going through all this effort to do this underwater, when you've been delivered by an LCPR or an LCPL that's on the surface. So you have to say, "Huh?" We could approach this beach in a boat, and nobody was going to do anything about it, or it could involve doing it from a submarine.

In most places, the gradient was such that for a submarine to have enough water under it to do the lock-on, there was only a very limited number of boats that could bottom. You were out there in fairly deep water when you were locking out, which meant a long haul to the beach.

Typically, people would lock-on through a standard escape trunk. It would be two, three, or a maximum of four at a time. They would breathe air from bottles that were tied along the deck of the submarine until everybody was out. On a signal, they'd then take off. It was a complicated business because people had a lot of gear and their buoyancy could be off a bit.

We lost a really good sailor who was swimming with Bob Valentine off San Clemente. They came off the beach. We were going to swim from the submarine into northwest harbor someplace,

where there's a beach, and do this evolution. They had all this gear with them. The guy was holding this gear, and getting ready after just coming off the deck of the submarine; he went into the screws of the submarine.

He was last seen going down into very considerable depth. Valentine followed him for some depth, but it was probably a couple of hundred fathoms there so there was a limit to how far he could go. That man died. He probably was using an air scuba because the description of it was that the manifold was broken by the screw, and all these bubbles were coming out. Mercifully, one hopes that he was hit in the head by the screw and killed by it, but we don't know.

It had those disadvantages. What you had to do when you had a submarine that could not bottom, was that while the submarine was doing an approach, you were doing your task. Then, when it was at the closest point to the beach, and you knew the course would be from your drop-off point, they would flash a light in the escape trunk. That was your indication that you were at the drop point. This guy would give a signal and everybody would roll off the deck of the submarine and go to it. If they had the currents right, and if the submarine could come in during the first instance and gauge what those currents were, maybe you could make it to the right flank of the beach. But you were starting to build up errors along the way, and the compasses were notoriously unreliable, as were the depth gauges.

The depth gauges that we had on the tack boards were not all that great; you had to tap them to make sure that you weren't exceeding depth. But that usually wasn't the problem because people swam fairly close to the surface, and it could be done because of the extended duration the Mark 6 gave you.

But from the point of view of going to war against the Russians, would you really want to have a submarine screwing around in that shallow an environment, that close to the shore, with a fair amount of bubbling coming to the surface, and a fair amount of underwater noise from all of this? Among other things, you had to rendezvous with the submarine. You lined up on the line and snagged the periscope, so they had to have a periscope up, which was not a healthy thing to do that close in. You would also do everything from banging on pipes to signaling with an underwater sound generator, an acoustic signal, and none of those were healthy things to be doing in a defended area.

But, lo and behold, we did much of it in Vietnam, but on the coast. An awful lot of the coast of South Vietnam was surveyed, and surveyed again and again, by units that were supported by a submarine, such as USS *Tunney* and also by detachments that were out on LPDs, the USS *Cook*, and *Dyshenko*.

The way of doing those beach surveys wasn't an awful lot different when it was done from the submarine, because it was done from the surface with Inflatible Boat Small's (IBS) out. The swimmer would swim into the beach with a line, with the other swimmers coming off one or more IBSs as bunting came up on 25-yard intervals or 50-yard intervals. You'd start at one flank and just go down with the IBS. A guy would walk along in shallow water at the inboard end and take soundings as it went along, guesstimating the lateral distance along the beach as we were doing our part.

We got a fairly accurate reconnaissance of beaches that already had been reconnoitered three times by then. That really didn't change an awful lot. During the monsoon season, you got some shifting of sand bars, but not enough to make a difference as to whether an amphibious landing could take place on them.

All this was done on the surface, whether by night from the submarine or in broad daylight from the APDs. There had to be a better way of doing this underwater thing. One way to do it is with a lot of the components of the swimmer support system, the need for a long-range, bubble-free, mixed gas rig leading to a very good piece of gear designed by Westinghouse. For complicated reasons, we went away from that to the General Electric mixed-gas rig, which was

really big and cumbersome. It was the forerunner to the Mark 15.

I really liked the rig made by Westinghouse, but only about two or three prototypes were made. When I was in NAVSEA, I bought the argument that we ought to have a common rig, that we were going to use this General Electric rig for both deep diving excursions for saturated divers and also for our purposes.

All of this was going on in 1970. When I was in the Pentagon, from 1965 to 1967, we launched the operational requirements documents for the swimmer weapon system and the swimmer support system. It took a long time for those things to mature, but what we were looking for was an SDV, a large people carrier and a smaller one, and one that we hoped would be stable and operate effectively in shallow water. That became the Mark 9, the flat boat with twins.

We were also looking for a very low acoustic signature, a bubble free, mixed-gas rig. Also, we were looking for a way of doing underwater reconnaissance by incorporating inertial systems into an underwater system and acoustic triangulation on it by putting out buoys as closely as possible to the known distance. We were trying to triangulate from what was called the "swimmer navigation reconnaissance system."



MK 16

We worked on that a good deal to try to get it to work. I think eventually, long after I was the commodore in Coronado, until 1983, that it came to pass. In the meantime, we got involved in mine hunting, using the Mark 6 and then the Mark 15.

The Mark 15 was a little bit dangerous because what we really needed was the EOD version, the Mark 16, to screw around with mines. The idea of landings on the coast of the Warsaw Pact did actually say we're going to encounter mines on that, or if we have to go into North Korea, we're going to encounter mines. Those mines in many instances are going to be scoured and covered by sand.

The way we were graded in Mine Countermeasures exercises was to have people put in mines that they would fairly promptly scour under the sand. At any rate, they were going to be pretty darn difficult to find unless you actually swam right up to them. We were fortunate enough to do that, and these things were sprinkled along Coronado Beach, for example.

Then, you got graded on your ability. If there were twenty mines put in there, and you found only two, you were a "bunch of bums." I argued, unsuccessfully, saying, "Hey, we found two mines." They probably just didn't fall off something. To me, it was an indication that there was a mine field there and that was already a great accomplishment.

What we had to do was go back by other means, concentrate on overhead collection using water-penetrating optics or lasers in order to do it, blue, green lasers and the like. We had to do that to be able to take a really good look at that bottom, take away the clutter, and see whether there were any anomalies on that bottom indicative of the presence of mines.

Further, we should ask ourselves, "What's the beach lane doctrine of our opponents?" If you find two or three mines, as we did, what can you assume about where the others should be laid out? Can we then use that to go back and

look for the others on a separate mission if we do have to send swimmers back?

EOD would be used, I think, to render these things safe. As in the Second World War, the frogmen were looking for beach obstacles, some of them with small mines attached to them. That became our job. What we were saying in the late 1970s and early 1980s was that just because there were no obstacles along the beaches did not mean that they were not defended. They were probably defended by a lot of mines, cylindrical mines. Then there were plate mines, and there were various kinds of them developed by Warsaw Pact nations. These things would have very seriously complicated and probably led to the defeat of any amphibious landing craft.

The Navy was going at it through several approaches. One, they had to find out if the mines were there. That was the UDT job. Then the Navy had to think of a number of ways of dealing with the mines. The problem was getting rid of the mines way ahead of time.

When you are at peace is not a good time to be letting off explosives off the coast of another nation. If, on the other hand, you wanted to get rid of the mines, and leave such a short interval between the clearance and the actual landing, or leave them with enough time to replace the mines, you had to have some way to get rid of the mines. It had to be practically instantaneous before the landing or in the course of the landing by using line charges and other things to clear lanes. It was a big problem then. I don't think that the Navy really solved that until the Cold War was over.

By 1982, the UDTs had been re-designated as SEAL teams, but with the combined missions that formerly belonged separately to SEAL teams and UDTs. They were to go in, in a way that they would not be discovered. Again, it involved operations from a submarine. We did these practice things with swimmers. The real way to do it was with an SDV, and to figure out in an operations analysis how many discrete cross sections of a beach you would need to take and not find mines, to determine that the entire beach was not mined. You couldn't go over every square yard of the area underwater. We needed courageous operations analysis to be able to say, "If you do this, this, and this, and you don't find a mine, then the probability of that beach being mined is 0.01 percent."

It was a statistical problem, and you had to know the enemy's doctrine about how he was going to put mines in there. If there were only one or two mines in there, and you were invading Russia or the coastline of one of the Warsaw Pact nations, or North Korea, you'd expect to have some losses. On the other hand, if you mess around, trying to find every single mine in there, you'll be discovered doing it. The enemy is going to know that that is where the landing is going to be. They had to trade off those things.

Now that was the reconnaissance mission. The other mission was the attack mission. Initially, we started building capability without really figuring out what we were going to attack or why underwater attack by swimmers was going to be the preferred means of attacking.

For example, if you had to have a submarine deliver you most of the way to get into an SDV and put a limpet mine on a ship, why was it not better for that same submarine just to lay some mines at the entrance of that harbor so that you were not going through all the excruciating difficulty of getting the limpet onto it? When that ship came out, it would be destroyed by the mines, or at least give the Russians a sense of having to deal with the mines before their ships could come out of that port.

There was a lack of adequate strategic thinking about it. Part of the problem was that we didn't have sufficiently senior people at the time. Our senior people were captains, and we were given fairly respectful hearings on those.

We started to get SEALS like Bob Mabry and Bruce Dyer, for example, onto the 7th Fleet staff, and similar efforts were made on the east coast to get people on the 6th Fleet staff. There were commanders and lieutenant commanders on the staffs of the fleets, with views of looking

at things in an integrated way to determine in what circumstances it is best to risk putting people into the water to attack things.

One of the operations was to go after a nest of mine sweepers in a port at the southern end of the Kamchatka Peninsula on the La Perouse Strait. The whole idea was to mine the La Perouse Strait to keep Soviet ships from coming out into the northwest Pacific. But you also needed submarines or aircraft that would be laying the mines to get the mine sweepers.

There you were, in a pretty tough place up there at the southern end of Kamchatka or Sakhalin. The water was cold; I don't know what acoustic conditions were like. We were going to be using an SDV, coming out from a dry deck shelter. That was a long evolution with the submarine going slowly in shallow water, a dangerous place for a submarine to be in a hot war.

Again, it depended greatly on how accurate the navigation of the SDV was. By that time, we had put acoustic Doppler sonar navigators into them, with which you bounced signals, preferably off the bottom. By measuring the shift of the return, you would know where you were going at all times.

We started developing, and had, the prototypes of those systems in as early as 1972. I was working on it when I was with Group ONE, in 1981 to 1983. The LAM was the Limpet Assembly Modular. It was fifty or a hundred pounds each of those beer keg-like components. You could put several of them together with one firing train. They were neutrally buoyant, but still not all that easy to handle in and out of an SDV.

There were a fair amount of explosives in a submarine; therefore, there was a lot of effort to make these things sub safe, but still have assurance that they would detonate. You didn't want to go through all of that, and not have them explode, because it was a very tough evolution to take the SDV into a Russian port during a hot war. In order to be able to rendezvous with the submarine, to be able to deal with the succession of depths, you needed to be able to ultimately end up on oxygen for the last several hundred meters of the evolution that you were operating under the target.

That led to the requirements for tables and being able to do the diving with a combination of several breathing media, such as mixed gas with the Mark 15, perhaps some of it done on air and then some of it on oxygen. You also had to be able to switch breathing media underwater. That was the kind of work that we were doing.

It is important to get the operational community together with the research community so the researchers will have a perception of the operational limitation and requirements. A researcher can come up with something that's physiologically sound and works engineering-wise, but doesn't work the way that you have to use it in the mission.

I hope that they're breaking through on that now. For one thing, the operators have to be explicit about what they want to do. Can you attack with aircraft-dropped delivered torpedoes? Can you attack the Italian fleet? Well, the British did that at Toronto, but one of the things they found was that Toronto had shallow water. On their initial run, the bloody torpedoes just stuck into the bottom. So they had to modify the torpedoes and their procedures. All of these things are very sensitive to what it is you want to do.

There are two things with the SEALs and the special warfare community. They now have admirals, and all of that, but they still need to be talking to the theater commanders and chiefs, to the war-fighting four stars and their staff, saying, "We think we can do this. Is it of value to you? It looks like it's of value to us, and here are the circumstances in which we can do it."

Then, you need to get very fine grained about your operations analysis, what you need to do in order to accomplish this mission. Then, you say, "Oops, we've got to go to 500 feet on this." It's most unlikely, but let's say that. You need to go talk to the Dick Vann's of the world and say, "Okay, we've got an excursion to 500 feet in this. How do we do that? Okay, we need new

tables, and by the way, the gear you have won't do it, but they're very much needed." The British are very good at that, getting what they call the "boffins," or the researchers, the scientist engineers, and the physiologists into the operational planning.

What can happen if you don't know what it is that you ultimately want to do? You can build a whole lot of capabilities that remain unused in search of a mission. You build a capability and then you feel there's got to be a mission for it. Well, not necessarily. It can be a huge waste of time and a waste of lives, by the way. For example, in the SDV work, the men doing that were unintentionally put into very severe physiological stress. Some of them have died from hypothermia in missions.

A young man at Keyport went into irreversible hypothermia. The problems of dropping blood pressure from fluid loss and everything in those operations is well known among medical researchers. I don't know if we are ultimately going to solve those things, or if we're going to rely on tough guys.

Some of these guys, like Fletcher and some of the really good SDV guys whom I talked to later, I would ask, "How did you prepare for these things? Would you build up your carbs beforehand?" The guys said "I'd be so busy getting that damn boat ready that I'd have a can of Coke and a Twinkie before I got in it to do the mission. Or I would have a good cup of coffee." They were so brave, adept, absolutely unbothered by all of the darkness and cold and everything underwater, and we were enormously assisted by the kind of work that they were doing.

Ultimately, the Cold War ended. I don't know what kind of missions people are thinking of today for ASDS, perhaps the miniature submarine that is going to attach to a parent submarine. But it seems to me enormously important, again, that the research community knows what's involved in that.

How deep do they intend to lock out from that ASDS? If it's very shallow water work, then you might have problems with embolism, because you're in an environment in which the pressure changes rapidly as you ascend between fifty feet and the surface. You've got to watch what you're doing from that point of view, so you don't have problems with the build-up of gases.

In South Vietnam, we were training people, and they were really quite good. We were training them around Da Nang and in the Da Nang River. They could swim fairly prodigious distances. They were using full-scale Emersons, and they were pretty good at it. But when they actually went to attack, they got caught and inevitably would be looking back on it. What it involved was going from Da Nang, in a swift boat, 150 miles or more to some place like Dong Ha. That was not the smoothest ride in the world.

Then, you got into a rubber boat from that and went in the rivers of Vietnam, which are typically silted and have bars where they meet the sea. You needed to get around that and then launch the swimmers. To do that, we tried to show them on maps and otherwise what they were facing. God knows we didn't realize what the currents were.

We put the divers to the test by taking them up one of the local rivers and doing a full mission profile, a full simulation of it, and they did pretty well. They were actually pretty gutsy guys. When they found out that they couldn't make progress in the water or whatever, they just went ashore and walked along the shoreline to get to it. We didn't know that until after they actually went on the live mission. They were good fellows.

By the way, that's something to watch out with the frogmen, too. Ask them, "Did you succeed in doing the mission?" "Yes." "Now, tell me exactly how you did it." They may have done something that they could get away with at Little Creek or off the Silver Strand, but aren't going to get away with off North Vietnam. That, in effect, was what happened. Those guys got captured. The North Vietnamese held show trials with them. They were put into North Vietnamese jails. I don't know what ultimately

happened to them, whether they are still in jail or whether they've been released.

There were four swimmers for our exercise, using CIA limpets. Probably, the fusing on them was okay, but they were pretty small charges, with perhaps a kilo of explosives in them. It was enough to blow a substantial hole in a patrol craft. Again, the United States was trying to create the appearance of a North Vietnamese resistance force, a North Vietnamese Maquis. It indicated to them that we were in the position to increase the support and recruitment of that. They were going to have just as large a problem with the resistance in the north as we were having with the Viet Cong in the south.

It was utter malarkey. There wasn't a prayer of bringing that off, because they never actually recruited anybody in the north. It was all the attacks from the south that were staged in ways to make it look like it was sabotage by people in the north. This also complicated all the mission planning because it wasn't a straight forward "let's-sock-them." Finally, we got away from that and just shelled them from the sea, which led to the Tonkin Gulf activity and other things that were not good.

The only time when we actually launched was against Noriega's patrol boat down in Panama, and the guys who did it were fine. They were doing their mission, and they did it well. Whether that mission needed to be done is highly dubious. Whether we ought to have been doing it in a way that was going to kill Panamanians was even more dubious. Why? We had been training with those guys days before. The United States Navy had a considerable presence. We had an admiral down there who was training their navy, and it was not stopped. Aspects of it are Pearl Harbor-like, with us on the bad side.

Norm Curley, I think, was the commanding officer of the team. He was one of the best operational guys. He fought operationally and lived operationally, and he had Team Six experience, too, which was highly operationally oriented. That command atmosphere probably affected everybody beneficially, including the guys in the water.

Again, I want to distinguish two things here. I don't imply any criticism. On the contrary, there's only praise for the guys who did the mission. But from the point of view of coming up a few echelons in command, I think it was a dubious mission.

Then Maynard came over while I was in command of UDT Twelve in Subic. That was in 1968. He came over during the time Al Todd and others were doing something with SDVs, the USS *Greyback* and a fast surface boat. They were going to do something in Vietnam, I think. Possibly, they were going all the way out to Korea to do it, but I think it was a Vietnam operation. But it was very tightly held, and I didn't ask Maynard what he was doing, but I know he came over to have a role in that.

Now, let me get to the development of the SDVs. There was a number of Italian or foreign boats, such as the Trass boat, and we had SPUs, or swimmer propulsion units. Swimmers lay on them and steered them more or less by shifting the body. They had very limited range, and there was no protection for the swimmer. It was marginally better than swimming yourself, by relying on your leg power to get you through the water, but not very accurate with regard to navigation.

We had SPUs in the early 1960s. Then we had the Trass boat. Then, we had the Drut, which was built by a bunch of guys in Underwater Demolition Unit One in the diving shop. Guys like Gionatti were involved with it. "Drut" is "turd" spelled backward. They actually built it with salvaged pieces of equipment and stuff, but they gained a fair amount of experience from it. We thought that we needed better SDVs, and that was part of the swimmer support system. As I said, we wrote the OR for that in 1965, shortly after I got to the Pentagon. It included a six-man and then a two-man SDV.

You could call this in-house development, in the sense that there were engineers with blueprints.

All of that was way above the actual level at which these guys did their best. This laid the ground work for the eventual formal plan that was called "Code 3802."

Specific operational requirement SOR 3802, swimmer support system, included navigation, scuba, the mixed-gas scuba, underwater communications, and the SDVs. We started 3802, and it was a fairly long, cumbersome thing of doing research and development with a contract with Aerojet. It had to go through budgetary hoops and everything.

In the meantime, a warrant officer who was part of Underwater Demolition Unit One, said, "We really need to rebuild some Trass boats and we need money to do that." Because the Vietnam War was on, I got him the money. It was no big deal, but I was in Washington and got the money for this, put it through NAVSEA, and the money went to Convair. The Mk-7s were officially rebuilds and rehabilitations of Trass boats.

This was done in 1966 in parallel with the 3802 but much faster. They built the Mk-7s very, very quickly. The 3802 project was looking far beyond that to much longer range: 36 miles, 6 hours, 6 knots. You were going to need to have the advance scuba, the life support system, the heating systems. All of that was part of 3802.

In the meantime, Convair built a boat that was typical of all the boats we've had since. It had a rigid aluminum frame with fiberglass sheeting over it, a hard tank, a soft tank around the midpoint, and fairly rudimentary controls.

There were two boats, the Seahorse and the Trass. In 1965, when I was going back to Washington, I went to see a fellow named Ken and said, "Tell me about these SDVs and stuff." He gave me a ride in the Seahorse. He would put a pinger out way ahead some place, and we would track in on the pinger. That was reasonably accurate. You'd know where you were, so you could put a stream of fingers behind you and steer a course 180 degrees away from them.

Well, that was pretty tricky on the way in, because your signal was weakening as you went away from it. How were you going to fix it? You were going to drop these pingers off on some sort of anchoring system. We really hadn't figured out all of that. But Ken said we had to have something to improve on that; that was obvious. They built the Convair Mk-7s over there at the Convair plant in San Diego. We just built five of them initially. We got those things going, and then they proliferated. Other people came in and said, "We need to have more of these things."

Well, it wasn't worthwhile having very many of the Mk-7s. They weren't quite Kitty Hawks, but they certainly weren't DC-3s. I mean, it was much closer to Kitty Hawk than a DC-3, and much closer to Kitty Hawk than a P-51. We weren't even up to a World War I Spad in the evolution of where we needed to go.

We wanted to get something going and parallel with them. I thought five of those things were plenty. By the way, I also thought that you needed very few automatic mixed-gas systems. When I was in NAVSEA, I was thinking of buying dozens of them. Dan Hendricks came in after me and decided that every swimmer had to have one. He brought hundreds of them. It was an expensive buy, and it overwhelmed the teams. The logistics of maintaining those things was way over their heads. No one was getting sufficient number of hours in the water to be really proficient with them.

What you really had to do was concentrate and do that only. Instead, they were doing all kinds of things. Well, first they had to do PT. They had to do small arms, and then they had to do land combat and all that stuff. People would get into the water with those things once a month, maybe, and that was no way to really understand how the gear worked.

A lot of gear would get knocked as being no good, but people just weren't familiar with it. They weren't given the chance to get comfortable with it. By the way, you would need to bend down full length. A lot of people didn't have the patience and endurance, absence of claustrophobia, and all that, even in a group of SEALs, to handle that stuff.

We knew even when we were doing the Mk-7 that we had already written the requirements for 3802. It had to go through a huge bureaucratic process. That was why Ken said, "Just give me the money to repair these things, these Trasses or Seahorses." He didn't repair them. With that amount of money, they built the first five Mk-7s. The Mk-7s got to be more loved than we had anticipated. Everybody had to have a lot of them, and you know how we navigated with those things—with dead reckoning. You had no idea what the currents were doing. You could do some missions in very familiar waters, like San Diego or Subic. Probably, there were East Coast equivalents where people knew what the bottom gradient looked like and so forth.

Little Al Todd of UDT Twelve had the SDV platoon. Those guys put in a lot of time in Subic Bay, just dead reckoning around and doing occasional stuff with simulated limpets and so on. We didn't have real ones. They did attacks and delivered scout swimmers and the like. It was pretty easy to do that there because, you didn't have to wear a lot of rubber, and when you went ashore, you could go ashore naked.

Later, when we started using the boats off Korea, where you had to have a lot of clothing if you were going to be inserted onto a shore, you had a whole lot of clothing to take with you. It was a real problem, because the clothing had a lot of entrapped air in it, and consequently, it was buoyant.

I remember once when the crew was trying to submerge a Mark 8 SDV. They were unable to do it, because the clothing of the team wouldn't sink. We weren't able to extract the air from it. Had they been able to power dive it down, that would have compressed the air and, all of a sudden, they would have had to compensate for a considerable loss of buoyancy quickly if they were in deep water. Then, when they were coming to the surface to put these guys off, instead of being able to do it in a measured way, this air in the clothing would expand and they would be popped up to the surface faster than they wanted to be. By the way, that sort of stuff needs to be worked out with the new ASDS, or they're going to have guys popping to the surface when they don't want to.

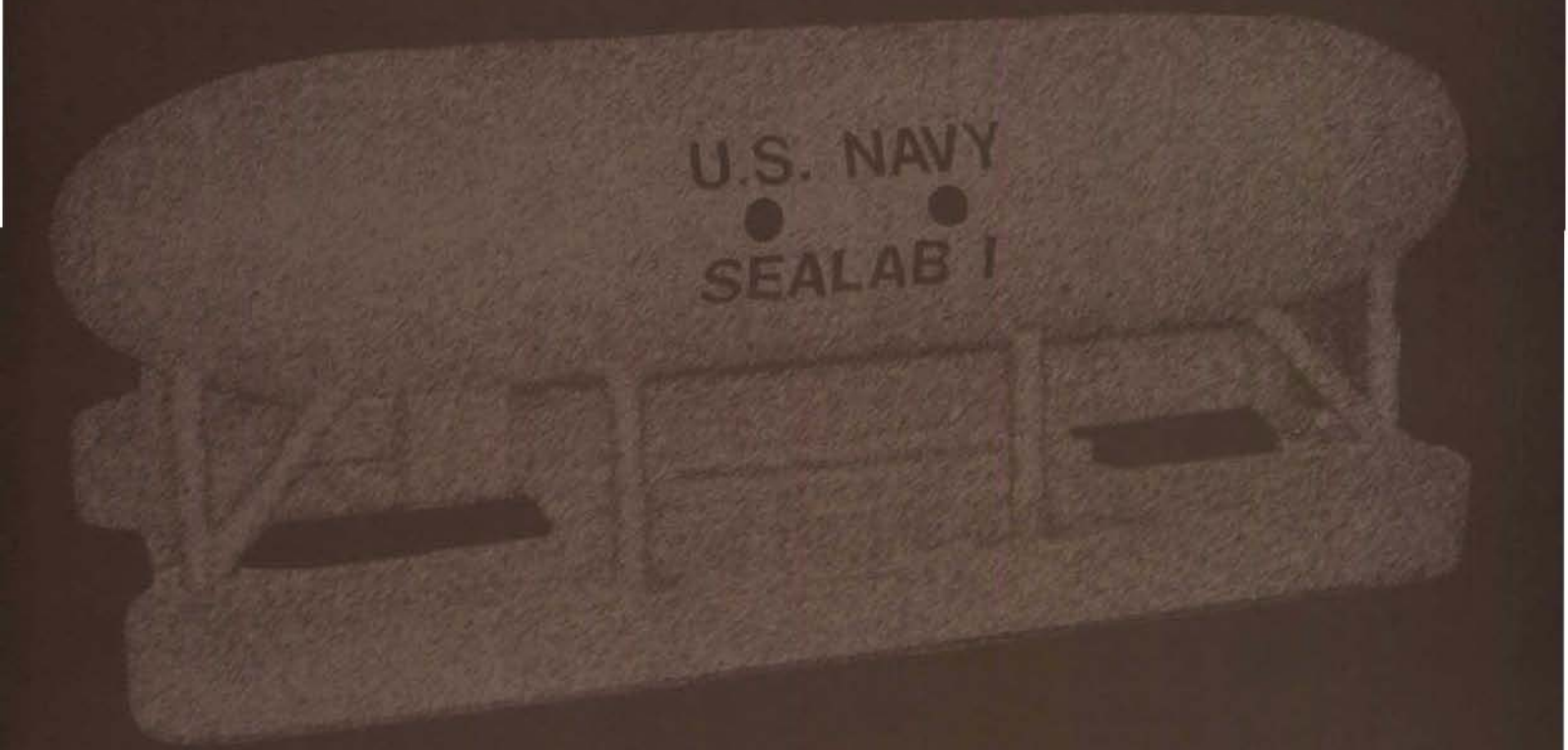
The Mark 8 was a 3802 project. We went initially to Aerojet. Aerojet, instead of using the aluminum frame, wanted to put the strength in the structure. Part of the reason was that we gave them unrealistic weight requirements. The whole idea was that you were going to be using a mixed-gas rig. Anyway, it got way overcomplicated, but it wasn't all Aerojet's problem. Ultimately, because it wasn't going anywhere, I terminated the work with Aerojet. I scooped up the remaining money, and Ken went up to China Lake and built the Mk-8 and 9 as we know them.

We had the first runs of them done in Lake Isabella and a true Skunk Works. I doubt that there were a dozen people working on it. It was probably more like eight or ten whom Ken hand-picked, like Frank Gorlic, Gator Parks, guys like that, guys who really knew how to do things. Some of them were still sailors.

Frank Gorlic was my leading PO in the fourth platoon in UDT Eleven. I could have gone home and just left him to run the platoon. He probably wished I had.

But you're starting to get a lot of capability into it. For one thing, you've got the forward-looking sonar, which, by the way, we had started to use in the Mk-7, by retrofitting an obstacle avoidant sonar. The obstacle avoidant sonar allows you to pick up underwater topography, particularly in San Diego. It shows very clearly the side of the dredged channel. It shows up remarkably well, so you can follow the side of the dredged channel all the way into the carrier pier or down to 32nd Street. I think if you were ever going to do a real operation on it, you'd have to do some probes first and figure out what the underwater landmarks are.

Genesis and SEALAB



SEALAB I

The US Navy conducted SEALAB I off Argus Island, Bermuda, in 1964. Four divers remained at 193 fsw for eleven days in a cylindrical habitat measuring 9 feet by 40 feet. The breathing mix was composed of 79% helium, 4% oxygen, and 17% nitrogen. The eleven-day operation was shorter than the 21 days planned, owing to an approaching tropical storm.

SEALAB II

For SEALAB II in 1965, operations were moved to La Jolla, California, off the campus of the Scripps Institute of Oceanography. Three teams of ten divers each remained at 205 fsw in habitat tours of ten to sixteen days. Former Mercury astronaut Scott Carpenter, a team leader, did two tours. SEALAB II was a cylinder 12 feet by 57 feet, divided into living quarters, lab section, and diving locker. The breathing mix was heliox, with a partial pressure of 4% oxygen.

Three history-making conversations were made. One was via a radio link between Carpenter, on the bottom, and astronaut Gordon Cooper orbiting the earth in Gemini 5. Another was an electronic relay establishing communications between SEALAB II and CONSHELF III in the Mediterranean.

Dr. James Vorosmarti relates an amusing story of a third conversation, between Scott Carpenter and President Lyndon Johnson. Dr. George Bond was arranging the call with a White House telephone operator. Bond explained that the aquanaut was on the bottom in a chamber filled with helium gas, so Carpenter's voice would sound funny. The operator responded that the president wound never speak to anyone in a gas chamber and hung up! Connections were eventually made, but it was apparent that the president could not understand a word that CDR Carpenter was saying in his helium voice.

SEALAB III

The Pacific Ocean off San Clemente Island, in California's Channel Islands, was chosen for the 1969 SEALAB III. The scheduled experiment was for five teams of divers, with eight men in each team, to remain for periods up to 12 days at a depth of 610 fsw, in the refurbished SEALAB II habitat. The experiment was to be an international cooperative operation with a mix of civilian and military divers, including many from SEALAB II.

Many engineering and physiological problems were encountered during SEALAB III. The transition from the depth of 205 fsw to 610 fsw proved challenging. The effects of current, cold, and other exposures proved extraordinarily difficult, both on divers and equipment. The umbilical designed to allow divers to work away from the habitat, supposedly neutrally buoyant, was rendered stiff and impossible to carry in the cold water.

When SEALAB III was lowered to the bottom on 18 February 1969, helium leaks were discovered and water was flooding the habitat. During the dive to determine the extent of the problems and begin repairs, one of the team, Berry Cannon, a civilian engineer and diver from the Navy's Mine Defense Laboratory, died. The presumed cause was carbon dioxide poisoning resulting from a faulty CO_2 scrubber in his diver gear. SEALAB III was halted and no further US Navy saturation diving open sea experiments were ever mounted again.

—Arthur J. Bachrach, PhD


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SEALAB-1





SEALAB was an ambitious US Navy project and the brainchild of Dr. George Bond and Captain Walter Mazzone. These historical "giants" of the Golden Age of diving, accompanied by other key aquanauts, were the forefathers of saturation diving and early innovators in equipment development and undersea medical research. From 1957 to 1963, under the auspices of Dr. Bond (Papa Topside), Genesis mastered early saturation dives utilizing animal subjects and blazed the way for the SEALAB projects (1964-65), the US Navy's Man in the Sea program, and eventually revolutionized the commercial diving industry. The results of Genesis led to manned research in saturation diving with ocean-floor platforms appropriately called SEALAB. There were two highly successful SEALAB projects before US Navy authorities terminated the program during the third project, SEALAB III, following the death of aquanaut Berry Cannon. Two of the more prominent leaders of the SEALAB III project were convinced that the third project had a saboteur within the team who manned the habitat and the support facilities. Why would anyone sabotage this highly visible and newsworthy project? Interestingly, the mission that was to be accomplished during SEALAB III did not stop when the program was terminated, but continued under the wrap of a highly classified and compartmentalized project. Read below what these "giants" of undersea technology had to say in their oral histories. The following are only selected portions of the complete oral histories that may be found on the enclosed CD.

Editor's Note:

The following eyewitness accounts of Genesis as well as SEALAB I, II, III, represent the personal perspective of a group of individuals who were involved either directly or indirectly, in these historic events. As the reader will soon note, the individual recollections often represent very different points of view and are sometimes in total disagreement about what happened, when it happened, and how and why it happened. No effort has been made to make the information agree or be consistant. Rather, the varying points of view clearly demonstrate the many sides of these fascinating stories. It appears that where the individual was working, the time of day he participated, and the role each played impacted significantly on that person's concept of exactly what took place and the cause.

GENESIS (1957–1963)

CAPTAIN WALTER MAZZONE

One day while I was assigned as a contracting officer at the Brooklyn Navy Yard, I met Dr. Harry Alvis. He was a former submarine medical officer and was now working for the State of New York, at the University of New York in Buffalo. He wanted to know what I was doing in New York, and I told him. He said, "You belong in submarines. Take advantage of your background."

Within two weeks, I had orders to go to a submarine base. I went to the submarine base as the officer in charge of the School of Submarine Medicine for Hospital Corpsmen. All the hospital corpsmen going to submarines had to go through the school because it involved independent duty and much more specific knowledge than a corpsman trained at a hospital. In those days, they didn't have doctors on submarines. All they had was a Squadron Medical Officer.

That job then expanded, because the Polaris program came along. They put in submarine medical officers. They wanted a medical officer on every Fleet Ballistic Missile submarine with every crew. They had gold and blue crews.

I helped to set up the curriculum for the School of Nuclear Medicine for doctors. All the doctors assigned to submarines had to go through it. The squadron medical officer was somewhat like a circuit rider, serving several submarines.

The school was at the Submarine Base New London in Groton, CT. In one of the buildings, you had the research lab, another the hospital.

The school ultimately became part of the Naval Submarine Medical Center.

When I first got there, I met Dr. George Bond. I had been there only a few days when I first met him. He was, at the time, a commander and staff member. He was not the officer in charge. I mentioned that I hadn't seen him before and he said that he had been down in Washington. I asked what he was doing down there.

He said he had met with the surgeon general. Actually he said that he was having lunch with the surgeon general, and that he was the lunch. I asked what had happened and he said that he had written an article that was published in the *Hartford Current*, in sort of the "Parade" section. I think they called it "Roto Gravure" or something. The picture on the front showed this diver with a gill-like structure.

He said that he predicted that man would one day live and work in the ocean as a free agent. Bond said, "You know, they're going to do that some day. We'll have a city center down there." I said, "George, you can't do that." He asked, "Why not?" I said, "Buildings under water?" He said, "We'll just build a dome over it." I said, "Well, okay." He said, "That's an engineering problem, not a medical one." He was a very charismatic guy.

I've said this before. Dr. Bond had more original ideas in 15 minutes than most people have in a lifetime. Like a lot of people who are of his ilk, they need others around them to pick up the good things and run with them. Fortunately, for me, that was the position I was able to fill with Dr. Bond and later on with Dr. Workman. They were two really smart idea people, but they needed somebody like me who wanted to hang on and do the work.

Dr. Bond called his early experiment "Genesis." When I asked him why, he said, "Well, I call it 'Genesis' because it said in the Good Book that man would one day acquire dominion over the seas and all the animals therein and, by God, that's what we're going to do. We're going to help Him." That was even reflected in the SEALAB prayer that he wrote, when he said, "And when the divers work and thy will together be done." He was a driving force of the Genesis project.

Some of the other medical officers who were in the Bureau of Medicine and Surgery at that time, in the chain of command, were not keen on it. As a matter of fact, I'd love to find something—an individual who was in the chain of command of providing funding wrote a letter to us. He wrote, "Cease and desist because I see no social significance to be gained from continuing this type of research."

That letter was just a bump in the road, because we kept going even to the point at which Dr. Workman and I often bought guinea pigs and mice food for them to continue the experiments. Finally, we got some money, little by little. But whenever George had an opportunity he took advantage of it.

It just seemed serendipitous that he would be asked to fly on an airplane that Secretary of the Navy Paul Nietzsche was flying on—and they would talk. George told him what he was doing, and the secretary went back and called, I think, the surgeon general at that time, and asked about this project of George's. That changed things a little bit, and the surgeon general went back and asked, "What is he talking about?" He found out that we were doing it. Then, George was called down and we started to get a little laboratory funding to support the effort.

When the project first started, it was not at all sanctioned. To us, it was the right thing to do and we believed it. The unfortunate part for us, at any rate, was that no roads had ever been paved for us. Everything that we did was kind of blazing of a new trail. Even the monitoring equipment for the atmosphere had not yet been developed except very crudely. We still used the old Dwyer apparatus for detecting carbon dioxide, which was good, but not automated. I think the program came a long way with limited funding and limited technology, to support what we wanted to do. I think that we drove the technology, somewhat.

It was 1959 and early 1960 and with all the wrangling that was going on, we finally got permission to do some of the animal work. We were trying to develop an atmosphere in which a human could breathe for long periods of time at high ambient pressures without physiological impairment and could really work so that we could then look at this habitat and deep diving. We needed to find an atmosphere that would do that.

The first experiment we did with the animals was with compressed air. It worked like a charm on the first day. On the second day, at about 35 hours, all the animals were dead. We would bring them up, decompress them to the surface and do an autopsy and try to find out why they died. We thought we saw problems related to those things you see with oxygen toxicity. We said, "Aha, we'll cut the oxygen down." We cut the oxygen down to about thirty percent of the surface equivalent.

We did not control the amount of nitrogen. We essentially had, at depth, 97 percent nitrogen and 3 percent oxygen. We saw pretty much the same thing, except a couple of animals survived for a little longer. We brought them to the surface through decompression, autopsied them, and we saw pulmonary changes with atelectasis and pneumonitis and things that you would associate with oxygen toxicity.

We said, "We need to try something else." Helium had been used in diving. Dr. Al Behnke and some others were using helium as an inert gas. We put them down on helium and oxygen. We stuck with our philosophy of maintaining control over the amount of oxygen because we knew that was going to be a problem if it got too big. I think the first ones that we put down under helium-oxygen maintained a surface equivalent of seventy percent helium and thirty percent oxygen. They survived. All the animals survived and we saw no problems.

For some reason, the male guinea pigs seemed to be overly active, sexually. We thought that maybe helium was an aphrodisiac. We never did see that on compressed air. But we didn't do any more helium work with guinea pigs. We couldn't really confirm it. That was the animal work. Then, with a lot of hassle, we got approval to do human efforts.

With humans, we had to do the same sort of thing. First, we had to prove that helium, at one atmosphere, on the surface, was not harmful. We then did a series of dives. That was all part of the so-called "Project Genesis." The Genesis had two animal phases and one human phase.

The first animal phase was the initial exposures to determine what atmosphere was suitable. Second, we had to work on a decompression schedule. We moved to primates. We used a monkey run and two goat runs and had no problems with the monkey run, as far as physiological changes were concerned. A goat has a lung function very similar to humans, and we found that goats will tell you when they hurt. With decompression studies, the criterion was that you were either bent or not. That goat would pick up his foot, and "say," "I'm hurting here." We'd stop and go back down and get it treated. We did that and we found a good decompression schedule.

One time, we put a couple of goats in there and one was a friend of Bob Barth. This was Gladys, a blonde goat. We started the pressure chamber down and the goat raised its leg. We went back down a little bit, and said, "Let's try something." We ventilated the chamber, which means that we opened up the vent, turned on the air at an equal rate so that we weren't moving the internal pressure at all, and the goat raised her leg, reacting to the noise of the air.

Once that was over and we had a breathing medium, we could put them under pressure, keep them there, and we had a way to decompress them, which we felt reasonably sure would work. We got approval to go to humans.

The last phase of Genesis consisted of three human runs. One was at one atmosphere pressure, which was right at the surface. One atmosphere absolute, was done in Bethesda, MD, because we had to use their chambers so that we could keep out the nitrogen. I think all

those runs were 144 hours, and we saw no problem. The only problem was helium voice with the divers. It's a real bear to understand, because sound travels so much more quickly. I think it's 17 times faster in helium than in air, so the voice is very distorted. The divers were kind of cold because heat is dissipated at a faster rate from the body. Other than some practical jokes that were played by the divers on the inside, the runs were sort of uneventful.

The first runs were in Bethesda, because the arrangement in Bethesda had two chambers tied together that tied into an igloo, or wet pot. We flooded everything and then forced the water out with the helium environment. When the divers were ready to go in, they went into one of the locks. They were breathing helium and oxygen. We pressurized with helium. We were reasonably certain that we had the nitrogen down to less than one percent.

At this time the funding was coming from ONR. Special Projects was probably providing some funding, and there was some coming from the Bureau of Medicine and Surgery.

In 1959 I went to diving school, the US Navy deep-sea diving school. As it was, I became a helium officer and a diving officer and then had scuba training. To get a little more training in physiology, the Navy, for my good fortune, sent me up to Harvard University for a year to get my Master's Degree in some area of pulmonary physiology.

When I got to go to school at Harvard, the detailer said, "You're going to come right back to the sub base." It was kind of like a favor they were doing, to send me to school. I didn't move to Boston and I came home every weekend and worked with Dr. Bond. We did what we could, as far as getting ready for all these things.

The human phase was well established by then. We had accomplished one atmosphere. We did the hundred-foot dive at the Navy Experimental Diving Unit in Washington, D.C., at the US Navy Yard.

At that time, we were having a chamber built in New London. It was a big chamber that could do depth pressure work, as well as atmospheric space work. We had a big valve that could do these explosive decompression studies in a matter of milliseconds. At any rate, we got that chamber ready to go, and we did the last of the human efforts there.

One of the things that I saw at Harvard was the box of books and notes that had been left there from 1935 or 1936. The notes belonged to Dr. Louis Shaw. He was a hyperbaric man. He had postulated that if you could control the rate of ascent from any given depth, you should be able to intercept all the stages of a stage-decompression so that you could travel continuously, rather than coming up, stopping for five hours, and then ascending more.

Dr. Bond and I talked about it. He wasn't too keen on it because he already had the people in the chamber at 200 feet, and he said, "Talk to Dr. Workman." We talked to Dr. Workman, who remarked, "Well, it sounds like it might work." Dr. Workman gave me a decompression schedule for some heavy dogs. I got in a car, drove from New London to Washington, D.C. and went over to the Naval Medical Research Institute (NMRI) and said, "I want to borrow one of your chambers. I want to do this." They said, "Well, you can't. You need a protocol." We argued, but at any rate, by that late afternoon, I had three large dogs down to seven atmospheres.

We did it right there at NMRI and we did it without going to a motel for a night of rest after the drive. We saturated the dogs. The saturation for the dogs was done in a shorter period of time. We brought them up on a continuous decompression. It worked fine. I got in the car, drove all the way back to New London and said, "Bond, it works." He said, "But we've got to make some changes."

One of the things we had to do was take one of the relief valves of the chamber and hook up a regular valve so that it could be controlled with an "on/off" switch. We could sit there with a gauge and gradually decompress on the surface.

It was the first time a continuous rate of ascent had ever been done by a human.

We saturated dogs in New London, too. There were a lot of dives we did that were not recorded, because the programs were thrown together and we went ahead and tried various theories.

Interesting aside, in between SEALAB II and SEALAB III, we had a call from a doctor in the New London area who had a dairyman who had tetanus and wanted to know what we thought of treating him with hyperbarics. At that time, the work that Boerema had been doing, over in the Netherlands was being discussed, and we thought, "Let's try it." Dr. Bond had him come up. We brought him in, put him in the chamber, and in taking his history, we found out that his tetanus came from the fact that he had had an injury, an abrasion, to which he had applied a cow manure or horse manure poultice.

Well, it was good as poultice because it generated heat but, unfortunately, it was contaminated with tetanus. We treated him with hyperbaric oxygen and also with curare to block the effects of the tetanus itself, and he survived. I don't know what the history is on survival of tetanus, but he walked out.

Another interesting event was when a diver came to us from the Bahamas. When we were first notified, he already had been bent and treated for about three days somewhere in the Bahamas. We didn't get him for another two days or so, because he essentially had to hitch-hike by plane, and whatever, up to New London. They brought him in an ambulance, and he was paralyzed from the waist down. The medical officer started debating as to what the rationale was to be for treating a five-day-old case. Bond said, "Put him in." We put him in the chamber and took him down. He had a little relief at 165 feet. We gave him what they called a "Table IV Treatment," and he walked out of the chamber on his own. He had a limp, but he walked out. That taught me a lesson. Never refuse a treatment unless it's dead on arrival.

WARRANT OFFICER BOB BARTH

I found the work at the submarine escape training tank interesting for several reasons. First, you were looking at a column of water that was 120 feet deep. It was 92 degrees and as clear as any swimming pool. You were doing training with submarine school candidates or submariners who were back for re-qualification. It was just breath-holding. Most of it was breath-holding, and I thought it was just swimming around the pool, diving down, holding your breath to forty, fifty, sixty, or 120 feet.

They stressed repetition. You saw other people doing it, so you knew that it was possible, and you wanted to do what they were doing. You were somewhat fascinated by a guy who could take a breath of air, kick off, and swim down to the bottom of the training tank. He might have taken his shoes off before he left and thrown them in the water and watched those shoes go down to the bottom. Then, as they hit the bottom, he took a breath of air and dove down and picked up his shoes very carefully and not in a big hurry. Then, he put his shoes back on and tied them and he made sure that they were just right. They'd do that as a demonstration. They'd come back up a couple of minutes later. I said, "Man, I want to do something like that."

Your lung capacity had to be improved. You had to be able to pull in a lot more air than usual. You had to be able to blow out a lot more air. Your residual capacity and total capacity grew. You practice holding your breath for, say, six hours a day, taking breaths, holding them, and taking breaths and holding them. If you lifted weights for six hours a day, you can imagine how muscle-bound you'd be. Your lungs developed that kind of ability. Then, you knew that when your lungs were hollering for you to take a breath, you didn't need to. You could hold it a little bit longer. Those things you wanted to learn.

While I was there, I met Dr. George Bond, who has been dead now for some years, a Navy doctor. He was an old country doctor from around Bat Cave, NC, who came into the Navy after years of practice there. Dr. Bond worked at

the Submarine Medical Center at the submarine school. The role of the doctors at the medical center was to assist us. We had to have a doctor on the scene. Dr. Bond was one of these doctors. Dr. Charlie Aquadro was there, along with some others, and they all worked the Submarine Medical Center.

I met Dr. Bond a few years before, when he and a fellow, a chief engineman by the name of Cyril Tuckfield, were working together. That was during the development of the buoyant ascent jacket. It's different now, but the way you got out of a submarine in the old days was to put a jacket on. You inflated it, got out of the submarine and went to the surface, exhaling all the way. It was called "buoyant ascent."

Dr. Bond and Cyril Tuckfield did a buoyant ascent off the USS *Archerfish* in 1958, I think. I went to swim school with one of the guys involved with that. I had met Dr. Bond then, and when I went to the tank, of course, I met him again.

Dr. Bond had been embarked on a program called "Genesis." Genesis was an idea that he and Jacques Cousteau formulated in 1957. They were at a Boston Sea Rovers Conference and put together everything they had. He met Cousteau, and they became good friends. Cousteau had his Conshelf program habitat in the Mediterranean, back in the early sixties. Cousteau did not know a lot of things about the physiology involved in "saturation diving," as we call it today. We had the knowledge that we could dive with helium. We had been diving with helium for years, but just on a dive basis in which you go and come up some time later and decompress.

Bond was prompted and motivated by Cousteau's questions. They agreed that they would exchange information. Bond went back to the Naval Submarine Medical Research Laboratory (NSMRL) and embarked on his studies to see if we could do saturation diving with people. He started with animals but eventually got to people. From 1957 to the early part of 1962, we used nothing but animals. I was there and helped just because I was interested.

Bond was a unique guy. He always had ideas, and there wasn't a guy who worked with him who didn't feel that any idea he had was worth getting into. I got involved with him but not up on the hill, at NSMRL. We had an old chamber down at the training tank, which was on the waterfront in New London. He brought a bunch of goats down. We could get goats easily to use as subjects for research, because we kept them on the other end of the base where we had a storage area for explosives. It was grassy and we kept goats there to keep the grass down. The respiratory system of a goat, I am told, is somewhat similar to the respiratory system of a human, or at least close enough to conduct studies on them so that you got some useful data relevant to human beings. We saturated goats.

By that time, it had been about five years since they had started. All the data that they collected, all the way up from guinea pigs, mice, or whatever they used in the lab, had proven that it looked like a viable thing to put people under pressure, breathing helium for long periods of time. That was what saturation was all about. They thought it would work.

I worked with him on the goats for a while. He got permission from the Navy after showing the Navy all the data. He said, "Look, I've got five years of this stuff, and it looks good." He had to convince everybody that it worked.

I was still at the training tank. I could have just been released from the tank to go Temporary Additional Duty (TAD) somewhere. Two other doctors and I went down to the Naval Medical Research Institute and were put in the chamber.

The chamber was one in which helium and oxygen could be used. Dr. Bond didn't want to have to be burdened for days on end with decompression if we had a problem with people breathing helium and oxygen. If we had a problem, we could open the door and walk out. You couldn't do that with diving. You had to go through decompression.

We did the first dive in November of 1962 in Bethesda. There were three of us in a chamber. We stayed there a week. We breathed helium and oxygen. It worked fine. Bond showed the powers that be the data, and got permission to go to the next phase, which was "Genesis."

We went to the Navy Experimental Diving Unit (NEDU) which, at that time, was at the gun factory in Washington D.C., where the diving school was. I and two hospital corpsmen did a one hundred foot dive. There was water in the chambers at the NEDU. It had a small chamber below it into which we could put water. But that wasn't our purpose. They were physiological studies to find out if you or I could live in a helium atmosphere under pressure. We did it for a couple of weeks.

At this point in time, we didn't have a goal, necessarily. We were taking each step one at a time. You didn't go to the Navy and get approval to get all the way to the end of where you wanted to go. You got approval to go one step at a time, and that was what we did.

We were trying to convince ourselves and the powers that be that we, in fact, could put people in a chamber, take them to depths, and leave them there. That eventually led to saturation diving, as we know it today.

Why do we have saturation? We can take people today and put them in an environment, a saturation system. We can put them in a bell or in a habitat, like SEALAB, at the bottom of the sea, where they can stay. We know that. We proved in the chamber runs that you can breathe helium for long periods of time. Breathing helium at the bottom of the ocean is no different.

Before we had saturation we were limited to the 300- to 400-foot range. Granted, there were times when we, at the NEDU for example, would go down to 400- and 500-foot range, but we didn't do much saturation. We made an excursion run and ran down to some particular depth. Let's say it was the 400-foot range, for a nice round number.

At the 400-foot dive, it required a 350-foot stop, as I recall, for an hour. It required several hours of decompression. How long could we have kept that up, and how much useful time could we have gotten on the bottom? Now, I can turn right around and put a man in a saturated mode out of a bell or out of a "SEALAB," put it on the bottom, and leave him there for a three months at depths in excess of 2,000 feet. That's our capability today. We increased our depth capabilities to around the 2200- or 2300-foot range and are able to stay there, whereas before we could never get to 2000 feet. Earlier, the only guys who ever went to 2000 feet stayed there—we never saw them again.

Genesis was designed to do the physiological studies. We did the first and second ones at the NEDU and a final one at the Naval Submarine Medical Research Laboratory at the Navy Submarine Base New London. Bond was at the NSMRL.

We did what was scheduled with a three-week, 200-foot dive. One of the guys from the second Genesis, a doctor, a hospital corpsman, and I did it. When that was over, we had shown the Navy we could, in fact, put men under pressure and leave them there. We went into the SEALAB mode after that.

Dr. Bond was a big guy. He was friendly. He had the kind of face and personality to which you just took. There wasn't a guy who didn't love him. If he said, "Let's go to the moon," they would have been fighting to get in line to go with him. He would do anything that you asked him, or he would ask you to do something that he could do himself. Generally, you had to fight him for the chance to do it, because he'd be in the water doing something.

We were at the training tank together. It was him, some other guys, and me. We would come in the evening, and the submarine officer's class would bring their wives down. We would show them all these neat tricks. I would cover for Bond on the tricks he'd do. There would always be somebody in the water who would help the other guy.

Once, Bond did a very fast free ascent. In a free ascent, you used the volume of air in your lungs as a buoyancy factor and exhaled as you came up. You kept safe by exhaling so that you didn't embolize, but you kept enough air in your lungs to keep that upward momentum. Bond did that.

We used to take a bucket down with us, and down below we had a little blister stuck on the side of the tank, at the 85-foot level or 100-foot level. We would empty the water out of the bucket and put the bucket over our heads and use it as a buoyancy factor.

We'd also take a pair of Levi jeans, or whatever, and put them over our swim trunks. We'd swim down to the 100-foot level and take our jeans off and tie them in a knot, like they taught you, to hold you afloat. We'd put our heads up inside the pants, which were full of air, and do a free ascent. We just did foolish junk like that. We also made bottom drops, going down to the bottom and so forth.

Things like that were fun for me, maybe because I was a water baby. I just liked the water. Gosh, you wouldn't be an instructor in the training tank unless you really liked the water. You had no business being in there if you didn't like the water. People who are scared of airplanes don't become pilots.

During the Genesis experiments, we had programs and projects that we did to answer the questions that Dr. Bond had about what you could and couldn't do. We'd work hard and get the heart rate up, for example, and see what it was. Everything that we did, although I don't have the medical term, was normal.

SEALAB I — 1964

WARRANT OFFICER BOB BARTH

It wasn't until the first SEALAB began that I was officially attached to a project and working it full time. We'd get Temporary Additional Duty (TAD) from the tank. We were TAD, but my tour was at the training tank, and I knew I was destined to get into the SEALAB program. But the program was just somebody's idea that was tolerated by a few in the naval hierarchy. Few people knew about it. I went back to a submarine in Key West, but Bond kept pulling me off to go TAD where we were building SEALAB I in Panama City. That annoyed the heck out of my commanding and executive officers on the submarine because I was a chief quartermaster at that time. They would say, "We've got a chief quartermaster, and he never rides in the boat."

We did SEALAB I during July 20 to July 31, 1964. Everyone who was in the SEALAB I program was TAD from our respective commands. It wasn't until January of 1965, prior to SEALAB II, that we were pulled in as a permanent entity. We stayed that way until the end of the program.

By the time of SEALAB I, I had three saturation dives in chambers to my credit. It was really physiological information data, not credit. They had a lot on me, so I was selected to be one of the four guys who were going to be in SEALAB I. One of the others was a guy who had done two of the Genesis programs with me. He was "Tiger" Manning, or Saunders Manning. He was chief and then senior chief hospital corpsman. When we both got out of the Navy, he and I worked together at Taylor Diving and Salvage in Belle Chase, LA, some years later. Tiger, two other guys, and I were on SEALAB I. We built it, tested it, took it to Bermuda, put it on the bottom in 193 feet of water, and lived in it for eleven days. It was scheduled to be longer than that, but it was during the summer (hurricane season).

Pulling up a picture of SEALAB I in my mind, I see a round tube, similar to one you might find if you lived in an Airstream trailer and were camping. I don't even remember the length of the doggoned thing now. It was big and comfortable, for four guys. The bottom of the ocean has water as clear as the water in a swimming pool. The water temperature is in the

80's. We have four portholes, two on each side, and the entranceway is through the bottom. You don't have doors, you have to go in and out from the bottom hatch.

It's the equivalent of taking a glass, an empty glass, and holding it upside down and trapping the air. That's what a habitat does. We lived in it and were free to come and go as we wanted. We could turn the lights out in it and read a book from the light coming through the portholes. The water was so clear, light was coming through the water from 200 feet up, or thereabouts. We had good times. Probably the best project, out of everything I did, was SEALAB I.

We weren't fully recognized as a group by the Navy. They thought we were a bunch of blockheads who were eventually going to do something incorrectly and kill ourselves. They didn't want to be any part of that. They were always hiding behind trees until we were successful enough. Then, they came out like termites. But they left us alone, and we did just about whatever Dr. Bond wanted us to do. We drew blood. We put other body fluids in bottles and sent them up to him. We did all the tasks and were then allowed to go outside and play.

The hatch was constantly open. We had a hole in the floor. Actually, it wasn't just a hole in the floor it had a tube that came up. We had a lot of rise and fall in terms of the water level, so that tube went outside and extended below the habitat itself, which was a cylinder. It came up about three feet or so. It had a ladder going up and down. The hole was just about three feet square or maybe a little more. When you were ready to go outside, you could look into it. It was a hole full of water. We'd just put on our gear and go outside.

When we finally got to the bottom during SEALAB I, we could get in the water and go outside. We still had work that we did. We had the physiological stuff, at least, proven. You had to go through it, many years afterward, to get it all ironed out and refined and make sure that you got everything done that you needed to. We had a lot of time to just go outside and go scouting around. They gave us other things to do.

The habitat was no different than going camping in a motor home or trailer or whatever. It was just a haven, really. It trapped the air that was in it. We scrubbed the carbon dioxide (CO_2) out of the air. We added oxygen, as it was needed. It was a helium-oxygen mixture. We would add oxygen when we needed it and scrubbed CO_2 when we needed to do that. It was warm outside and very comfortable. We couldn't cook in it, though. We ate out of cans. We had a refrigerator, but it broke. We kept our shoes in it, actually, but never used it. We just ate out of cans. It was great. I'd do it again today, if we could.

Communication was always a problem in a helium environment, particularly with some words. The deeper you get, you know, the more pronounced that helium distortion becomes. Two hundred feet is not bad. We didn't get into lengthy conversations about Einstein's theory of relativity or anything. We avoided some of the stuff. We found some words that we just didn't use at all. Swear words were always very intelligible. We could understand them anytime, so we swore a lot.

We raised all kinds of stink about being brought to the surface, even in the face of a hurricane. We had one guy topside who was a little scared of everything that went on. We kept saying, "Send him home." But they were right. It was very rough and our decompression was based on bringing the habitat up very slowly and staying in it. It got so rough that we couldn't stay in the habitat. When you're going up and down a dozen feet, you can't maintain proper decompression.

Decompression from saturation diving is one day for every one hundred feet, so we had two days of decompression. We had a hard time maintaining the constant ascent and keeping it exactly like it should have been. We had a small chamber that hung outside. It was just a single lock recompression chamber. We didn't have bells in those days. We didn't have anything around for doing that, so we took a one-lock

recompression chamber with the door at one end. We hung it and built a framework on it with weight. We had that hanging outside, full of air, all the time, as a safety precaution. If something happened inside and we were in a contaminated atmosphere, we could go up inside it.

We went over there and the four of us got into the thing and shut the hatch. They brought it up on deck, maintaining the last 85 or 90 feet that we had to go and hooked air up to it. We went off helium and onto air and decompressed. They picked the thing up from the level that we got in. I think it was about ninety feet; I'm not sure. We were on a four-legged structure called Argos Island. They called them "jackets" in the industry. It was a Navy listening station. They put us on deck, laid us on our sides, and we decompressed inside of that for the next day.

Argos Island was 194 feet deep and had four legs sitting on the bottom. We went out and did work on the legs. We inspected them. We looked at the wells. We did this and that. Not all of the tasks really required us, but we were a great help in completing them. They gave us different tasks to do. We had a lot of cables that came off Argos Island and went over the side of the bank and listened to things underwater. We'd inspect the cables. We were told to scout a certain area. We could organize a sortie from the habitat to 200 yards in that direction. Pick up a rock. Move it ten feet. Put it down and go on back, or something like that. We just did anything that needed to be done. We could go out and do whatever we wanted to do. We would swim around in a radius of about two hundred yards away.

Dr. Bond had a staff of people to think up things to do. He had his "shrinks," as I like to call them—the people who still had physiological questions that they wanted to answer. We were constantly drawing blood. We never did stop drawing blood. You learn a lot from blood, evidently. We learned what it was like to give a couple of gallons of blood over a period of time. There was always something. Bond had a lot of medical people there.

The psychological aspect of it was something that they looked into, the effects of isolation. The National Aeronautics and Space Administration (NASA) was so interested in the isolation idea that they later put Scott Carpenter down to work with us. Scott would have been on SEALAB I, but he broke his arm and some other things in an accident in Bermuda and didn't get to go. He was on SEALAB II.

Every day we had something assigned to us, but we had a lot of leisure time, too, and we'd go outside and hold our breath. The three of us were training tank instructors, capable of diving to pretty good depths, like 120 or 130 feet of water. We were pretty good. Bond was interested in that, you know. Hyperventilation. How long could we go outside and hold our breath? He'd keep a record of it. He did that during Genesis, SEALAB II, and in the preparation of SEALAB III.

One person on SEALAB I was a doctor by the name of Bob Thompson. He was a submarine medical officer who didn't have a great deal of experience in diving. He'd been trained as a diver, was available at the time and had good credentials, so he was a bottom subject. The other guy was Lester Anderson, who was a staff member at the NEDU when we did one of the Genesis runs. He was a good fellow, good friend and good worker and was interested in what he had to do. Bond pulled him in to do SEALAB I. Not one of the people was a stranger to the sea.

There were also a lot of guys off in the shadows. All we did was sit in chambers, and those guys were constantly standing watch topside, 24 hours a day—including the guys for whom we gave blood, and those for whom we looked at the Rorschach ink blots. The NSMRL had a lot of doctors there. Every one of them had something that he wanted to try to do. There were a lot of people—a lot of guys working a whole lot harder than we were.

SEALAB I was very successful. In everything we did, we proved what we could do. Believe me, there were a lot of skeptics during the very beginning that didn't think we would. We never

hurt anybody. We were capable of doing just about anything we wanted to do. It was quite successful.

The most skeptical of what we were doing were people from the Navy, in a general sense. When you have something new and different like that, not everybody in the Navy is going to jump up and wish you a "fare-thee-well" and shake your hand and say, "Good luck." They're going to say, "Hey, you shouldn't be doing that." I had a lot of that from friends I knew. They would say, "You don't want to get involved in anything."

When you work at something long enough, you understand what it is you're doing, and the fear doesn't even enter into the picture. But there are always people out there that you have to convince. They don't want to jeopardize their Navy careers by killing a guy or two, or whatever the case may be. That was always a factor. You have to convince them. That was why it took so long to convince them that we could go from laboratory animals to goats, from goats to people, and then put people in the water. We had to convince them to let us put people in the chamber at a hundred feet. We had to convince them to put people in the chamber at 200 feet and then in the water in a habitat. It took some doing.

When SEALAB I was over, I went back to being a quartermaster. The captain said, "Where the heck have you been?" I told him, but he didn't understand it. He wasn't interested in it. He was only concerned about the fact that his chief quartermaster wasn't riding the submarine. Where in the heck was the quartermaster? Then, an article came out. The *Saturday Evening Post* did a nice story on us. It had a lot of pictures and on the cover page was the SEALAB. After that, he relented.

My submarine was in a shipyard in Philadelphia. I went there and finished up my time. Then, in 1965, I got a set of orders to go to Panama City permanently, and that was the end of my submarine riding days. I did about ten years, I guess. Everyone who had been on the SEALAB program, including those of us who had been in Genesis, were brought to Panama City as part of the Man in the Sea Program.

By that time, it had been proven that we could put men under pressure, breathing helium at depths. We had actually had four of them at 200 feet on SEALAB I, so Dr. Bond had drive. He would answer all the questions and go from first base to second base and prove it to everybody on second base that he could go to third base and then go on home. He had a program to get it done and he brought us all in from where we were.

We all went to Panama City. Some of them went to the NEDU at the gun factory in Washington and continued doing some other work, such as tests and so on. The rest of us went to Panama City, and we brought in something like 20 or 24 more guys and trained them for different aspects of what we were planning to do on SEALAB II, which started in August of 1965.

The Navy base at Panama City was a small little base. It's still there today. That's where I worked. That's where the NEDU is. That's where the Navy Diving School is. It's a laboratory, really. It has a lot of scientists and guys who think they're scientists. But they're involved with a lot of things that take place under water. The diving community is well represented in Panama City, but it was smaller thirty-five years ago. The base is constantly growing, but it's a neat little base. There are some good people there. Of course, it's right on the bay. It's a good place to dive and probably the only base that has that much activity involved in the ocean. They wanted the SEALAB program there. They built SEALAB I there.

I was in the area because I was visiting my folks. That was in December of 1963, before SEALAB I. My parents lived in a town not too far from there. I was home visiting with them, and Dr. Bond asked me to come to Panama City. The people in the diving business at the base said, "Hey, we think we can help you with this project."

They had, in their scrap yard, a couple of those great big, old, long, steel HY80 tubes that

were roughly ten feet in diameter and about thirty-some-odd feet long. They brought us down there, showed them to us and asked, "Do you think we could make a house out of these?" None of us were underwater habitat experts, so we thought, "You know, why not?"

MR. BILL CULPEPPER

In 1963, I was in the Mechanical/ Hydrodynamics Branch of the Engineering Division at the Navy Mine Countermeasures Station (NMCS) at Panama City, FL. My branch head, Ray Kelly, was assigned to a study group for a six-month period, and I was acting branch head while he was away. At the end of that period, in January of 1964, shortly after I was relieved from that assignment, I was asked if I would like to design a SEALAB. I asked, "What's that?"

At that point, I had never been involved in diving, other than snorkeling and spear fishing, but not having another project to do, I said sure. I was introduced to Captain George Bond and a few of the other people, and we started having meetings in January. In February, we got funding and started to design SEALAB I. At that point, I think we had $35,000 in the budget. Bob Porter did the electrical and electronics designs, and I did the mechanical life support and structural designs. We did most of our own drawings, and we'd take them to the shops and have the hardware built.

The direction I was given was to design this craft, undersea house, or habitat, as Captain Bond titled it, to house four aquanauts who were to live on the bottom, at a depth of 200 feet, at ambient pressure for a period of two weeks. That was pretty much it. Tom Odum had sold the project based on the fact that we had these minesweeping floats, which were suitable for building the hull, out in the salvage area. They were 9 feet in diameter and 57 feet long. They each had a cylindrical body section, a conical tail, and an ellipsoidal nose section. Hull thickness was half an inch over the upper half and three-quarters of an inch in the lower half. They had been designed to resist the forces of mine explosions. They were adequate to meet the 15 pounds-per-square-inch design requirement. We were able to cut the tail section off of one and take the nose section off of another and put those together. That made the hull. It was 40 feet long and 9 feet in diameter.

We were pretty much dependent on Captain Bond to keep us on the safe side, as far as what materials that we could use. For example, we didn't want to use any plywood because the glues might outgas toxic or noxious fumes. We couldn't use anything containing solvents of that nature, certainly no hydrocarbons. It was a very challenging and interesting project, to say the least.

It took us three months to design and build the habitat. We delivered it the end of the first week in June. That included outfitting the surface support vessel, also. On Armed Forces Day, May 16, we had SEALAB I on display for the visitors. It was structurally complete at that point; we were still outfitting the internals.

Much of the equipment that went into SEALAB I was purchased with a Sears credit card. We had a two-burner hotplate. We had a thermo-electric refrigerator that, as it turned out, didn't work because we didn't take into account that the temperature controller was pressure sensitive. It stayed off. It served as a storage compartment, I understand. For heaters, we had Nutone electric bathroom ceiling heaters. The dehumidifier came from Sears. The water hose was a thing of its own. Commander Roy Lanphier, who was the project officer, selected the garden hose. He would go to Sears, buy a hose, bring it out to the Navy base, fill it with water and let it lay on the pier for a day. Then, he'd go out and sample it to see how it tasted. It took him three or four hoses before he got one that didn't affect the taste of the water.

Everything was surface-supplied, including water, air, helium, electrical, communications, electronic sensor data, and so on. Make-up oxygen was stored below the hull in three 1300 cubic-foot bottles. Emergency helium was stored in

one 1300 cubic-foot bottle. The only real background we had for a design reference was a *National Geographic* article written by Jacques Cousteau about his thirty-foot saturation dive. One of the big problems that Cousteau had was with helium leakage through hull penetrations.

Since we didn't have a lot of time or a lot of money, we totally had to take a shotgun approach with most things. One of the things that we came up with was to use an umbilical tube that penetrated through the bottom of the hull and extended well below the entrance hatch. We brought all of the surface supply hoses and cables through that tube, like the electrical, air, water, gas, and electronics hoses, the whole nine yards.

We also set aside the after-nose section, the nose cone section that we welded to the SEALAB hull as an air space. It was separated from the living area by a watertight bulkhead. We had the electrical transformers in there, along with several other things, such as circuit breakers and other electrical components that might have caused problems.

The air space had a hatch that was adjacent to the entrance hatch, and it was to serve as an escape chamber in the event that the habitat became contaminated. The aquanauts could exit the living space and climb back up in the air space temporarily, until they could get to the surface transfer capsule down there and be brought up. The umbilical tube worked great, and we had no problem with leakage or loss of helium.

We circulated the helium atmosphere, made up oxygen, and had carbon dioxide scrubbers. We had two submarine auxiliary CO_2 scrubber units utilizing lithium hydroxide.

We also mixed the breathing gas for the Mark 6 semi-closed circuit scuba. We had high pressure air but nothing to pump oxygen. We couldn't afford a $6,000 pump. Roy Lanphier said, "Well, let's build a pump, a water ram." I said, "How do you do that?" He explained the principle to me, and I started looking for tanks. I could not find stainless steel tanks, so I ended up using carbon steel tanks.

We had three vertical tanks that were connected from the bottom of the air side tank to the bottom of the center tank, and from the top of the center tank to the bottom of the oxygen tank. Tanks one and two at the air inlet side were filled halfway, with water, and oxygen or HeO_2 was cascaded into the third, or output, tank. Then all of the water was forced into tank one, with the gas to be compressed filling tanks two and three. The output side was then valved to the flask to be filled, and high pressure air was valved into the first tank until all the water was forced into the center tank. The process was repeated as necessary to provide the amount of gas and pressure desired. We were able to find 3,000 pounds-per-square-inch sight gauges so that we could determine where the water levels were. But I was quite concerned about the possibility of rust and fire, especially when jamming oxygen.

As it turned out, Roy Lanphier operated that ram. Nobody else touched it, and it did the job without incident. We were able to get that all together and build it. We even built air filters with the air piped into the bottom at a peripheral inlet so that the air spun as it went into the filter. In the upper section, we installed cotton and charcoal.

We had to build everything, and I didn't have any experience with oxygen cleaning. We ordered some Jamesbury ball valves, and I ordered them oxygen cleaned. Then, when we were pressure testing some of the life support systems, Lance LaBrache, who had done the high pressure piping for me and was involved in the testing, came in and said, "We have a problem." I said, "What do you mean?" He showed me some black material that had blown out of one of the lines, and as it turned out, the ball valves had graphite in them. We had to pull that entire system down, clean it again, and start all over.

A major stumbling block occurred one Friday morning. I came into work and one of the leading men in the shop, Bill Hodges, called me and said, "Bill, you need to come down here.

We've got a problem." I said, "What is wrong now?" He said, "Well, we've got a cracked weld."

I went down to check it out. The legs were attached to the SEALAB hull with doubler plates to better distribute the load on the hull. These plates were cut from scrap hull material and were two feet square and three-quarters of an inch thick. The plates were attached to the hull by continuous, three-quarter inch fillet welds on all four sides and had been in place for several weeks. One of those welds had opened up with a ten-inch crack.

The drawings for the floats had called for high tensile hull plate for the material. Therefore, we had selected the 125 low hydrogen rods that were specified for that material. We took a sample of the metal and sent it over to the Pensacola Naval Air Station to be analyzed. They reported that it was similar to HY80, with which we had no experience.

I called over to the Biloxi Shipyard, and we were able to get a Navy commander to come over and look at our problem. He was knowledgeable of HY80 welding. He came over, and after looking at our problem he said, "Well, the only thing you can do is go up to Charleston and get a couple of HY80-qualified welders and bring them down here to finish this job."

At the time, I had already called in an x-ray crew and they were x-raying all the welds. We got the x-rays while the commander was there, and we looked at them. Only about ten percent of the welds were defective, and that was out of over 600 feet of welds. He said, "Well, you've got some good welders. I'm amazed that the welds are this good."

I told him, "Well, we had a problem to start with. They were tacking the plates onto the hull, a tack each corner. By the time they'd get to the last corner, the first corner was cracked. I told the welders to put on temporary clamps and run a bead all the way down the first side, immediately chipping the bead and running the next pass. I told them to keep it going and keep it hot. That was what seemed to work.

As it turned out, the commander gave us procedures for HY80 welding. We only had three welders in the welding shop at the time. One of the requirements was that if welding was interrupted, that weld and the heat-affected area must be thoroughly ground back to base metal, plus all sorts of re-prepping before you could start over again.

The last weld we had was the nose section to the hull, which was nine feet in diameter, requiring a 27-foot long, 21 pass weld, and we needed to preheat to 150 degrees Fahrenheit. Time was running out, so we decided to weld continuously, day and night, until we finished. I had our three welders make the required sample welds using the HY80 procedures. All three passed with no problems. All defective welds were repaired and passed inspection.

The only place we had to build this thing was out on the pier. We didn't have a house big enough to put it in, so they rigged up a makeshift heater, which consisted of a welding machine hooked to a steel band wrapped around the hull. Then, we paired two welders together and one welder with a helper. While one guy welded, the other one used a gas torch to preheat ahead. He used a temple stick to determine the temperature. They welded for 72 hours, 12 hours on, 12 hours off, to complete it. The weld was x-rayed and passed inspection.

They took the habitat out on Friday, May 22. We anticipated that they were going to have some problems in handling, because they really were not set up for it. They had the YFNB 12, which was a barge. They had winches on the fantail with wire rope. They had a big fair lead, a roller fair lead, over the fantail, and they were planning to shackle the wire rope to the SEALAB.

Another story was the ballasting. Back then, lead cost 12 cents a pound, out of standard stock, and I could not buy 120,000 pounds of lead. I ended up at the Bayline Train Depot. I bought used railroad axles for five cents a pound. We had 167 of them, and those had to be put in the ballast bins with a small overhead

winch that was supported by an overhead steel beam that extended out over the stern.

Another complication was the fact that there were three sizes of railroad axles, and there were six ballast bins on the SEALAB. The axles weighed about 550, 700, and 900 pounds each. I calculated the number of axles of each size to place in each bin.

They were ballasting the thing down, and we had about a state-two sea, maybe, with around three-foot swells or so. It was enough that when the barge came up, it snapped that wire rope pretty tightly, and it got to the point at which it almost took off a sailor's leg. That was when they decided to change things.

They had a large air winch forward of amidships that they had been using for some previous project work. The winch was big, but it didn't have a lot of load capacity. There was also a set of two biaxial traction winches aft of the forward winch, and they had some nine-inch nylon line. They reeved that line on the forward winch, then around those biaxial winch drums in figure eights about four to six times, then back to the fantail, which was about 120 feet or so. We talked them into using that nylon line because it had stretch, and it would tend to absorb the shock of relative motion between the barge and the SEALAB.

The next problem went like this. Since we could not afford a watertight hatch, both the main entrance hatch and the air space hatch covers were bolted on with flat rubber gaskets. Unfortunately, they required some 18 to 24 bolts each. Because of the anticipated difficulty in removing the hatch on the bottom, someone made the decision to lower the habitat with the main hatch cover removed. The plan was to keep the internal pressure above ambient during the lowering process by using air through the air supply hose. Well, the air hose had been specified to be a half-inch dive hose and a thousand feet long. The pressure loss through a thousand feet of hose to the regulator below was great enough that the air supply could not provide sufficient flow. As it began to go negative while they were adding axles, which were not all in yet, a swell came along, and seawater apparently went up into the entrance hatch, flooding the inside. After one or two more waves, the SEALAB went quickly to the bottom, in 54 feet of water. It was half full of seawater, so they had to try to recover the habitat.

But after the SEALAB was on the bottom, continued pumping dewatered the SEALAB enough, and by removing axles three and four, it become buoyant. It was then a matter of surface handling, to control assent as air bubbled out of the hatch. Once on the surface, more seawater was blown out, the hatch was reinstalled, and we returned to the Navy base. That was Sunday afternoon, May 24.

They brought it back in and put it on the pier Sunday afternoon. Bob Porter and I went in and started cleaning it up. It had been fully provisioned. Toilet paper was everywhere and in everything. We had to pull out and wash all the electrical receptacles. Regulators were disassembled and cleaned. Everything had to be washed down and cleaned up. All the labels were coming off of the cans. Anyway, it was ready to go back out on Tuesday, May 26.

They took it back out and put it on the bottom without incident. We left that hatch on until it was on the bottom. Then, we took it off. I'm not sure. We may have improved the air flow, too. The hatch could not be removed until the internal pressure was equalized. Ambient pressure would have been higher, preventing hatch removal.

We got it on the bottom. We got it open. Captain Bond went down and spent the night in it. He wrote a wonderful story about it. The SEALAB was successfully surfaced, returned to the Navy base and loaded onto the YFNB 12. A tug took it in tow on Saturday, June 6, and arrived in Bermuda on June 12.

When they got to Bermuda about two weeks later, and this was back when the fiscal year ended on June 30, Bob Porter and I were permitted to go down the first week to get it on the bottom and witness the startup of the operation. Bob was the electrical engineer. Jim Bladh was there, too.

We went down during the last week in June. All of our divers were out hunting for bodies from an Air Force plane that had augured near Bermuda, so nothing was happening. We were supposed to come back in a week. Well, nothing had been done. We called home. They said, "Okay. We'll send you some more money. Go ahead and get in your funds request." We got some more money. We stayed another week.

We ended up staying for a month, and they finally got it down, but not before they flooded it again.

This time was different. The commode, the head, had a three-inch drain line, a through-hull drain line. For double protection, we had a stop valve inside and a pipe cap on the pipe outside. We had provided two ten-foot sections of fire suction hose, which would attach to that pipe on the outside and take the effluent away from the habitat. However, the pipe cap was not to be removed, nor the hose attached, until the SEALAB was on the bottom and pressure equalized. During the pre-dive check, someone forgot to close the hull valve. That was the first mistake.

Again, someone decided it would be easier done on the surface, so it was the same scenario. The habitat was half full of seawater, but this time, it was in 187 feet of water. The nine-inch nylon hawser was stretching big time. You could see a little fish hook on the hawser, moving fore and aft a distance of up to eight feet. We were in rolling swells of about six to seven feet. Captain Bond and I were on the aft bridge walkway, looking down on this operation. I could see that fish hook going eight feet back and forth. Then, the line started smoking. They broke out a fire hose and sprayed it down to keep it from burning.

Again, we got to take the railroad axles out, blow it down, get it back to the surface, take it back in and put it on the pier.

Bob Porter and I got to clean it up again. I'm not lying. We got in and started cleaning it up. At quitting time, everybody went ashore except Andy Anderson. He was the only one that stayed there and helped us. I really don't remember how many days lapsed between that incident and getting back out the next time, but it was more than one.

There was some very serious consideration of canceling the project at that point. There were questions like, "Now, what makes you think it's going to work the next time?" But we finally got an okay to try it one more time. That time, we took it back out. Everything went great. Then, we got it on the bottom and got it manned.

SEALAB I was about 3,000 pounds negative for lowering. I had planned to have it 15,000 negative for good bottom stability. I wanted it very negative so that it was not going to move or float away in any current. That was one of the questions that Captain Melson had for me while we had it on the pier that last time in Bermuda. He said, "Now, how about your righting moment?" I said, "Well, you know, we have that big hull up top, and we have the ballast on the bottom. This thing is 14 feet wide." He said, "Well, what current did you design for it?" I think I told him three knots. He replied, "What coefficient of drag did you use?" I told him it was 1.25, or whatever it was. He was satisfied with that. "Besides, Captain Melson," I said, "It's not going to turn over. It might walk a little due to turbulence, but it's never going to turn over. There's just too much buoyancy there for it to do that."

We had a single lock steel chamber, and we rigged it up vertically with a framework and a platform underneath the lock and ballast in the platform. Jim Bladh operated it. He bragged about getting it on the bottom, 187 feet down, in five minutes. The aquanauts were transported to the bottom in the personnel transfer capsule (PTC), from which they swam over to the SEALAB.

At the end of the program, the habitat was slowly raised toward the surface without problem until it reached 81 feet. At that point, surface wave action caused shock loading in excess of twenty tons on the Argus Island crane. The aquanauts were then transferred to the submersible decompression chamber via the PTC and brought to the surface to finish decompression.

Even with all the problems, SEALAB I still ended up to be an incredible success. We lost one light bulb in the operation. It was rather fantastic, I thought.

MR. TOM ODUM

When Dr. Bond was ready to test his theory of saturation diving in open water, I approached him to let us build the habitat at Panama City. I told him that we had some cylinders that were left over from a mine countermeasures experiment that would be easily modified to make the habitat. He agreed, and I asked NAVSEA to task us with $50,000 to build a habitat for the SEALAB I program.

We cut the tail cone off the cylinder and put on spherical noses and then put it on stilts with large bins on the bottom for ballast weights. We used railroad axles, which we could rent for almost nothing to ballast it down. It was, of course, a nightmare to handle that many axles.

The electrical system was housed in a compartment in the front end of the SEALAB. All of our electrical connections terminated in the forward compartment and were fed out through the apartment part of the SEALAB.

We built the SEALAB I habitat in three months and ran into several problems that you wouldn't normally think of. The first severe problem we had was that the cylinders were made out of HY80 steel. Who would expect a cylinder, in those days, being made of HY80 steel? It was unheard of—that was very new material.

We had welded most of the habitat. One March night, the temperature dropped down into the 30s, and all the welds cracked—we had cracks all the way around it. Since we did not know it was HY80, we did not preheat the cylinder. When the welds cracked, we had to figure out how to preheat that large of a cylinder. The cylinders were 15 feet in diameter and difficult to preheat with no ovens that size available. We wound up wrapping steel banding over an asbestos insulator around the full cylinder and preheated it with the welding machine. We got enough preheat to weld the HY80 and the welding worked out well.

We had a lot of sailors from the base who volunteered time to do the chipping and painting. This made it possible to meet the schedule and also saved a lot of funds. All of the engineers, of course, were salaried and they worked long hours without any overtime pay.

We were running three shifts a day to make the deadline. We had to ask NAVSEA for $35,000 to modify the control platform, which was the YFNB 12. We made things like a transfer pump for large volumes of oxygen for mixing gas. We did so by taking two large cylinders with a connecting loop on the bottom. We put water in the right hand cylinder and pumped compressed air on top of the water, forcing the water into the other cylinder to compress the oxygen. That was the only way we could get the volume in those days to charge the storage banks.

SEALAB I was finished in three months and was to be tested in the Gulf before going to Bermuda. Instructions required the hatches to remain closed on the surface. However, a hatch was left open and as the SEALAB was being ballasted, a swell went over the top of it, and then it was like a dog chasing his tail. It flooded and went right to the bottom. This was on Friday, and it was supposed to leave on Monday for Bermuda. We had to put everybody we could find on it. We washed it down real good and had all the motors rewound. The local electrical shop stayed open and rewound all of our motors for us over the weekend. We had it ready to go on Monday morning. The only failure they had at Bermuda was one light circuit burned out, so it was a real successful series of tests.

Dr. Bond was at the laboratory the whole time with all the aquanauts, including Scott Carpenter, who had a lot of press when he was present. I was naive enough to think that I could limit the press to certain times. So, I called everybody in and said that we were going to have a press day, and that was going to be the only day we were going to have the press.

We could not make our three-month schedule, taking off every four or five hours for the press.

Dr. Bond said, "Tom, don't worry about it; it will work out okay." I said, "No, Dr. Bond, we've got to either have the SEALAB or the press; I can't have both." Of course, every time they'd come, we'd have to take everybody out of the SEALAB and let the press go in. We had one or two that were really persistent; they wanted to have a single day by themselves.

Dr. Bond got pretty upset with me when I told him that I wasn't going to let the press in on a routine. It was naive of me to think I could control the press to one day, so we had to break down and let the press in, occasionally. We tried to hold it to people like *Time* and *Life*, rather than just letting every newspaper throughout the Southeast come in on any day.

But we got it ready to go. It was loaded on the YFNB 12 and it went to Bermuda. Like I said earlier, the only failure they had was one light circuit failed. It was a successful series of tests, except they had to cut it short because of storm warnings.

The personnel transfer capsule was an old chamber that we inverted to the vertical position and put feet on it, so it could sit on the bottom. It was parked right outside the entrance to the SEALAB, so that in emergencies, they could go in, close the hatch, and pull it up. They did the decompression on Argus Island, which was an offshore research tower out from Bermuda.

CAPTAIN WALTER MAZZONE

With SEALAB I, we had support from ONR, and we had a fellow by the name of Hal O'Neil, a brilliant man. We also had Denzil Pauley, another smart individual who was a doer, and Lou Nelson, who was a naval officer, helping us. They found a buoy from the net-tending days when they had to close off harbors in Panama City, FL, and it was of a pretty good size. They thought that could be modified into a habitat. It was then the Mine Defense Laboratory in Panama City, and they refurbished the thing into a habitat. They put it up on stands and legs and whatnot, and it worked out really well.

We had to have a personnel transfer capsule to get the divers from the surface down to the habitat. We didn't have one. While we were looking around for a chamber that we could adapt, we got word from somebody in Virginia Beach that if we could get a truck there within a day or so, we could have a chamber. But if we couldn't get it, it was gone. I was talking with Bond and we decided that the best way to do it was to just get a truck and go.

I checked out a truck and drove to the base and got hold of the people and said, "Put the chamber on here." They said, "We need an officer's permission to do that." I said, "I'm a captain." They said, "Driving the truck?" I said, "Yes." "Yes, sir," they replied, and they put it on the truck and I turned around and drove back up to New London. We modified it and made it into a personnel transfer capsule to get the divers down to the SEALAB.

We also needed something to decompress the men when they came back, so we rigged that thing with a stand and a platform so that it would act as a personnel transfer capsule, or you could roll it over. We had the valves on it to use it as a decompression chamber. That's what we used. We took that to Bermuda with us, and we had SEALAB I transferred down to Bermuda on one of the YFNBs, and that was where we married up the system. We did SEALAB I off of Argus Island (manmade), which was east of Bermuda.

Earlier, before we really got started looking for a suitable habitat or money to build one, the officer in charge of the Naval Research Oceanographic Support Center in Bermuda said that they were going to take down the Argus Island sooner or later. But they were getting rid of what they called a "survival sphere." It was a large sphere that, in the event of a hurricane, all the people working on the offshore islands could get into, shut the little hatch, and it would roll off and somebody could then find it and rescue them. We thought that it would be a nice habitat and had it shipped to the submarine base.

Bob Barth, some other people, and I were out looking at it and started cleaning it all out and getting it ready to see what modifications would be necessary. Barth and I got outside, and it was a very warm and humid day. I took my brief pencil and wrote on top, "Bond's Folly, SEALAB I." The name stuck and Bond was quite pleased. He didn't like "Bond's Folly," but he did like "SEALAB," so the name has stuck with it ever since. We called it "Bond's Folly" then, but look at what it did for the world, insofar as the offshore oil industry is concerned. Was it really a folly?

SEALAB I was just an orange buoy tapered at the ends. It had legs. It had a little stairway coming down, which was the access to the inside. There was a hatch there. When you shut that hatch and built up air pressure inside, or helium pressure, whatever it was, the hatch could no longer be opened until you dropped it down in the water to where the pressure outside was equivalent to the pressure inside. Then, you could open that up and the divers could go in.

Water would not go in the habitat because you had an equal pressure on both sides of the hatch that you opened up. It was like if you take a glass tumbler and put it in the water and pushed it down, the water will just only go up so far. Well, if you made a hole in the top and decreased that pressure, the water would go all the way up. We had a pretty good system there and it was maybe 36 feet long and maybe seven or eight feet around at its widest part.

We had a galley installed and life support equipment was installed. Electric power was available. We had hot water for showers and a television camera for monitoring for pain.

The camera was mounted up in the forward part. It essentially looked down on the access hatch where divers would come up. Unfortunately, beyond that was the shower, and so there was really no privacy unless they closed the shower curtain. Every time we had visitors on board or expected visitors, we would notify them. One time, Dr. Bond said that someone was coming out from National Geographic and he wasn't sure who or how many, but he would like to have everybody on their good behavior.

It was going really well. All of a sudden, the curtain slid back and the SEALAB diver put his hand up in the shower curtain just bare naked, turned around, and walked off and said, "How do you like that?" Things could prove kind of embarrassing, but in the right light, they were humorous.

SEALAB I being the first thing out of the box, really, in open water, we were primarily concerned as to whether or not we could get the divers into the habitat safely, have them subsist for 144 hours, and then bring them back up safely. We didn't care if they did anything specific in the way of projects, other than to go out and take their diving equipment with them, swim and play with the fish, or whatever they wanted. The fact that they could do that was what we were really looking for. It was basically a physiological run. We wanted to be sure that we could do it.

The habitat was at 192 feet. We had a couple of problems. First, we were using a thing called a MK-6 diving rig, which was semi-closed and, by his own error, one of the divers forgot to open up his carbon dioxide canister. He went out to dive and had absolutely no carbon dioxide removal and blacked out. Dr. Thompson, who was inside the habitat and saw him flailing, ran out, grabbed him, and brought him back in. His eyeballs were absolutely black from the lack of oxygen. Theoretically, he should have died, but he lived and became much more morose than he normally was. He was "Tiger" Manning, or Saunders Manning, a really good hospital corpman.

SEALAB I didn't go to 144 hours because a storm came up. A hurricane was coming through, so we had to get the divers out and back into this chamber, up to the surface, and then tip it over and decompress them.

There were little pranks. I noticed one when I said, "Stand by." At that time, we could now ventilate them with air, so I said, "Stand by to ventilate." We were ventilating the chamber for a few minutes every half-hour or so. Well, I

noticed a lot of water was coming out, and what they would do when that happened was put a hose on the inside and suck out the water in the bilge, and the pressure would force it out.

But I was looking in the window and I saw this man urinating into that hose. The next time we were going to ventilate, one of the divers was in there and getting ready to do the same thing, but that time, I turned on the vent without the air. Then I hit the air wide open. He spoke to me later on. It was not much, but there were little things like that.

Between Dr. Bond, Dr. Workman, and myself, we knew a wide number of the divers because of our association with the training tank in New London. The submarine medical officers were obligated to provide medical coverage for the training tank, and with my interest in this, I was there every day for probably two hours. You got to know a lot of divers.

SEALAB II — 1965

MR. BOB BARTH

SEALAB I was fabricated at the Panama City base and SEALAB II was made from scratch at the naval shipyard at Hunter's Point, CA, near San Francisco. It was a different habitat altogether. It was bigger. SEALAB II had a lot more stuff inside.

While we were doing all that, we were also learning to make it work better. We built a bigger habitat. We had electric heaters in the floor to keep it warm. We had a better system for scrubbing the carbon dioxide, for heating the place, for everything. It was a little bit fancier.

The aquanauts were involved in the human engineering side of fabricating the habitat.

It was like "where to put this," "put it here as opposed to putting it over there," "where do you think we can put this," "we can put something here or there," "where do you want it," and that type of thing.

Scott Carpenter, who is a smart man, was involved in some of it. Scott was due to be the team leader of the first and second teams of SEALAB II and, in fact, was. A lot of us were up there. The builders of the habitat would rely on us to help with the ideas. We did that extensively on SEALAB I. By that time, we had some people who had SEALAB I behind them, so they knew a little bit more about where we wanted things. Obviously, when they were designing something, they had to design it so that it was safe and worked better one way, as opposed to another. As far as where something was to be placed, they'd put it where we wanted it, if it were at all possible.

SEALAB II was taken down to Long Beach Shipyard. We put it on a barge. It was taken down to the shipyard at Long Beach and the final outfitting took place there. Accumulating all of the stuff that we needed was done there. There were some parts still missing and so forth.

From there, we picked it up, put it in the water and towed it down to the Scripps Pier near San Diego. We had a support ship anchored, an old barge that had been used during the Polaris days, and it was our topside support ship. It was a mile off the inner Scripps Pier, if that, and we put it on the bottom and made sure it was working. The first team of divers went down on August 28, 1965 which happens to be my birthday. That's the reason I remember the date.

Now, today, when you do a deep dive, you can't swim down. You have to be transferred under pressure, and you make your descent into the pressure zone by means of a chamber and a bell, and you ride the bell down. On SEALAB I and SEALAB II, the teams left the surface, swam down 205 feet and got into it. Of course, when they came up, they had to get into the bell, surface, and decompress from the bell into a chamber. They all went down, two at a time, got in it, and stayed for 15 days. The second team went down and relieved them, and the third team went down and relieved the second.

We had one doctor go down on the first team and he stayed 15 days. He came up after that 15-day period and went back down for the third team. He did a total of thirty days, but had

15 days off in the middle. Scott was the only guy to do a full thirty consecutive days.

In picturing SEALAB II in my mind, I'm not seeing much because it's dark outside. There's no light from the surface. It's cold, as opposed to the bottom on SEALAB I, because we had coral heads and clear, warm water. On SEALAB II, we had darkness. There was some visibility, but with a light. We have beautiful, big portholes in SEALAB II. You just couldn't see a doggoned thing outside.

In the case of SEALAB I, there were a lot of critters out there, including some nice fish. We were in tropical waters, as opposed to the chilly Pacific off California. SEALAB II was dark, dingy, and very cold, and we saw little of the tropical fish. We had fish down there on SEALAB I. We always had light coming through the porthole, and we had minute shrimp, or perhaps plankton, that stuck on there all the time. The shrimp would come and eat the plankton or whatever small critters those minute shrimp ate. The fish would come and eat them and then a bigger fish would come and eat those fish. We always had that going on. It was the big guy eating the little guy, and it was to the tune of sea lions coming by and eating all of the big fish. You couldn't see anything on SEALAB II. Visibility outside the thing was so bad that if one of the guys was outside, he'd have to come to the porthole and make a face at you or something before you could see him.

Going outside of SEALAB II wasn't a lot of fun because you were cold. The water temperature was cold. I don't remember what temperature we had, but in SEALAB I, we could sometimes go outside, in a set of trunks and nothing else on but a facemask. We were always told to go back inside and to cut it out, but we were just horsing around. We would go out naked. We couldn't do that on SEALAB II. It was cold, dingy, and dark. It was not a fun dive.

It was okay inside. We had good heat. We also had something in SEALAB II that we didn't have on SEALAB I. It was a big tub that we kept full of hot water, and there was nothing better than getting in it after coming in from the cold, and you were cold to the bone. Jumping in that warm tub was even better than making love to a pretty girl.

Well, they wanted a change. Divers did not generally get to work in the water in Bermuda, unless we were diving in the Bahamas or got to go to pretty places. Generally, it was in the middle of the winter, in a lake that an airplane crashed in. You chipped the ice and went down and recovered bodies or you were recovering a drowning or something. They thought, "Why don't we make it realistic?" We were also looking for somebody who could support us. We went around the country like a bunch of gypsies, looking for somebody who had a pier and electricity and was willing to take all us mavericks in and support us. They had to give us the facilities on the beach, in the case of Scripps, to do it. All those things came into play. I was never involved in what went on in the offices in Washington. I was just one of the grunts in the water.

For SEALAB II experiments, there was more of the same as far as research and physiology. We were still sending them bottles of bodily fluids and blood and so forth. We had a dexterity coordinator outside, one of those things you had to crank one way and crank another way to get the thing to travel in the right direction. It was like one of those mazes that they had you go through, and all kinds of stuff like that. We had equipment that we were testing.

We had three teams. Each team was geared toward a specific thing. They may have been the salvage people. Their job was to salvage an airplane, float it, and let it go to the surface. We had an airplane lying out there. They had to go out there and float the airplane.

We had three oceanographers. They were Bill Tolbert, George Dowling, and Wally Jenkins. We had Berry Cannon on, as well. All four of those guys, including Berry Cannon, came from the base in Panama City. I was on the bottom with three of the oceanographers on team two on SEALAB II, and they had different things that they wanted to do, but we would help.

We also had Art Fleshing (and others) from Scripps. I call him Art "Flyspeck," but the other two I don't remember.

Some teams had multiple programs. They weren't all salvage. One had salvage as opposed to the other two, which didn't. There was always something that we had to do. We had a weather station. I was the one who maintained the weather station on my team. I'd go out and up the line. We had this thing hovering off the bottom roughly thirty or forty feet. We'd go out and work on that.

We worked with a porpoise from Point Mugu named Tuffy. One of the guys in my team, Ken Conda, had the job of working with the porpoise and a sea lion, both of which were trained animals. I'd go out and work with Ken, a friend who's long since gone now. But he worked with those porpoises.

We developed a heated electric suit to warm divers. I had one. Some of the other guys had them. They were battery-operated suits. We'd go out and make dives and try to evaluate those suits. We had different pieces of equipment. We were on the edge of a canyon. We made excursions down into the 350-, 360-foot range down this canyon. We used different apparatuses to do all these different things.

We had a lot to do. We got up early in the morning, had a bite to eat, and talked about what we were going to do that day. The team leader would go over everything, and each team had its work laid out. Once it was their time to go outside, they'd go outside and do their thing. They went out for an hour or two, more or less, and came back. The next team then went out, or we might have had two teams out there.

The porpoise trainer, Kenny Conda, was a Coca-Cola freak. He was, I think, addicted to the stuff. We didn't have any Coke on the bottom, for some reason or another, and the doggoned porpoise would come down with its harness on, and just about every time the porpoise came down, he had a bottle of Coke tied to his harness. Kenny would take it. He'd grab it and run into a corner somewhere, like a caveman with a side of beef, and drink his Coke, daring anybody to come try and take it away from him.

We were somewhat envious of the manned space program and their ability to garner the attention. Nobody is more of a space freak than I am. I think it's the neatest thing going. I think that NASA has done fantastic things with what they've had. Of course, they've had good money to do it. They've put men on the moon and done all those things. Granted, they lost people, but never in space. I'm fascinated. Of course, my friendship with Scott and the ability to ask him questions all these many years has added to that, but I wish that we, in this country, had just a fraction of the knowledge about the ocean as we have about space. I'd sure like to have just the money that it takes for one shuttle shot for our underwater programs. But I don't deny them. I don't have a bit of animosity toward those guys. I think the space program is the best-run organization in the United States of America. I just wish that we had been that lucky, to do the things they did. They've always had a neat group of guys to get done what they've been able to do. NASA, for example, has, gosh, sales promotion people for the space program and they are great guys. They're unique. We never had that capability.

I would like to be able to say that in SEALAB II, we answered a lot of our own questions. We proved that we could get the job done. As a matter of fact, all the skeptics, who were obvious to us, never showed up after SEALAB II was over. It was successful. We put 28 or 30-some odd people in the depths, left them down there for two weeks and never hurt anybody. One guy got the bends. Then, all of these guys started coming out of the woodwork, you know. The Navy decided, "Yes. Those guys know what they're doing." We proved to them that we could do what we said we were going to do.

COMMANDER SCOTT CARPENTER

My first affiliation with diving was with the SEAL team guys at Little Creek. Then, through

Cousteau, I met George Bond. He told me about SEALAB, and I told George Bond that I was fascinated with what Cousteau was doing. I said this to Cousteau, too. I said that I could be a representative of NASA technology, which was keeping men alive in space.

I thought it had a lot of trade-offs with his technology, which was not anywhere as nearly well funded as NASA's, in keeping men alive underwater. If I could be a team member, I could be a representative of that technology and might be helpful. Cousteau said, "You speak the wrong language. We can't pay you very much, but the technology might be of value to underwater work. Why don't you go see George Bond?" I did. George said, "Come aboard." That was my first association with Navy diving. That was SEALAB I.

That was in 1963, or maybe 1964. That's part of the record, but it was where I met my good friend and mentor, Bob Barth. It was under his wing that I got my first training, but I didn't make the SEALAB I dive in Bermuda. I had a motorcycle accident and broke an arm, and I didn't make that. But I went back for SEALAB II. SEALAB II took place in 1965.

The best training I received was the training with the new breathing apparatus that we had planned to use for SEALAB III. I never got any training in completely closed-circuit gear. I regret that. But the best training was throughout the SEALAB series. I don't think of any of the training as being tough. The most difficult thing for me was the cold water. That was tough. I don't think of anything else as being tough. It was just the cold water.

The person who made the most lasting impression on me was Bob Barth. He and I volunteered to go down to something like 220 or 230 feet to recover a camera that one of the SEALAB II guys, a civilian from the Scripps Institution named Bill Bunton, had lost. It was sitting on the bottom, and Bob and I were diving as a buddy team to go down and get it. We went down the descending line and got to about 200 feet, I guess, and I spotted the camera. I was always trying to prove my merit to Bob Barth, because I was an imposter from the aviation Navy. But I saw that camera and took off at full speed for it. Bob kept his cool and watched the neophyte run himself into nitrogen narcosis.

He saw me come back, and we started back up. He didn't say, "No, don't do that," but he didn't do it, either. He let me exert myself, which, of course, made it worse. I learned about the "rapture of the deep" from that. It was a good lesson. I was undone, and of course, he hadn't exerted himself and was fine. I was loony.

I volunteered to get into saturation diving because of SEALAB. The only way for me to get into diving was through that program. It accepted me from the outside. The entire SEALAB II experience was the acme of my underwater work.

The SEALAB experience gave me great personal satisfaction knowing that the Navy divers and the others in the SEALAB crew had accepted me. I had reason to believe that I had been accepted into a group of divers for whom I had great respect. That gave me great self-respect.

MR. BILL CULPEPPER

We finished up all the paper work and reports probably in October or November in 1964. During the same time frame, Tom Odum and I attended a SEALAB II planning meeting at Scripps Institute, which was to be the SEALAB II test site and base of operations.

After that, I accompanied Captain Melson and Al O'Neal, of the Office of Naval Research, to Hunter's Point Naval Shipyard. Before we arrived, I asked Captain Melson why I was going to Hunter's Point. He replied that he wanted me to show them how to design SEALAB II. I answered, "Yes, sir, but I have never worked with a shipyard before," and I had no idea what was ahead. The meeting went well, and the shipyard was agreeable to accepting the challenge.

In January, we had the first organizational meeting for SEALAB II. It was held in Panama City, and folks from Hunter's Point came down. Larry Ju headed the Design Division there.

He came down. We had previously put together a Program Evaluation and Review Technique (PERT) layout for the operation. It started in January and was to be completed in October. The PERT chart was reviewed and met with general agreement. We missed the schedule by two weeks.

The habitat was designed and built, starting in February, and it was delivered in July. I had people out at Hunter's Point almost continuously for that six months. I was there for at least half the time. One of the interesting things that developed was that Larry Ju wanted to design the habitat similar to a submarine. He wanted to put the variable ballast down low, with tanks on either side. My position was that we wanted that area clear so the guys inside could look out and observe the bottom.

It came to a standoff late one afternoon. There were six or eight of us in the conference room. Ed Carpenter, a mechanical engineer from the Naval Ordinance Test Station in Pasadena, was there to provide final outfitting support at Long Beach Naval Shipyard, the surface support vessel, and some onsite support. Larry just wouldn't move. He said, "You know, it's got to be designed like a submarine." I said, "No. It does not. Put the weight low and ballast up high." I had gotten up to go to the bathroom.

When I came out, I stopped to get a drink of water. Ed Carpenter was out there, and he said, "Bill, you've got to call back to Panama City to change this." I said, "I don't have to call anybody. I made the decision." We went back in. He said, "Larry, Bill has made the decision. You don't have to call anybody in Panama City." He threw up his hands and left the room. Later on, we became very good friends.

On SEALAB I, we said, "Let's see if we can do it." We thought, "Let's do it in nice, warm, clear water—the best environment—with no extraneous studies or experiments." SEALAB II was in a dark, cold environment and was a much larger operation. There were ten guys instead of four, with two-week periods for three teams. There was a lot more experiments, studies, equipment evaluations, underwater tasks, et cetera.

SEALAB II was designed to test a lot of equipment, diver heating, communications, dolphin work, salvage, tools, studies, and all sorts of things. It was a little deeper, but only by 10–15 feet, which was not that much.

Of course we had a little more time to design and build. We had twice the time frame. Instead of three months, we had six months. That was great, but the job was much larger and more complicated. One of the key things in SEALAB II was the role for which Panama City was responsible. Our group provided design concept drawings, sketches, written specifications, and general guidance to the shipyard for all the designing and building they were assigned.

We provided the specifications and technical support for the development and procurement of the personnel transfer system. We tested, evaluated, and modified, as necessary, many of the components that were to be installed in or on the habitat. We coordinated the efforts and interfaces between eight major activities involved directly in the operation.

SEALAB II differed in many respects from SEALAB I. The hull was designed for a 15 pounds-per-square-inch differential, since we felt we could control internal pressure during descent within those limits. It had bigger view ports. Our first ones were six inches, maybe. These were 18 inches, to better observe the surrounding sea floor. The hull was 12 feet in diameter, 57 feet long, and three-quarters of an inch thick.

We had learned a lot from SEALAB I. For instance, with the refrigerator, we put in an indoor switch that cut off the inside fan, to prevent the cold from being blown out when it was opened. We also made sure the temperature controller would work in the higher pressure environment.

We didn't have an air space in this habitat, so we put sensitive things in pressure-tight containers, or we modified them to become non-pressure sensitive. We used rough service light

bulbs and pressure tested them to twice the operating pressure. They were more rugged than regular incandescent bulbs. We did not use thermal circuit breakers but substituted magnetic/hydraulic circuit breakers because of the greater heat transfer rate in the hyperbaric helium-oxygen atmosphere.

One major problem arose in the procurement of the dished heads for the hull. The steel workers were on a strike, and the only response we got was from Lukens Steel. They required six months of lead time. That was our entire schedule.

The design people tried to come up with other solutions, from flat plates to cones and others, but all were rejected because of stress analysis difficulties. As it turned out, the semi-elliptic dished head was the simplest thing we could use. Mal Mac Kinnon, who was a lieutenant commander at the time, asked, "Why don't we form them explosively?" The design people replied that they had never done that before. Mal reminded them that they had formed some heads for a previous project. The reply was, "Those were only three feet in diameter." He said, "Well, these are only twelve." He was a real optimist.

Anyway, they decided to go along with it, and they made up a big concrete mold and clamped a plate on it, set some shaped charges out in front of it, lowered it down in the water, and blew it up. A wrinkled mass and partially formed head came up. Then, someone said, "Maybe we ought to evacuate the cavity before we try this again." They put a tap in the back of the form, pulled a vacuum on it and went, bang, bang, and they had two perfect heads. It worked very well. That type of leadership was probably one of the reasons that Mal made admiral, and it was key to maintaining the schedule.

For hull penetrations we used packing glands, but we put all of them down low, so they were actually at or near the water line in the habitat. We used good packing glands. Those were rigidly inspected. They were not a problem.

One of the interesting things that happened was at the end of the 24-hour air pressure test. The habitat was vented too quickly, and a large portion of the cork insulation, which had been plastered over for appearance, was blown off the hull. It didn't take too long to replace it, though. The pressure test was otherwise successful.

In July, the habitat was barged down to Long Beach Naval Shipyard for a final outfitting. We had it on the pier there and did all those kind of things. We had an interesting experience in the shipyard. We had designed a diver way station so that divers out in the water, if they got in trouble, could pop up into a dry atmosphere, or gas bubble. It was sort of a do-it-yourself project, something that the divers could do after they were on the bottom. The divers did not assemble it, but placed it, set it up, ballasted down, dewatered it, and all that.

I was fortunate to have Bill Frost, who was a naval architect, and also the grandson of Robert Frost, the poet, working with me at that time. He was also into value engineering (VE). He used some of his VE and came up with a neat little design. He used three residential fuel oil tanks. I think they were 175 gallon fuel tanks, and they were about 24 by 36 inches in a cross section and about 48 inches long. The narrow sides were rounded, and the top and bottom were flat. Bill took two of those, set them up lengthwise and cut the tops out of them. He took the other one, cut the top end out of it, turned it upside down, placed it on top of and between the other two, and then welded the three together. He cut square holes in the sides of the upper one and put two Plexiglas windows in it for view ports. That was neat. They could move that thing to the bottom, and the divers could shovel in mud or dirt, or whatever was on the bottom, into the side tanks and then dewater the center tank.

We had a set of drawings that we sent to the Long Beach metal shop, apparently by way of a scheduler. The leading man in the shop called me up. He wanted me to come over. He had some questions about the drawings; he couldn't understand them. I went over. He had some questions, which I thought were kind of dumb, but I tried to explain them to him. He said, "Well, you don't specify the thickness of the

material. Would an eighth of an inch be all right?" I said, "Wait a minute. On the list of materials, it calls for an oil tank. You go buy three oil tanks and weld them together." He answered, "Oh, we don't do that around here. We build the darned thing." That took more time.

We got some real experience in how some shipyards worked. You'd have a little welding job, maybe a thirty minute job or so. The welder's helper showed up, and he sat around for a couple of hours. We said, "Where is the welder?" He said, "I don't know, but I can't do anything until he gets here." I think he spent a half a day doing nothing. The welder finally got there. They did the job and were gone.

We had a hookah, or push-pull breathing rig, furnished by Westinghouse. We had a few problems with it. We had to reconfigure and rework it to get it installed in the habitat.

We got everything together and put the habitat in the water. That was the only time I went down with it, in 12 feet of water. I noticed one of the view ports was leaking. There was just a trickle of water inside. I think we pulled it up and reworked it some. But that wasn't a great concern because we would normally have had a positive internal pressure differential and did not feel that it would be a problem.

SEALAB II cost about $3 million for the entire operation, if I remember correctly. The habitat was subsequently moved down to La Jolla, to the Scripps Institute. Scripps had already run the water line, power and communications/electronics lines, and other support systems. They had put in one three-quarter-inch water line, which would not flow the required ten gallons per minute to operate the showers. The hose was 3500 feet long, and it was plastic pipe.

I asked, "How did you decide to do that?" They answered, "Well, that was what we had," or whatever. I said, "We need more capacity than that," so they went out and laid another line. Some problems developed here and there, as would be expected in such an operation, with a number of activities and a tight schedule. What I was trying to do was coordinate those efforts to minimize the holdups.

There were eight activities involved that we, the Panama City group, coordinated with the others, as required. We didn't use interface drawings like they did on SEALAB III, but ours worked and theirs did not. Generally, where we had an interface between two activities, I would task one activity with both sides of that interface. In that way, when it all came together, everything fit. It went pretty smoothly.

We had a helium tube truck on site in the water on a Mike Boat, and Mal Mac Kinnon was there. He said, "Bill, we're going to have to send this tube truck back whether we use the helium or not. We've had it too long. What do you think? We could just go ahead and put it in the habitat, and when we get ready to go down, we'll just be that much further ahead." I said, "Well, you can put it in there, but it will be gone before you get down with it." He asked, "What do you mean?" I said, "Well, we had a small water leak in one view port at 12 feet in Long Beach. It isn't going to hold helium on the surface." He said, "We've got nothing to lose. Let's try it anyway." I said sure. I went back out the next morning. I asked Mal, "Now, what's the pressure in the habitat?" He answered, "One atmosphere." But SEALAB II went down without incident.

One thing that happened in Long Beach that I thought would be of interest had to do with the PTC. Walt Mazzone worked on clocks. He made clocks as a hobby and had designed a Geneva mechanism for the escape winch on the PTC, something that would let it come up at a controlled rate from a weighted platform on the bottom of the PTC support. It could be operated from inside the PTC in case they needed go to the surface without surface support, such as a crane to lift them. This thing was monstrous. It had about a three, three and a half, maybe four-feet long, two-inch-diameter steel lever arm with a large steel counterweight at the upper end. The ratchet wheel was attached to the winch spool and positioned at the lower end of the pivoted lever arm. It looked quite impressive.

The PTC was lowered to the bottom pier-side for the initial test of the raising mechanism. To everyone's surprise, when the system was activated, the PTC rose rapidly, apparently out of control, splashing to the surface.

Well, Bill Frost and I got the drawings out, and we were in the ward room on the USS Berkone, the support ship. We had a half a dozen people looking over our shoulders, including the division heads, branch heads, and people like that, trying to solve the problem for us. We finally said, "If you guys would go away, maybe we could solve the problem."

Well, they had used Formica, a laminated melamine plastic material, for the water-lubricated bearings in the mechanism. At this time, this material was used extensively in underwater applications, such as ship propeller bearings. I had some experience with those in my Mine-Countermeasures days.

Normally, the rough bearings were soaked in water for thirty days before the final machining. They had to be used immediately, or kept wet until used, or they would dry out and shrink. The inside and outside diameters would increase or decrease, causing excess radial clearance between the shaft journal bearing and bearing housing. That was what had happened. They had originally machined up at the true dimension, but they had been sitting in the dry for weeks and had shrunk so much that everything had too much clearance. The ratchet wheel and lever arm didn't make contact. It just free-wheeled.

I had used Teflon bearings in some of my underwater Mine Countermeasures equipment, so we managed to find some Teflon and had new bearings machined and installed. It worked fine.

One of the other problems involved the deck chamber and the PTC. It was the first PTC/deck chamber complex built for the Navy. We had the chamber on the second deck of the ship. The PTC, of course, sat on top of it. The PTC was vertically oriented and had seats around the inside, circumferential seats, at two levels. Five guys could sit on each level. During the first test of the decompression complex, we found that there was no way to vent the pressure in the trunk between the PTC and the deck chamber. The two could not be separated. Walt Mazzone came up with the idea of using a syringe needle. There was a face seal O-ring in between the two chambers. They inserted the syringe through the O-ring and let it bleed down that way. We had a lot of things like that happen, but we worked together and with all hands cooperating, most problems were solved without serious results.

After the habitat was on the bottom and manned, we had a problem with the television cameras. They were inside the habitat, and they worked fine for a day or two or three, but then they would screw up. We'd take them out, bring them topside, and check them out. There would be nothing wrong with them. We would put them back together, take them back down in the pressure cooker and put them back in. They'd work for two or three days, or whatever it was, and they'd screw up again. Finally, the third time this happened, the technician who was working on them happened to notice that when he opened the housing, there was a slight hissing sound. Then, we figured out what was happening. The helium was getting inside this watertight camera housing, which was good for 10,000 FSW, and it was detuning the camera. We rigged up some mounts on the outside, in the water, looking through the portholes, and they worked fine.

We used electrowriters so that the aquanauts could write messages on the bottom unit, and it would be transcribed on a topside unit. The helium speech unscramblers were not very good at that point in time, especially with Scott Carpenter. I just could not understand him at all. We pressure tested the electrowriters, and when we decompressed them, the oil filled capacitors blew up. They had absorbed helium. We found that we had to decompress them or replace the oil-filled capacitors with dry capacitors. Then, we had no more problems with that.

But we found a lot of unique problems, particularly in the helium hyperbaric atmosphere. We did a lot of research in developing film

coefficients for use in calculating heat loss for the habitat. Subsequently, we calculated how much heat capacity would be needed to maintain a comfortable environment. We relied heavily on the services of a consultant at the University of Florida in this effort, with Jim Fife successfully supporting the effort for us. Jim's theoretical calculated heat loss was 54,300 btu per hour. The average measured during the operation was 60,000 btu per hour.

We also developed a relative humidity chart to use in that environment. Jim Fife did those. We found that the guys liked to keep the temperature around 85 or 87 degrees, to be comfortable because of the high heat transfer of the atmosphere.

I was on site about half the time, going back and forth during the design and fabrication at Hunter's Point. But some of our team members were there almost continuously. I was in Long Beach continuously during the final outfitting, and at San Diego during the operation. We were there for some three months. We went out in July, the first week in July, I believe, and stayed through August and September. We left around the first of October, and it didn't finish up for a week or two after that.

Bob Porter and I then went back out for the surfacing of the habitat, because our team was responsible for the engineering evaluation. We planned a complete inspection of the habitat and all systems and equipment. During the raising, operational problems were encountered with maintaining an over-pressure in the habitat, and partial flooding occurred. There were about six inches of seawater on the deck. Again, Bob Porter and I enjoyed cleaning up and conducting our inspection. I remember the skin on our feet peeling off from the lithium hydroxide in the water. The scrubber cans were down low near the deck.

During this time, the Office of Naval Research had sponsored SEALAB I and SEALAB II, but the Deep Submergence Systems Project Office took it over at SEALAB III. We finished that in 1965. I want to say that it was the next year that SEALAB III began.

DR. SAM RIDGWAY

I was recruited as an Air Force veterinarian and started working with the Navy Marine Mammal Program. When I got out of the Air Force in 1962, I went to work as the first fulltime civilian employee of the mammal program at Point Mugu. I was charged with keeping the dolphins healthy, and I became interested in their blood and their physiological capabilities.

It immediately occurred to me that we ought to try to find out things, like how deep could they dive, in addition to how fast could they swim. We started training a dolphin that's discussed in my book, *Dolphin Doctor*, a dolphin we ended up calling "Tuffy" or "Tough Guy," to dive voluntarily in the open ocean.

As we were doing that, SEALAB II came along, and Captain George Bond, who was the medical officer of SEALAB II, invited us to participate in that project. He, along with Captain Walt Mazzone, was very interested in understanding how dolphins could dive, and employing dolphins to help man in undersea investigations. We very quickly trained Tuffy to swim back and forth between divers, to carry rescue lines and mail and tools to divers on the bottom. Since it was a saturation dive, SEALAB II was at 205 feet off of the coast of Scripps Canyon and La Jolla. The aquanauts, who were joined by astronaut Scott Carpenter, were living on the bottom. We had the dolphin dive down and carry things to them. We spent a week just trying that out. After about the third day, the dolphin worked very well with the aquanauts and got accustomed to the cables and lights of the SEALAB habitat. It was apparent that the animal could work with people in the open ocean without a tether. We didn't have to have lines.

Tuffy did wear a harness at SEALAB, but it wasn't connected to anything. Later, we dispensed with the harness, but at SEALAB, he had this harness on that we thought would help retrieve him if he ever did take off. But he never did.

I think that Dr. Bond had just been to Vietnam, or had some interactions with Vietnam, and we knew at that time that the saboteur

swimmers had blown up several Navy assets in different harbors and operational areas in Vietnam. Bond suggested to me that we should train our friendly dolphins to defend Navy assets against the swimmers that were very hard to detect with sonar, especially the loincloth swimmers, who didn't have much of an echo return on sonar.

We then went back to Point Mugu and fairly soon started training other dolphins to detect swimmers, both scuba swimmers and swimmers carrying tanks, closed circuit and open circuit, and loincloth swimmers. That program then transitioned to Hawaii, where we had warm water, and where the swimmers could stay in the water longer than at Point Mugu. That program was successful, and we deployed five dolphins to Vietnam in 1970 to guard the ammunition depot at Cam Ranh Bay. It worked there for about a year, and during that time there were no attacks in that area.

CAPTAIN WALTER MAZZONE

For SEALAB I and SEALAB II, Bond and I essentially selected almost everybody. Except that in SEALAB II, we had civilians from Panama City. I think we had two of them. We had one from the Naval Ocean System Center and the command selected those people. They came aboard, trained, and went with us.

The Applied Science Laboratory in Brooklyn, which was a Navy activity at that time, worked with an electronic device called a "helium descrambler." We tried it. It helped a little bit. They also had an electronic device, which was hard wired. It was a pad that you could write on, and it had a slave pad and pencil at the other end. As I would write there, it would write on their tablet down below, and as they would write, it would record up there. It was a pretty good way to communicate, but it was slow because, you know, you had to write. Readability really depended on a man's penmanship.

SEALAB II was going to be much more ambitious than SEALAB I. We weren't too interested in going a lot deeper. We wanted to know if man could actually go to these depths and work, or do tasks. Could we do multiple team concepts, such as you do in industry? If you wanted to take advantage of a 24-hour day, you had two or three teams that could alternate, all under pressure. SEALAB II was set up to use multiple teams.

We had three teams. I think there were eight people in each team. We intended for them to stay for two weeks. Except on one team, one individual, Commander Carpenter, as a matter of fact, was going to stay on for another team. Dr. Sonnenberg was going to stay for his team, come back up for 15 days and then go back down again. They each stayed, really, for sixty days total (thirty days each). Only one was interrupted. The building of the habitat was funded by ONR and by the Office of Special Projects, and they built a whole new habitat at Hunter's Point in the old shipyard in San Francisco.

It was a complete cylinder with hemispheric domes on each end that had to be explosively formed, because no one in the industry could roll domes that size. They were 18 feet in diameter or so. The gas bottles that contained the helium and the oxygen were all welded and fixed to the outside of the stand, and it was on the stanchion so that divers could have access; in and out, without having to crawl on their hands and knees. We built a little room underneath the access area that was called a "shark cage," and that was essentially it.

It also had all of the accouterments you needed. It had a range, a refrigerator, life support, and communications. We also had a wire hooked from the habitat to the surface so that we could take pressure pots to bring supplies down and take waste away. We had a better version of the unscrambler. In the meantime, we looked at other diving techniques, such as how far down you could go if you were in the SEALAB habitat and wanted to go out, how long you could stay and then come back to the SEALAB habitat without decompressing.

Those were the start of the excursion dives, but they were not yet really finalized, such as when we were getting ready for SEALAB III. That was the start of the excursion dives, and we found that you could go two atmospheres below where you were and come back and not have to worry. But you could not go much more above, maybe one atmosphere.

We thought the Navy would find great value in this type of diving. It could be used in any kind of salvage in which you could move a ship above a site. Instead of having divers go down and work at a hundred feet for twenty minutes, you could have them go down and stay there for a whole shift, and then come up and stay at a pressure activity on the surface while another group went down. Then, you could alternate them.

Mal Mac Kinnon and I got talking about using one of the submarines, the USS *Seawolf*, not the nuclear one, but the older one. We were going to use it to do personnel transfers of individuals from sea to shore and drop them off like you would do with SEALS. It would be a covert method of clandestine entry through submarines.

We worked on life support systems, too. That didn't go far, but it certainly gave George and me an idea. What happened if we could make one end of it, like the forward torpedo room, into a decompression chamber? Then, we could make a hole in there and go down and have them go out and come back, close the door and bring them up all under pressure. With us, it didn't get that far.

We were looking at emergency procedures; what you did if you lost your helium. We checked around and looked at the literature and found that a human could not survive breathing compressed air at a pressure of 450 feet of seawater. I think it was a Dr. Hempleman in England who had postulated that. If that was true, then using air underwater could have been a real problem.

Dr. Bond, forever the doubting Thomas, said, "We ought to go down and test this." We worked with the Navy Experimental Diving Unit. They had the facilities for us to do it. We had, by rote, a procedure to follow. What they were going to do was see if they could have me change my mind because of the narcosis that you get from nitrogen. We went down in the chamber, on helium, with masks. In the chamber, we had a safety diver with us who was breathing masked helium-oxygen. The chamber was brought down to 450 feet on air, at which time I had to take off the mask and do the task. The topside people said, "Now, do this, and do this."

I was able to function for about five minutes. After that, I was in "la la land." At that point, the safety diver put the other mask on, and the narcosis cleared almost immediately. They did the same thing with Dr. Bond at the end of nine minutes. He was still functioning. They stopped. Well, they came to find out that your tolerance of nitrogen narcosis was enhanced if you had a capacity for drinking.

There was a 1,000-foot dive in the making. We were getting ready to finish our workup dive for SEALAB III at the Experimental Diving Unit. They had just had all the chambers reworked and re-certified to 1100 feet, I think. I was working with Gene Mitchell, and it was Captain Mitchell who was head of the research and NEDU. I asked him what he thought about it. He said, "If you can get permission, yes, let's do it."

I went to the Deep Submergence Systems Project (DSSP), for whom I worked, and we finally got approval to make the 1,000-foot run. But we had to get the Secretary of the Navy's approval.

The profile for the thousand-foot dive was that we would go to 850 feet, saturate all the divers there, and take two divers and put them in a wet pot or under the igloo. Then, we would close that off from the pressure chamber and take it down to a thousand feet. The divers were on breathing equipment in water, not dry, and they were observed through some ports. I was a diving officer at the port, and when one diver, Fernando Lugo, came to the port, I noticed his hands. Both hands had tremors. I asked him, "Are you scared?" He said no. We were at a

thousand feet, and I think it was Dr. Bond who said, "Okay. You're at a thousand feet. Bring him up."

Secretary of the Navy Nitze was standing behind me, because we had invited him to come over. He said, "Could you go deeper?" I said, "Yes, but we need approval." He said, "Who would have to approve it?" I said, "You." He said, "Do it." Not wanting to push our luck too much, we went to, I think, 1024 feet and then back up. We were on an excursion dive that we knew was safe, and we kept the divers at 850 feet until we finished the experiment and then decompressed to the surface.

There was one particular maneuver that was very valuable, according to Dr. Al Behnke, who was a world-renowned diving physiologist. One of the most important features for our system, having gone commercial, was our gas savings. If you could go to 850 feet and then to a thousand feet, and then come back to 850 feet, it was an accomplishment. If you could do that anywhere along the line, stay at a shallower depth, conserving materials like helium and oxygen, it would help. Those things were expensive, and at that time, the gases were non-recoverable. You just wasted it.

Fernando Lugo's little tremor became very important to us. Herman Rahn and other observers up at the University of Buffalo in New York, said that they had observed the same thing, subsequent to our dive. It ultimately became known as High Pressure Nervous Syndrome (HPNS). I think a lot of people have tried to solve it.

To saturate a diver, simply stated, means that as we sit at one atmosphere and breathe, the gas that we breathe is essentially about eighty percent nitrogen and twenty percent oxygen with maybe a couple of percent contaminants that we don't worry about. As you breathe, those gases go into your blood stream. They're absorbed. When it gets equal so that there's no further uptake by your body, you're saturated at that level. If you increase the partial pressure out there and start to breathe that, you also increase the partial pressure of the gases you're breathing. You're driving more into the fluid portion of the body and it's either taken up by blood or deposited in body tissues. When that comes into equilibrium, you're saturated. We figured that tissues have half-lives, and if the longest half-life is say, ten hours, when you get to that point, you are saturated.

If you went to that depth and came right back to the surface, it would be a surface-supported dive. You went down and stayed a short period of time but had to decompress on the way up. The deeper you went, the longer the decompression. But when you got saturated, the line went up, and then it flattened out.

Workman and Bond were talking about that. They said, "Well, when you get to this point, decompression doesn't increase. If you keep him here for a week, ten days, or a month, we can pay the decompression price all at one time." That's the basis of saturation diving. It's a difficult question to answer when you go somewhere to talk and the people are not acquainted with it.

Dr. Bond and I were interested in submarine escape, because we worked in a submarine escape training tank and wondered about the possibility of going deeper than a hundred feet, because that was what you did in the training tank. I think 118 feet was the deepest you could go. Dr. Bond set up some experiments. There were two teams, Dr. Bond and Cyril Tuckfield, and Dr. Van Orden and me. We went down to Key West and made the escape from a submarine. Van Orden and I would make one escape. Then, Bond and his partner would make one.

It was Bond's stipulation that he and Tuckfield were going to be the only ones to make the deep dive. Somebody brought them to about 307 feet or something like that, and Bond and Tuckfield came out. We used just the life vest with relief valves on it. As you came up, the excessive buoyancy would bleed off. You, as one of the participants, were required to blow all the way to the surface. That was called a "blow and go system."

Luke Van Orden and I got to take them down to 200 feet, and I got a little bonus. They were going to send a diving bell down for the photographers to photograph Bond and Tuckfield escaping from the submarine. Well, I was in there with a new diving rig on, and all of a sudden, the chamber started to go, and the word came in to stay there.

I started thinking, "I have no way to take decompression." At about 225 feet in just a few minutes, I stepped out and made a free ascent to the surface with nothing other than a breath of air that I had for positive buoyancy. I controlled my rate of ascent by the blow. As the gas expands in your lungs, you blow out the excess. The only problem was that we did those things in the training tank day in and day out, but you always had the side of the tank as a point of reference. Were you going up or staying down? Were you staying with your bubbles and were the bubbles going up or were you going down?

Not having those markers, I stayed as close as I could to the bubbles, and I think I came up at about two feet per second, which is the proper rate. Had I stayed down there much longer, I could have had decompression problems. I wasn't breath holding. I was breathing the air. In the bell that went down, we had to have water up to a certain level and then air space, so I was breathing air.

We had a submarine medical officer by the name of Sam Wrench, who was trying to make an escape suit. It was a whole body suit. It had a facemask. The theory was that as you started up, the expanding air in the suit would provide a breathing medium for you. There was a relief valve on it. If it got to be too much, it would pop off.

One day, in the training tank, I stepped out, I think, at a hundred feet with it, or maybe it was fifty or seventy-five feet. I guess I didn't have enough air in the suit, because when I stepped out, I went down a little bit, and the excess pressure just squeezed the face mask right on my face, so I came up a little bit and it eased off.

When I finished that, I took one of the life jackets, filled it, went back down, and put it in the suit. As I came up, all that air started to pop and it was easy. I could breathe all the way up. Harold Steinke, who was the officer in charge of the training tank, said, "Hmmm." He took one of the life jackets home and had his wife make a hood that encompassed the relief valves so that air coming off the life jacket would come up into this helmet and you could breathe it.

That was the start of what was called the "Steinke Hood." It was then called the "ho, ho, ho system," because as you made the ascent, we wanted to make sure that the diver breathed so that he wouldn't embolize. He said, "Okay. Once you leave the platform, start hollering, 'ho, ho, ho' all the way to the surface." The reason was that if you held your breath, you would embolize.

If there was air in your lungs, it could rupture your lungs, which could lead to an embolism, because the air would get into the blood vessels and go up into the brain, and that was something else. Embolism in diving was a big thing. It happened in submarines. We had it happen in submarines during training, and this is one area in which I like to take a little pride.

We kept noticing that all the embolism cases were put in the pressure chamber and taken down to a depth of 165 feet for relief. They would then bring them back up on a standard table four, which is the long table. At about the forty-foot stop, not always, but usually, they had a recurrence and would have to go back down and treat it again.

We went back and looked at some of the physiology. We found that by the time they got to the forty-foot stop on a table four, it was about the time that they got maximum cerebral edema. Could we avoid that?

I got hold of a guy with whom I worked by the name of Mike Greenwood. He was a laboratory psychologist. We dug up an experiment that was done elsewhere, in Italy, I think, in which they used a Calvarial window. They actually put a window in the skull so that we could observe

the brain. We induced embolisms through the carotid artery and were able to photograph the embolism as it occurred and what happened when we treated them in the pressure chamber so that we could see the bubbles resolved. We were able to photograph that on movie film and said, "If these bubbles resolved that quickly, why don't we take them to 165 feet? If they feel good, have them decompress from 165 feet or 170 feet for a twenty table." We did that. It worked like a charm, but we had one setback.

One medical officer out in Hawaii had an embolism case at their training tank, and mindful of the work at New London, he was going to try this. The only problem was that he didn't read the part that read, "If the patient stabilizes at 165 feet and is recovered from the symptoms." Well, his patient had not done that, and he started to back out and, of course, he got in a lot of trouble. It didn't kill him, but he got in a lot of trouble, and we had a little setback because of that. Our system really worked and was approved, and it's still in use today.

SEALAB II was done just off the Scripps Pier. I think it was about three thousand feet offshore. We had a habitat in two hundred feet of water but had a lot of different projects. One was to look at the impact tools that could be used. You needed to come up with some kind of zero gravity tools or zero impact tools. You pushed on a screwdriver and you were going to push away. Anyway, we came up with tools that divers could use, and we tested those.

We had bottom stabilization experiments. If you got on the bottom, you would have silt coming up. How could you stop all that? We had chemicals and things you could put down. We had salvage work in which we had to rig or damage an airplane that was sitting on the bottom and bring it to the surface.

We had some construction projects in which you had to put big sonars on top of each other and bolt them. We had meaningful work. Plus, we tested other things. The divers were to test the heated suits for diving, but the suits were electrically heated. My favorite slide, whenever I used to give the talk, was of a diver standing there with this cord in his hand, saying, "Now, you want me to do what with this?" Dr. Sonnenberg tested the suit to try to overcome the cold. Cold is, particularly with helium, a real bear. In deeper depths on other dives, we found that the cold gas could really ruin your day.

Dr. Bond set the priority as to what would be done on the SEALAB II missions. There were other people from ONR involved with other questions related to the unseen operation. When it came to the people and their activities, it was Bond and I who called all the shots.

Each team stayed down two weeks and did their projects. Each team was trained for different projects. Not everyone trained on the same projects.

We did have interplay with NASA when they used a lot of tank divers and our SEALAB divers to do the gravity free training in that tanker plane to compare performance results. When you worked in the training tank, you were, essentially, in a gravity-free state for four or five hours each day. They wanted to try to measure performance standards accomplished by the astronauts versus those accomplished by the divers. Other than that, from my point of view, I saw little other than the phone conversation between Commander Carpenter and Gordon when Carpenter was in the chamber on decompression.

SEALAB II was an excellent project. The only problem we had was that Commander Carpenter was stung by a scorpion fish on the last day of his bottom stay. Much to his credit, he did well in decompression. Master Chief Sheats, before he went down, told me that he had been bent about two weeks before he came to us and had to be treated in Seattle, where he was at the shipyard at Keyport. It was at about two or three in the morning of the last day before coming to the surface with his team and he called and said, "I think I have a problem."

At about that time, we had maybe three hours left to go on this long decompression. We got in touch with Dr. Bond. Then, we opted to

treat Sheats in the chamber and put the other people in this little chamber, bring them to the surface and continue the decompression at the surface. We had one going up and one going down. We took Sheats down to depth for relief and then back up, and he was all right. We then brought him to the surface. Those were the only real mishaps, if that is what you want to call them; that occurred during SEALAB II.

The support vessel was really a combination of three barges tied together in a "U," and no one wanted to keep calling it "the barge." This other fellow who worked for the Naval Ocean System Center was named Joe Berkitch. He and I had worked together for long hours on SEALAB II.

He and I became very close. He said, "I'll tell you what. Why don't we use our names? We'll use 'B-e-r-k,' for Berkitch, and 'O-n-e' from Mazzone. We'll call it the 'Berkone,'" and the name stuck. But when Captain Melson, at the commissioning of the SEALAB, announced it, he said, "We have the Berk One," so that was where that came from.

Topside, there were two people. Dr. Bond had the daytime shift and I would relieve him at 4:00 in the afternoon. Dr. Bond would then go ashore on one of the boats. He had a motel over in La Jolla. When he came back in the morning, to relieve me, I would go down below, into one of the closets in one of the storerooms. They had made it into a bunkroom for me, and I slept there. I stayed aboard the barge full-time. He and I were the only people who ever really controlled the topside. Other people controlled the behavior of the divers and other mechanical things.

At the end of SEALAB II it seemed like there was much more interest in what the future of this program was going to be, and at about that time, they had the *Thresher* disaster. They had a deep submersion committee come up and it made recommendations to do certain things. One of them was to establish the Deep Submergence Systems Project Office, I guess, and we were going to become a part of that.

MR. TOM ODUM

We did SEALAB I completely in three months with $85,000. SEALAB II was a multi-million dollar experiment that took over a year to prepare for. SEALAB III was quadruple the price of that one.

It was something to see the difference in the people who were not trained in underwater equipment, nor in physiological processes; who came into the program, and to see the mistakes they made, not having a background in diving. We spent most of our time at the Laboratory trying to correct those things that were happening.

Captain Mal Mac Kinnon built SEALAB II. He was head of Hunter's Point Navy Shipyard, where the habitat was fabricated. They did some really innovative work. Like, they did some explosive forming of the dish heads for the ends of the habitat. That was something that was unique for that timeframe. They put a whole series of explosives next to a steel plate, and when they fired it into a mold, it formed just perfectly. They machined the ends of it and welded it to the habitat.

Captain Mac Kinnon did some good work. We did the preliminary design and they made the detailed designs. At the Laboratory, Bill Culpepper, Bob Porter, and George Combs were the three engineers involved in SEALAB II at that time. They had been involved in SEALAB I and had gained valuable experience. They were involved with our diving work along the way, so it was not something new to them. They had the background and the knowledge to do the SEALAB program.

SEALAB II was a successful program, which operated off Scripps in the canyon in 200 feet of water. Bob Dill, Dale Good, and I made a preliminary search for a spot and the best place we found had about a 10 degree slope on it. SEALAB II was placed on the slope, and they called it the "Tiltin' Hilton." That made it fairly uncomfortable for them during the whole test, but that was the best place we could find in the time that we were limited to in 200 feet of water with scuba.

SEALAB II tests went very well. There were no serious problems. Scott Carpenter was stung by a scorpion fish as he was coming up. They advanced our technology quite a bit in the process of building SEALAB II. We had money and time that we didn't have for SEALAB I. So, they had a much better organized ballast system and a much better organized air supply system. The whole system was better. SEALAB II had a pressure hull, whereas we went with an ambient hull on SEALAB I.

On the SEALAB I program, we had a big meeting on whether to use a pressure hull or an ambient pressure hull, full pressure versus ambient pressure. I made the decision to go with an ambient pressure hull because, first of all, we did not have time to build and test a pressure hull. Certification was not really a word in our vocabulary at that time. Unfortunately, before SEALAB I was scheduled to go to Bermuda, I got a call and was told we had to certify the SEALAB.

Of course, I thought this was the end of it, because there was no way we could certify a pressure hull in four days time. So I went to Washington and reported that SEALAB I did not require certification, because it was an ambient pressure hull and there were no requirements to certify it as a pressure hull. And they bought it. I was shocked that they bought it—but they did. Fortunately, we were able to go ahead and ship on the scheduled date.

MR. WALLY JENKINS

After I left active duty with the Navy I moved to Panama City, FL, and went to work for a guy named Tom Odum, who had the Swimmer Diver Branch. And I got a job as a GS-9, which paid $7,020 a year, which was pretty good money for that time and place. It's hard to believe, you know. That's hardly beer money any more. But that was really good money back then.

I got in the Swimmer Diver Branch in 1964. Remember, we were very active. Tom Odum and Bill Culpepper—they usually don't get much credit for this—are the guys that kind of designed and built the first SEALAB. I'm giving credit out, because I wasn't involved. I know Tom was really involved, and Bill Culpepper was really involved.

They got some old mine warfare floats, they did some work, and they made them into a habitat —SEALAB I. When I got there they were working on SEALAB I, and they trained off-shore there. There was Bob Barth and three other guys. That's when I first got to know Bob Barth. It was Barth, and Tiger Manning, and Lieutenant Johnson, and another guy, Lester Andy Anderson.

They made their dive off Bermuda, in clear, warm water, because Dr. Bond wanted less hassle. And their dive was cut a little short because of a storm warning, I think it was. Scott Carpenter was supposed to be involved in SEALAB I, but he had a scooter accident on Bermuda.

Meanwhile, I was diving for Odum and his branch. We were working on things like the buoyancy-compensated Explosive Ordnance Disposal (EOD) filament (wound fiberglass scuba, non-magnetic). We were also working on a new face mask, a PQS sonar, and the boats for Vietnam that Bill Quigley headed up.

We had some guys like Roger Johnson and Don Patterson, who just retired after 40-something years, who probably was as good with PQS sonar as anybody ever in the Navy, probably more experienced than anybody in the Navy. But anyway we did all this diving stuff. That's all we did. And then they started making plans for SEALAB II.

Well, I got on SEALAB II. I was new enough at the Lab that I wasn't controversial. That is, I didn't have any enemies yet, really, and I hadn't made anybody mad. And I had a lot of diving experience. I think I had, like, 1,300 dives when I went to work there, something like that. Maybe 1,500. I had done a lot of deep dives. But I hadn't made anybody mad yet, so Tom Odum was the first choice. He was the branch head.

We were going to have four civilians. Berry Cannon was going to be the second choice.

The first back-up was Bill Quigley, and the second back-up was myself. Bill Tolbert and George Dowling went from the Oceanography Department, which made four civilians: two from Odum's branch and two from the Oceanography Department.

Dr. Jasper, who was the technical director, said Odum's not going to go make that stupid dive. He's too important, you know, being branch head. So poor old Tom got shot out of the saddle. And Bill Quigley? I'm not real sure why he decided not to go.

So pretty soon I'm going. Berry Cannon and myself, and then Bill Tolbert and George Dowling. So we started training for SEALAB II in March of '65. We did a lot of training there with the old Mark 6. In the meantime, I was going to scuba school. And you know how the Navy is. I mean I made, like, 1,300 or 1,400 dives in all that deep stuff, but you still had to go to Navy Scuba School and learn how to clear your ears, which was fine. It was fun, but I wasn't ready for the PT. I wasn't ready for that, you know, because I hate running. Never have liked that. But it was a good school. I got a lot out of it.

Then I went down to a mixed gas school in Key West with Mark 6 with Don Patterson, and that's where I met Jimmy Stewart and Art Fleshing from Scripps. I had a good time down in Key West using the Mark 6. So, in SEALAB II we used the Mark 6 and we trained in Panama City. We went up to DeSoto Canyon and made some deep dives. Then we trained off Stage One and Stage Two before they were blown, and made just bunches of dives.

Then, of course, Carpenter was back in the swing. We left here July of '65. I got to go with the trunks and I got to fly over in an old C-118 box car. The rest of the guys were already gone, and for some reason I went later with all the trunks of stuff. That was a fun trip.

SEALAB II was in July/August of '65 and had three teams. There were 10 guys on each team, two of whom did two dives. Carpenter stayed down for Team One and Two as Team Leader. And Sheats was Team Leader of Team Three. Dr. Sonnenberg was the doctor of Team One and doctor of Team Three, so he made actually two dives. We had 28 divers, 10 of whom were civilians. We had civilians from Scripps, Art Fleshing and Ricky Gregg, who later won the world surfing championship. Ricky went on to get his doctorate in oceanography and did a lot of deep diving with submersibles for Red Coral off Hawaii. He was quite a sailor. Also, there was Earl Murray, who dove the *Andrea Dorea*—lucky son of a gun. Then there was Bill Bunton from Naval Electronics Lab, and George Dowling and Bill Tolbert, Berry Cannon and myself from the old Mine Defense Laboratory. Morgan Wells was there, too.

There were 10 of us civilians; each team had a few civilians. And Wilber Eaton and Carpenter made the entry dive. That dive was 205 feet deep, give or take.

Carpenter went down in a wet bell with a little air pocket on the top, you know, real crude. He went down about 150 feet, and then swam over to the habitat. It was dark and dirty and miserable: mud, scorpion fish that don't move out of your way, visibility about 15 feet, maybe 20, dark green, and the water was cold.

Of course, the suits were permeated with helium, and we were breathing helium. I'm not sure what the doctors tell you about that, but it wasn't like being permeated with air and breathing air. So our biggest problem was cold—pure, unadulterated cold. We had EOD guys; we had your hard hat guys. I wasn't on Cannon's team. He was on the First Team. We had Tuckfield, and Barth was on my team. Barth did most of the cooking.

We did a lot of oceanography experiments, a lot of strength experiments. We did an excursion dive. We had a pneumo-fathometer we carried with us. Then Carpenter and I swam from the habitat to the ledge. The habitat was, like, 205 feet. We went down the ledge. It was dark and dreary; no sharks swimming around, just dark.

Anyway, the ledge goes down like a straight wall. We went down to about 250 feet, so about

a 50 foot excursion, something like that. And then the last team, Sheats and Bill Bunton, went down to 300 feet, which is the old excursion type thing. That's about the nicest dive we had, because it seemed to be a little clearer than where our habitat was located. I think we did 15 days, or something like that.

There was only one guy out of the 10, Bill Tolbert, who was able to dive every day, because everybody got ear aches. That seemed to be one of our biggest problems, ear infections.

In 15 days I got about 23 hours outside the habitat, which was the most. I didn't do it to get numbers, but it just happened to be. Tolbert and Dowling were the two oceanographers, and Tolbert had a bad leg, so it was really taxing for him to make these kind of dives. I'd dive with one in the morning and the other in the afternoon. So I actually made two dives a day, and lost a lot of weight. But some of the guys didn't get out more than an hour or so, because it was miserable.

No one realized it was going to be that miserable. I mean, it wasn't like the Bahamas; it wasn't fun. It was exciting. It was high adventure, but it was rough diving because the scorpion fish didn't move. Carpenter came up the ladder and put his hand on one. Very painful. They were all over the bottom. And the bottom was kind of a muddy sand, and you couldn't see very far, something like diving in a cave.

I think that SEALAB was not worth the logistics. It's so logistically intense that you just spend all your time existing, you know. That's why now they have the chambers on the ship, and the guys go down in capsules.

Bill Tolbert and I were out one day, and we were wearing the electric suits. The electric suit had a 38-pound battery pack, and we used that for a weight belt. And it was the first day of diving, or maybe the second. The Mark 6 had a purge valve that hung down where the battery pack was. The battery pack slipped off and caught the purge valve and inflated his bags. He started going up. Bill hooked his knees to hold the battery pack and did not surface. If he would have gone up, he would have been toast, of course, because he was already saturated.

I managed to grab him and get upside down and squeeze his bags. Then, in a vertical, foot-up position we swam over to the habitat. We grabbed the habitat. Thank God we weren't very far from the habitat. And then Kenny Conda helped us get inside. That was one close call.

I think we were very fortunate we didn't lose anybody, because it was hairy diving. But everybody was very careful. So SEALAB II, in my impression, was very successful.

A typical day would begin at 0630 or so, and you get something to eat. The environment inside was very pleasant. There was no humidity. It was warm. We ate a lot of peanut butter. After breakfast, we'd get ready for the first dive.

Carpenter was a very good team leader. He wasn't a diver, you know. He got trained as an astronaut, and diving, he probably made, what, about 20 dives, or something like that. So you've got to give the man a lot of credit for going down there in the SEALAB habitat and making that dive with probably less than 100 dives under his belt. Good team leader, very understanding. If he had an idea and it was dumb, we'd say, "Commander, that's not really the best way to do it." He'd say, "Oh, okay."

I told him that we needed to get two oceanography guys down; one with Tolbert and one with Dowling. So we would make a dive about 0800 and stay out as long as the temperature would let us, usually about 45 minutes, and we would be just wasted from the cold. We would go out and do a whole series of experiments. We did visibility tests, and we did strength tests, and we set up stations for checking water temperature, and guys did foam-in-place salvage tests, and bottom sampling, and things like that.

We did have a hot water shower, which was really great. We would shower off, then do housekeeping or whatever, or just get our body heat back. Then we would make another dive in the afternoon. By six or so, we were absolutely done, absolutely wiped out.

We ate a lot of candy bars, but we never sat down to a meal, because it was just not practical. Because guys were out in the water diving, there were guys cooking, and there were guys nibbling. But we got a lot of dives in. I think we got all the tests done, all the experiments done that they wanted us to do.

SEALAB III —1969

REAR ADMIRAL J. EDWARD SNYDER

Dr. James Wakelin, Assistant Secretary of the Navy for Research and Development, had Captain Cousteau over to get involved with diving. It had nothing to do with what you and I would have considered scientific oceanography at the time. He wanted to have an "inner space program," as we called it.

It was Senator Warren Magnuson who led the crusade, if I remember correctly. Magnuson was as crude as I was and always drunk. I can remember that he said, "We know less about the ocean's bottom than we do about the moon's behind." Wakelin and Magnuson were very close friends. One of my jobs at parties was to keep Magnuson happy, but not drunk. That was an impossible task in those days. I didn't know the word "alcoholic" but maybe he was an alcoholic. He sure liked to imbibe—let's put it that way. He drank a heck of a lot.

I always went as the aide when we had an ocean function, because the naval aviator would handle all the other things. But Dr. and Mrs. Wakelin always wanted me to come along because I was their Special Assistant for the Ocean's Bottom. Although my title was for surface, I spent at least 45 hours a week on oceanography, which included diving at that time. That was why he had Captain Cousteau over.

Wakelin had in the back of his mind the need to have a program that would be, and these are my words, a poor man's space program. The Assistant Secretary indirectly sponsored the Bureau of Medicine and Surgery, and we were also trying to convince someone to do surgery underwater in pressurized chambers. We were doing this also through the Interagency Committee on Oceanography (ICO), which at that time included a rear admiral from the Public Health Service as a member. It also included the Bureau of Commercial Fisheries and all these other ocean agencies.

When the Bureau of Commercial Fisheries reported to the ICO that they were having money troubles and would have to get rid of all their ships, Wakelin said, "I can help. The Navy needs to get some information about the oceans. Eddie, you go get some money and transfer it over to the Bureau of Commercial Fisheries so that they can operate their ships." Now, if you try to do that in today's world, or even when I came back as the oceanographer, you will be court-martialed. But we did have the authority to do that back then. We had the 6.1 money and could move it around.

We were looking for words to put the same kind of public emphasis on our inner space program that National Aeronautics and Space Administration (NASA) had for its outer space program. Do you do it remotely or do you do it with man? The Deep Submergence Systems Review Group had recommended both.

Like all good scientists, we never had enough. We hadn't studied it enough, so we needed both man in the sea and remote sensors in the sea. Wakelin was looking specifically at the business of putting man in the sea, and somehow or other through the ICO or things like that, he was also aware of Ed Link's work. Ed Link had been acquainted with him in the past.

Wakelin's background was in aviation, so they might have met through that or possibly through the connections they both had to the National Geographic. But Ed Link was involved. Dr. Wakelin put him on the DSSRG. We were trying to look at how we could get people excited about the oceans. One of the ways of getting them excited was, of course, through the Bureau of Commercial Fisheries' interest in feeding the world's population with fish.

Everybody had his own ax to grind, but Wakelin decided that, irrespective of my recommendation to him and of the cost of putting man in space versus the remote, we would follow the space program and somehow or other we would have a manned diving program. I don't remember who invented the word, but it would be called "SEALAB." The reason it was called SEALAB was because we were doing this through the Office of Naval Research, as that was the only legal way we could get a new program started.

We had the concurrence of the Senate. We also had support from the House of Representatives. I can't remember the house members who were supporters of it, but it was in a subcommittee. We took all of them on a flight to show them Scripps and all the other labs. From that, we got lots of supporters, including, I think, the congressman from Michigan, who may still be in the Congress. I remember riding in the plane with him and we were talking about its importance. To me, it was absolutely fabulous to realize that we had supporters from places like Michigan, who maybe had a lake but didn't know what the word "ocean" was. They were interested in Detroit and automobiles, but you had those gentlemen really believing that it was a great program, that the United States really needed to do something about it. We were trying to get something started in the manned side of the program.

We had a lot of those programs run by the Bureau of Medicine and Surgery and the Supervisor of Salvage and so forth. But Wakelin had a broader concept and said, "Eddie, we're going to do this like the space program. You go get Scott Carpenter. If we can put him in the SEALAB, then we're going to have a program that will get us some attention. We need attention to get more support from Congress so that we can get the program financially sound." I don't remember what words he used, but they basically meant you could not have a program without people and you could not have a program without money. The problem was getting the people and the money.

George Bond briefed Dr. Wakelin. I don't remember whether the secretary was there, but I seriously doubt it. We're talking hours of briefing, because Dr. Wakelin could get carried away. The Secretary of the Navy can't do that. But that was Dr. Wakelin's personality.

He was using Captain Cousteau, and nobody used Captain Cousteau. Captain Cousteau used other people. But Wakelin thought he was using Captain Cousteau to get the Man in the Sea program moving, because the French had already done it and that was how Dr. Bond came in. I didn't know him personally. I had met him and was impressed by him, but I didn't know anything about medicine. These new subjects could easily impress me. My background was in hard physics. It wasn't biology. I couldn't understand what the medical problems were but knew that you had to have people. In those days, the people who really understood man's ability to survive in the ocean were, in fact, in the Navy under the Bureau of Medicine, and that was where Captain Bond came in.

I think the Man in the Sea program and SEALAB were things we were looking forward to for the future. I didn't realize how dumb it was, since the electronics we had in the SEALAB program were not solid state but filament, the old vacuum tube. That helium gas wiped out the vacuum tubes and we lost communication.

Stupid little things like that used to happen. I think that was because we were using people to run the program who shouldn't have been doing that, but we couldn't do it any other way. We couldn't get anybody outside of the Office of Naval Research, because they were the only technical people that the Assistant Secretary actually controlled and owned.

He didn't own the Bureau of Ships (BUSHIPS). Some of the people in Bureau of Ordnance (BUORD) could have helped a lot. They did help some, but if you had put them in charge of the program, it would have never gotten

done. We made a lot of mistakes because we had a lot of people, including yours truly, who didn't really understand anything.

You remember I didn't know biology and certainly had no knowledge about medicine and still don't. Yet, I made the decision to keep the Bureau of Medicine strategically involved with it and made the decision to convince the secretary to enhance what was going on in Bethesda in the diving program.

I didn't know if Bond was a politician. I really couldn't have cared less. I knew that he was a good spokesman. I knew he could get the attention of the assistant secretary. I knew the assistant secretary would listen to him. I knew that the assistant secretary wanted to do something but wanted somebody to tell him what to do, and I wasn't going to tell him because I didn't know. One of the things that kept me alive for five years was that if I didn't know something, I called somebody who did. I would say, "I'm sorry, sir. I don't know. I'll find out and let you know." That was so unusual in the E Ring in the 1960s.

During that period of time, it was characteristic of both the Wakelin and Ed Snyder approach to life that it didn't matter what the chain of command was. Go find the guy who knew the most about it.

Captain Lew Melson was the only one who was actually trying to take charge and get something done at ONR, and only ONR was doing it. I kept telling them how important it was, in a classified sense, to have the capability of putting a man outside a submarine. It was obvious to me.

I used to kid the boss. I would walk in his office and say, "Well, the forces of darkness got to me again today." He'd ask what I meant. I'd say that the submarine community had closed their doors again. I'd say, "I may need your help," and he'd say, "Okay, call me if you need me," or something like that. It became a joke in the office.

That was the time when Admiral Rickover was totally in charge of nuclear submarines. He didn't really appear to dislike research and development, but he didn't like it. Then, he almost went down on his hands and knees to get my boss to agree to let him have the first nuclear research submersible, the NR-1. We had an interchange with R&D for not the first time. After that fiasco with the USS *Seawolf*'s sodium reactor, Admiral Rickover just didn't trust anybody in ONR.

The assistant secretary talked the Secretary of the Navy into hosting a lunch with Captain Cousteau for the Man in the Sea program. Wakelin had been the director of *National Geographic*'s research team, committee, or whatever they called it. He had been involved with the *Calypso* and with Captain Cousteau on other subjects.

We needed somebody to get the secretariat up to speed on how important it might be to have manned capability. We weren't telling Captain Cousteau about the long-range view of using it in the classified sense, only about the ability to exploit the ocean. I think it worked. I remember it only because Mrs. Cousteau was the first woman ever to have eaten in the Secretary of the Navy's mess.

As a result of the Deep Submergence Systems Review Group (DSSRG), Dr. Wakelin wanted to support the Man in the Sea program. That was what we called it, "Man in the Sea," but we didn't have it all clear in our minds. We made a heck of a lot of mistakes.

I remember the first absolutely stupid mistake was that we forgot that vacuum tubes were not solid state in those days. Helium wiped out a vacuum tube. There we were, trying to do research with cameras and stuff, using vacuum tubes in a helium atmosphere and all of a sudden, the gas wiped out the entire communication net. Those were the kinds of things with which ONR should have helped us. There was no reason in the world, in my mind, that the assistant secretary for research and development should have been running a technical program. Wakelin did not want to run a program. He just wanted to see that it got going and that he was kept aware of it.

As a result of the *Thresher* loss, the SEALAB program got attention from the office of the Secretary of the Navy. Also, the Deep Submergence Systems Project (DSSP), PM-11, was set up as a consequence of the DSSRG's report. ONR had done SEALABs I and II, but SEALAB III was transferred to John Craven at the DSSP to carry out.

John Craven was, to my knowledge, the first civilian, or civil servant, chosen to run a major project within the Navy materiel establishment. It was intended as a permanent selection, but interestingly enough, within a month after I left ASN, all of a sudden there was a Navy captain running the DSSP.

They relieved Craven of chief scientist of PM-1, the Polaris Project Office, when he became the program manager at the DSSP. He thought he was still their chief scientist. He may have been to Admiral Raborn and Admiral Levering Smith, but his official job was the program manager for the Navy's Program Management Code-11 (PM-11) and that was to be permanent. I don't care what anybody else says. That was permanent.

The assistant secretary for Navy R&D did it. You've got to remember the Secretary of the Navy owned and controlled not just ONR, but the entire materiel setup. We established the Chief of Naval Materiel (NAVMAT) as a four star admiral's billet. The blue suit Navy didn't do that. They didn't want a four-star running something big outside their chain of control, pushing buttons and stuff like that.

The Assistant Secretary of the Navy (ASN) controlled NAVMAT and PM-11 came under NAVMAT. We made a recommendation for the first chief of Naval Material. Remember that it was four stars, and in those days, we didn't have many of them. It was not like the world today. You haven't got a room big enough to bring them all together. I'm being facetious, but it was important and meant that the Navy had to give up another four-star billet somewhere else in order to make the chief of Naval Material four stars. We made a verbal requirement, not in writing but verbal, that no one would be promoted to that job unless he had previously demonstrated successful management of a major program. I forgot that it was another thing that I got Secretary Nitze to sign. Who did that leave you with in those days? Red Raborn, the head of the very successful Polaris Development Program was the most successful program manager in the 1960s.

DR. ARTHUR BACHRACH

I was involved with isolation studies at the Naval Medical Research Institute (NMRI) but, at the time, the program was mostly isolation research for the National Aeronautic and Space Administration (NASA). It was social psychology, and that was not what the Bureau of Medicine and Surgery (BUMED) had in mind. They at least felt that the isolation work had contributed to the ideas of undersea habitats and space, but they were interested in different aspects of it.

Well, we began phasing out the isolation studies. It was in a contract with NASA, and there were some realistic aspects of isolation. One of the things that I think we learned from the isolation studies was seen on SEALAB III.

When you get into a limited stimulus situation, the fourteenth cough behind you, in the movies, is no louder than the first cough; but, by the time the fourteenth cough comes, you're sitting there with your shoulders tensed. That is stimulus intensity in a low stimulus area. You get high in stimulus intensity from limited space. I'm sure it was also true on SEALABs I and II.

We did see in the isolation studies, and this has been reported generally, that there were mannerisms that would really get on people's nerves, like the way people ate or repetitive phrases, or things like that. People would keep using the same phrase. I don't believe in simulation, in that sense, because they can get out and know that they can get out, but you still get some reality in there.

I remember talking to the divers in SEALAB II. Some of them didn't get along on the surface

at all. But the phrase I heard several times from people, about when they were in the isolation habitat, down on the bottom, was that they were "walking on eggs." They were very careful not to do anything to annoy each other.

The isolation studies taught us something about what happens in a low stimulus situation. In my own opinion, I don't think that they contributed too much to the reality of the situation because of that one factor: they could get out.

We're getting into sea stories, but there was a time they were doing a thousand-foot dive at the Navy Experimental Diving Unit (NEDU) in Washington, D.C., at the Washington Navy Yard. One diver's wife was allowed to talk to him on the radio. The chief never should have let her in to NEDU, but he did, and she announced over the phone that she was leaving him. Of course, he went berserk. They had to sedate him and keep him down, but what a wonderful "Dear John" letter that was. She knew that he couldn't get at her. That was an aspect of it. But I think that there was a technology transfer there.

There were, I think, aims in NASA. There was a guy by the name of Chuck Kubokawa with whom we worked, and he gave us some thermal suits from the space program. We tried them out for divers and it was good transfer. Of course, NASA, the Navy, and the military in general, I think, have contributed a great deal to what we know now as medical technology and scientific technology.

Working with divers is so rewarding in so many ways. On SEALAB I, I became very close friends with Ken Conda, and one of the first things I did when Ken got out of the Navy was to hire him at NMRI. I also hired Bill Armstrong. I got two SEALAB divers, as civilians, and my belief was that you couldn't train a scientist to be a diver very well, but you might be able to train a diver to do research. We had Ken Conda on the bottom in the ocean habitat Aegir, in Hawaii, and you couldn't fool him, because he knew when a diver was fooling around. He was an excellent researcher. Ken Conda and I got to be very, very close friends. On SEALAB III, I was put through a gauntlet. I came aboard SEALAB as a psychologist, and for the first two weeks, they took me down to the Blue Fox in Tijuana. They took me to the Body Shop in San Diego and ran me through this test.

At the end of two weeks, Bob Barth said to me, "Well, you're okay for a ding-a-ling." I got to really respect and know the divers. Bob Barth is truly one of the people who has always stuck out in my mind as a leader, an individual who could do anything, and a good, respected person. I felt that George Bond was an incredible father figure, almost, "Papa Topside." George was maybe not the greatest scientist because we know, and I was in on some of this, that he would interrupt some of the research on the bottom at times to give a sermon. He was religious and loved to quote scripture. In the middle of an experiment, his voice would come down, and he would read to them. But George Bond was one of the people I really respected.

Let me tell you a story I have never told anyone. A bunch of us on SEALAB were sitting in the Bali Hai on Shelter Island, and we had one Navy grog after another. A grog was the rum drink at the Bali Hai. George Bond said, "Let's all go downtown and get 'SEALAB' tattooed on our arms." We said, "What a great idea." We went down to First Avenue in San Diego, I think it was, and it was probably half a dozen of us. We went down, and the tattoo artist looked at the SEALAB patch that someone was wearing and said, "I don't think I could do justice to that, but there is a tattoo artist in San Francisco who could do a beautiful job." George Bond asked, "What's his phone number?" The tattoo artist gave George the phone number. By the time he got around to phoning, we all sobered up a little bit and decided no, we didn't want a tattoo. If that tattoo artist in San Diego had been sufficiently confident in doing a good job, I'd probably be walking around with a SEALAB tattoo. I don't think I've ever told that story, but George could lead you anywhere. People would follow him. He was a remarkable person.

I told Barth this story about the tattoo when I was down for the dedication of the George Bond Saturation System in Panama City. Afterward, a bunch of us went out to a bar and had some drinks. I was sitting next to this young diving officer and he said, "Sir, could I ask you a question?" I said sure. He looked around and asked, "Who was George Bond?" I thought, "Oh my God," and I told him. I got hold of Barth and said, "You have got to brief these guys." Some of them, or at least this guy, didn't know who George Bond was. I guess there was an assumption that well, everybody knows who George Bond was. But here was a diving officer who didn't know who George Bond was and he was too embarrassed to ask. I guess he could feel comfortable asking an outsider, as I wasn't going to see him on a day-to-day basis. But that was something by which I was really astounded.

MR. BOB BARTH

When SEALAB II was finished, I was living in Panama City. We went back to Panama City and knew that Dr. Bond was going to try for SEALAB III. That was in November of 1965, and the ball started rolling.

The next year, we all met outside of the city. We left Panama City and went to San Diego and set up housekeeping there. We started bringing in newer people and training them for SEALAB III. SEALAB III was made from the SEALAB II habitat by refurbishing and redesigning it.

We added a room on each end. It gave us more space. We did different internal things like what you would do on a car. (You know, the 1980 version looks the same as the 1981 version, but there are new and improved things inside. The cigarette lighter works better.) The bunks were better. The refrigerator was better. The cooker was better and so forth. The biggest thing was that we had to set SEALAB II on the bottom. Unless we had a level field down there, the habitat was going to be at whatever the angle the bottom was. We changed that. The habitat was buoyant and hung off a clump that we put on the bottom. It hovered, so to speak, not floating around, but it hovered. Then, we clamped it. We put legs on it. The legs were kind of my idea. By that time, I was the habitat officer and was therefore responsible for some of the things we did, like outside storage, for example.

We had new managers on SEALAB III who we didn't have previously. We had to recognize other people who were part of the management staff of the Man in the Sea program. Obviously, we didn't always agree with things they said. We had almost ten years of experience doing it ourselves and never having to worry about doing it right or wrong and so on. All of a sudden, we had people who made sure that we did it safely. It grew from a ma-and-pa outfit to a large corporation. That is what it boils down to.

I didn't like it. I didn't like the idea that there were a lot of people who didn't know my job telling me how I should do it. That's Bob Barth. I have been known to be a little outspoken and opinionated, but I don't believe anybody should direct me as to how to do my job when I've done it for a long time, and they have just gotten here. I blame some of the problems that we had on things that we shouldn't have had to go through. That is my opinion.

I was selected as the team leader for the first team on SEALAB III. I had eight guys with me. We trained to do our particular jobs. We had five teams on SEALAB III, and each team had a lot to do. My team was to get in and open it up. Then, we had projects that we did outside. The second and third teams both had different things to do. Man, we hadn't gone to 600 feet before, and we were going to go down and live at 600 feet. We were quite confident that we were going to be okay. It didn't work out that way, but it was a good opportunity. Not once in my life did I ever think that I wanted to be elsewhere.

Maybe things went wrong because it was just a question of some people who weren't trained enough, a problem with equipment not functioning as it should have or different things that went wrong that shouldn't have gone wrong.

There was a redesign of something that worked fine in the first place. For example, the redesign of the penetrators that fed the electrical and other stuff into the habitat. They changed that on us, and that was where we had our leak problem.

The habitat was going to house forty people or better. Each one of those forty people, or at least every two out of that forty, in each group, had a project. Plus, everything was new. We had new people who wanted to put a stamp of approval on something. We had new systems in effect in the Navy that we didn't have before, regarding decision-making and the certification-type people and so forth. We were constantly being told, "You can't do this that way. You have to do it this way," as opposed to another way, or "Here's the way we're going to change it. Instead of doing it the way you thought, we're going to do it this way." We had equipment that didn't make it there on time, and we had to find a different way to do it. I think you find that in any organization that grows as rapidly as we did.

I saw things that annoyed me, and other guys saw things that might have been just the way they had to be. Heck, none of us like change. We were confident that we could do it, having done it before. You know, in my case, I was maybe so confident that I should have been more aware that all those things were going on. But I had done two SEALABs and had been involved in all of the tests before that, with the Genesis programs. I was kind of a smart aleck. I didn't need to be told by some Johnny-come-lately what it was. It didn't create a problem with me doing my job, but I just didn't always agree with the changes. Equipment was placed in there or reshuffled and I didn't think that it should have been.

We were going to live in 600 feet of water. The physiological attack on the human body is more pronounced as you get deeper, so your danger, if you want to call it that, is heightened. There was really nothing dangerous about saturation diving, but danger, if you want to use that word, increased as you got deeper. All of that was fully known by us. None of us were worried about it.

DR. JOHN CRAVEN

The people involved with the saturation diving program and the Trieste did not realize that they were about to be picked up by an intelligence-motivated project under my direction. They didn't know anything about it, and I didn't know that the Man in the Sea program was going to be assigned to the Deep Submergence Systems Program (DSSP). When I made that decision, I just presumed somebody else was going to develop saturation diving.

All of a sudden, to my shock and surprise, I was assigned the responsibility for saturation diving and the responsibility for SEALAB III, right in the beginning. It came at a time that was very inconvenient for me to do anything other than to tell the commanding officer of SEALAB III, "Go do what you're going to do and just keep me informed." Yet at the same time, I knew that I had real responsibility if anything went wrong on SEALAB III. SEALAB III was not organized properly, from a naval standpoint, in my estimation. At the time I took over, it may have been organized correctly, but the commanding officer was not in attendance one hundred percent of the time. He went back to the Office of Naval Research (ONR). He was from ONR. He had responsibilities in ONR. I don't blame him. I'm just saying that was the way it was organized.

The way I organized it, CDR Jack Tomsky was going to be there one hundred percent of the time. A commanding officer was going to be there one hundred percent of the time, and if he were not there one hundred percent of the time, he would have needed a commanding officer to relieve him. That's what an operation in the Navy is all about.

I started to visit Hawaii in connection with the classified programs. These were visits that took place for one or two days at a time. When one of those visits took place, because of classification, I tried to look like a college boy

and not indicate to anybody that I had any relevance to the United States Navy. On one of these trips, I got off the airplane and these two local guys came up to see me and said, "Aren't you Dr. John Craven?" I turned around and said, "I don't think so." They said, "Well, we've got your picture right here. It looks like you. It must be you." I said, "Yes, it's me. Why are you asking?" They answered, "Because Governor Burns wants to see you."

I had no idea why Governor Burns wanted to see me. I said, "All right." At that time, because I was in charge of the SEALABs, we were deciding where we were going to locate them. There was a moderate amount of competition from various areas of the country as to where they would be located. I went in to see the governor, who was a fabulous guy and not a politician in any sense of the word. He was very laconic. He smoked a cigar. He spoke in grunts and grimaces more than anything else. He was puffing on a cigar when I was introduced to him. He said to me, "Dr. Craven, why won't you put SEALAB in Hawaii?" I thought to myself, "This is the first governor who has knowledge about a thing like SEALAB, and he thinks SEALAB should be in Hawaii."

I started to enumerate on the reasons I might not put the SEALAB in Hawaii. I said "Well, Governor, it's a very complex thing. We have to have very good medical services available." He said he had hospitals and that it had already been arranged. I said, "Well, but you've got to have a diving unit of significance." He said to me, "We have a diving unit here, at Pearl Harbor. I've already talked to them. It's already been arranged." I said, "But you've got to have water close to shore. You have to have a base right on the shoreline, where you could easily get out to the lab." We needed water that wasn't too deep. He said, "We have Barber's Point. It's already been arranged." I said, "The big problem is that you have to have water that is cold. We want to test these guys in an environment that they might be in, and we want cold water."

He didn't know, and I didn't know, that there is cold water there, but at that point, he said to me, "Dr. Craven, that's a mistake." I asked, "Why is that?" He said, "You're going to be doing this for the first time. You don't want to make it so difficult and so hard that you can't do it. You want to do it first in the warm waters of Hawaii before you do it elsewhere." I thought that was pretty remarkable, so I said, "All right, Governor. What I'll do is I'll have my site review team come out and visit you." but I knew very well that we would not do it there. Then, I thought to myself, "How did the governor know I was involved, and how did he know what is involved?"

That night, I went to the officers' club and met with Admiral Chick Hayward. Now, Chick Hayward was a very significant admiral in the Navy and knew about all the strategic planning. The reason he was so important was because he had started out in life as a batboy for the New York Yankees and had then become a sailor. As a mustang, he got in the Naval Academy and progressed through the services, but during all that time, he stayed a lifelong Democrat. As he proceeded, he became a flier, and a very distinguished flier at that. When the carrier USS *Franklin Delano Roosevelt* was launched, he said they had to select a captain who was a Democrat to be the commanding officer of the *FDR*. He said that he was the only captain in the United States Navy who was a Democrat. They made him the commanding officer of the *FDR*.

That is relevant, because I first ran into him when he was head of the strategic program office in the Pentagon, and at that point, he had to rule on one of our programs as to whether it would exist. A secretary recorded the meeting. When the meeting was over, he approved the project. There were other people in the Navy who felt that he did not approve the project. We went back to the transcript, and the last lines on it indicate that he holds his thumbs up says, "Bet on the Yankees, the Navy, and the Democrats, and you'll never lose."

That could be subject to interpretation, but that was his statement of approval. By this time, I was getting to know this guy extremely well, and he was out here, at Pearl Harbor. He was at Pearl Harbor and meeting with Governor Burns once a week, and Governor Burns was very much interested in getting Navy projects to come out to Hawaii. Governor Burns said to him, "Hey, I hear there's this project called 'SEALAB.' Why isn't it out here in Hawaii?" At that point, Chick Hayward, though he should not have, said, "Dr. Craven is in charge of this thing. He is going to be out here next week. I can arrange to have him meet you." In a sense, that was a security violation of some sort, I suppose.

I suddenly realized that they should have assigned SEALAB to me because I now saw the connectivity between the SEALAB and the *Seawolf*. But I also knew that, in the nature of this security, no one was to know that connectivity unless they had a need to know. When the *Seawolf* was being modified, the people on it had no idea why the *Seawolf* was being modified. The shipyard had no idea why the *Seawolf* was being modified. We just told them, "We want you to cut the *Seawolf* in half and open it up and get ready to put another section in and so on and so forth, with certain characteristics." That was very bad for the morale of the *Seawolf* crew. It was terrible for the morale of the crew of an operational submarine to be sitting there for a long period of time with all sorts of phony stories being given to them as to why it was still there in the yard.

We got through, successfully, with SEALAB II and started to organize for SEALAB III. As we did that, I was working with Bill Searle, the supervisor of salvage, on a joint project for the development of deck decompression chambers, personnel transfer capsules (PTC), and all the things you needed for an operational navy of saturation divers. The operational equipment development was carried out jointly between Bill Searle and us as part of our large-object salvage capabilities and part of his responsibilities. Therefore, we built a very elaborate, thoroughly tested set of equipment. SEALAB III did not have laboratory equipment on the whole thing. Everything was there and ready to go into the fleet.

As we started on SEALAB III, I had already decided that the management was inappropriate, in terms of an operational command. I was looking around for a project manager. Bill Searle called me up and said, "You want to get 'Blackjack' Tomsky." I asked, "Who's Blackjack Tomsky?" He explained that CDR Jack Tomsky, having come through the enlisted ranks, was what the Navy calls a "mustang" and who had a lifetime of experience at sea with salvage, and he was the head of the Engineering Duty Officers, and so I said to Searle, "Hey, I don't want that. I want a project manager, okay? I want a project manager." Searle said, "Well, you should take Blackjack, okay?" That was it.

An hour later, I got a call. A man said, "This is Blackjack Tomsky. Can I come over and talk to you?" He came over and he talked to me. He sat down and leaned over and said, "What makes you think I can't be your project manager?" He said it in the same tone of voice and I later recount him saying, "What makes you think I haven't got an ace in the hole?" If you play poker long enough, you know exactly what a guy means when he says it to you in that tone of voice.

I went down the list of all the elements of the project, and he answered, "Yes, I can do that," or "No, I can't, but I'll learn." When he finished that whole thing, I said to myself, "Congratulations, Jack. You're the commanding officer and project manager of this project. You are the kind of guy I want." Again, he had the credentials of solving all these problems in battle. If there's anybody who has a terrible time during a war, it's the salvage master. Can you imagine that? You're getting shot at while you're doing salvage and things of that kind.

The next thing that I immediately did, and I knew I had to do it, was to tell Blackjack, "You know, I do not like to be head of a project for which I don't know the technology. I want you to get me acclimated and help me learn this

technology as fast as you can. I don't mind if you cut corners or anything of that kind. I want you to do it as fast as you can." He said, "All right, I think we can do that. Are you in good health?" That was my medical exam. He said, "Can you swim?" I said yes. That was my swimming proficiency exam. He told me to report to the Navy Experimental Diving Unit at the Washington, DC, Navy Yard the next Monday.

I reported to the diving unit the next Monday and the first thing that happened that morning was that I swam with every single piece of open-circuit and closed-circuit scuba gear in the United States Navy. As I swam, I had a chief going alongside me with his fist clenched, ready to punch me in the belly in case I held my breath. I finished the morning, and we had a little lunch. I asked, "Was that it?" No, no, no. They took me and they put me in a hardhat diving suit. They took me and dumped me in the Anacostia River and gave me a thing to assemble. When I got down to the bottom of the river and put the thing up to my face, I couldn't see anything.

I don't know if you saw *Men of Honor*, but the toughest thing in *Men of Honor* is when he gets down to the bottom. The assembly's been thrown down and he has to assemble it. He's told, "You've got to stay down there and assemble it or you flunk." I got down there and dropped this equipment. I called up to Tomsky and said, "I've got this stuff in the mud. What do I do now?" Tomsky said, "You get it and you assemble it." I got it and assembled it. It was difficult, though, you know, and they pulled me up. I asked, "Okay, am I finished now?" No, no, no.

Then, they put me in a compression chamber and they took me down to 200 feet and brought me back up again so that I could get the feeling of going down to 200 feet and coming back up again. That was all in one day. That was my certification qualification. It served several purposes. First, it served the psychological purposes of Tomsky telling the team about it, because the whole team was comprised of master divers. They were all mustangs. I had the advantage of being a mustang. I was this man with service at sea and a good conduct ribbon before I became an ensign. That immediately put you as a mustang. In the Navy, a mustang has credibility as a sea person, almost above academy graduates and legitimately so.

At that point, we started moving out. Jack moved out on the SEALAB program with a great deal of resistance from the people who didn't like the fact that it was being transferred over into this military thing. He never told them anything about the future operational capability. He didn't know too much about that.

MR. BILL CULPEPPER

During this time, the Office of Naval Research had sponsored SEALAB I and SEALAB II, but the Deep Submergence Systems Project Office took it over at SEALAB III. We finished that in 1965. I want to say that it was the next year that SEALAB III began.

The most astonishing thing happened when we had the first SEALAB III organizational meeting at Hunter's Point. We had a big meeting, and Commander Jack Tomsky, the project officer, made the statement that the people who were involved in SEALABs I and II would not be technically involved in SEALAB III. We ended up being tasked with the engineering evaluation after the fact. We were also to provide some equipment, such as a combination washer/dryer unit, an infrared oven and a carbon monoxide burner.

They used the same hull for SEALAB III, but they added a big room on each end underneath the hull. I think the one on the entry end was primarily like a dive locker. There were spaces and hangers for dive gear and the showers, and all that stuff, to make more room inside the main hull. The other end contained a freezer and other storage space, plus the emergency exit.

One of the things that happened to SEALAB II, with all the survey work they had done at the habitat bottom site, was that they had determined the grade was three percent.

We decided that leveling jacks would not be needed. But when the habitat was manned, they found that the bottom grade was near ten degrees. That was where they got the name, the "Tiltin' Hilton." On SEALAB III, they wiped the bottom structure off and made an anchor, in effect, with the habitat articulated above, so no matter what attitude, the bottom of the habitat would hopefully float at level.

In Panama City, we sent out requests for quotes (RFQ) for a washer/dryer unit. Although we had not RFQ'd Sears, that was the only quote we received. We bought the Sears unit but found that it was too large to fit through the hyperbaric chamber lock for pressure testing. We called Sears and ordered a technician to come out to disassemble the unit and then reassemble it inside the chamber. After a successful pressure test, the Sears procedure was reversed.

We also procured, modified, and tested an infrared oven, as well as designed and tested a carbon monoxide burner. This unit utilized a heated catalytic bed to convert carbon monoxide to carbon dioxide and was designed by Ray Bentz. The operation started out badly. In doing our engineering evaluation, we had everything instrumented. We had flow meters on all the gas lines and sensors on all the electrical systems, the motors and things of that nature.

While the habitat was pier-side, in Long Beach, we did our final checkout. In checking the motors, like the scrubber motor and DH pump, a total of six three-phase motors, we found that all but one was running backwards. The electrical system was monitored by a frequency meter to indicate the proper power phase connection. The meter indicated that the phasing was correct. But Bob Porter, wanting to be sure, went up to the electrical shop and got another frequency meter, which was good, and brought it down to check it out. He determined that the installed meter was defective. We reversed two of the shore power leads. Then, five motors were running correctly, and the DH pump motor was running backwards. We rewired the DH motor to make it run forward.

When we were at the site and they were doing the surface checkout after hooking up the power, they found that all motors were running backwards. Someone in the group noted that my team had made some changes to the electrical system in Long Beach, and I was in trouble for not reporting the fact. I informed them of what we had done at Long Beach and that the frequency meter was defective. The shipyard folks said that was not possible because they had built it in strict accordance with the drawings.

In answer to the question, "What do we do now?" I suggested to Ed Carpenter that if he went down to the shipboard power panel and reversed any two leads, everything would be fine. It was. The next morning at breakfast, I was told that I was right and a new meter had been obtained and installed in the habitat. But for what? It didn't make any difference at that point in time. Everything was hooked up and running correctly.

The next problem surfaced when we found that the heaters inside the habitat had not been turned on before the habitat was lowered. It was at 600 feet, in 45-degree water, with no heat. The next question was how long it would take to heat it up after we got inside and turned everything on. We went back to the beach and worked for several hours that night, calculating how long it would take to heat it up. I don't remember the number now, but I remember it was quite a number of hours.

The next problem was that the habitat was leaking gas at a significant rate. There was an urgency to get someone into the habitat to try to stop the leaks. The night before they pressed the divers down, Berry Cannon and I had a room together. I didn't have a room at that time. He did. He had a double bunk. We had breakfast together and went out to the support vessel. I was the last guy to talk to him before he went into the chamber. I asked him if this would be his last dive and he answered, "No." He wanted to go to 1000 feet. I wished him good luck and we shook hands.

Berry and Bob Barth were on the first team. They were selected to go down first, open the habitat and check out all systems. That night, Wally Jenkins and I were ashore and had our engineering van manned and monitoring all the systems in the habitat. In order to try to stop the leakage of gas, Berry and Bob were lowered to the habitat, but they could not open the hatch and were returned to the surface chamber. There was no heat in the PTC, nor was there any surface-supplied heat to the divers. At 600 feet in 45-degree water breathing helium, hypothermia was a real problem. The divers were very cold.

Due to the concern over the loss of helium with only a limited supply, another attempt to occupy the habitat was made about one in the morning. On that dive, Bob said that he had gone off to look for a crowbar, or something to pry the hatch open. That was when Berry passed out. Bob went back to him, but was too weak to pull him back to the PTC. Blackie Blackburn was the PTC operator. I talked to Blackie personally. He said that he went in the water and pulled Berry back into the PTC. I asked, "Well, how was it?" He said, "It was cold. Going in that water was just like jumping into ice water." Berry was pronounced dead after returning to the surface.

There was no heat from the surface. All of the heating systems were on the habitat. They had a four-foot square entry hatch on the habitat. The hatch was counterweighted. It had a cable/pulley/counterweight system to offset the hatch weight, but a half a pound per square inch differential is 1200 pounds or so. Since they were supplying gas to prevent flooding, it was certainly possible that there could be internal over-pressure. Things got worse after that. They were running out of helium and pumped air down to prevent flooding. The surface support also wasn't rigged to bring that thing back up. They spent the night re-rigging from the lowering mode to rigging up so that they could bring it to the surface. They brought it up the next day.

It was negatively buoyed. They had to winch it to the surface. They could blow the variable ballast and maintain a small negative buoyancy. I was in a cloud during that time. Nobody would talk to me. Tomsky and Nicholson were both there, and I wanted to know why this thing happened. Wally Jenkins and I had gone out that morning. It was before daylight. We went down to the pier and got on the boat to go out. Mike Greenwood was on the boat, and he said, "Hey, guys. I'm sure you probably don't know, but Berry is dead." That was the first we knew. They had probably called Mike during the night or something.

I wasn't there. I was ashore, asleep. I knew nothing about it. We thought they were going to go down the next morning and open it up. Apparently, with the leaking they had, they decided to go sooner. It was either try it or scratch the project at that point.

I never really believed the empty canister story until fairly recently. Bob Barth and I were talking about it at the last SEALAB reunion. Somehow, we brought up P.A., or Paul Wells' name. He said that he tried to get Paul to come to the reunion, but Paul wouldn't come. I said, "Well, does he believe he's responsible for Berry?" He said, "Well, sure he does." Up until that time, I had assumed that he had just died of hypothermia. I just didn't believe that could happen. I knew P.A. too well to feel like that he would let something like that happen. Apparently, it did happen.

I've heard that some people believe there was sabotage, but I figured that it was somebody trying to lay the blame somewhere else. I don't know. I just don't have any background or any information to express an opinion about how it might have happened. I felt that with P.A. in charge, something like that would not have happened. I won't say that it was P.A.'s fault, other than the fact that he was in charge. I don't know that he was supposed to personally check the rigs, or whether somebody else was assigned that responsibility and didn't do it or what.

I don't recall any decision being made to cancel SEALAB III. First of all, we had to go through Berry's personal belongings and itemize

all that stuff. We then went to a memorial service in San Diego. Then, I went to the airport to get a flight back to Panama City. I called my good friend, Danny Roberts, because I couldn't get a plane. He called the manager out there and got me on a plane somehow. That got me back to Panama City. Shortly thereafter, we went to Berry's funeral. As soon as the funeral was over, my family and I took a week off and went to a park near Ocala and spent a week and relaxed.

SEALAB III cost $30 million. There were many, many more people involved than with SEALABs I and II. I really don't know and am not able to say how many, but there were many folks. Just the Steering Task Group meeting was attended by a large roomful of people. All the minutes were taken verbatim by a transcriber, and the minutes of the meeting were like a Sears catalog, with every statement that anybody made. The modus operandi was that all the activities involved were going to be inter-coordinated by a contractor who sent people to Panama City, and they'd go through every task that we had. "Where are you? What's this? What's that?" They had the latest drawings, and they were supposed to be tying all this stuff together, particularly the interfaces, making sure the interfaces were going to work and all that. They had some good people involved. Dr. John Craven was there. He was involved and had very capable people working for him.

The problem, apparently, was in the shipyard. When they built SEALAB II, I had people there who monitored everything the shipyard did. When they saw anything that was not according to plan, they had it redone. On SEALAB III, they didn't do that. Now, as bad as it was leaking, my question is, did they pressure test it? We pressure tested SEALAB II. I don't know.

Bob Porter was involved in the inspection of the habitat afterward, and he told me that there were stuffing tubes in which the components were incorrectly assembled. There were some that had silicone rubber in them instead of the packing gland they were supposed to contain. There were some that didn't have any packing at all in them, and there was a report written containing that information. I managed to get a copy, even though distribution of the report was barred. Dave Haswell worked on the report and managed to get me a copy of it. I had it until one day when Captain Bond was still in Panama City. In fact, he had an office in Building 49, where my group was. George came in and asked if he could borrow my copy of the SEALAB III report. He said, "There's some things in there I'd like to look at." I said, "Sure, Captain." That was the last I ever saw of it, and then they planned to tow the habitat out to sea and scuttle it but apparently didn't have funding to do that.

We were allowed to go and take out some of the equipment that we had installed in it. Bob Porter, I believe, and I went out. It was sitting there in the shipyard, locked. We got it open and got our stuff and left, hearing later on that it was scrapped.

In my opinion the most significant thing that has happened in undersea technology during the past fifty years was SEALAB. If we could do it over, and all the barriers were removed, I would have had people out there on the job to monitor the shipyard's work and make sure that things were done correctly, because we had a lot of experience from SEALAB II. We knew the shipyard workers were not experienced in doing that kind of work. One of the things, as an example, was with one of the people in the design division. I had sketched out the scrubber/dehumidifier unit, and I had 12 lithium hydroxide/carbon dioxide canisters. They were on the bottom, at floor level, and it was an updraft system. I had the filters above, which used activated charcoal as a multi-purpose filter for hydroxide dust, odors, and other atmospheric contaminants. I had very carefully scaled the volume available and had specified the volume of charcoal to be included. Above the charcoal was the heat exchanger.

The guy doing the shop drawings to fit this into the habitat was a short little guy. He said, "There's not enough room." I said, "Sure,

there is. I've got it sketched out and scaled." He complained that he was having trouble getting that much in. He asked, "Why do you need so much charcoal?" I said, "Well, I put the carbon dioxide canisters in there. I then put in the heat exchanger core. What was left, I filled up with charcoal." He asked why. I said, "Well, I really don't know how much charcoal is going to be required for forty-some days of operation with ten guys in there. Do you know?" He said no. I said, "Well, that's how much we are going to put in there."

But they do most things by the book. They don't think. Well, they think, but they're just not used to doing research and development-type work. As it turned out, apparently, the charcoal filter worked pretty well. I don't know whether I had too much or too little, but I don't think that I had too little. I did have some literature on charcoal filters for restaurants, but that's totally different. You have cigarette smoke, grease, and all kinds of stuff in a restaurant. But I got some feel for a human quantity.

We were blazing a new frontier with SEALAB. It was fun, looking back. When I was there, it wasn't so much fun.

One of the problems that we had back then, in the days of SEALAB developing saturation diving, was that the Navy could never really come up with a solid mission requirement. Therefore, after SEALAB III, there was little effort or interest for a number of years. Commercial folks in this country have far exceeded anything the Navy has done on a volume basis, anyway. A while back, I went to an Association of Diving Contractors (ADC) symposium. It was probably three years ago, and I was amazed to hear that they were routinely working at 1200 to 1300 feet. I didn't know that. I knew it was possible. The oil companies have missions at those depths, but the Navy doesn't.

I think we ought to have a limited-depth capability in saturation diving, to 600, 800, even 1000 feet, or something like that. I don't think we need to go to the extreme, but it's something that, if we needed it, could be accomplished in a relatively short period of time, I think. We know the technology. It's just a matter of equipment.

CAPTAIN WALTER MAZZONE

All of a sudden, SEALAB became a part of the Man in the Sea Program. They were going to move away from New London at some point in time and find a base somewhere, and they had a dock in San Diego. In the meantime, we got to do a lot more work at New London in preparation for SEALAB III. We explored more fully the excursion diving and some other things.

Then, we moved the operation to San Diego. DSSP, the Deep Submergence Systems Project Office, opened up a facility there called the 'Deep Submergence Systems Project Technical Office.' Because of my background, I became the officer in charge (OIC) of that.

Unfortunately, we couldn't operate with the complete autonomy you would expect an OIC to operate with, because we were supporting a program manager in Washington, D.C. who said, "That's my office, only three thousand miles down the hall." That kind of an atmosphere was very difficult to operate in, because we had to start getting approvals, explaining, and getting things turned down only because of a lack of understanding.

It was as though you had people working for you and you were working for somebody else. All of a sudden, you found that your boss was going directly to people and you were not sure if it was the same message that you wanted or the same program that you really wanted done. You found people getting Temporary Additional Duty (TAD) orders somewhere without knowing about it.

What we really wanted to do with SEALAB III was go to 600 feet and do a multiple team concept. It was really an expansion of what we did in SEALAB II. We also wanted to see men do work with underwater equipment.

We had tremendous leak problems when we tried to pressurize the habitat. At first, we thought, "Well, somebody made a mistake and

put O-rings in or something. Somebody put some kind of pressure sealers in backwards." These were helium leaks and, of course, helium will diffuse through most anything and it would certainly go right through an O-ring. Technology had not kept up with the containment of helium, for one thing. We saw that on SEALAB I, II and III.

On SEALAB III, the only problem was the recognition of how to correct it or figure out what you really did see. The way to put it is that you really had to know what you were looking at and what it meant before you could take the proper corrective action. Then you had to convince people who were outside your field of expertise as to what needed to be done. But how could you do that if you were a lone medical service corps officer or up against a line officer or medical officer? I really don't need to say any more than that.

Looking back on the whole program, I suspect the line Navy had already acknowledged or absorbed the technical know-how to realize what they needed to do and didn't really need to go further. But I have a feeling that was kind of a blind decision on their part. I don't think they recognized the problems of containing helium under pressure in just a hose or umbilical to support things. But they knew what they wanted done and I think we demonstrated what could be done.

SEALAB III was a DSSP project, but Dr. Bond never went to DSSP. He went to the staff of Admiral Smith, I think, in the Office of Special Projects as an advisor. He stayed there.

Dr. Bond and I were the brains of the SEALAB projects, and both he and I were, in effect, removed from the front lines. It may sound like sour grapes, but we were sort of shunted to the side.

Someone else took over the project, but I was still supposedly the diving officer. There was even some talk about putting somebody else in there who might have more public appeal. Those are not the exact words, but I think you understand what I'm saying.

SEALAB III was an upgraded SEALAB II, but in a different way. Dr. Bond and I always visited the team's habitat while they were down there, except on SEALAB I. He and I went down and opened up the habitat to make sure it was okay. Then, I went down every day with the photographers because we wouldn't allow the photographers to go down and take pictures with the guys running around. So, I was there to cover every day.

On SEALAB II, I went down and inspected the habitat and came back up. The habitat was tilted. When I went down to visit the team, they had named it "the Tiltin' Hilton." They had a sign that read "Welcome to the Tiltin' Hilton." The SEALAB III leaders then said, "Well, we have to get away from that. We can't ever guarantee we're going to set it on a flat bottom."

What they essentially did was make a big pod that had all the heavy things and the gas bottles. They were going to make the habitat float above that. They wanted positive buoyancy, so that no matter how that pod was there, the habitat would float on a parallel. We don't know how well it worked. We never got a chance to use it.

With SEALAB I and SEALAB II, whenever there was going to be an evolution, we sat down and wrote a procedure. Most of the people we had, including myself, knew every single valve in the system, its function and its number. I don't think that was really true for people who were going to operate SEALAB III. For example, I went back to my apartment late in the afternoon, thinking that the evolution for the day was over, only to find out that one of the program managers decided to test the habitat that night by floating it in the dry dock.

When I came back in the morning, they were pumping it out and there was a lot of consternation going on because it had leaked. I asked questions about rigging it for dive. They said, "Oh yeah." I said, "Did you have a check-off sheet?" They said, "Well, we had a check-off sheet." I replied, "Well, dang it, you must have left a valve open somewhere," and the only valve that could really flood at that level was one drain valve, which was behind an access hatch and

about six inches around. I said, "Did you shut that valve?" They said, "Oh, yeah. We must have." Well, I went up in the habitat and it had not been shut. That's shows what can happen when you have a project run by committee.

The selection of the SEALAB III aquanauts was different than for the SEALABs I and II. Although we still had a lot of our original volunteers, new people were brought into the program. Some were people Bond and I picked. Others were direct inputs by people in the DSSP office. They would say to these people, "I'll get you in there."

DR. JAMES VOROSMARTI

I was assigned to Pearl Harbor when I became interested in the SEALAB project. I had been there for about two years and had a senior chief hospital corpsman there named Saunders Manning. Shortly after I arrived, Manning disappeared. He went on TAD somewhere. I didn't know where he was. He came back months later. I didn't ask him where he had been because in those days, if you were in submarines for diving, you never knew who was going where for what reason. He came back and then disappeared again. He got TAD orders. I asked, "What are you doing? Can you tell me what you're doing?" Well, he was on SEALAB I and II. He was on his way off to SEALAB III.

That sounded pretty interesting to me, so I volunteered for the program.

A few months later, the detailer from the Bureau of Medicine and Surgery stopped in and said, "We've got your letter volunteering for the SEALAB program, but we've decided we're going to keep you here for another year." I said, "Well, okay. I'd rather go to SEALAB, but Hawaii's pretty nice." He left. I think that was in July or August. On the first or second of September, I received orders to report to San Diego to the SEALAB program within twenty days.

We packed everything up and I went off to San Diego to what was the Deep Submergence Systems Project's technical office. I arrived there, and there was a master diver chief and nothing else, because part of the crew was still back on the East Coast. They were making dives at the Navy Experimental Diving Unit. We didn't have any facilities, so we used the commodore's office while he was at sea so that we had a telephone. SEALAB II had ended. They were getting organized for SEALAB III. That was in late 1966.

By that time, I knew who George Bond was. I knew who Workman was and I knew who Mazzone was. I knew him because he had taught us at sub school. I knew who all those people were.

It was amazing, though, thinking back on it, that we didn't know anything about the SEALAB I. It was not publicized at all. Even the people in the diving Navy didn't know what it was all about. SEALAB II had not gotten much more publicity. We had no idea what was actually going on, except for what Manning told me about living in this habitat under the ocean.

Shortly after I arrived at the Deep Submergence System Project Technical Office, within a few days I guess, Mazzone arrived and so did a couple more administrative officers.

A couple more people dribbled in and we ended up taking over a huge, old building above the submarine base on Point Loma, which had no facilities in it. We started planning for SEALAB III, ordering lab gear and designing laboratories and the spaces. Basically, we were trying to renovate the building and get ready for SEALAB III. Loads of equipment that had been used on SEALABs I and II arrived from the sub base in New London. We just started setting up the medical department and designing the medical research program for SEALAB III.

By that time we had a good idea of what SEALAB was about. They had come out with a big thick report on it. A lot of people who came to San Diego came there from SEALAB II. There was plenty of information from those people.

SEALAB III was going to be a lot deeper than SEALAB II, which was at 205 feet down or

somewhere in that range. SEALAB III was supposed to be on the bottom at 600 feet.

We started writing the instructions for the medical department and setting up procedures. We had to design our own spaces. We wanted to put in a research lab to do the research, so we had to design that. We had to order all the gear for that.

The research lab was going to be in San Diego. The support for the habitat was separate. Northrop Nortronics had gotten a contract to build the medical van and communications van, which went on the deck of the support ship, the USS *Elk River*. I was a contract monitor for that, so I used to go back and forth to Anaheim to talk to the engineers there who were designing the lab and buying all the gear for it.

At that point in time I was strictly a support person. There was a big argument that went on at higher levels about who was going to run the research program, whether it was going to be the medical department in San Diego or the people back at the DSSP and in D.C.

The medical department that was out there said, "We've done research. We know about these things. Why can't we do research? Why does it have to be done out of the office in D.C.?" Basically, they were going to contract it out to somebody, I guess. There was a big argument that went back and forth for months before they finally decided we would run the research program from San Diego. That meant we had to design the research programs and start setting up all the gear, calibrating everything, starting all the pre-dive, do all the baseline studies and everything else.

We were planning to pick up where SEALAB II left off. There had been a little research on SEALAB I, a little more on II, but nothing really exciting had been done. It had been of one of those piggyback deals with people thinking, "Well, we're going to have them down there, so let's draw lots of blood," and all that business.

The other thing that we were covering was a whole series of work-up saturation dives at the NEDU. At any one given time, about half the crew was back in Washington covering those dives or being subjects on the dives. We had started doing research during those dives, too. I think we did quite a bit of research during dives. We had all these different things constantly going on two different coasts. Shortly after I got to San Diego, I was sent off to the underwater swim school in Key West for a month to learn how to use the mixed-gas scuba Mark 6, which we all had to learn to use. It was the equipment that the EOD people used. It was semi-closed, so it didn't give off a lot of excess bubbles and stuff.

The Mark 6 was a semi-recirculating system. It was small. It was not much bigger than a regular scuba set and was non-magnetic because they had to get close to mines and other ordnance. I remember that school very well, because I was not in very good physical shape, as you can imagine one to be, after a couple of years on submarines and shipyards. The EOD class was composed of all these 18- to 21-year-old football players who wanted to be EOD people.

We had to get out and do calisthenics every morning at 6:00 or 6:30. It was too hot during the rest of the day to do it. The PT instructor was this 6'2"-240-pound American-Indian masochist who used to run his German shepherd into the ground before we showed up, and then he'd start working on us.

The other problem was that we didn't have a car. There was another medical officer and I there. We had to live in the BOQ, which was somewhere else. I can't remember where, exactly. We rented bikes and had to bike back and forth to the base every morning. It got us in shape in a hurry, I'll tell you that.

At that point, I knew that I was going to be actively diving in the habitat. That was exciting stuff. There must have been 35 people who were actually going to be doing things on the bottom or living in the habitat. Almost everybody who was in the program was basically going to be an aquanaut.

There weren't a lot of people standing around in the wings, hoping to get chosen.

There weren't a lot of support people either. It was basically just the divers who were going to be aquanauts or those who had been on SEALABs I or II.

When I returned from underwater swimmers school, the program was kind of stumbling along. There had been some delays with some gear. There had been delays with getting the habitat ready. I think it was originally scheduled to take place late in 1967, but it kept getting delayed and delayed for various reasons, most of which were engineering problems. Actually, they didn't start sinking the habitat until early February of 1969.

They had the SEALAB II habitat refurbished and added a few odds and ends to it. It was a long cylinder. It looked like an oil tanker, a railroad oil tanker. It had a little tower on the top that was used for controlling the flooding and the blowing of the habitat itself. It had two big items that looked like cages underneath it at either end. At one end, divers exited the diving station, and the other end was where they had an observation cage of sorts. In the middle was a huge anchor clump attached to the bottom of the cylinder to hold it down on the bottom. Also, it had some hydraulic systems so that you could level the habitat no matter what the angle of the clump was. You could make the habitat itself level on the bottom. They painted it bright orange.

To get into the habitat, you arrived at the depths through what's called a PTC. It was a personal transfer capsule, which was basically a big ball that was pressurized according to the depth to which you were going. The whole scheme was to pressurize people in the chambers on the support ship to the depth that they needed to go to.

The reason for that was that the pressurization had to be done very slowly because of problems you ran into while getting to that deep depth. You could have all kinds of aches, pains, and joint cracking. The way to get around that was a slow compression. We were also planning to do some studies on the way down to depth in the chamber on the support ship. At the top of those chambers you could mate the PTCs by a mating system that enabled you to go from the chambers to the PTC at the same pressure. Then, that was lowered over the side with a huge crane down to depth. Basically, you just took a breath, held it, and swam into the habitat. To open the habitat you needed to have diving gear in there, in the PTC, because you had to do a lot of work outside before you could actually get into the habitat. But once it was set up, you could just do a breath hold dive from the PTC to the habitat.

The habitat had eight bunks at one end. That was the living space. There were two bunks up, two bunks down. There were only eight total bunks. The center section was the galley, the lab, and the atmosphere control equipment and all of that business. One end was where all the diving equipment was kept and where all the gas controls for the divers were located.

There were some engineering problems in design of the equipment. We were using a lot of stuff that had never really been used before. The diving equipment was new. We were using the Mark 8 and Mark 11 semi-closed rigs, which were in the process of being built. They were basically prototypes. I can't remember specific engineering problems, but I know a lot of stuff was getting delayed along the line. We didn't get much involved in that side of it because a lot of that was being run through the office in D.C.

Saturation diving was a practiced thing already. The first saturation dives were made in the early 1960s. Workman, Bond, and Mazzone had started doing the animal work in the late 1950s. I had found out that animals could live in a helium oxygen atmosphere with no problems.

They did some short manned runs. I think one was done at the Naval Medical Research Institute and one at the Submarine Medical Research Lab, and maybe one was done at NEDU. Then they had SEALAB I. Well, SEALAB I was not the first in-water experiment because Jacques Cousteau had stolen a lot of information and came up with the Man in the Sea program. Ed Link had done at least one

saturation dive before SEALAB I. He also used information provided by the Navy. In 1966, a commercial diving company made the first commercial saturation dive at Smith Mountain Dam in Virginia. It wasn't new, but there was not a heck of a lot of it going on anywhere.

I remember George Bond as a nice old guy. He was the hero of everybody in the SEALAB program, because he was one of the guys who came up with the thing. I think he liked to envision himself as a poor, humble, country doctor GP, which he had been at one time. We didn't see all that much of him, because he was in D.C. But he certainly drank a lot. I remember that. That could sometimes be a problem.

SEALAB III had a very sad ending. Berry Cannon, Bob Barth, Blackburn, and somebody else, but I can't remember who, were in one of the chambers on the IX-501. They started pressurizing to depth about two hours before the rest of Team I was to pressurize in the other chamber. Well, when we reached the bottom, those of us in my chamber were supposed to do an exercise study. I think we got down there late at night and were told not to set up the apparatus. We weren't going to do the experiment. We asked, "Why not?" Well, they wouldn't tell us. We found out later that a leak had somehow developed in the PTC mating system in our chamber, so we had to put a strong back on the hatch inside the chamber.

In the meantime, Barth and Cannon had gone down in the PTC from the other chamber to try to open up the hatch to get into the habitat. Well, those of us in my chamber didn't know what was going on, but the habitat had started leaking. They couldn't get into the chamber on the first try because they were trying to keep the habitat pressurized so that it wouldn't flood. But if you try to push up a hatch that's four feet square against even a half an inch of pressure differential, you can't do it. He and Cannon made one dive and came back to the chambers on board the ship and then tried again a few hours later, and that was when Cannon died.

Well, they found out afterwards that there was no carbon dioxide absorbent in his breathing rig, so he died of carbon dioxide poisoning. That accident effectively put an end to SEALAB III. They raised the habitat. They brought out a submarine or two from San Diego and used the submarines' high-pressure air flasks to keep it from flooding as they raised it. It was taken off to Hunter's Point shipyard. That was where it sat. The investigation was finished. The SEALAB habitat was cut apart.

MR. JIM MCCARTHY

My involvement with the Navy's SEALAB program began after I completed my work on the Polaris Missile program. I was with Northrop Corporation and while the SEALAB program was foreign to me, the people were genuine all the way from the very beginning. My engineering task was to design and build a SEALAB III Command and Control Center and a Biomedical Van. The system was designed to perform biomedical testing for the aquanauts and moved the central control platform for the entire operation.

The first van was the primary Command and Control Center for the SEALAB operation. The van contained everything that communicated with the habitat, with the ship, with the operational side of controlling the program and was housed in the control van. Both the command van and the biomedical van were located and installed in the port side of the USS *Elk River* (IX-501) and connected through the umbilicals to the habitat as well as the two deck decompression chambers. The chambers were the primary compression chambers and/or decompression chambers to pressurize the aquanauts that were going to be transferred under pressure, in the Personnel Transfer Capsule (PTC), down to the habitat.

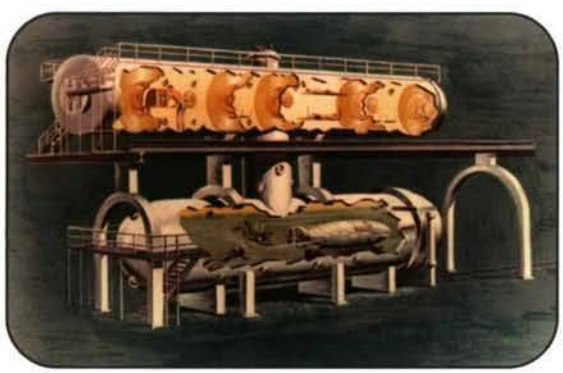
We developed the Command and Control Van and Biomedical Van in Anaheim and then shipped them up to Hunter's Point Naval Shipyard, where we installed the vans on board the IX-501.

The installation of the recompression chamber, the Command and Control Van, the Biomedical Van, and the piping system took the better part of nine or ten months to oxygen clean and install everything. The entire SEALAB crew went to work on Monday through Friday and sometimes even went back home on weekends.

I traveled to Anaheim and everyone else was stationed in San Diego, so we were doing a lot of back and forth traveling. After every segment of the system was installed, we started to test the system in the dry dock where the IX-501 was resting on blocks in a dry configuration.

When the habitat was lowered into the dry dock and then the dry dock was flooded, the habitat itself would do all the communication links and testing between the control van, the chambers control station and the command center. The Command and Control Van was primarily designed for command and control, gas analysis of the habitat environment, audio and video recording of all cameras located in and around the habitat, the onboard chambers, and the dive station. We recorded everything between topside and the habitat, the two decompression chambers, and the deck of the IX-501.

After the termination of SEALAB III with the death of Berry Cannon, the program just kind of fell apart out there and the only thing that we were doing was getting things off and ready to go back to San Diego for storage. At the time, we didn't know whether the US Navy SEALAB was going to continue in that configuration or not.



Navy Experimental Diving Unit (NEDU)

I went back to the engineering department at Northrop Anaheim. The US Navy was requesting three or four major companies to build the Ocean Simulation Facility. At the time, it was a Naval Facilities Southern Division program, but ultimately, everybody knew it was to be built for the Navy Experimental Diving Unit (NEDU).

The reason SEALAB III didn't succeed, I am sure, is recorded history as precisely what had happened, but let me first explain how the electrical interface for SEALAB I and II were both designed. The electrical cable (umbilical) was connected from the surface ship or barge down to the habitat and routed below the habitat then up into the habitat through a stuffing tube then connected to the main power panel. In the design of SEALAB III, the stuffing tube was not the current technology. The current and new technology is to have the umbilical connect to the habitat through large electrical connectors, and so to provide a quick and easy field connection instead of a hard wiring configuration.

The new interface, I believe, was designed by the Naval Research Laboratory. All our systems were located on the *Elk River* topside. Upon lowering the habitat to the bottom, it was secured with all hatches closed so it was essentially equal to water pressure outside. The pressure within the habitat was maintained maybe five or so pounds over pressure to the sea depth. As we were lowering it, we could continuously monitor the interface pressure in the habitat up in the Command and Control Van.

We knew exactly what the depth of the habitat and the corresponding internal pressure was at all times inside the habitat. When the habitat reached the bottom, the cameras were turned on and everything progressed as scheduled. The two teams of aquanauts were pressurized to the pressure of the habitat and for traveling to the habitat. Water leaked into the main electrical connector and across the pins, which in turn shorted out and blew a hole into the habitat.

When the connector shorted out there was an enormous in-rush of water. With the in-rush



Command and Control Van

of water, they tried to pressurize the habitat to keep out the seawater. With the massive amount of helium that we were pumping down into the habitat to try to keep it from flooding, the amount of helium was obviously running out rapidly, and we had a limited supply on the ship. We had the helium supply, which was to support breathing gas for life support down below, but it wasn't enough to keep the water out.

But, during the course of things, that was the failure. Then more helium was barged from the Long Beach area. We brought helium and oxygen, in tube trucks on a barge, and tied up along side of the *Elk River*. The barges were right along side of the Command and Control Van. While we were transferring oxygen, a fire started on board the oxygen barge, which started out as an explosion, then a stream of fire. Fast reacting Navy divers entered the ball of fire and secured the oxygen. It saved us from a massive disaster not only down below, but then up topside and in the chambers.

We had two teams under pressure in the chambers on board the *Elk River* at the time, and we were communicating with them as well as the team in the PTC. The PTC contained a four-man team with Berry Cannon and Bob Barth who were trying to get down below to open the habitat. The problem with the connector was the initial problem but there's nothing wrong with moving upward in technology. That's just saying if something works and works quite well, why go ahead and change it and make something brand new, but good engineers are always looking to improve the system. Engineers are engineers, you know. If we think we can make it better, we'll try, but in this case it caused the problem.

Overall the people on the SEALAB team were the very best; every one of them from George Bond, Tomsky, Mazzone, to the entire SEALAB teams—a very dedicated team. We also had people in Washington D.C. that I know were very supportive to the program. I saw no reason why anyone would ever want to jeopardize a great Navy program, or our sailors' lives. I've heard it but just discount it and say, "You know, I guess I've been around you guys long enough to know that I'm proud to be a part of it, and knowing that how proud I am, I can't believe that anybody would ever be negative about the program."

As to the leadership in the SEALAB III program, we were all extremely close to the shipyard people in the San Francisco area. We all dealt day to day with everybody. Captain George Bond was essentially the main driving leader for me and the head of the program. Primarily I was in more of the medical side than I was in the operational side, so George supported me. Walt Mazzone was my direct boss, and Jack Tomsky was his boss. All three of them, George Bond, Walt Mazzone, and Jack Tomsky, were like close friends of mine. They knew who I was and that what I was doing was an important part of the Northrop program.

My direct point of communication link was Commander Jim Vorosmarti. At the time, Commander Vorosmarti was more my leader in the Biomedical Department because my background was not medicine. He in fact, assisted me in every design decision. I consulted with him in every selection of medical equipment and proposed clinical procedure.

"Okay, Commander Vorosmarti, what is it we need to build for the aquanauts?" And, he'd say "Well here's what we're going to do. I'm going to sit you down in a room and here's what I want you to do. I'm going to give you certain things that I want done, for an example, I want

all blood and urine chemistry and hematology." I knew basically what it was, but I did not know anything about the details of doing the clinical work. Jim Vorosmarti was my mentor in leading me to do the best job for the US Navy, building the Biomedical Van.

We did all the blood work, physicals, and we continued this every day. It was enjoyable, because at the time, I did not even know how to draw blood, and they taught me how to draw blood from the divers. It was kind of a kick for me to be doing this with them. After we finished it, everything was put together up in San Francisco, and then was moved on board the *Elk River*.

We went to the island to make sure we had all the island support and facilities to support the program. We all had quarters, a good chow hall, movies, tavern, and all the amenities for good living. Every night was a pleasure, shared with all the team, including the upper management. The nice thing about being a Northrop employee was I got support from Northrop to get a lot of computer work; down load recordings of everything, both video and audio, including everything we were doing on board the ship.

I had permission from Commander Tomsky and Captain Bond to go back to the mainland, which was an experience in itself, since we had an old DC3B (Mercer Airlines) that flew us from the island to Long Beach every day. In flight, the oil would blow off the wings and it was unbelievable. Everyday, we prayed that we could make it out to San Clemente Island or back again.

We made trips up to the San Clemente International Forest, which was three trees on the island. Goats were everywhere. It was a firing range and some days we would get a large Navy ship that would fire salvos over the *Elk River*. They'd fire salvos down range over our heads to the other end of the island. It was a unique place to be and a great bunch of people to be with.

The four unique management leaders that I worked with were Captain Walt Mazzone, Commander Jack Tomsky, Captain George Bond, and Commander Jim Vorosmarti, all individuals in themselves.

Captain Bond knew that a lot of people would say there was a little conflict between Jack Tomsky and Walt Mazzone, but when you boil it all down, these four will stand together, shoulder to shoulder. They were US Navy and you could not find any finer. There is always a small turmoil between great leaders, on what to do and how to do it. Everyone wants to be "the Main Commander." Tomsky was the on-scene commander, but it was the dreams and hard work of George Bond that again brought us and the US Navy out to San Clemente Island preparing to continue the SEALAB experiments.

CAPTAIN WILLIAM MAC NICHOLSON

In the case of SEALABs I and II, Bond and company, as the scientists and medical people, were pretty much in charge of the entire operation. In a sense, they were doing it outside the system. It got formally approved. When the PM-11 office was set up, that became an official goal. The operational goal was to get diving to 600 feet. The SEALAB program melded into that.

The SEALAB people were a bright bunch and they knew what they were being melded into. They understood what was happening. Jack Tomsky had been selected to head that part of the program.

Tomsky reported to me. We were going to do an operation at sea, a habitat in the ocean. In the Navy structure, you couldn't have an Engineering Duty Officer in charge of that. You had to have a line officer, and John Craven chose Tomsky for that job. As I said, the basic structure was in place. John did a good job of that. Tomsky was the officer in charge of SEALAB as a diver, line officer, and ship commander qualified.

We were so heavily involved in funding problems. They had been operating with ONR money and we were still operating, to a very

high degree, with ONR money, which was limited. We were getting into an operation in which we were picking up fleet operating requirements so that there was a big fight over money. I was always involved in that. The big question was, "Can we get money enough to do it right?" I think those guys were happy that we got a little bit more money. We were not doing it under the table. We were doing it out in the open. What we wanted was to do it correctly.

We had a goal to go to 600 feet. I can't tell you who chose 600 feet, because that was a goal before I got there, but it seemed reasonable. It was something that they had demonstrated with saturation diving capability. George Bond had done that very effectively with SEALABs I and II. It was clearly possible to do it. The science said to go, and that 600 feet was a reasonable limit. I suspect that had a lot to do with it.

You could have picked 700 or 500 or some other number, but 600 looked reasonable. It had been proven in tank diving. All the signs were "go" when I got there.

We were in an incessant, bitter fight for money. I think the total Man in the Sea program was running on about $5 million a year. At that time, the National Aeronautics and Space Administration (NASA) was getting $5 billion a year. That was a real thorn in our collective side.

We cut a lot of corners in order to try to get the job done on the money we had available. Reprogramming money, or taking money from one pocket and putting it in another, was something we did quite regularly. There were other requirements that I think John Craven could probably talk about, such as fringe requirements that were developing in the classified area. We were building a capability to support that. It was not apparent with the SEALAB program or anywhere visible because it was classified. The training of divers and the building of the whole system fed into some classified programs.

We cut corners, no question about it. One of the corners we cut, for example, was when we had the SEALAB habitat ready to test and were flooding it in a dry dock and putting it under pressure. We did not pressurize it with helium, and I fault our management for that. We pressurized it with air and it passed the tests. I think that if we had pressurized that with helium, we might have found that the fittings were not working. When we took it out and put it down on the bottom and pressurized it with helium, we started losing gas in large quantities and couldn't sustain it.

We didn't test it with helium because helium was expensive and hard to get, so it was one of the corners we shaved. We didn't know that those packings weren't going to work. The packings may not have worked because it was cold. I don't know. When you dropped it down 600 feet and you were in cold water. It was different than doing it in a dry dock, where it was warm. Ideally, we would have found that out earlier, but the real cause of that fiasco were the packings.

Obviously, we didn't test the packings well enough. In hindsight, we probably should have bit the bullet, gotten the helium, and tested it with helium both in the dry dock and at a low temperature, but we didn't do that. That was one of the things that Rickover was always trying to do. We fought him on many occasions. He insisted on getting everything tested, retested completely, and he was right on that. He was absolutely correct.

When the habitat went down, we were unaware that the helium leak was going to take place. I asked myself frequently, "If we had insisted on testing it with helium in the dry dock, would we have found the problem?" There was a problem in the packing and we didn't find it until it was too late.

We scrubbed the SEALAB program but the divers were all trained. We had a separate classified program the divers were aimed at. Again, John Craven could probably tell more about that, because he was in on the classified portion more than I was. Let me put it this way. I think enough of it has been declassified, because of the things going on in Russia.

MR. WALLY JENKINS

SEALAB III was to be 600 feet or 610 feet or something like that—pretty deep. We did a lot of PTC training with the personnel transfer capsule. Before that we had to do training in Washington, D.C., in chambers, all kinds of physiological tests. We did the tests in old chambers that were not made for saturation dives, and we did 100 foot, a 200 foot, 400 or 450 foot, and a 600 foot dive.

We would stay in the chamber about a week. The first day or so the water would get polluted in the wet tank, because the filter system didn't work. So we read a lot of books, and did a lot of psychological and physiological tests. We did all those work-up dives, and Berry Cannon was always my partner on those dives. We probably did four or five of them. Then we headed out to the West Coast, got to San Clemente Island and did more PTC training.

They were having all kind of problems with the habitat. You remember in SEALAB II the support gas lines and everything went down under, up into the habitat so the air pressure kept it from leaking. There was a great big round flange that came through with no stuffing at all, because the air pressure kept it out. Well, in SEALAB III a lot of those things were in a bulkhead up overhead. So the air pressure is going to try and get out.

Well, we were at San Francisco Bay Shipyard, putting this together, modifying the old SEALAB II for SEALAB III. They had a great big sign as you drove in that said, "The Midway—our biggest challenge"; a big flattop getting converted. Well, we all figured all the real priority went to Midway, and SEALAB III was kind of sloppily done. They had put it on the bottom and it was leaking. Gas started coming out of those ports.

The entry team was Berry Cannon, Bob Barth, John Reaves, and Blackburn. They put them down under pressure pretty fast, because they had to get into the habitat and stop that leak. And we learned on SEALAB II that you don't go down fast because you get compression pains, and you ache for about half the day. Anyway, they put those guys down fast, and I was a safety diver that night with some lieutenant, I forget his name. And I did a 60-foot check of the PTC, and they were all in there. I looked through the port, and I could see them all in there, you know, getting ready to go down to the bottom.

I was in the water at 60 feet. It was a safety check to make sure everything was OK. It was dusk. So I went home, went back to the barracks, and they went down and tried to get in the habitat and couldn't. The hot water suits didn't work at all. They had a fan in there to circulate the gas in the PTC, and they had a helium atmosphere. So thermally they were absolutely wasted before they got in the water. Barth could tell this a lot better than me because he was there. But, anyway, one thing led to another, and they came back up, got new rigs, and went back down, and Berry got killed.

So SEALAB III was scrubbed. And that was the end of that. Who do you blame? It was beyond our capability. Now 620 feet is a piece of cake, but back then the hot water suits and a lot of other things didn't work. Maybe we should have gone to 400 feet first, or something. I don't know. But, you know, hindsight's always 20/20, and it was very disappointing. I don't know, I think maybe the program just got away from them, what with all the press, and the deadlines, and the funding, and so on. That's why I don't want to cast any blame on anybody, because the bottom line is Berry should have checked his canister, but, you know, I'm sure he was too tired, too cold, and didn't even think about it.

The guy responsible for Berry Cannon's rig, unfortunately, feels responsible for Berry's death to this day. And we all talk to him like a Dutch uncle, "You are not responsible for his death." Basically Berry is responsible for it; he didn't check his gear and it was just an accident. I mean, accidents happen. But he still takes blame for it. It's a darn shame, because he's not at fault.

I don't think sabotage had anything to do with it. I think we were in a big rush. We were losing gas. It was probably either go now, or the whole thing is going to be aborted. It's probably too much pressure on the leaders to make the dive, and kind of like NASA sending that space ship up in that cold weather, it blew up.

Now, looking back, we really shouldn't have done it. Well, we were under all kind of pressure. You can't even imagine. All these admirals back in Washington asking why you can't do it, and guys on the scene, and it's hard to explain that you have a leak; you have hot water systems not working right; you've got a bunch of tired divers, all kind of things. But I don't think there was any sabotage. I think it was just a sad situation.

You know, I think maybe those umbilicals they had us programmed to take out—I think that was a little ambitious. The water was gin clear. Some of the guys went down in submersibles, and, I talked to Bob Barth about it. He said he made the entry dive, and he said it was like being in the middle of a great big baseball stadium; you could see forever, using the lights, and everything. So it would have been a fantastic dive. No mud, hard sand bottom, none of that silt that we had on SEALAB II.

THE DEATH OF BERRY CANNON AND THE END OF SEALAB III

At a little after 5:00 a.m. on Monday, February 17, 1969, off the coast of San Clemente Island, at a depth of 610 feet, Aquanaut Berry Cannon died of CO_2 poisoning while attempting to enter SEALAB III. His death brought to an end the SEALAB III project. Whether his death was an accident or murder remains unresolved.

COMMANDER JACKSON TOMSKY

I took command of the *Chanticleer* in 1962. From *Chanticleer*, I went to become the assistant officer in charge of the Navy Deep Sea Diving School in Washington, D.C. I was there just a few months and was asked if I wanted to take over another job. In those days, it was under the Polaris Missile Program. It was the Deep Submergence Systems Project (DSSP). I took over the job, and that included the SEALAB project, the Large Object Salvage System (LOSS) project, and the submarine escape project.

That's where I met George Bond. George was probably one of the most unique individuals that I've ever met in my life. He was one of the kindest people that I've ever met. He was every inch a gentleman and an original thinker. George, you know, really developed the concepts that we're using today in saturation diving. But George was undisciplined. He was not a reliable individual. If you said, "George, I want you to come and be interviewed at 9:00 in the morning," George would say yes, but something might get in the way. He had his own sense of priorities, which differed from those of most everybody else.

That was one of the reasons I ended up in that program. We had two factions within the Navy. We had the engineering and salvage people, under the supervisor of salvage, and we had the medical people. When the Deep Submergence System Project was given the SEALAB program, I ended up with the job and the responsibility for that program. I was with a bunch of strong-willed medical people and a bunch of strong-willed engineering people who all had their own ideas on how the program should be run.

I was given this task because the powers-that-be decided that we should take saturation diving and make it an operational capability of the Navy for a specific reason. It was an intelligence gathering reason. When it was decided that the research and development had reached a point at which we could start to develop and train people and equipment as an operational

arm of the diving Navy, those people still wanted to stay in research and development. They wanted research and development programs. My task was to take this group and bring it to an operational capability.

There was a fundamental difference in philosophy. You had the George Bond philosophy, which was Genesis. In other words, you had the mindset of putting men on the bottom and having them colonize the ocean floor. The Navy had a job to do, and it didn't include colonizing the ocean floor.

It was further complicated by the fact that we used it as a cover story for our real intentions. Therefore, we had scientists who still had scientific programs in the mix and were not allowed to get in the way of our operational development. That further complicated matters. Again, you're talking about a lot of independent-thinking, strong-minded people, and they didn't take too kindly to the word "no."

My role was very much being the disciplinarian, trying to take these disparate groups of people who had worked on SEALAB I and II and get them to work for the Navy's goal, rather than their goals.

Everyday problems were so, so numerous that I was sort of at a loss. First off, there was money, and the control of money, and where the money was to be spent. One officer wanted a photography lab at our base out in San Diego. I said, "And what do you want the photo lab for?" He said, "Well, we need to do this and we need to do this other thing." You looked into the photo lab. In those days, being designated a US Navy photo lab was a function of the Bureau of Aeronautics (BUAIR). You had to go to BUAIR in order to get the authority to create a photo lab. I had no desire to go through that. I kept stalling and finally visited that place, Ballast Point, and there was a photo lab. They just went ahead and set it up themselves. Those were the kind of people with whom you were dealing.

I was able to distance myself from most of the individual people issues. My problem was that at that time, I had in my budget, let's say, a half of a million dollars for biomedical research. I kept getting proposals from various universities and Navy laboratories. I'd look at those proposals but didn't understand them. I'd look at the recommendations and the conclusions, but they didn't really make too much sense to me.

For example, the head of the Navy's toxicology laboratory wanted money to conduct a toxicology program under pressure. I didn't understand the program. I went to my boss, John Craven, and told him I had to have a medical officer by my side. I couldn't depend on Bond, because he was too busy to fool with that stuff. I was able to get hold of Bob Bornmann and add him to my staff. He took that burden and did a wonderful job.

He was my medical authority. When Bob said that it was so, it was so. If Bob recommended we do something, that was the way we would do it. It was very, very difficult until I had Bob Bornmann on my staff.

I must say that the medical people always cooperated. I think the situation with the medical people can best be explained by the assertion that they didn't know what we were doing. We had an intelligence program and I was the only one in that particular group cleared for the knowledge of what we were going to do. I think that was one of the big problems. They really didn't know why I wanted to proceed in a certain way or why I needed certain things.

The difference was that SEALABs I and II were strictly research and development programs. SEALAB I was pretty much on a shoestring, but Bond got it up to funds and forced his issues. SEALAB II was supported by ONR. SEALAB III was taken from ONR and put into the Deep Submergence Systems Program (DSSP).

My whole awakening in management occurred when I went to the DSSP. Six months before that, I was the commanding officer of a ship and needed $1,500 to buy a head for an engine. The squadron engineer wasn't going to give me the $1,500, so I had to threaten him with dire results to get $1,500 to buy a head for

the engine. Six months later, I was thrust into this job, and my budget for those four programs was $135 million. I didn't know how to spend that money. If I wanted a case of nails, I'd tell my supply officer to go down to the supply depot, take a 307 form, and draw a case of nails. I was expected to research the materials, design them, build them, and get them distributed into the Navy. I didn't know how to do that. Fortunately, I was given a staff of people, primarily civilian engineers, who had been in the Polaris program, who did know how to do it. We worked very well together. I learned an awful lot. What an education it was.

There were many aspects to my job, the DSRV being one of them, but I really wasn't too involved in the DSRV, other than a little bit on the lab support system. That was another group of people in our project.

I was focused on personnel selection, figuring out how to train people, and the equipment designs we needed. We did some very, very interesting things, and fortunately, they worked out. We designed a new semi-closed circuit breathing apparatus for our project, which ultimately went to Westinghouse, and they built them.

Not everything went without objection. For example, the supervisor of the salvage office wanted to have a closed-circuit carbon dioxide-removing system. I didn't want one. I had two very good reasons why I didn't want it. One, it was a long way off from being developed. Two, I couldn't understand how we would ever take an umbilical off of an individual and send him down to, say, a depth of 600 feet as a free swimmer. He would have needed to come back to a pressurized capsule somewhere. I couldn't see how you were going to develop the means of him finding his way back home, whether it was sonar he was wearing or some visual aid. I stuck to my guns and we developed what we called the Mark 11 semi-closed apparatus. That was what we ultimately used. But by doing that, we kind of ran over some of the people in the Navy who had other views and other ideas.

I worked for Dr. John Craven, and relationships are funny. When John interviewed me for the job, he said, "Well, I can't use you because, from an academic standpoint, you don't have the background. You have a lot of practical experience, but you don't have any background in academia." I refuted that, in the sense that my practical knowledge was probably greater than one could learn in years of institutions of higher learning. The only thing that I lacked was the ability to understand engineering systems management—later I found that to be a necessary function. John's real apprehension was in management. I finally convinced him that I could handle it. We became great friends later on. John listened to me. I certainly listened to him because John is an extremely brilliant man. But I laid out where I thought our program should go and how to get from here to there. He, for the most part, accepted it. He developed a trust in me.

John has just finished writing a book, *The Silent War*, and a lot of things are explained in it. It is not a hundred percent accurate but for the most part, the common bond that we had was the end objective of our classified project, or working to make it a reality. It was a very hazardous undertaking. We were designing, building equipment, and training people. We were going to interface them with a submarine and they were going to come out of a submarine at deep depths. These were the things that had never been done before.

That was where SEALAB fit in, as the training ground and the equipment test program for clandestine operations using submarines and saturation divers. We got the people, selected the people, and trained the people. Most of the people involved with SEALAB didn't know what was going on. SEALAB III was a very good cover for what we were doing.

We fine-tuned the manning. In fact, we pre-selected. The people who were to ultimately go out on the missions were all pre-selected and sent to this program. Those would be the top-secret missions for which they could get

experience on SEALAB. They also got the know-how.

Being from the old school, I decided that I was going to put every officer and every man through the six-month deep-sea diving course at the diving school, because I had gone through the program as an officer. I decided that was the greatest training and if we were going to weed people out, that was the way to weed them out. We put them through the deep sea course. Then, we took them to San Diego and put them in a group that we had formed there. We then trained them to do saturation diving.

The problems we experienced with SEALAB III were mechanical. The shipyard installed the seals and the penetrators that the cables went through. They had seals to block the helium from leaking, and they installed them backward. Even though they were tested in a dry dock, they didn't show the leaks until we got it down to depth.

I retired soon after that. I had completed my thirty years and had to retire, by law. I was asked if I would stay on an extra year, as a retired officer, and help to finish the work in the project. I did. There was nothing more on SEALAB. I got strictly classified work.

The SEALAB was taken back to Hunter's Point and presumably cut up for scrap at some point. It was examined. It was found that the seals were in backwards. That was the usual post-mortem, I guess, in that type of tragedy.

We concluded that our biggest problem was that we had a saboteur on board. I certainly thought that. That was not based on the death of Berry Cannon and the fact that his diving rig did not have the carbon dioxide absorbent in it.

On three separate occasions, we found that breathing gas mixtures had been tampered with. We had gas with different mixtures for different depths, plus we had pure oxygen, in case it was needed later on. You switched the different mixtures in the chambers in an emergency. But you also had emergency mixtures. In the case that something happened, they could put on the masks. Three times, we found that the valves had been changed and pure oxygen had been put into the built-in breathing system. Had they grabbed one of those masks, it would have killed them. You can't breathe pure oxygen at those depths. We wired the valves. Somebody unwired and changed them. Then, I put guards on everything.

There were indications that we had a saboteur somewhere in the group, and we had so many civilians; naval ordnance test people were helping to run our thing. We had military people and civilian scientists. We literally had hundreds of people involved in the operation. To isolate who was doing it was impossible. I did have the Office of Naval Intelligence send an investigator out while that was going on, but nothing ever came of it.

Strangely enough, my best recollections are not of Berry Cannon, but of his diving partner, Bob Barth. My best recollection is the heroic effort that Barth made to get Berry back into the chamber, what we used to call the "personnel transfer capsule." He got him out of the water and in there. Then, other people gave Berry mouth-to-mouth resuscitation. Unfortunately, it was to no avail. I guess that's really my most vivid recollection.

Berry just grabbed the wrong unit. It could have been anyone. It could have been Bob Barth who grabbed that unit. Later, we checked. There were eight units hanging on the outside of the capsule. The other seven were all right, including the one that Barth had and the other six that weren't used. The only one that did not have the baralyme was the one that Berry Cannon used. If he had grabbed any one of the other ones, I'm sure he'd still be sitting here with us today.

Somebody emptied the canister in the rig that Berry Cannon wore. The man responsible for putting those units together and getting them ready to dive was an extremely reliable person. Nothing in this world could convince me that he made a mistake. He filled all of them, and he filled them properly. But somewhere in the interim, somebody got to one of them.

DR. JOHN CRAVEN

The SEALAB had a disaster when they lost Berry Cannon. That was very clearly the result of sabotage. We know who did the sabotage or we think we know who did the sabotage. I know what the motive for sabotage was, but all I'll say is that we had a psychiatrist on our staff. I'm not going to say anything except that there are certain aberrant personalities who, if they're frustrated in achieving their goals, will retaliate with sabotage. I'm getting close to indicating who that might be. I don't want to do that.

We turned all the evidence (of sabotage) over to the Office of Naval Intelligence (ONI). Representatives from ONI came and said that there wasn't enough evidence to warrant including that in the speculations of the Court of Inquiry. The Court of Inquiry met, and CDR Tomsky behaved as a true Navy Officer. He just walked up and said, "I'm the Commanding Officer. There was no baralyme in Berry Cannon's canister, and I am fully responsible."

Chief Wells got up and said, "I signed off saying there was baralyme in Berry Cannon's canister. I thought there was baralyme in there, but it was not in there. It's my fault and I take full responsibility." Both got letters of reprimand and both retired from the Navy. We, who were up there in the top, felt very badly about that, but we suddenly realized this was a tremendous opportunity to put that program into classified projects, in the "black" as they say.

MR. BOB BARTH

I was never one of the topside decision people. My job was to look after the habitat and the people. I chose Berry Cannon. Berry was an electrical engineer who had been on the bottom on Team I on SEALAB II. He was a good man in the water. He was a good worker. There was nothing about Berry Cannon that was in the negative column at all. I wanted him on my team, and he was needed on my team. If there was a problem with the habitat, Berry knew how to fix it.

I was lucky enough to be able to select the majority of the people who were on my team, and those were careful considerations to make. A thing that you broached was personality. You can get a person who might be the smartest guy in the world but has a personality like a dead cat and doesn't contribute to the rest of the team, someone who is not a team player. That guy annoys everybody. He doesn't pick up his share of the work. He's lazy. That is the kind of guy you don't want. Of course, we didn't have them. We had good people, all around.

I was able to pick the cream of the crop for SEALAB III, Team I, and I had good people. Berry was the unfortunate victim of a little bit of chaos and equipment malfunctioning and so forth, and he paid for it. I knew Berry Cannon pretty well, and I know darned well that Berry would have never said to quit because he was lost.

If you want to know the story about Berry's loss, I'll tell you. Team I had gone down. We had two Personnel Transfer Capsules (PTC). By that time, we had developed a chamber on the surface with a bell on top. We had two on the support ship. The way it was laid out was that I took half of Team I in my bell, down to the ocean floor, 610 feet down. We went out and over to the habitat and worked on it. But we had some problems with the habitat, like getting into it, pressure, and some other problems.

We didn't get into it on our first dive. Berry and I had on apparatuses, the diving equipment that was sent to us through the medical lock, and we took it to the bell. He and I each wore one when we went out and did our first dive. We didn't get in. We were extremely cold. We didn't have any heat, so the cold was getting to us. We came back, got in the bell and came back to the surface. We warmed up a little bit. Then, they took those two apparatuses out and fit in two new ones.

They had a habitat and were worried about it imploding on the bottom. It was leaking. They were trying to keep from losing it. Everybody was running around. Everything was accelerated.

In the effort, somebody inadvertently grabbed an apparatus out of the rack that didn't have any CO_2 absorbent in it. The two of those were locked into us to replace the ones we had worn on the first dive. Berry grabbed the one that didn't have any CO_2 absorbent in it and I got the other one. You don't last too long at 600 feet without CO_2 absorbent on a semi-closed circuit apparatus. He was re-breathing his CO_2 because there was no absorbent. He got a high concentration of CO_2. It only takes a few minutes for that to happen. By the time we had been out for maybe four or five minutes, he went into convulsions, and that was it.

MR. JIM MCCARTHY

Some believe there was a saboteur in the SEALAB team. Personally I don't believe there was any sabotage involved. With my relation with all the SEALAB Navy and civilian personnel there was nothing but a close relationship together, always helping each other, living together and partying together. I would say there was a similarity to the astronaut program.

I think the sodasorb was washed out during the transit to depth, because everything was chaotic and rushed trying to get people inside the habitat at the time. The communication link was primitive at best, with Bob Barth and Berry Cannon by umbilical to the PTC trying to open up the hatch. We were trying to keep the pressure on the habitat so it would not flood, so as you know, this is an uphill battle. The coordination of opening up that hatch exactly at the time when they depressurized, is the thing that did it.

When we knew that it was depressurized enough so that Bob could open it up, seawater started flooding rapidly into the habitat at the bottom. Then Bob would have opened up the hatch to a flooded habitat. There's a "Catch 22" whereas Bob and Berry tried their very best.

When they come back up to the Deck Decompression Chamber (DDC) they were exhausted. They were cold, and I mean it was miserably cold; you could see them shaking. Bob was a pretty healthy diver and he could take the extreme cold and he could take a lot of shock. He did his best. He and Berry came back to the cold PTC, and they came back up to *Elk River* and locked into the DDC. They wrapped up to warm up and they ate dinner at this time.

It was chaos on board the *Elk River*. The topside crew was trying to keep the water out of the habitat and trying to get ready for the next morning's dive. It was suggested at one time to change the team and put the second team in. Bob, Berry, and Blackie decided that they had been there and knew what they were going to do, and that the same team was going to open the habitat. They did get some rest. The topside aquanaut teams were frantically trying to get everything ready to go for the next morning's dive. That meant refilling the sodasorb canisters.

The assumption was that the divers' sodasorb canisters were repacked and hung on the outside of the PTC. Whether the canister was not filled in all the confusion or the sodasorb was washed out of the rig during the rush to get back down to the bottom the very next day will never be known. The washout could easily have happened, because they were traveling to depth at a pretty good rate to get from the surface and back down to the habitat. It could have flushed out at that time.

COMMANDER SCOTT CARPENTER

Both Berry Cannon's death and the tragedy of Gus Grissom and his crew were showstoppers, but the nation had a vested interest in a glorious pursuit, that of preeminence in space. That was part of our national defense. The nation realized that we had to have preeminence in space. Forget preeminence in the deep ocean.

MR. WALLY JENKINS

I think he got killed because he didn't have any absorbent in his canister. But anyway, he

was killed. They say that's why the program was scrubbed. But really, I don't think the habitat would have made it. They never did get inside the habitat to try and patch those leaks.

But what they did do, they had great big tanks on it that you open up and let the water come in, like a submarine, to make it stable on the bottom. Then the habitat was sitting on the bottom and very heavy. So they got this great big crane from Germany or someplace, and they barely got that habitat off the bottom in the next day or two.

Bill Bunton went down for a check at about 30 feet, and there was Berry Cannon's mask lying on the step platform. It came all the way up from the bottom, where he lost his mask. Bunton gave me the mask, and I kept it for years.

Editor's Note:
Speculation About SEALAB III

The US Navy never released the results of the SEALAB experiments to the public; but, that hasn't thwarted intense speculation and ongoing discussion. Public information about what the Navy did with the information from the SEALAB experiments ends with the abrupt cancellation of SEALAB III, but not the discussions of what happened next. Whether the Navy had the information it needed or if it had learned what it needed to know has been discussed endlessly. The truth of the matter is classified information. Those who know the true reason for SEALAB and how the results were used, can't discuss it. This has led to more questions than answers.

Many have questioned why the Navy was allowed to spend hundreds of thousands of dollars, maybe millions, to test and re-test whether divers could be saturated to work at depths of 400-600 feet and if the Navy Decompression Tables were accurate and standardized. Others have questioned who authorized these tests and projects because, by the late 1960s, civilian contractors were already using deck mounted saturation systems with attached lock-out bells (Personal Transfer Capsules).

Widespread speculation now concurs that the Navy's secret project, *Ivy Bells*, the most successful and productive intelligence gathering project of the Cold War, was made possible by the information learned from the SEALAB experiments. This speculation is based on actual facts and circumstantial evidence. As noted in the previous personal interviews, the burning question following the cancellation of the project, at least among many of those who participated in the SEALAB projects was, "What did the Navy and/or the US government plan to do with the information they learned from these projects?"

Now we have some of the answers; but not all of them. Some of the factual information about the length, success, and purpose of the *Ivy Bells* mission came from the trial of Ronald Pelton who received a lifetime sentence for selling information about the project to the Russians for $35,000—the amount he needed to avoid bankruptcy. Other facts have gradually come forth from those who have studied US espionage extensively, speakers at the various conferences on successful US espionage undertakings, and the numerous books written on the subject. Inasmuch as the information about *Ivy Bells* mission has never been declassified, the following summary of *Ivy Bells* is based on the data compiled from these diversified sources.

Compiled Information

First: It is common knowledge that Genesis was started by Dr. Bond at NSMRL at SubBase New London in 1957, and the Mine Defense Laboratory, which became the Naval Ship Research and Development Laboratory, was the Navy division that acted on original construction on the now famous Genesis Project (1963), the world's first saturation studies. SEALAB I and II projects were managed under the Office of Naval Research and it was NSDL that created SEALAB I, the first open water saturation diving experiment. They also operated the successful SEALAB II habitat. The project manager of SEALAB III was under Deep Submergence

Systems Projects (PM11) whose purpose was to saturate a crew of divers to 600 feet, but was abruptly cancelled after one of the divers was killed in an underwater accident in 1969. Although there is no proof at this time, it just stands to reason that the Navy's Experimental Diving Unit was involved at some level with the highly successful mission *Ivy Bells*. In the absence of hard data, there seems to be no other area of the Navy that would have the expertise to train the Navy divers who were an integral part of the mission.

Second: The ship that initially carried out the *Ivy Bells* mission was the USS *Halibut*, a submarine that had already been converted to a "special projects" boat. One of its unusual features was a large hump built on the outside, which was referred to by Navy personnel as the "Bat Cave." This first hump contained many new and experimental cameras and computers. For the *Ivy Bells* mission a second hump was welded to the frame of the sub. The Navy told the media that the second hump was a Deep Submergence Rescue Vehicle (DSRV), but in truth this hump was a diver's decompression and lockout chamber. This fact brings forth other questions: Why did the Navy need a submarine with a diver's decompression and lockout chamber? What did the Navy plan to do that required both a submarine and divers trained for deep water assignments and decompression?

Third: It has now been revealed that there were actually two missions of the USS *Halibut* at that time. The first was to find and recover pieces of a new and deadly Soviet ship-to-ship missile that was known to have been tested in the waters of a Soviet test range. While other submarines could locate the pieces of the missile, only the *Halibut* had the divers who could swim out and pick up the pieces. The second mission was to try and find the Russian subsea phone cables that were hypothesized to run parallel to the Kuril Islands and connect the Soviet's submarine station on the Khamchatka Peninsula to the Russian Pacific Fleet headquarters and, possibly, to Moscow, by going under the Sea of Okhotsk. Both of these missions were eventually successfully completed and probably were great contributors to the final end of the Cold War. But the success of the *Ivy Bells* mission is without precedent. It lasted from about 1972 to 1981, and was the forerunner of other similar missions, some of which may still be in existence today in other parts of the world.

The Ivy Bells Project

This is a brief synopsis of what occurred in the *Ivy Bells* mission: A Navy Captain, sitting in his office at 3 a.m., was pondering how wonderful it would be to gather intelligence from this suspected cable. He wondered if there was such a cable and if one of his submarines could find it. Then he remembered how underwater cables are usually marked in some way so that other ships can avoid them and repairmen can find them. He decided to try to find this "probable" cable, but he needed funding. Eventually, Henry Kissinger and his top deputy, General Alexander Haig, granted the approval to undertake this secret mission.

The submarine *Halibut*, with its new hump, set out on this mission in the fall of 1971. The *Halibut*'s submarine crew was never told the real purpose of their mission. Only those with a "need-to-know" actually knew what the divers were going to do. It took nearly a month to reach the Sea of Okhotsk, and much maneuvering to avoid being detected by the Russians. Miraculously, using the simple idea of "possible location markers" in that 611,000 square-mile span of water, it took the *H*alibut only a week to locate the cable.

From the "hump" on top of the submarine, divers were sent out to try and tap the cable. Their system was to take turns and swim out with a recorder filled with rolls of tape and then return to the submarine decompression chamber. Some people insist that those first divers held the recorder up to the cable; others say that the recorder was somehow attached to the cable and the divers would return in a few days and

retrieve the tapes. What is known is that, while waiting to gather an adequate amount of intelligence data to return to Washington for review, the *Halibut* went to the second site and the divers retrieved the pieces of the secret missile that other submarines could only locate.

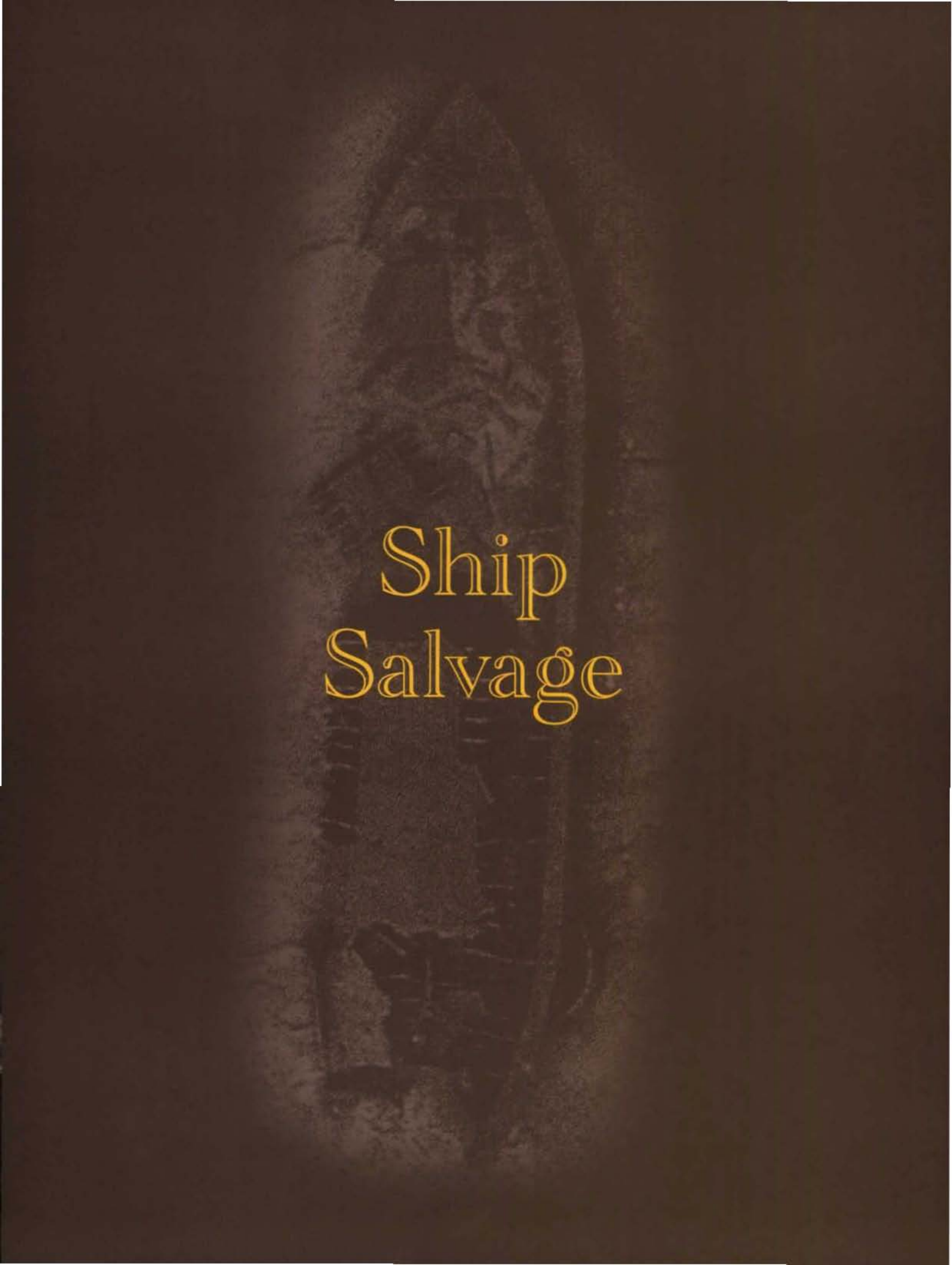
The information gathered by the *Halibut*'s divers was easily decoded and proved so valuable to the National Security Agency that a device, called a pod, was created to gather information on the Russians. The pod was nearly 20 feet long, more than three feet wide, and weighed approximately six tons. It was powered by some type of nuclear power and was designed so that data could be collected from it after long periods of time, perhaps as long as six months to a year. The pod was designed to fall off the cable should the cable be moved (for repairs) by the Russians.

The Russians never found the pod until it was betrayed by Pelton. As the mission progressed, two other submarines, the USS *Parche* and the USS *Seawolf*, each equipped with a secret decompression chamber, were subsequently assigned to the task of maintaining the pods and collecting the data.

This mission and the technology used to attach the pod, record the information, and retrieve the intelligence information has fascinated espionage experts and authors for more than 25 years. There are still many unanswered questions and dozens of theories. It is known that the word "bells" signifies a top-secret operation because it has five letters in it. It is also known that the Bell laboratories developed and created either the listening devices or the pod. The names of the divers or the crews aboard the *Halibut* or the other two submarines have not yet been made public, neither have the fascinating stories these Navy men could tell. Someday this may happen. Then we will know the true story of the *Ivy Bells* mission.

In what other ways the information learned from the SEALAB experiments may have been used by the Navy is still a topic of intense discussion.

Another interesting fact is that one of the *Ivy Bells* pods, that was removed from the cable by the Russians, is still on display in the Moscow museum of the former KGB, but most Americans are not even aware that the pod existed or the role of *Ivy Bells* in ending the cold war.


Ship
Salvage

The word "salvage" has undergone many significant changes since the Navy first used the term during the Civil War. At that time submarines were quite small and used only in harbors. They were provided with a lifting eye at each end so that a derrick could hook onto them and pull them up should there be any incident.

As designers included more and more machinery to increase the reliability of operation, the radius of action, the power of attack, and the habitability, submarines grew larger and much heavier. By 1926, submarines had grown sufficiently enough in size and reliability to begin to venture out of the harbors, in deep water where they were likely to sink when exposed to severe storms.

Although these bigger submarines became less likely to sink due to defective design, the increase in size made it more and more difficult to salvage them if they did sink. For this reason, the term "salvage" expanded its emphasis from its involvement with salvaging ships to the process of developing a standard method of salvaging submarines. This urgent need became apparent after the failure to rescue the crews of several sunken submarines. For example, divers worked steadily for five days, without success, after the *S-51* sank off Clock Island, New York, in good weather. In this case, the divers attempted to pass heavy wire slings under the *S-51*'s stern, which was just clear of the mud.

The Story of the *S-51*

JOHN C. NIEDERMAIR

It was on September 25, 1925, that the *S-51* was hit by the *City of Rome*. It wasn't very long before I got a telephone call that alerted me to the problem I was going to be faced with on the *S-51*. So, on October 19 Captain Edward Ellsberg, USNR, and I left the yard on the *Vestal*, which was a repair ship.

When we arrived, the *Falcon* was out there, with Captain Ernest King and Lieutenant Hartley, who was the captain of the *Falcon*. He later on became a rear admiral in the Navy and was the captain of a cruiser during the war. Dick Hawse, who was an expert on handling small boats in the rough seas, was always there.

When we got there, we found out that Merritt Chapman & Scott contractors, originally hired by the Navy to salvage the *S-51*, were out there with their big crane. They had attempted to raise the submarine, but in maneuvering their crane around, they dropped an anchor overboard. It so happened that they dropped it on the bow of the *S-51*. This gave us quite a bit of trouble later on because when we tried to get the buoyancy of that compartment, air was leaking out of the rivet holes. The seam cavity sort of spread the plating apart. We had to fix that up with white-pine wedges that we drove in there. They'd swell up and we solved it in that way. It was a simple solution.

There was also a salvage crew out there that had been down in Guantanamo Bay, practicing the raising of a German submarine from World War I. They never did really raise it. I found out later on that they had done a lot of things wrong. They could always get one end up, but they never could get both ends up.

I had collected some plans of the *S-51*, and some particulars about her capacity plans and arrangement plans. First, we had to start mooring the *Falcon* by putting down five-point moorings so that you could always position the ship anyway you wanted over the wreck. That's where Dick Hawse was a real expert. In the beginning, we only had a Navy small boat to do this job, and it wasn't very long before we found out that the Navy didn't have a single small boat that we could handle out there. We had to borrow one from the Coast Guard, a 26-foot motor whaleboat; that worked perfectly. Hawse managed that thing. He was really clever, all right, and we'd get our five-point moorings no matter which way we had to have the *Falcon* arranged. We could, depending on the weather and the way the sea was running.

One thing led to another. There was no one alive in the *S-51*. They were all gone, except the three who had been rescued from the water. These three had been up on the bridge when she was hit, and they were rescued from Long Island Sound. They were the most forlorn three people I have ever seen. I still think of them, how forlorn they were. You can imagine. They didn't live very long after the *S-51* went down. Somehow or other, they died one after the other in a very short time.

I got interested in making an estimate of the situation and how we would raise this submarine. I began to make some calculations: how much buoyancy we had to have by pontoons, what to do with the pontoons. It so happened, however, that the salvage crew who was there had their own way of handling the pontoons. I described my system of doing it to Captain Ellsberg, but we had to let the salvage crew do it because that was their specialty.

When the day arrived to drop the first pontoon down for a test at a depth of 150 feet or so, I didn't go out because they weren't doing it my way. I felt they might be nervous about the fact that I was standing around, nosy about what they were doing. They were always conscious of the fact that I was there, so I stayed away for two reasons. One was my own reason, that they weren't using my method, and I felt sure their system wasn't going to work.

Ellsberg left and I stayed in the office because I had plenty of calculations that I had to make. He came back that night about 11:00, and I was about to ask him—in fact, I did say to him, "Well, how did you make out?" He said, "Niedermair, first tell me again how you would handle those pontoons? How you would lower them?" So I told him how I would lower them. "Well," he said, "from tomorrow on, you're going to be in charge. We lost our pontoon today." We later found [the pontoon], but they couldn't find it at that time. They hadn't found it by 11:00 that night.

These pontoons had a problem because they had 120 tons of buoyancy capacity; the pontoon itself weighed 40 tons, and if you blew all the water out, you had 80 tons left, net. The trouble was when the valves opened and let the water run in, 40 tons pulled on the little lines that you were trying to lower it with. This was all right when you were working in 60 feet of water or 50 feet of water; then you could let it run before it gave you any trouble. But now, when they had to go down to 150 feet or 160 feet, that was too much. By that time it got so full of water, the lines started snapping, and they broke off.

What you had to do was allow so much water to get in; you had to put in enough water to sink the pontoon. I did it with a stopwatch. I would time it after we let the water run into the pontoon. So, the weight would begin to come onto the lines before we started lowering. I would give it about five minutes or five seconds or some interval of time with the water still running into it to give it weight so it would pull it down. Then you'd shut it off; you'd shut it off with an air bubble left in the pontoon. It was as simple as that, but they didn't realize that.

So we started working on it. We had various problems in drilling underneath the submarine to get the chains down. There was the buoyancy problem of which end would be raised first. It appeared to me that the best thing to do was to raise the stern first because your chains could go through, just forward of the propeller. The struts came out where the propellers were so you ran your chains down in between them and they wouldn't slide off.

We finally got all our pontoons down, but, in the meantime, we'd learned how to handle the pontoons. We put six forward and two aft. The winter weather was coming, and we wanted to come back in November, around Thanksgiving Day. When Dr. Flothy and I made an estimate of the situation, using the Farmer's Almanac to judge the weather, we judged that we couldn't get more than one diving day a month from now on, or some such figure.

I remember Thanksgiving Day when we were sitting there. The Navy wouldn't let us go back home because the public wouldn't stand for this.

They said we couldn't come home because the bodies were still in the submarine. We finally prevailed on them to let us go back because we had certain other things we had to do to improve the compressor up on the *Falcon* and the manifolds on the *Falcon*. There were certain things that had to be done to get ready for the final salvage. They finally allowed us to go back home, but I remember listening to this Cornell-Pennsylvania game that they play every Thanksgiving Day. The radio on that ship was terrible, but I was listening to it out there.

The officer, who was in charge of the crew's mess, had Thanksgiving dinner with the crew because they were having turkey for dinner. I was eating in the officers' mess and we had meat loaf for dinner on Thanksgiving Day! Everybody chipped in about a dollar a day. The government paid me for that later, but I did it exactly the way the officers had to do it. I felt that was the way to do it.

During my period back in the yard, in December, we did a lot of things and worked on the pontoons. We also found out what it felt like to be in a diver's suit. Ellsberg did this, too, only he went further than I did. I only went far enough to know just what a diver was up against. I wouldn't dive. I felt that it wasn't my job. Ellsberg learned how to dive and he actually went down. He was a real daredevil; one of the bravest people I've ever known. He didn't mind it at all. I found that later on in his career he did a lot of things. I was beginning to wonder whether he had his wits about him, but he knew what he was doing, all right. He knew just how far to go, but it looked pretty risky.

We got all ready, and sometime in February we went back out to the salvage operation and got started again. We were having trouble with the divers' air hose freezing up. Air was being cut off because the water was getting colder and the air would expand into the diver's suit, because the air was coming down at a higher pressure than was in the suit and now had to bubble out through the helmet. That would drop the pressure at the valve. The combination would be such that the moisture that was deposited would freeze up the air valves. So we had to work out a method of drying the air before it got down there.

We partially solved it so that by the time the next salvage operation came around we had a way to rig to take care of that. But on the *S-51*, we didn't have any way to take care of it so we didn't go out there until the weather started warming up a bit. It must have been the end of February. We got out there and started placing the pontoons, digging tunnels, and all. For part of that operation, Ellsberg went down, because we had to haul out the main induction line, which was where the air came in for the diesel engines, to run the engines. The valves on that and the hatch covers weren't right, because when you put pressure inside the hull, they would lift because they were designed to be closed by water pressure around the outside.

Now we had no way of getting at the valve that was on this induction line. All we could do was to tear the deck out and get a section out of that main induction line. The divers went down and took the bolts out of the flanges of the section that we wanted to get. Ellsberg went down just as the risky part was coming. You had to have something hauling from the deck in order to yank this section out between the two flanges. It was pretty tricky stuff; so he decided to do it himself.

Now, he got into trouble with the salvage crew and the warrant officer in charge of the salvage crew's divers. Ellsberg talked to the telephone operator and asked him to ask this officer how the lines were tending. All this officer would say was that it was okay and that's what the telephone man told Ellsberg. Ellsberg wanted to know which way it was tending because down there he couldn't tell and "okay" didn't tell him anything.

One thing led to another, but they couldn't get together. I had never been on the telephone before, but Ellsberg, who was down there, asked me to get on the phone. So they hunted me up and I came down and picked up the

phone and talked to Ellsberg. And, you know, listening to someone under pressure down there is not the same as me talking to you. I finally understood through the squeaks what he was talking about, and he asked me the question, "Which way are the lines tending?" He had it all hooked up, with a line coming down that was on the hook of the crane on the *Falcon*.

I called over to the officer and asked him which way the lines were tending. I tried twice to get him to tell me which way the line tended and he wouldn't tell me. Then I said to Ellsberg, "Hold everything. I'll go over and look myself." So I went over to the side of the ship, examined the line and the way the crane was going, came back to the telephone and told Ellsberg everything looked all right to me. He told me where he was standing, which was out of the way of it.

Then we gave the signals to haul the thing up. As a result of that little incident, this officer went to Captain King and told him that I was ruining the morale of the diving crew. King looked him in the eye and said, mentioning his name: "You know, you're sick. I recommend you take sick leave, and when the reporters' boat comes in, you go back in it." So King was on my side.

Merritt Chapman & Scott went off the job because the Navy decided that we would do it. They didn't have any equipment. We had the divers; we had the salvage ship. Their big cranes couldn't stand the rough weather out there. They could never get it that way, anyway, so they were sent back home. They never liked it.

I had never been inside a submarine. I never took a dive in a submarine, and the S-50, a sister ship of the *S-51*, was right there. We could go and walk around on it, but I wanted to be in it when it was diving.

So I went to King and said: "Why can't I go down in the S-50 and walk around while she's running submerged, just like the *S-51* had been running?" I wanted to visualize where the doors would be open and what the condition of the ship would be. I understood it just as everyone had told me, but now I wanted to see it. Not having been in a submarine I thought, "Here's a good chance." King said, "No. I don't think it's necessary. Your place is up here."

I said, "Well, but I really think I ought to make a run in it." Finally, he gave in to me and I went down in the S-50 for a short haul. He gave orders to the captain about how long he could keep me down. We made a little run around out there in Long Island Sound, not very long, back and forth. It was just enough time for me to walk back and forth, climb up in the gun access hatch and look out, and see how that operated. I came back and that was it. Now I was an expert!

I was never an expert. I'd never been on a submarine before, but everybody thought I was an expert from that day on.

We were back again in the spring and got our pontoons working and so on. We had the pontoons up, but some of them were leaking. We went out in June to get ready to raise it. We were getting ready to raise it the next morning when a storm came up that night. We had to go out in the storm and get divers down to see how everything was going down below.

We thought we could get divers down, but as it turned out we couldn't. We could see that some pontoons were leaking very badly. It was very, very rough. I remember looking it over and trying to put a little air into a pontoon that was leaking. I knew which ones because they had told me the day before. I tried to compensate for that. We now had all our pontoons buoyant, but if they moved up the least little bit, the air would start blowing out the water and it would lift them. Once they started moving up, you didn't have to blow them out anymore because they would blowout automatically. It was that ticklish at that depth.

So the bow went up, and the result was that we got into all kinds of trouble that day. We had to let the bow down again. Then we got everything ready again and within two weeks' time we raised the submarine and brought it into the New York Yard. We took it down Long Island Sound. Just before we got into the yard, we had all shaved, ready to go home.

The sun was shining. Thousands and thousands of people lined the shores of Long Island Sound to watch us come down with this long tow through Hellgate that was 1,000 feet long.

Just outside the Navy yard, there was a submerged rock. We were to the right of the rock on the course we were going. I think they call it the White Horse Rock. We had a pilot aboard, and that pilot was afraid that our tow was going to hit a yacht that was in the fairway. It wasn't supposed to be in the fairway, but there it was. So the pilot veered to the left. As he veered to the left, we were closer to that rock than he had estimated. We hit the rock and knocked out our middle pair of pontoons forward, and down went the submarine. It wasn't very deep, but the speed of the water is terrific in the East River. (It was down by the Navy Yard where you had a riptide.)

After we got the submarine up out at the salvage area, I had noted all the drafts on the pontoons so I knew how much reserve buoyancy I had in each pontoon. That was a lucky break because now we'd lost the forward middle pair of pontoons.

We had only four left. We had to have six because when you were lifting at the angle we were at, the water was deep enough so that we had about a 30-degree angle. This is about the maximum angle you could swing a bow up like this because everything would slip away from you beyond 30 degrees. It depended on a maximum moment to lift it, more than on how much buoyancy you had. You had to have a moment to do it.

I had made this estimate. I was pulling my notebook out and (as Ellsberg said in his book) as I was looking over my notebook—everybody was ready to go ashore—I yelled out, "Well, if we're going to hit a rock, it's a good thing we have a salvage crew on board." And all the people who had been kind of glum awakened to this. Now we all had to go to work again. I imagine Ellsberg thought my statement really got them going. He was looking over my shoulder and he could see that my next idea was this: if we lowered the four pontoons that we had up forward and had lift, we'd get some cranes out and the chains up, and sink them down till they were underwater. Then we could get this reserve buoyancy, the amount of buoyancy that was sticking above the waterline when we were coming down the sound. That was just enough, the way I figured it out, to pick it off that rock.

By midnight we were able to do it. It was so close, I remember, that we had the floodlights going down. I think Ernie King wanted a boat to go out with a sailor on it to stick a flag up on the bow of the submarine. In order to do that, the sailor stepped out of the boat, stepped on the bow of the submarine, and it started going down. I didn't know how far it would go. Maybe we had a little reserve buoyancy. He couldn't stay there, anyway, but he noticed this happening and got off the bow right away. It gave me a clue as to how close my figures were.

Now we had to turn the submarine around 180 degrees and swing it into the yard at night. The tide was going out in the East River; so when we got it swung around the tide was against us, and there was a very heavy riptide there.

I had a beat on some way of telling whether we were moving or not. I was giving a signal when we were going to move. Ellsberg was ahead of me and he would get my signal, then he would signal the tugboats. What we wanted was to just get the tow moving forward, but not anymore than that. We didn't want to have much speed on it because we were pulling on a bow piece that I had worked up to put a hook into the bow of the submarine. It was like a shackle up there that I had made to hook the towline on, and we didn't want to lose it again. If we could creep into the yard, that was sufficient.

We managed to creep into the yard and got it moored alongside of a dock there. Then I went home. Everybody went home. I probably only got home for a couple of hours; then I came back again the next day, and we put it in a dry dock.

That's the story of the *S-51* as far as the salvage itself is concerned.

As a result of this tragedy, Salvage Officer, Edward Ellsberg wrote to the Chief of the Bureau of Construction and Repair that "Based on personal experience in salvaging the downed submarine *S-51*, and on consideration of other salvage work on submarines, it is believed possible to adopt a standard method of salvaging submarines, which will be available in all waters in which divers can work, and which will produce quick results."

Specifically, Ellsberg thought that, for the purpose of rescue and salvage work of submarines, two things were required—properly designed pontoons, and properly fitted submarine boats. Furthermore, he recommended "all doors and hatches (on submarines) should be of such size that a diver can pass through without endangering his life."

Editor's Note:

The rescue and salvage of the submarine USS *Squalus* in May of 1939 was another significant event in early Navy Salvage. Among those Navy personnel who were aboard the USS *Squalus* when it went down in 240 feet of water during a test dive off the coast of New England was Mr. Carl Bryson. This rescue involved the use of a diving bell for the first time. Mr. Bryson was rescued, along with 31 others, but 26 men perished, lost in this tragedy. He vividly recalls the rescue efforts as well as the changes that were made in the construction of submarines because of this incident.

In a personal interview he said, "We didn't have oxygen on the boat in those days like they have today. All we had was a couple of cylinders of oxygen and a bunch of CO_2 absorbent. It was very cold and people huddled together to keep warm. Finally, the USS *Falcon* came up from New London with the bell. BM1 Martin C.J. Savitsky, the first diver down, was able to attach the down-haul cable to the boat." Bryson was subsequently involved in other submarine salvage, many of which were unsuccessful.

There has long been a friendly disagreement among Navy salvors about the actual start of Navy salvage training. Some say it was the raising of the early submarines, others believe it began at Pearl Harbor, but most think that it was at the *Normandie* site in New York Harbor where formal training began. In any case, Navy divers were at work trying to rescue equipment and personnel years before official salvage training began.

When the word "ship" is added to the work "salvage," it brings an entirely new concept to mind. Now, thinking is not only about sunken submarines, but also about wartime sinking of fighting ships, hurricane damaged boats and ships, ships and equipment that has run aground, and finally, the attack of the Japanese on Pearl Harbor on December 7, 1941 in which the harbor was nearly unable to operate for one month.

The salvage tasks at Pearl Harbor required all available manpower, civilian and military, to put the battleships, cruisers, destroyers, a seaplane tender, a repair ship and a floating dock YFD 2 back into service, or declare them beyond salvage. On all of these ships, long and exhausting efforts were required to remove human remains, documents, ammunition, and other items from the oil-filled interiors of ships, some of whom had been underwater for months by the time divers could be assigned to them. It took over two years to complete this task.

This was the beginning of modern Navy salvage operations. To complete the task required that Navy and civilian divers spend about 20,000 hours underwater during approximately 5,000 dives.

The rest of the oral histories in this chapter begin after the attack on Pearl Harbor and continue through the clearing of the Suez Canal in 1975.

Post-Attack Pearl Harbor Salvage

(Previously published in FACEPLATE)

During the weeks following the Japanese raid, the repair work was done by the Pearl Harbor Navy Yard, assisted by tenders and ships' crewmen. These efforts, lasting into February 1942, put the battleships *Pennsylvania*, *Maryland*, and *Tennessee*; cruisers *Honolulu*, *Helena*, and *Raleigh*; destroyers *Helm* and *Shaw*; seaplane tender *Crtiss*; repair ship *Vestal*; and the floating dry-dock YFD 2 back into service, or at least got them ready to steam to the mainland for final repairs.

The most seriously damaged of these ships, *Raleigh* and *Shaw*, were returned to active duty by mid-1942. Five more battleships, two destroyers, a target ship, and a minelayer were sunk or so severely damaged as to represent nearly total losses. These required much more extensive work just to get them to a point where repairs could begin.

Starting in December 1941 and continuing into February 1942, the Navy Yard stripped the destroyers *Cassin* and *Downes* of serviceable weapons, machinery, and equipment. These two ships came back into the fleet in late 1943 and early 1944.

To work on the remaining seven ships, all of them sunk, a salvage organization was formally established a week after the raid to begin what would clearly be a tremendous joint effort.

Commanded from early January 1942 by Captain Homer N. Wallin, previously a member of the Battle Force Staff, this salvage division labored hard and productively for over two years to re-float five ships and remove weapons and equipment from the other two. Among its accomplishments were the re-floating of the battleships *Nevada* in February 1942, *California* in March, and *West Virginia* in June, plus the minelayer *Oglala* during April–July 1942.

The Salvage Division also righted and re-floated the capsized battleship *Oklahoma*, partially righted the capsized target ship *Utah*, and recovered materiel from the wreck of the battleship *Arizona*. These three ships were not returned to service, and the hulls of the latter two remain in Pearl Harbor to this day. Much of this work had to be carried out in gas masks, to guard against the ever-present risk of toxic gasses, and nearly all of it was extremely dirty.



USS Oklahoma (BB-37) Ship righted to about 30 degrees, on 29 March 1943, while she was under salvage at Pearl Harbor. She had capsized and sunk after receiving massive torpedo damage during the 7 December 1941 Japanese air raid. Ford Island is at right and the Pearl Harbor Navy Yard is in the left distance.

LEONARD GREENSTONE

At one time, I thought that I was the youngest person involved in the salvage of the *Normandie*. I have found out since that there were several guys there who were younger than me by one or two years. I was 19 at the time.

I went into the Navy in 1942 after serving six months in the California State Guard with my cousin Jerry. We wanted to be in the Navy. We were allowed to leave the Guard to join the Navy.

I began diving by being a plumber in the wrong place at the right time. They shipped me to Pearl Harbor in 1942. I went to work in the Navy Yard. While I was there, a truck backed into a fire hydrant. Water was shooting up everywhere. A lieutenant was running around making all kinds of noise and trying to get the

thing shut down. I walked over to him, as this humble little kid, and said, "there's a valve on each side of that fire hydrant. All you have to do is dig down and there are flat head valves. You just turn them contrary to the flow of the pipe and you'll shut that system off." He then used nasty language to tell me to get off my behind, get down there, and do it! A buddy and I dug down on both sides of the hydrant to the valves. We got the valves and water turned off. The lieutenant asked where I was assigned. I answered, "The AIEA Receiving Barracks." He said, "Report back here in the morning."

The next morning, Ed Raimer picked me and my buddy up on the docks in a vessel he had converted into a diving boat. There were four on the boat who were going out to the USS *Oklahoma* that day. We went out with them as a work assignment. We were deck hands helping as needed thru most of the day. Near the end of the day, Ed asked if either of us had ever dived or would care to now. I wasn't too anxious, but my buddy went along with me; he actually volunteered me. They dressed me, took me to the ladder, handed me a canvas bag, and said "Follow the line, and if you can pick up any personal items put them in the bag." He described the basic 1-2-3-4 pull signs and said, "We'll talk to you on the bottom." He closed my face plate, hauled me over to the down line, and I slowly went to the bottom in very murky water. After being on the bottom awhile, topside asked, "What are you doing down there?" I didn't want to tell him I was expelling my bladder. I felt very uneasy, but remembered my dad always said boys don't cry. I was sure my mother would question if this was a job for a Jewish boy.

I could hardly wait to get out of there, and they brought me up. I figured that was the end of my diving career.

Then Ed asked, "Are you coming in tomorrow?" I said that I had no idea. He said, "Yeah, show up here tomorrow at 0700 hours." Well, I wasn't overjoyed, but that started my diving career.

The first time I ever dove, I dove in full dress. I had no knowledge of what diving was, other than jumping off a diving board and doing fancy things with your hands and feet.

After some five or six days of working together, they decided to send me over to the submarine base to get some training so that I wouldn't be a disaster to them. At least they'd have the backup to prove that I had some practical or educational experience to help me do what I was doing. It was a partial thing anyway. I'd go to AIEA Naval Barracks to the Navy Base every morning, and they would teach us some of the physics and physiology and stuff that were involved. Then I would go back out and go to work. That went on for some three weeks, I guess.

They ultimately classified me as a second-class diver. I never took the test, but I got a funny looking document, and I got a chance to work a lot on the USS *Oklahoma* and the USS *Oglala*. Then I was assigned as ships company aboard the YR42 Yard Repair Vessel.

While in Pearl Harbor, I also met Frank Prepazich, a second-class diver who was doing salvage work. Prepazich was going back to New York, and he gave me the idea that I could get back to the States by going to New York to work on the *Normandie*. They were looking for people



Diver Greenstone being dressed by his crew.

like me, he said. I applied. It didn't take very long; in only a couple months I was back in New York at Pier 92, which was where we lived. We marched from Pier 92 to Pier 88 every day to work on the *Normandie*. It was really arranged by Prepazich, who didn't get to Pier 88 until three or four months after I arrived.



The USS Normandie *capsized at Pier 88 in New York, 1942*

The Salvage of the *Normandie*

When the *Normandie* capsized in New York Harbor in February 1942, it changed the way the Navy trained men for salvage work. Because of the extensive salvage work that was needed on the *Normandie*, and the lack of trained salvage personnel, for the first time the US Navy initiated a formal Navy Salvage Training Center. For most of those who were trained in salvage at this center, the *Normandie* was the site of their "hands-on" training.

The *Normandie*, 1,029 feet long, with a beam of 119 feet was designed with a unique hull that featured a fat-centered hull, with a bulbous bow and pointed ends. From 1932 to 1939, because of the fancy Art Deco interiors, she became the ship to sail on between Europe and the US, and boasted, among other features, a first class public room that was 300 feet long, 46 feet wide and three decks high. It was in this area that the fire started and was unable to be controlled.

When hostilities broke out in Europe in 1939, the *Normandie* was in New York Harbor. The French government decided to leave her there until she could return to pleasure sailing. After Pearl Harbor, however, she was taken over by the US government and her name changed to Lafayette, the French leader who had helped the US during its Revolution. The plan was to convert her to a troop ship that could carry as many as 18,000 men at a time. Before this could happen, however, she needed to be converted from luxury status to one of useful military status. Because there was no dry dock large enough to convert her, it was decided to do the work at a pier. As a French ship, she had only French fire fighting equipment on board; thus, a fire watch was established in case of a fire on board.

The fire began about 3:30 one afternoon when a spark from a welder's torch in the over-sized public room caught nearby stored, highly flammable life jackets on fire. The fire quickly spread, but did little actual damage to the inside. Instead, after 12 hours of taking on about 10,000 gallons of water from fire hoses, the Lafayette (*Normandie*) rolled over on her side in the icy water. Her bulbous bow was out of the water, with the port side sunk in a bed of soupy mud that was actually 20 feet of sewage.

When the *Normandie* turned on its side, nearly everything about her position in the water and the situation caused a serious problem. As outlined in the book *Normandie: Her Life and Times*, by Harvey Ardman, the four major problems were these: the underwater surface on which the *Normandie* was lying consisted of three strat, a twenty-foot layer of black, highly organic and almost liquid "mud' (actually sewage); a second stratum of gray, silt-like organic clay; and a third straum of fine gray sand. But at the middle of the ship (had it been upright) a hard edge of rock reared upward and caused the ship to rock fore and aft as the tides came and went. The second problem was caused by all the mud and silt on the bottom. The enormous weight of the ship had caused her to sink into the semi-liquid "mud" about forty feet. The third problem was the condition of the

water in the slip where she sank. Because a sewer line emptied into this area, combined with the oil and gasoline leaking from the ship, the water was almost opaque, even under bright lights, and made it impossible to see. The fourth problem was that over 350 portholes and 16 large cargo ports were either left open or forced open by the pressure of the two-by-fours from the repair scaffolding that splintered and rammed through many closed portholes.

The job of salvage was quickly assigned to the Navy, as the task was far too large and complex for the contracting firm who had been working on the remodel of the ship. Before the ship could be righted, all of the open and broken portholes had to be sealed by divers working in zero visibility. No one in the country, including the Navy, had the number of divers needed to complete this task. As a result, three salvage diving schools were quickly set up: one for civilians, one for Navy officers who would direct salvage operations, and a salvage school for enlisted men who were pulled from the fleet because they possessed mechanical skills. The logic was that it would be easier to teach a mechanic to be a diver than it was to teach a diver to be a mechanic. Of those who attended the schools, more than one-third were unable to complete the training because of lack of mechanical skills, stamina, or emotional problems caused by the working conditions. Nevertheless, more than 2,500 Navy men completed the salvage school, allowing as many as 75 divers at a time to work on the ship.



Officers in the first class of the Navy Salvage School at Pier 88.

To make the ship watertight so it could be righted, 6,000 tons of rubble, and 4,000 tons of smashed glass had to be taken off the ship and all portholes and cargo ports sealed. The major problem was that diver's had to seal these openings one at a time; sometimes it took as long as one week to seal a single porthole. They used a newly designed plug, called the "Tooker Patch."

It was not until 1943, nearly two years later, after 98 pumps had been installed, via derricks lifting them on to the ship, that a tunnel was made under the ship to prevent the hull from being held in the mud by suction, and the pumps were tested. After several delays and unexpected leaks corrected, in November, the ship was towed from the harbor to a Navy dry dock in New Jersey. Later that year it was decided that the cost of refitting the ship was unacceptable, and it was sold as scrap metal in 1946.

One of the young men who was successfully trained and worked hundreds of hours on the *Normandie* was Leonard Greenstone, the same young Navy man who became a diver at Pearl Harbor.

LEONARD GREENSTONE

When I first got there, I found it exciting. The training was a lot different. They took a guinea pig and created problems, when he did not ascend properly, and after too much time on the bottom, the little guy got bent. After you dove for a while, you understood the dangers. They spent a lot of time with us because they were trying to quickly develop divers at Pier 88; because they needed them.

The most difficult thing to get used to was the make-up of the bottom. Pearl Harbor had sedimentation, but it was nothing like New York. In New York, when you went into the water, you buried yourself in mud filled with tons of rubble and sewage. Because of this, we learned to blow ourselves out of the mud off the bottom, which was contrary to what other diving schools taught. Here, working on the *Normandie*, every one of

us had to experience a controlled "blow up" as a preparatory procedure to ensure you could successfully work your way out of the mud by working your chin button and kicking your arms and legs outward until you freed yourself. This procedure created just enough buoyancy in your dive suit to start the ascent. Once you got out of there, you were on your way up. Then, you had to dump your gas as fast as you could so you didn't just go to the surface and explode. You had to learn to control your ascent like an elevator ride to the surface without having any assistance or you'd pay a high price.

The danger of blowing up was twofold. First, there could have been something up above and you hit it. Second, you could rupture the suit, fill up with water, and down you would go. Everyone had to get out of the mud alone. You didn't have anyone to help you break loose; you had to make it to the surface on your own. There were many who came up spread eagle on the surface. Through the graces of the good Lord, they didn't blow their dresses to kingdom come, and/or their own lives.

Some salvors will tell you that salvage diving in the US Navy began with the work on the *Normandie*, but I really think that salvage diving began in Pearl Harbor. I think the work we did on the *Oklahoma* was salvage work. I was not the shipfitter nor was I a great welder. They didn't teach us as well as they taught us at Pier 88, but we did learn to weld and burn under water. The burning tools and equipment that we were using in Pearl Harbor were greatly increased in their proficiencies at Pier 88 because the guys there were experimental. They developed equipment that we didn't have in Pearl Harbor.

Salvage diving was created by necessity. During the war salvage became important, and it was necessary to create another class of divers. Pier 88 and the *Normandie* happened to be the school that became available to create the Navy Salvage Diving Corps.

President Roosevelt requested Commander Sullivan salvage the *Normandie*, where upon the US Navy Salvage School was established. It was called the "US Navy Ship Salvage School."

Sullivan also got the Bureau of Naval Personnel to designate another diving class named "Salvage Divers." They were second-class divers who were limited to 90 feet maximum, and salvage divers who could go to about 150 feet, whereas deep-sea divers were the mixed-gas divers and could go deeper on mixed gases.

You had the designated diver, the first-class diver, who had the insignia, the second-class diver, who had the same insignia, but with the number "2" on it, and the salvage diver, who had the same insignia with an "S" on it. Of those three categories of divers, the salvage diver was the last one to come along.

You got certified from the diving program or a diving school where they trained you. Nothing like that existed before the *Normandie*. The Navy had minimal salvage capabilities, so they had to contract with the East Coast group: Merritt, Chapman & Scott, and on the West Coast with one of the maritime groups. Sullivan was the Navy's liaison officer to monitor that contract.

Most of his salvage experience, up to that time, really came from England. He was successful on some very interesting salvage projects out of England, which is what excited the President.

President Franklin Delano Roosevelt had been the assistant secretary of the Navy under Woodrow Wilson. He was the guy who came up with the idea of compartmentalizing the *Normandie*. He was the guy who said, "Let's do it this way." Along with him was Russian Naval Architect Vladimir Yourkevitch, who came into the program and had his own idea about the use of the compartmentalization and/or filling and dumping these compartments. In our business, we used to call it "par buckling." This guy had all these ideas.

Sullivan had a whole flock of people helping him to come up with different designs and philosophies on how to salvage the vessel. Yourkevitch and the President of the United States were the two most effective people in

providing him information on the systems he used to salvage the *Normandie*.

Ultimately, Sullivan got promoted to rear admiral and he did all Navy salvage, worldwide, during World War II.

The reason they wanted to salvage the *Normandie* was because it was taking up all of Pier 88, and they had the whole harbor screwed up. They had to get it out of there. That docking space was extremely valuable. They needed it not only as a ship, but also they needed the area to bring other ships in that would get troops out. The easiest way to get it out was to salvage it.

The real benefit of Sullivan was that he talked about the benefits of getting that ship out of that area. He said it would be a two-year experience. "In two years, we'll spend $4 million and we'll have this ship out of here. It'll be ready to put airplanes on the deck." Sullivan wanted to make an aircraft carrier out of it. The people before him were talking about a troop ship.

If a disaster can be a blessing, the *Normandie* was, because it was able to provide the Navy with capable training facilities for divers. All the ARSs, salvage ships, and diving personnel were trained, for the most part, at Pier 88, on the *Normandie*. They manned the ships that went worldwide during the war for salvage purposes.

I think the thing that what was important is the fact that there was so much structural work done on that ship during its preparation to re-float it. The kinds of bulkheads that were built to divide the ship, to compartmentalize the ship, were really somewhat unusual. They used massive timbers with two-by-four interlocking timbers and created a bulkhead by establishing a steel frame and putting this one major piece of timber on top. Then, divers would take two-by-fours, simple two-by-fours, and bring them down and put them up into the groove. Then, two divers would dive down with another piece, move it under that, move it up and lock it. They were taking a piece of eight-by-twelve timber and they couldn't see the other diver or what he was doing. He could only adjust where that timber was going by his feel. Too often, there was one guy down and the other guy got all the slivers in him, when that piece of timber took off for the top. They had to control that.

The introduction of the Tooker Patch changed everything. It was designed to go from inside the vessel to outside, with the strong back and wing nuts close against the outside of the vessel. In this instance, you couldn't do that with the *Normandie*. You had to go down to some of the portholes that were beyond sinking depth, with sinking depth anywhere from six to eight feet in mud and then depressed. If you wanted to go further than that, you had to wash yourself in there. You washed yourself down to the porthole. Then, the first thing you did, so that you didn't screw up, was lock in a device that let you know where that porthole was so that you didn't have to spend a lot of time finding the thing again. Then, when you went back the next time, you felt around and tried to find out about that porthole, which opened up on the inside of the vessel. That had to be done away with because you were going to put the patch on from the outside. You had to use pneumatic tools to chop off the hinges and junk from the inside and stuff the junk in, take a saw and cut the timbers off, shove the timbers in, and then, take the tooker patch and put it inside. You didn't have much of a lift on some parts of the inside of that opening, where you could adjust this patch when you put the strong back on. The rubber was going to be able to lock from the inside.



Scale models of the Normandie were made and studied in preparation for the ship's refloating. From left to right: Captain C.F. Chandler, Commodore W. Sullivan, and Captain John T. Tokker

One of the dumb things, that made me laugh while I was in the mud, was that I could be holding one of the wing nuts and the patch, trying to put the other one on, and I would drop the wing nut. In the water, you did not go reaching for it. You got your hand out of the way and then went down below the mud to where you thought it was, and started shaking the mud. The wing nut would come down through the mud in your hand. Then, you took it and put it on again. You couldn't help but laugh because you had never ever touched, witnessed, or involved yourself in a thing like that before.

When they attempted to raise her, they found her bottom was split and leaking. They tried several methods to seal a crack. They tried jamming bags of rags in. For five or six days, on an almost continuous basis, night and day, jamming rags in the cracks. They were also taking down bags of sawdust. Sawdust, when you dump it, is supposed to follow wherever the water is traveling. Then, when it gets in there, it expands. But the divers couldn't see what they were doing; they just dumped the bags. Three quarters of the sawdust went to the surface, where it was not supposed to go. Some of it got in there, but it just didn't work.

They ultimately sealed the crack with concrete. They probably put in almost 300 yards of concrete, filling the double bottom. This was the method that ultimately slowed down the seepage.

At that time, it was probably the largest capsized ship in history, and they were able to right it and float it. It was probably the most successful marine salvage operation ever.

When the ship was being prepared to be towed out of Pier 88, I looked at her in awe and was almost speechless. I was nearly overcome with feelings of pride in the work accomplished, the triumph of raising the great ship back to life. It was almost like being a member of a winning super bowl team.

Later my Navy term would take me in another direction; one of them being harbor clearance. The origin of harbor clearance arose from capturing harbors during World War II. When the military captured an island or a harbor, there were scuttled enemy ships and so forth that needed to be cleared out of the harbors so we could bring in our own ships. Hence, harbor clearance became essential. But at that time, there was no special harbor clearance unit so they used all kinds of divers, including salvage divers. In early 1944, six of us were sent over to "McArthur's" Navy Base under Admiral Kinkaid for salvage work in New Guinea to clean up a harbor. We got involved in the construction of an emergency hospital for his injured troops. For this operation, we were awarded a Commendation Citation.

Editor's Note:

During Greenstone's stay in New York, he wrote a letter to his parents about his experiences and what he had learned. In part, the letter said, "Our salvage school is also called 'Elimination School' because so many men did not make it... The elimination began when we were awakened to make our first dive. The guys claimed colds, earaches, cramps, etc. The elimination continued when claustrophobia took some. Our second dive was that night and the elimination continued. I dove first not to be influenced by others' problems. Some guys even refused to leave the ladder, and so forth. The water is always black and the stuff we have to bury ourselves in is not 'mud' but sewage... when we drop our tools or materials they don't sink very far—we can reach and pick them up, down among the tons of sewage."

Greenstone returned to Pier 88 in September of 1944, for a refresher course and as an instructor. During that time he became an expert on salvage. Later he noted, "When I look back at working on the salvage of the *Normandie*, it's like an eerie, unbelievable dream. When you're young, you don't realize the danger or the working conditions. But, for a youngster, it was exciting."

After the ship was raised and towed away, he continued to work on Pier 88, where the ship had capsized, to help clear the dock area of debris and work on the reconstruction of the pier.

WWII

World War II created no end of work for Navy divers. Harbors needed to be cleared, damaged or sunken ships had to be salvaged, and submarines had to be rescued. Commander Jackson Tomsky was involved in some of this work.

COMMANDER JACKSON TOMSKY

We were in the Atlantic, and we did largely mundane things. Because the submarine rescue vessels had sonar on board, we were always tied into the tail end of convoys, using our sonar. We just operated in the Atlantic. There were two things prior to the war, O9 sank off the Isle of Shoals and all hands were lost, and during the war, the R-12 was rammed in Panama and sank with the loss of all hands. We went to both of those scenes.

The O9 was in around 400 to 440 feet of water. That was a very, very significant depth. As a matter of fact, if my memory serves me correctly, we managed to get divers down to the submarine and at a very, very great risk. The risk came in the guise of air hoses that were not designed to withstand the pressure that was required to pump the breathing mixture down to the diver at the bottom. There was a great fear that one of those hoses would burst. We were doing helium and oxygen diving then. It was the early part of 1941, before we were actually at war.

They found the submarine, but nothing could be done. Submarines weren't designed for those depths. They did a memorial service.

There was one interesting chore that we had. The Portsmouth Naval Shipyard had a task to experiment on submarine hatches. They filled a COC section of a submarine and put hatches on it. Then, we would take it out, tow it, put it down to depth, and set off depth charges to see the effects. We set off one too many and blew the hatch. The section sank. We had to recover it, which was quite a job. We used these things designated YSP; they were big pontoons. I think they had a 60-ton lifting capacity in each one of them, and they were huge cylinders. To maneuver those things was quite a chore.

Then, I went out into the Pacific and we did the same thing. We were in Guam in 1945. I was on a salvage vessel, an ARS, in Okinawa. We cleared up the bottom in Okinawa, getting ready for dredges to improve the harbor. We were doing a lot of harbor clearance work in shallow water.

It was work; just very hard work. In most cases, we couldn't raise them, so we'd just blow them up and lift out the pieces. The ultimate goal was to bring dredges in and dredge the harbors so that they could bring in the cargo ships and other ships, and start stockpiling for the invasion of Japan. It was very late in the war. We were there when the war ended in Japan.

Post-World War II Salvage Work

When World War II and the Korean War ended, there was much less salvage work for Navy divers, but that doesn't mean they were idle. Captain Rusty Mirick recalls some of peacetime jobs that he worked on.

CAPTAIN RUSTY MIRICK

The operations I recall sometimes involved the conventional diving mode, typical of salvage ships in the southern California area. It all came together for us when the Mark V [marine mammal] system failed one day off of Point Mugu and a telemetry round of some significance, and certainly some serious monetary value, was lost. There was a general location, but the Mark V recovery system failed because the seal had a cold. The Department of Defense (DOD) gave SUBPAC a call and the Navy had to go to its next best thing. "If the sea lions aren't working, maybe saturation divers could," they figured.

We gathered our tools of the trade. The crew was excited to get underway on a real job, for which we had no canned scenario. It was a real thing and the ship (USS *Pigeon*) performed

superbly. That was an operation we conducted in December of 1984 and finished in January of 1985, off of what is now the naval base for Ventura County. We were in the sea range for the Point Mugu Naval Air Station. We were successful in finding the warhead. When I say "warhead," I mean the telemetry round, which was buried in the mud. It wasn't something a sea lion could have gotten anyhow, because of the position of the hardware in the mud. We were able to, with SAT divers, recover it in about 250 feet of water, get it on deck, and pass it on to the folks that needed the data.

We located the target by using a couple pingers set in the general location by the DOD. They were able to localize the ordnance; they were just not able to recover it. We picked up the frequencies, added our own pinger matrix, and went to work. The conditions were such that divers had to get to and from the search area with line. I remember the line getting entangled with the stage and how it hung below the PTC, which doubled as a weight to keep the PTC orientation correct.

The PTC was a ball with an open bottom. You wanted the open bottom pointing down. That's what the stage's job was, and it was over a thousand pounds of lead, basically. It hung from the PTC with four wires. Those wires became a source of entanglement for all the lines.

That was stressful, because divers only had so much time for excursion before the lack of heat became a major factor and they had to be recovered. You couldn't recover them if they were tangled and there was no one down there to untangle them but themselves. That was the major challenge to this operation, but it came off very well. It was one of those things the whole crew could rally around. It was real world salvage.

I have another example. It was earlier in the year, which was why the crew was so keyed up for the salvage operation that I'm retelling. If you back up in this conversation six to eight months, we had an unsuccessful salvage operation. It was unsuccessful on several levels. The Coast Guard kept losing a weather buoy off the entrance to the San Francisco harbor, maybe 15 miles out at sea. There was something unique to this buoy. We were told it was because fishermen kept purposefully sinking it, because it was in the way of their dredging, or long lining, or whatever business the fishermen had.

Whatever the reason, the sailors down in the mess decks made up their own reason for this buoy. They said it was part of our nuclear deterrence, that there was special equipment on the buoy, and that was something that only a cynical sailor could come up with for why they wanted it back. The Central Intelligence Agency needed it or whatever.

Well, I wasn't so cynical. I believed the cover story was that they just needed the buoy back for an admiralty claim against fishermen. Nonetheless, that was the salvage project. It was in about 200 or so feet of water. The USS *Florikan* was assigned the job, and she was capable of doing it.

Unfortunately, there were some equipment, depth, and weather problems, and the naturally occurring cold water and current all combined to be, unfortunately, a fatal dive for one diver. If you're thinking of the USS *Safeguard* accident in the early nineties, or mid-nineties, it was the same kind of thing. This was in 1984.



Open bottom PTC

The surface supplied diver got entangled and tried to ascend, either being pulled up, or was on the stage. The harder you pulled up, the more force was pulling down, because the diver was entangled on the bottom by the umbilical. The umbilical was no longer a route to safety, and the surface world and the umbilical became the forces that kept the diver down on the bottom. That drowning scenario was what played out on that job for the *Florikan*, and that was exactly what was replayed for two divers, I think, on the *Safeguard* almost a decade later.

The point is that when we went to this job, the saturation divers made a bronze plaque dedicated to the *Florikan* crew and those lost in that operation. My crew was very solemn.

We were realistic about the chance of getting this weather buoy back. It was quite a large disk-shaped buoy with tons of gear on it. To re-float it would have required a classic salvage technique. It was not at all an elementary procedure of recovering a little buoy. It was pretty heavy duty. The Navy had already spent significant resources and the cost of divers.

Up we went and laid the four-point moor. We got ready. We loaded the divers in the DDC, and they were given a 12-hour order from me to get in the PTC to go in the water column. The commanding officer put a hold on loading the PTC, which would have immediately resulted in getting those divers in the water column to go to work. Instead, in the DDC, they were on board the ship. They were comfortable. They were getting their meals. They were safe. That was where the CO wanted them, because he was watching the weather and sure enough, the surface weather hampered our operation and we never did get anybody wet for that one. We had to recover all of our preparatory salvage equipment and steps we had made as we briefed. We had to reverse everything and keep the divers on board. About ten hours later, we were in a full-fledged gale force storm that had suddenly erupted outside of San Francisco.

We tried to recover the moor to flee the storm, but the weather was too rough to even deal with the four-point moor. A four-point moor is basically a length of chain at four points, terminated by a buoy, to which the ship is tethered by a ten-inch nylon line. Ten inches is a very significant diameter; most ships don't work with that kind of large dimension. This ship was designed to handle that, but not in sea-state six and winds gusting to sixty miles per hour, and that was what we had. All we could do was sit almost helplessly and watch those lines part, one at a time, and they did.

It was a good call by the captain to not deploy in a diving mode. We would have had to recover them in a hasty fashion. It would have added a complication to an already bad situation. For the weather buoy operation, again, divers didn't get to play, but we were being blown out of a four-point moor, watching those lines part with explosive force. I'll let somebody else's oral interview explain the latent power behind a nylon line stretched to its breaking strength and suddenly released when it parts. I'll let somebody explain the physics and what the feel and smell of it are like, but it was very scary.

Finally, because of Mother Nature, when the last line parted, we were free of the moor whether we liked it or not. We were able to make way for safe haven, and recovered our four legs when the weather cleared without incident. That was our first foray into real salvage after we certified the *Pigeon*.

COMMANDER DEWITT "RED" MOODY

We did a lot of diving jobs. In those days, the local people did not have the resources or diving capability to go out and look for drowning victims. Up and down the East Coast, we used to get called upon quite often to go and search for people. It was not something that we volunteered for, but once the request was made, and your superiors said, "Let's support them," you went ahead and did it. Usually, we would report to the local sheriff of the area, and the sheriff would take really good care of the crew once they got there.

We had one occasion when a young man was undergoing scuba training from the administrative assistant of one of the state senators in South Carolina. Well, he apparently drowned, so they called us to send some people. It was in a reservoir with a lot of underwater structures and it was a very dangerous place for scuba divers to be working. After thoroughly briefing a young officer, I told him to go report to the sheriff. If he couldn't find the body, to give the sheriff a briefing as to exactly why he could not. He was well prepared to do that, and he finally had to because they didn't find the guy.

In the meantime, I got a call from a friend of the administrative assistant. He told me to have my divers report to him. I said, "We don't work that way. We report to the county sheriff. He's the one who has jurisdiction." Well, the guy had a keen interest because he was liable to be charged with negligence or something. I said, "If you want to go with them, they'll be roaring through your town in about three hours. You can follow them." Then I called the sheriff and told him what I had relayed. He said, "Good. That's exactly what I would have told him." We had very good rapport throughout the areas in which we worked with the local authorities.

There was a another operation in which I got involved. I got a call one evening after Hurricane Betsy went through Louisiana. They said that they had lost a chlorine barge on the Mississippi River inside the city limits of Baton Rouge. Lyndon Johnson had flown down there and directed the Navy to locate the weapon, get it out of there, and locate the chlorine barge. They were really concerned that the chlorine tanks would rupture.

In view of the seriousness of the operation and knowing that there was going to be mass confusion there, I felt that I should go to be an interface and protect my people so that they could get on with the job. We flew down in a C-130, but all the motels were booked because people had come there from New Orleans, which had been pretty well devastated. I went to a meeting with the Coast Guard and all the local authorities. When they asked us where we were going to stay, I said, "Well, that's a problem. We need some search boats that we can use as diving platforms. We also need a place to live."

One of the managers from the company that had the anchorage responsibility as to where the vessel was tied up offered us berthing aboard one of their pusher boats, one of their tugs. It was a beautiful craft. It was about 98 feet long. It had beautiful accommodations for us, and they also said they would make available some boats for us. We went down and looked at their boats. Two of them were work barges. They were about, I would say, 24 feet long and 9 feet wide. In fact, I think those dimensions are actually in there somewhere. They had what we called a "harbormaster unit," which you clamped onto a barge. It was kind of a self-contained power unit.

They furnished the crews. They had canopies over the ships and a nice workspace where we could put our air compressors and diving equipment. We did not have a recompression chamber, but had an established liaison and knew where the nearest various decontamination and recompression chambers were. We felt that in view of the situation, we had to get on with the program. We went out and started doing our diving. The only ship to help us, initially, was the USS *Hineman*, which was a World War II destroyer. It did have search-like sonar on it. It found all kinds of contacts, but most of them were mud banks. But, it had to be done, so we were out there diving in conditions that were pretty grim. Some of the reports said the current was anywhere from three to nine knots. I would have estimated that it was between two and a half to three knots, in general. It was a tough current, and unfortunately, a lot of debris was coming down. We had to be very, very sensitive and needed somebody to watch the surface and report to us.

The other thing you needed was a pretty hefty clump to get to the bottom. We managed to get some old 180-pound clumps that the Army Corps of Engineers had. Of course, the EOD

divers started vying to see who could pick up two at the same time. I had one or two guys who could, and some guys on the workboat could. They were really tough roughnecks. Once they saw the sailors get involved, they got involved, too, so they were helpful.

We were asked quite often, "Why are you doing this hazardous work?" Our stock reply was "Well, we've been trained to respond to emergencies." We were asked, "What happens if this chlorine gas gets to you?" We responded, "Well, we'll take care of it."

We didn't have gas masks. We didn't have respirators. We didn't have anything, but we figured we'd put on our diving gear and at least use our air to take care of it. It was very frustrating, difficult, and arduous work. We had to go in every night and report the fact that we weren't successful that day. There was a lot of pushing and shoving and calling going on at those meetings. It seemed like every politician who was there wanted to say something. Fortunately, there was a captain in the Coast Guard who was in charge, and he kept things going in a very professional manner; plus, he liked what we were doing. He really helped us with anything we wanted to do.

Eventually, the Army Corps of Engineers brought in some commercial divers from New Orleans. They also brought in an oil drill rig and anchored it. Then they put the drill stem down and tied a diver onto it. Actually, they put a safety belt around the rig, and the diver who was in deep-sea dress went down that way. His mobility was extremely limited. Something happened and the belt slipped, their diver ended up under the surface being towed. After two or three days of trying, they went back to New Orleans. They didn't want any part of it.

In the meantime, we knew that our scuba gear was very ineffective because of the big front it had presented to the water rushing down the current. We had all of our shallow water rigs lifted out to us. We started using the shallow water gear and did several little elevations that helped us in the operation. Of course, the biggest elevation was getting the biggest, strongest diver, and putting a lot of weight on him. Also, when we did our search with the180-clumps, they would hold in the bottom pretty well. Then, we'd get them taut with the descending line and take a shackle and the search line. When we went down, we did kind of a pivotal search at the end of where the current was working with us, rather than against us. The only time we'd have to really work against the current was when we were coming back up. Sometimes, they'd just work against the current and come on back up. Any operation like that is very discouraging, but we kept going.

They had a lot of guys who worked on the river. On the first night we were in Baton Rouge, I told my sailors, "You guys can go ashore. When you come back, have some information from the waterfront as to where that barge is." They went down to some of the local waterfront bars and made friends with some of these guys who worked on the dock. When they came back, they all said, "It's almost underneath where the moored barges are." We couldn't convince anybody that we should go in there and make a sweep underneath those moored barges. Of course, we weren't too eager to do that anyway, with the existing current conditions.

Well, they brought in a piece of equipment and it was, to my knowledge, the first time it was ever used. It was what they called a "bottom profiler." The transducer looked like a little football, and the guy who was operating it was from Raytheon. You would have thought he was with the Central Intelligence Agency because before he would unmask that thing and put it over the side, he looked around to see if anybody was taking pictures. They would put it over the side; it had a beautiful plotter, about 18-inches squared, with the bar arm plotting system. As that little starter thing started losing its signal across, they pulled up alongside, close to where the barge had been initially, and sure enough, it painted a picture of the barge underneath the other barges. They didn't want to announce that on an unsecured channel so

there was a lot of waving of arms and attention-getting mannerism until they managed to get us over there.

I had one of my divers go in first. He got in and reported, "Yes, there are some tanks in there and everything." I don't really think that he was too comfortable being underneath there so I'm not sure how effective his search was. The second diver went down and immediately went to the chlorine barge tanks and worked his way to the dome area, which was the loading area. They had a seal on it. We instructed him that if he could find that seal, we'd send him down with some snips and ask him to snip it and bring it on up so that we could possible identify it. That was what he did. We were then able to announce that the chlorine barge had been found.

I don't remember the exact number, but I believe we found it in five or six days. It seemed like it was about ten months, but it was just a short time. Most of the crew went on back from Baton Rouge. Lieutenant Eastman and I went to Mississippi as guests of the owners of the pusher boat. We saw the devastation of Hurricane Betsy. I tell you, it's hard to imagine just what a hurricane can do until you see it firsthand like that. It was really devastating.

MR. EARL LAWRENCE

A military seaplane that had struck a log during take off went down in the Columbia River near Astoria, OR. The impact of the log broke the plane right in half. There were four people in the plane, but only one survived. A little, redhead lieutenant fell through the hole in the plane and was able to make it to the surface. They didn't have any divers in that area, so they called in the Navy Yard to recover the plane. Three of us from the diving crew went to the job. A Navy captain briefed us on what had happened. It turned out that the plane went down in fifty feet of water with four depth charges [onboard] set to go off at fifty feet. The depth charges were still on the plane, hanging on the wing. If any of the depth charges were hit or dropped below fifty feet, they were likely to explode.

Because of the danger of the job, the captain asked if we still wanted to dive. I said, "Heck, I'll dive down there. If the thing blows up, it's going to blow you up topside, too." The captain said, "Yeah, but we aren't going to be here. We're going to put you out on the tender, in a small boat, and you're going to do the diving while we circle around and watch what happens!" I said, "Heck, I'll go!" The captain told me, "Don't go inside the plane. The men are in there and we don't want them disturbed."

I made my dive and found the plane completely broken in two, split right about where the men would have been sitting. The plane was resting as described, but the tail had broken off from the main portion. I swam inside the plane and discovered that there were no bodies inside.

Meanwhile, the topside crew came out with a small tugboat and wire, which I used to hook to the tow pendant on the seaplane. When I got topside and climbed into the small tugboat, they started towing the plane to the beach. An ambulance came roaring down toward us as we got close to the beach. I asked, "What is the ambulance for?" The topside crew responded, "It's for the bodies in the plane." I said, "There aren't any bodies in there. I went into the plane and took a look while I was down there." They just blew their tops when they heard that. The plane was pulled up onto the shore. Of course, there were no bodies inside. They were never recovered.

That was the first time I had been called for a job because of a lack of qualified divers. It was my first job independent of the Navy Yard. I had been through a six-month diving school and was qualified as a first class diver. I already had the qualifications and more experience than those so-called "hotshot" divers did.

Suez Canal

In the process of clearing the Suez Canal, approximately 7,500 unexploded ordnance items were found, including rockets, anti tanks mines, anti-personnel mines, grenades and 25,000 rounds of small-arms ammunition. This was in addition to large amounts of scrap metal, wire rope chain, concrete blocks and other debris. Over four large loads were removed from portside harbor alone. This section describes how the US helped in this effort.

Navy salvage divers have, upon occasion, worked in foreign lands for foreign governments. In 1974, the Suez Canal provided such an opportunity. By 1973, two wars between Egypt and Israel had left the Suez Canal choked with war materiel. The 93-mile-long canal was clogged from one end to the other with sunken ships, boats, trucks and tons of ammunition. The canal was closed, and the government of Egypt was losing millions of dollars monthly in revenue.

Although officially, for political reasons there was a commercial contractor in charge of clearing the Suez Canal, the man behind the scenes was Captain John Huntley Boyd, Jr. This was not his first time in charge of a major project for the Navy. All in all, Boyd was the officer in charge of more than forty major salvage operations for the Navy as well as other major projects for the Navy, including serving as the project officer for the acceptance of the first deep diving system, the Mark I deep diving system and the trails off Santa Clemente Island in California.

His personal story is as diverse as the clearing of the Suez Canal. It was only after Boyd had graduated from the Naval Academy that it was discovered that he was colorblind. The Navy then made him an engineering duty officer and sent him to Massachusetts Institute of Technology for a graduate degree in naval architecture and marine engineering. At the conclusion of that degree, he was sent to diving school because there was a need for diving-qualified officers with some basic salvage training to help with emergencies that might occur worldwide.

His first salvage work came after Typhoon Karen had wreaked havoc with the harbor in Guam. After participating in the salvage caused by other typhoons, he became involved in clearing commercial ships that had run aground in the South China Sea or in Vietnam. Eventually, he became the Atlantic Fleet salvage officer. He said, "I loved to dive and was a good diver, but diving, to me, was the entrée into salvage, which is the really fun part and the reason for being. There has to be some reason to dive. In my case, it was salvage." In this role, he was the officer in charge of more than thirty salvage jobs worldwide (twenty-nine of them were successful) before he became involved with the Suez Canal job.

The one described here in some detail involves Boyd, who was supervisor of Salvage Operations at the time. The following is his recollection of the bureaucratic wrangling that was required to get the Navy involved.

CAPTAIN JOHN HUNTLEY BOYD, JR.

In 1968, the Israeli-Egyptian War took place. The Israelis were coming so quickly across the Sinai that the Egyptians were afraid they would overrun the Suez Canal, so the Egyptians scuttled ten ships, tugs, and dredges in the canal to prevent their use. The war ended fairly quickly, with the Israelis and the Egyptians facing each other across the canal, which now had a bunch of wrecks in the middle of it. In the 1973 war, the Egyptians beat the Israelis badly in the beginning, but as time went on, the Israelis got their act together and crossed the canal before a truce was established.

In January or February 1974, I got a call from our Navy Salvage Contractor Peter Barraca of Murphy Pacific. They had been nosing around Cairo, trying to get a contract to clear the canal. All of the predictions said that the

contract was already settled with a Dutch consortium led by Smit. Barraca wasn't getting much attention until he happened to mention that they had access to the Navy heavy lift ships, which were the former German heavy lift ships that had been used in the 1956 clearance of the canal. That got the attention of the people in Suez.

Late on a Friday afternoon, probably around 4:30, Barraca called me and said, "I have to have an answer. Can we lease the heavy lift ships from you?" I said, "This is a pretty politically charged decision. I can't make it at my pay level, so I'll call you back." I ran up to the commander of NAVSEA, Vice Admiral Bob Gooding, who was a great guy, and we sat down and talked about it. I had pictures of the heavy lift ships and told him what was happening. He said, "We'll both probably go to jail for this, but I like it. Go ahead, on my authority. Tell Barraca he can lease the lift ships for terms to be determined." At that time, it still seemed as though we might have to fund the operation and loan the lift ships through Murphy Pacific.

I remember I was called over to OPNAV on a Saturday. I went to the morning briefing of the Secretary of Defense and the Deputy Secretary and all of the chiefs of the services. They called it the "tank." I wasn't taken into the tank. I stood on the outside. They finally came out and said, "Huntly, there is no decision yet on whether we're going to do it totally with Navy resources or using contractors."

A couple of days later, I was called back again and told to sit down. They said to me, "You have the rest of the day, before close of business, to prepare two plans. Come up with one plan to clear the canal using Naval resources and one to do it with civilian resources, or Navy contractors. Oh, incidentally, whichever way it goes, you're going to be in charge." Of course, it was the Holy Grail for a supervisor of salvage to do something like that.

I prepared two plans. It turned out we would have had to make a significant draw on both the Atlantic and Pacific salvage resources, ships, and people. Of course, it would have cost us less money. On the other hand, we could have done it with commercial resources. We had an estimate that said it was going to cost $8.6 million. That was a "sight-unseen" estimate.

I told everybody that we could do it for $9 million in six months. Again, that is even before my meeting with [Deputy Secretary of Defense] Bill Clements. We had those numbers and he thought it was outrageous and impossible. We were going to do this for $8 or $10 million, using two cranes that cost only $8,000 a day each. It was incredible. But in fact, it was fairly easy to estimate. You knew what resources you were going to start with and the daily cost of the resources. It was just figuring out how long it was going to take and you had a number.

At any rate, after the next meeting of the "Elephants," I was told, "No, we're going to have the contractors do it." Remember, it was May of 1974. We were just getting out of Vietnam. Adamson said that the boss, meaning the CNO, did not want to get a bunch of Navy personnel in the Suez Canal, between the Egyptians and the Israelis, where they could get all shot up. So we were going to do it with the contractors.

Since Mr. Clements was so convinced there was going to be a financial and technical disaster, he didn't want us to be a part of the joint command. He said, "You guys do it at NAVSEA." In other words, we would divorce ourselves from the financial and technical disaster that was going to happen. I was going to be separate from the operation that was already going on over there.

We had the two heavy lift ships manned with all former Navy people, most of whom had served on them in Vietnam with Harbor Clearance Unit One. The contractor brought in first one, and ultimately two, heavy lift cranes from Germany. We had a very small Navy cadre. I had three or four officers with me. When the operation was going, we had operations in the northern and southern ends of the canal, as well as the center, and I had an officer in each of those places. We had a supply officer and a SUPSALV civil servant, who did logistics stuff.

We had one enlisted man. As I recall, he was a SEAL. A key man was Jim Bladh, retired lieutenant commander and diver. He worked for SUPSALV. He was our advance man and Cairo liaison.

The operation went pretty much according to Hoyle. There weren't many surprises. There are always little surprises when doing salvage work, but it went pretty well. As I said, we originally estimated that it would take six months. As it turned out, we spent $12.3 million, I think, which included a lot of Egyptian pounds. The US owned them and they were not converted. They weren't good for anything in the US, but were good for local use. All told, it cost $12 million and took us seven and a half months.

Editor's Note:

For his part in the clearing of the Suez Canal, Boyd was awarded the Distinguished Service Medal, the only ED Captain who ever received this award while on active duty. It was not the only award that he won for his long and prominent role in salvage operations. In 1966, the American Society of Naval Engineers awarded him the gold medal; this was the first time an operational person had ever won this award.

For much of his success and help along his career, Boyd says, "The person whom I admire most and who had the most influence on me was Bill Searle," whom Boyd served with on many different assignments. "He became my salvage 'rabbi' in the western Pacific."

COMMANDER RED MOODY

I got involved with the operation [Suez Canal clearing] because Tom Gore of EOD Group Two fell out of the running. They were going to send the chief of staff, but for health reasons, it was deemed that we should try to identify someone else. I made a telephone call to the action officer and the CNO and voiced my concern about it. I was asked if I would be free next week. Having opened up the subject, I had to make a decision. I said, "Before I make the decision, I'd like to talk to the commodore of EOD Group Two to ensure that we're not at crossed purposes with this." I made a call to Captain Dave McNulty and he, in effect, said, "Red, if I can't go to Egypt, I can't think of anybody I'd rather have go in my stead than you." For that reason, I was assigned to be a part of the initial team. I took my E9 chief petty officer with me as my good right arm and technical assistant. While in Egypt, we met with the Egyptian naval authorities regularly and had some very, very meaningful discussions with them.

I was very impressed with the Egyptian officers whom I met. They were bright, intelligent, and held much of the same attributes and philosophies we had in the United States Navy as far as getting on with the job. I was privileged to meet the senior commander of their combat swimmers, who was very secretive about his position other than to say he was a diver-qualified navy commander. After a series of discussions with him, I looked him right in the eye and said, "How long have you been with the combat swimmers?" His reaction approached surprise. He asked me, "How do you know I'm with the combat swimmers?" I said, "It's revealed by your general demeanor, the fact that you're in excellent physical shape and your knowledge of questions that have been asked at discussions about underwater work." In confidence, he told me that he was the commander of the underwater swimmers. We turned out to be very, very close friends for a period of time.

There was also a one-star admiral, a commodore, at the meeting, and I also turned to him and said, "Sir, I imagine that you're the commander of the salvage forces in the Egyptian Navy." He seemed to be quite surprised that I would make that assumption as well. I came to find out that he was the number two man in the salvage organization of the Egyptian Navy.

After a series of studies, we, in a very rough manner, tried to determine the length of the shoreline and the total area we expected to cover as far as EOD operations were concerned. We did a series of calculations, and I estimated that

it could be accomplished in about six months if we had a hundred divers to employ on the search. The Egyptians indicated that was not going to be a problem. They could come up with a hundred divers. Washington largely directed the concept. Some EOD people had been killed in South America, clearing a log jam with explosives shortly before that, and there was a big political outcry by politicians who didn't want any American forces killed overseas trying to help a foreign government. Therefore, we were told that our EOD people would not be doing the searches; the Egyptians would do them under our supervision. Knowing that, we established how many divers we thought might be needed to support the operation.

We decided to search the deeper waters of the canal with the side scan sonar to give us a faster search rate and enable us to search around all obstructions, pipelines, piers, and facilities such as that used by underwater swimmers. You did have surprisingly good visibility within the canal, with a slight flow to the north and the south. During part of the year, it flows north. During another part of the year, it flows south. There is quite a bit of sea life in the Suez Canal, which did create a problem because some of the soldiers who were put out in the field used explosives for fishing. It was kind of discouraging when we had our diver in the water and fishermen were about.

We were given $4 million to procure equipment. We bought four sets of sonar, and that was the first time side-scan sonar was ever employed for the United States. They were employed with the United States Navy to detect ordnance.

Our people were employed in two different ways. One was a crew that was with the Egyptian divers to ensure that they did their search in a particular area at a particular time, using a search line. As I mentioned before, in spite of orders, we did have to put US Navy EOD people with them to ensure that they would, in fact, report a mine if they saw one. Initially, when they reported something, they jerked the spacing line. Everybody would stop and the US guy would go over there and identify whether it was hazardous. If it were hazardous, they would probably go ahead with their search. Later on, we'd send somebody down to countercharge it. If we knew it was safe to move it, we would allow the Egyptians to pick it up and move it ashore.

We found every imaginable type of ordnance, because not only was there an air drop condition there, but also because the Egyptian military jettisoned ordnance in the canal. It was easier to throw it in the canal than take care of it ashore. Additionally, they had the Bailey bridges crossing the canal during the Yom Kippur War. The Israelis took out the Bailey bridges, which had vehicles going across them that were loaded with explosives. Plus, we found several bodies. Some of them still had their rifles.

Technical Advances

CAPTAIN JOHN HUNTLY BOYD

The most significant advance in technology in diving or salvage in the last fifty years was saturation diving, of course, and improved decompression tables. Mixed gas diving has come a long way in the last sixty years or so, and scuba and closed-circuit scuba were very important. In the traditional salvage area, the hydraulic cable puller is a tremendous advance. Instead of having complicated falls of four-art sheaves to pull on a wire, cable pullers are much safer, much faster, and much more convenient.

Heavy lift cranes were a really significant advance, although not so much in the US, and high-horsepower tugs. When I was doing it, our 3,000-horsepower ARSs were the best there were. Now, you've got harbor tugs that are more powerful than that and driven, perhaps, because of the mammoth growth in size of ships, but mostly overseas tankers. You have tugs that are 15,000, 20,000, and I think 25,000 horsepower. They're certainly significant to the salvage capability when you have them. The biggest salvage organization in the world is Smit, and

they've got several big tugs, but will take any job that they can. When one of those tugs is towing an oilrig from Singapore to Alaska, it's not available for salvage.

Another tremendous advance over the past thirty years is the underwater positioning and locating and precision navigation capabilities. We couldn't do many of the marvelous things that they do now without those capabilities. They've all come just in the last thirty to thirty-five years.

The Future of Navy Salvage

JIM BLADH

We're looking at the Navy diving fleet getting down to some very small numbers, with four salvage ships, and three or four saturation systems, run by the Military Sealift Command. I can remember when we had almost twenty salvage ships, submarine rescue vessels, and ships of that type.

Personally, I see it diminishing. Like after every war, after every need, they love their salvors and divers when they need them, but they don't want to pay the bill when they don't need them. We have to relearn that every time.

What I see as the biggest problem would be between the Corps of Engineers, the Coast Guard, the commercial companies, and the Navy. They're all going to get involved in a conflict over who is in charge. I don't know who's in charge. That's the biggest problem, I think, because everybody is going to get involved.

I think the assets are there. I think there would be some pain and struggling getting it organized, but there's no doubt in my mind that they would get it done. There would be some in-fighting and some mistakes, but they'd get it done.

I hate to say it, but I can see Navy salvage capabilities slipping away. I don't see the hard-charging Navy divers out there. It's not that the talent isn't there. It may be the regulations tying somebody's hands and telling them to do something. I think it's going to take some very strong leadership to say, "The heck with these things; this is what we have to do." There would be a need to take some of the noncombatant non-divers out of the decision loop. It might be hard to find somebody who wants to do all that.

CAPTAIN JOHN HUNTLY BOYD

Will we need salvage divers in the future? Sure. We need not only physically fit, but also smart people. Will we come to a time when we find that we suddenly need to significantly expand the traditional Navy diving community? I don't know. It's hard to maintain for a whole career, especially experienced officers. That's what you need, career divers and career salvors. It's hard to maintain them as an appendage to the Navy when they have limited funds and requirements for other things. It's the same with the fire department; they don't get the attention they need to keep them going until someone wants them. Then, they find out they're not there.

RUSTY MIRICK

Ship's husbandry works out great to keep the skills sharp and honed for divers who are committed and with resources to salvage, but it is not the case the other way around. Too often in the last decade the perception has been that divers do salvage, or call themselves salvage divers, for the "once in a while" when they leave their real jobs, which is underwater ship's husbandry, and go do salvage.

The point is that it's completely opposite the perception. The Navy requirement to conduct towing of disabled ships in war and conduct basic battle damage repair and emergency salvage is well-formed and written in blood. Navy doctrine should be reviewed on a periodic basis, but that is the basic requirement. Ship's husbandry is what the divers do to keep their

skills up because, thankfully, these emergencies and types of operations don't occur very often.

It's like a firehouse. Right now, the US Navy is trying to figure out how many firehouses they have and how many they need. But we've got to make sure that as we trim down firehouses; the fire trucks are the best we can get. I really think the Submarine Rescue Program has latched onto a mostly commercial, off-the-shelf, mostly Norwegian-inspired submarine rescue system, which will work very well. I think the salvage piece needs to be exercised and looked after with vigilance. I think it's doable. I think training can sustain the necessary level of salvage confidence we need with an ARS 50 class and shore-based salvage units. I'm a proponent of a lesser but better quality kind of salvage team.

We need to be less parochial. We have great salvage assets and capabilities with the Army, believe it or not. We have great salvage capability with our Seabee friends. We have to recognize that the divers who do most of the diving are special warfare divers or EOD, not salvage types, and piggy-back off lessons learned from spearheading state-of-the-art organizations like Navy Special Clearance Team One.

I think we ought to continue to invest money in national assets like the Navy Experimental Diving Unit. My experience has made me a product of many, many organizations that call themselves "salvage" that may or may not have been able to really do the job. I've grown up with that. I'm now advocating more specialized assets, fewer in number, better maintained, better equipped, better manned.

Deep Submergence Operations



It seems that when man views the oceans of the world, he soon begins to long for unlimited depth and time mobility beneath the surface of the oceans. In response to man's insatiable longing, akin to swimming with the fish, a few visionaries began to experiment with ways man could extend the time he spent underwater, to go deeper, and to return to the surface faster than ever before. Three major developments began: (1) saturation diving was born, (2) ocean floor habitats began to be built and placed in myriad locations around the world, and (3) the race was on for world record deep dives. George Bond, Jacques Cousteau, Ed Thalmann, Ed Flynn, David Elliott, Henri Delauze, Don Walsh, Ed Link, Sylvia Earle, and Joe MacInnis are names that quickly rose to prominence during this era of research and development. Of all the developments, nothing took the world by storm as did the science of saturation diving. This method of diving, which requires only one decompression no matter how long the diver may spend at any given depth, spread like wildfire throughout the commercial diving companies of the world and proved its worth in offshore oil field diving. When one talks about deep diving, it isn't only about saturation diving, but also about deep diving submersibles, like the *Trieste*, CURV, DSRVs, *Alvin*, and others. This section has excerpts from the oral histories from some of the major players in going deeper into the ocean and staying longer. We start this section with a complete interview of Rear Admiral Malcom Mac Kinnon III, USN (Ret). We start with Admiral Mac Kinnon because he touches on several of the subject areas we cover in this book: SEALAB and the hydrogen bomb recovery operation off Palomares, Spain. He was with Carl Brashear (Re: Movie *Men of Honor*) when he lost his leg, and, in general, gives the reader a good overview of what was going on as the US Navy advanced its capability in undersea technology in the deep oceans (other complete oral histories can be found on the attached CD).

ADMIRAL MALCOM MAC KINNON

I was born in Newark, New Jersey. I was raised outside of Newark, in a town called Maplewood. I graduated from Columbia High School in Maplewood, New Jersey and went right to the Naval Academy.

I guess of interest is that I was a competitive swimmer and was captain of the swimming team in high school, and came to the Naval Academy and swam varsity for four years. I lettered my plebe year and enjoyed my swimming career.

The rest of the time in the Naval Academy, I suppose significant was that during my four years, I discovered that there was such a thing as an engineering duty officer community in the Navy and that part of that was the opportunity to go to MIT for three years of graduate school. I had wanted to be an engineer before I entered the Naval Academy, and this looked like an ideal opportunity, but one couldn't go directly from the Naval Academy to engineering duty unless you were physically disqualified from the line.

I found out about engineering duty through Huntley Boyd, who later was Supervisor of Salvage but was also on the swimming team with me. Huntley was colorblind, so he went directly to the ED world, a couple of years at sea, and then to MIT. I followed him by a couple of years.

I went to sea for three years on the destroyer USS *Benham* (DD-796). I knew that the ticket to get to MIT was to serve as chief engineer of the *Benham*, and I wrangled my way into the engineering department after a year as CIC officer and became chief engineer for the last year I was aboard.

I did get to MIT, thoroughly enjoyed the academic experience, met my wife in Cambridge, married, and graduated. While I was at MIT, it was obvious to me and to other classmates that the submarine world was beckoning. So we elected to stay unrestricted line, go to submarine school, and then to a submarine to qualify.

In those days, most of the submarines were diesel-electric, and we all went to diesel-electric submarines. I stayed in New London and went to the USS *Grouper* (AGSS-214), which was a submarine that did experimental sonar work for the Underwater Sound Lab, and I thought that might be somewhat relevant.

I became chief engineer of the *Grouper* two weeks after I reported aboard, non-qualified, but senior. That was a very interesting tour. *Grouper* was the oldest warship in continuous commission in the United States Navy at the time. I guess there were some auxiliaries that were older. She had two main engines removed and operated on two main engines and an auxiliary engine that no one on the ship could remember ever working, so it was a major challenge.

I don't know what people thought I was, having just graduated from MIT. That didn't make me necessarily a practical diesel engineer, but I was thrown into the breach. It was a good tour.

In training for submarine service, everybody that went through sub school went through escape training. The tank at New London was utilized, and my recollection was that we did not do a free ascent from 100 feet, we did one from 50 feet, and it didn't seem to be too difficult to me. It was much later that I took up diving. I was a good swimmer, enjoyed the water, and it didn't bother me. Later while sport diving, I ran out of air at over 100 feet one time, and that training just clicked in, and I blew and went and had no trouble. I never had to do any escape from a submarine, however.

We were preparing for overhaul towards the end of my tour. I was still not qualified because I was too busy keeping *Grouper* running. Our skipper was transferred essentially overnight to replace a skipper that had been fired. Our XO fleeted up to skipper, and I fleeted up to XO with special permission of COMSUBLANT as a non-qualified executive officer. I am not sure how many of these there were; none since, I'm willing to bet. So we entered overhaul; I was the XO/Navigator, but did find time to finish my qualification during the overhaul.

I left the ship after a hairy swan song as navigator in zero visibility, going from New London to Halifax without a decent fix all the way across the Gulf of Maine, and that's a whole other story. I left the ship in Halifax to execute orders to San Francisco Naval Shipyard. I believe as soon as I reported, I shifted my designator to 1400 Engineering Duty.

After a year as Ship Superintendent, I essentially ran submarine overhauls as the submarine-type desk officer at Hunters Point, and it was while I was there that the opportunity to become involved in SEALAB and the early saturated diving experiments came my way.

It got to the point in the early 1970s that the material condition of the Navy was not very good, people were really looking critically at the technical side of the Navy, and we ED's were under the gun. One of the conclusions that came out of this was to start a school for engineering duty officers, which I was asked to do. This happened in 1974.

It really became a need as a result of Vietnam. It was more the result that the ships were run hard, particularly in 1200-pound steamships. There were a lot of casualties. Three things I think happened almost simultaneously: I organized and started the ED school, the Operational Propulsion Examining Board started for surface ships, and a school started in Idaho Falls modeled after Rickover's Nuclear Power School, called Senior Officers Ship Maintenance and Repair Course (SOSMARC).

They were all geared towards making a step improvement in the operational engineering performance of the ships, as well as in the engineering support of the ships. The discipline from nuclear submarines is sort of what drove these steps to solve the problems.

Before going on, let me go back to the SEALAB days and the Palormares search operation. Palomares followed directly from SEALAB, as a matter of fact. I think it was in early 1965, I was minding my own business as the submarine type desk officer. I had a boss, the planning officer in the yard, Captain Dave Sareker, who

was a very interesting guy who kept himself pretty well positioned in different technical areas in the Navy, including, in this case, the Office of Naval Research.

Apparently, the Office of Naval Research was looking around for a way to implement follow-on underwater habitat as part of the Man in the Sea program, which was part of the larger deep submergence program that came out following the loss of the *Thresher*, due to the recommendations of the Deep Submergence Systems Review Group (DSSRG).

Unbeknownst to me, I think my boss had already volunteered me, because I can't remember that I had much of an option. I was asked if I would like to undertake this job to design and build an underwater habitat. Of course I had no idea what they were talking about, but it sounded very interesting.

There had been some facetious comments made about the requirements, "Make it 50 feet long and paint it white." But there was a whole litany of things out of the SEALAB I experience that dictated how they wanted this habitat to be designed and operate.

One of my great advantages was that one of my friends at the yard ran the Submarine Support Group there and had been a long-time Navy diver and had been diving with many of the SEALAB I aquanauts. He had obtained Dr. George Bond's log from SEALAB I and he gave that to me. Here was, in simple, English prose, the real story behind not only SEALAB I, but saturated diving, and what the true intent was of the man behind all this for SEALAB II—the Office of Naval Research notwithstanding, the real mover and shaker was George Bond.

So I did have that advantage. This friend, Herman Kuntz, was a great advisor as we proceeded. SEALAB I was a surplus mine defense pontoon that they adapted for the SEALAB I habitat. Among other problems, they tried to pressurize it as they lowered it, and that failed miserably.

The ballast for it was 300-pound railroad axles loaded into trays by the divers. I certainly couldn't understand why. So we said, "We're going to design this with a ballasting system like submarines; there's plenty of salt water out there, it's all free, it can be moved in and out of tanks with air and really in many instances gravity." Submarine philosophy was the real basis for the design.

They wanted it pressurized on the surface, which they didn't need to do, but that led to the selection of an American Society of Mechanical Engineers (ASME) Boiler Code for Unfired Pressure Vessels for the design standards. We proceeded along those lines. It was 12 feet in diameter, 50 feet long, and we did paint it white. Weight and stability were pretty straight forward. I had covered these in graduate school. But the ability to provide life support in a helium-oxygen environment was another thing completely.

Some things worked in SEALAB I and some things didn't. No one understood why one worked and the other didn't, but we did have it as a basis. We had a very low budget and a very short schedule. Helium is very expensive, and we couldn't do extensive testing in helium. We knew that the heat transfer was a big problem.

The specific heat of helium is about six times that of air, its specific gravity is much less, and the distance between atoms is far greater than air. It had a tendency to leak through places that air didn't leak through. So it presented a whole bunch of challenges that we beat down one by one.

The ASME Boiler Code required ellipsoidal heads to close this cylinder, and the standard way to get ellipsoidal heads, particularly in the submarine world, is to go to a steel company and have them spin-form them. Simple, relatively inexpensive, and quick. But there was a pending steel strike and orders were backed up incredibly. We needed 30- to 45-day delivery but we were getting quoted six months, so that didn't work. The idea of building them up in an orange peel fashion with gores that would require a lot of welding with a lot of grinding was a possibility, but it would have taken longer than the allotted schedule would have permitted.

I was blessed with a very bright chief structural engineer and the West Coast Shock Test Facility was an integral part of the shipyard. I had very little oversight, so I was able to make decisions without any votes. It occurred to all of us that explosive-forming these heads might just work, and I became convinced that it would work.

So we built a 60-ton die that was probably about 13 feet in diameter, or maybe a little more. It was backed with a concrete female die, or female form. On top of that we dogged the blank inch-thick mild steel, 13+ feet in diameter. We drew a vacuum underneath it to make sure that the distortion was minimal. Key to the success of this operation was the mathematics of the explosive charge distribution that would give you a planar wave at the blank to avoid any undue rippling.

One hundred (100) pounds of C4 were distributed with a lump in the middle and then two concentric rings. We were also blessed to have the 400-ton battleship gunning crane available to us at Hunters Point.

We lifted the whole thing up and dunked it in San Francisco Bay. We were also blessed by the fact that this was long before any environmental impact statements were required and even before there were any Green Parties. We did not have to do it in the dark of night, I don't even think it was on a weekend. We whumped it and in four milliseconds, we got a perfectly formed dished head that we could trim to fit and weld to the cylinder. That dish head today is displayed at the Naval Underwater Museum in Keyport, Washington. I tell you, Bob Barth still thinks it's the hottest thing in the world. I had to write it up for his book.

There's an interesting twist on these dished heads. There was a major symposium held in Washington, D.C. four months after the experiment ended, a very high-level affair; the assistant secretary of the Navy and all involved in Deep Submergence were there. I gave a paper on the design and construction of SEALAB, stressing explosive forming of those heads.



SEALAB II explosive-formed dished head

I had found a clipping, a recent clipping, that talked about Martin Company in Denver, with the University of Denver being given a million dollar contract to develop explosive forming of metals. Apparently they recently were successful in forming ash trays. My ash trays would have taken very large cigars.

The big by-product of SEALAB II was this explosive forming. I got a tremendous amount of mileage out of that whole thing. I was made the special assistant to the on-scene commander, Capt. Lew Melson, who was the ONR deputy chief of Naval Research and funded the operation. I actually rigged SEALAB II for dive and pulled the vents and watched it sink. My first design was sinking, not what a conventional naval architect would hope for.

We had a leak because we had to pressurize it on the surface. We had to get another load of helium, because the helium obviously leaked through the O-rings, so we wound up essentially pressurizing it on the way down. But, you know, it was okay, equalizing the pressure on the way down. Worked alright. The sea floor was irregular, and we didn't have any provision for leveling, having been told don't worry about it, the bottom is absolutely level.

Our original design was a barge that was rigged with ballast; it would be ballasted so it was slightly positively ballasted, would be drawn

down by a winch, and pressurized. It would have achieved a level condition by its positive buoyancy and would have been perfect, no problems.

I mean, it's going to see 6.0 psi pressure differential on the bottom, so why does it have to be a steel cylinder capable of withstanding 125 psi internal pressure? So it was called the "Tiltin' Hilton"; I got a lot of heat out of that. Navy divers love to give you a lot of heat.

But I did get my first taste of diving there and enjoyed it. To keep the record straight, I should say that I never went to Navy salvage diving school, but I retired with a diving pin. The only other person to be able to wear the pin without going through diving school was Admiral Ike Kidd. So this was one of the greatest honors I think that they could possibly have bestowed upon me.

My diving training was ad hoc at SEALAB, and then, of course, I took courses and qualified in sport diving. That was by necessity out there. But diving was something that came very naturally, still does.

That whole operation got a lot of press. I was looking the other night at a scrapbook that my wife had kept. We had Scott Carpenter, the astronaut, involved, as you know. He would visit at Hunters Point and shake his head at the conditions that workers worked in. Too much noise, dirt, etc. He was used to aerospace, quiet and clean.

He said to me at one point, "Of course we're going to have a mock-up of the entryway."

I said, "Excuse me? A mock-up of the entryway?" I said, "You have two choices, either the mock-up or the entryway; we don't have money to do both."

"Of course, you've tested everything in helium?" Scott asked.

I said, "Well, we've tested a lot in helium, but not everything."

It's the NASA culture. But we did have a lot of fun with Scott. In those days, those original seven astronauts were like rock stars or movie stars. I mean, there was a very fine line between them and show business.

Another side story: "Scott," I said, "I'd like you to meet my wife; we should go downtown and have dinner."

And so we agreed, and he said, "Look, I've got to meet friends and we can all get together."

I remember he changed clothes at our quarters, and left his shirt behind. My wife was going to cut it up and sell the pieces. So we go downtown and we're meeting him at the Hungry Eye, and he arrives with a whole entourage. I mean, it was like a medieval parade with tumblers and jesters and this whole thing. It was Scott Carpenter and the Kingston Trio, who were very big in those days and owned the Hungry Eye. So here we were, two ordinary people with royalty, so it was very interesting. That was a lot of fun.

All through this, I was still overhauling submarines. We were extremely busy with the submarine workload. They had shut down the repair facility at San Diego, and these diesel submarines required battery removals and interim dockings, and we had just scads and scads of submarines in there.

The SEALAB project for me was collateral duty, except for the four weeks SEALAB II was on the bottom. I was back and forth in the summer. I was down there, I think, for two weeks running, to get it on the bottom, and then went down there a couple times in between and then down at the end. I really had to do it by commuting.

Just about the time of that symposium in January of '66 for SEALAB is when the hydrogen bomb went in off Palomares, Spain, and we paid little attention to it. We had done a lot of salvaging of experiments during SEALAB, and I had gotten to know the Supervisor of Salvage quite well, another ED, Captain Bill Searle.

Unbeknownst to me, he needed someone in Spain to worry about recovery when and if they ever found the bomb. I got the call on a Friday afternoon to get in an airplane on Monday morning to go to Spain. I suspect it was about a month into the problem, because by the time I got there, they had essentially formed the task force and we were based on the cruiser, *Boston*.

I was essentially detached from Hunters Point and went over there with a full seabag. I didn't believe that they would ever find the bomb. But I did make the rounds of a couple of West Coast activities to see what was there in the way of recovery devices.

One of the places I went was the Naval Ordnance Test Station (NOTS) Pasadena, which had invented and built the CURV ROV, and had just adapted it for deeper depths. I don't think they were thinking about the bomb, but they adapted CURV to be good to 3000 feet.

So I went there and I got all the dope on it, and if we ever found the bomb, I knew that we had to get CURV in the air. It probably made more sense to get it in the air sooner rather than later, but I didn't believe we were going to find it. So I really waited until we got to Spain. I also looked at a hydrozene lift bag, like a giant toothpaste tube; there was a hydrozene generator at the narrow end, and you energized that, and it expelled the water out of this thing and provided buoyancy to raise stuff.

My buddy at Hunters Point, the diver who had helped me out with George Bond's log, Herman Kunz, had been doing experiments with the hydrozene lift bag and had been the diving officer at the Weapon Station at Keyport, Washington. He had probably at that point recovered more ordnance deep, more torpedoes deep, than anyone else, using all kinds of techniques, but he was a rudimentary bosun's mate.

So I knew that there were two things I had to do if we ever found the bomb: one, get CURV; and two, get Herman over there. I was made a member of the tactical advisory group, which was largely there for the search, and I was sort of stashed there, three lieutenant commanders: George Martin, who was a classmate and good friend of mine, and Art Gilmour (class of '53), who was a sonar expert who had been at the Submarine Development Group during the *Thresher* search with Captain Frank Andrews. Frank was the real brains behind the underwater search business. He led the *Thresher* search and retired by the time the bomb went in, and then was pulled out of retirement to honcho the search. Brad Mooney was also there. He was the submersible expert and Red Moody was the EOD expert.

There was a lot of diving in shallow water going on when I got there. They got the SEALAB divers over there. We said it's sort of like if you lose your wallet on a dark night, it's much easier to look under the street light for it. So we had to look where we could. The real key to finding the bomb was the Spanish fisherman, Simo Orts.

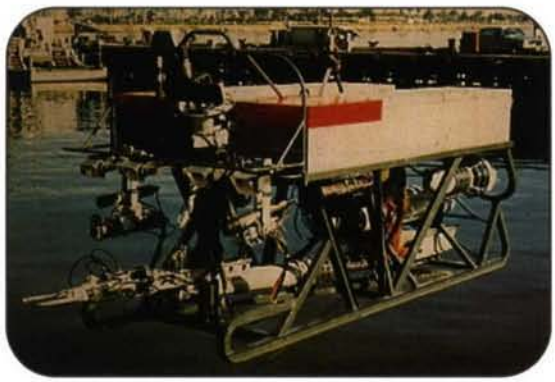
When the collision occurred, the four hydrogen bombs were discharged from the B-52. The remnants of two bombs were found on the beach. Their parachutes did not deploy. Another parachute partially deployed and fragments of that third bomb were found in the surf zone. All three had detonated the high explosive, so it scattered plutonium and chunks of metal around.

The fourth bomb had its parachute deployed. The prevailing wind was from the northwest, blowing the parachute out to sea to the southeast.

The fisherman saw the bomb go in right where the prevailing wind could have taken it. The fisherman was absolutely certain. Having qualified as a Spanish interpreter at the Naval Academy, I went to interview Señor Orts. He had already been visited and took people out to the site. I went back to see him because the Admiral was beginning to doubt Orts' observation. The Admiral wanted to search closer to shore. We had a hard time convincing the Task Force Commander to get *Alvin* back out there, even after they saw the track of the bomb on the bottom. It got to be pretty dicey.

I went out to see him, up the coast in Ayuilas. The Spanish fisherman I pictured as Spencer Tracy and the *Old Man and the Sea* rowing his fishing boat. It was just the opposite. Sr. Orts had two or three boats, modern and well equipped with nylon rigging and fish-finding sonars.

I asked him if he kept the sonar trace from that day, figuring that we might see the bomb on his fish finding sonar. Well, he had a bunch of traces, but we couldn't find the right one.



CURV I

He said, "I know where it went in because that's where I have to pick up my nets to avoid going over the precipice." It is 2250 feet at the precipice and was first sighted by *Alvin* at 2250.

We couldn't get CURV there in time. It was en route, so they "ad hoc'd" it, and it drove me, the Duty Engineer, crazy. They planned to have *Alvin* pick up a grapnel and attach it to the bomb, then the *Mizar* winch would recover it. They lowered a clump to the bottom from which *Alvin* picked up the grapnel and the lifting line and took it to the chute. They managed to hook it on some shrouds.

The grapnel had to be made light to allow *Alvin* to handle it. They actually cut metal out of the throat of the grapnel. Not surprising, it turned inside out like an umbrella when a strain was taken.

We had a destroyer tender there full-time, repairing small boats, primarily since the boats were run very hard supporting operations and providing logistic support. Ninety percent of all the tender's work was repairing small boats.

But the tender also made the grapnel, and I watched the chief shaking his head because he had to make the grapnel lighter and the only way he could was to make it weaker. So they tried to pick the bomb up and it broke loose and fell back down the slope, winding up at 2800 feet. When it was finally recovered, it had slid to 2850 feet. Once the bomb was refound, *Alvin* and *Aluminaut* baby-sat it until we could get CURV operating, and it kept moving, and it kept moving, and, of course, downhill.

We had an excellent stretch of the bottom configuration done by Dr. Smith of the Naval Civil Engineering Laboratory (NCEL). He was an interesting guy who chain-smoked Camels, smoking them like a European. He spent three days hiking inland with his shoes off. He said, "Well, you know the condition of the bottom if you know the condition of the earth and its topography inland." I learned a lot from him. Dr. Smith took samples and he knew that it was a nice slick silt, which didn't help keep the bomb from sliding. It provided very low friction.

The bomb went in on the 17th of January, and the bomb came up on Good Friday, in April. It was reported in the Madrid newspapers on Easter Sunday as "La Resurrection." If we had truly believed the fisherman and had put all the resources—you know, *Alvin* and *Aluminaut*—that's all that we had out there, we probably would have found it sooner. But the name of the game when we got there was the mathematics of underwater search.

Capt. Frank Andrews planned the search back in Washington, having run the *Thresher* search. He got Dan Wagner on board, who had done a lot of the mathematics for the *Thresher*, based on search effectiveness probability (SEP). Tony Richardson, a young Ph.D. mathematician, was out there with us. Tony's job (given the methods of search, the search rate, and the relative effectiveness of the search device, eyeball, sonar, etc.) was to set up the search plans so that we could go to the UN, to the world, and say we were mathematically 99.9 percent certain that if the bomb was there, we would have found it.

I never thought we would find the bomb until we went back and talked to the fisherman. I managed to get him on board a minesweep to go back out to the site. In route, he was telling us in the ward room of the minesweeper how, when we left, he was going to pick it up with two fishing boats and a long iron wire and grapnels on the wire, and he was going to catch the chute and pick it up by going back and forth, right where he knew the bomb went in. And he knew the behavior of the bottom; he knew a lot of stuff.



Alvin

While he was describing how he was going to recover the bomb, I got a call to go to CIC. Brad Mooney was on our tactical net. We had a code, because they were monitoring all our circuits; it was "Charlie Brown 3" or something like that if they found the bomb. And that was what I heard. So I had to quickly terminate the transit and reverse course. I had to say goodbye to the fisherman. He said, "You find the bomb?" I said, "I cannot say." He knew that we found the bomb.

The *Alvin* actually found the bomb. LCDR George Martin was the guy who put his eyeball on it. That was the key search device, the MK-1 eyeball looking through the view ports on *Alvin* and through the optics on the CURV. *Alvin* and *Aluminaut* were the only vehicles that could go deep.

We had a Perry Cubmarine there, good for 600 feet. You know, a little yellow submarine that Perry made, and that was good for shallow water contact classification. The mine sweeps had their mine hunting sonars, which were an approximation. When they picked up a contact too deep for divers, Cubmarine and rider's Mk-2 eyeball would identify it.

We had OBSS, an early sidescan sonar. And you know, unless something was really proud of the bottom, it is very hard to get classification out of a sidescan. So we had the problem, we were using Cubmarine and divers when it was shallow enough to go investigate all the contacts. Sidescan sonar was very difficult. I don't even know today with some of this sonar they're developing for littoral warfare, for bottomed submarines, whether you'd get positive deflections. I'm sure you can get a very good picture of the terrain. In Spain we had built a clay relief map that turned out to be relatively accurate and very helpful.

There was a tremendous amount of pressure on a daily basis. It was nice to be a lieutenant commander in those days. We lieutenant commanders didn't feel a hell of a lot of pressure. Brad and I wound up handling the communications for a large chunk of this. He was on *Mizar*, I was on the flagship, and we developed our own code. The world press was hovering, thirsty for information. The *Aluminaut* had to go into the port of LaGarrudia with its tender, the *Privateer*.

The word came back to the flagship that *Paris Match* was offering a full week in Paris, all expenses paid, for any information. I said they're getting close to my price...just kidding. The press were all over everybody, adding to the pressure on the admiral.

I explained that the bomb was lost and then had rolled back down the hill and was found again by *Alvin*. *Alvin* and *Aluminaut* took turns babysitting the bomb. They could each stay down for probably eight hours, maybe *Aluminaut* for a little more. But as *Alvin's* batteries aged, she was able to stay down less and less. So it finally got to about six hours, I think.

We had a buoy and pingers attached, but because we lost it, and I think quite rightfully, they wanted an eyeball on it all the time. And it was moving, so a buoy may not have done any good. Visibility wasn't always great. Another fact was that we only saw the parachute, not the bomb, but we did see the track of the bomb, a semi-circular trough in the bottom. Never saw the bomb until it was at 100 feet, and the EOD divers went down to ensure that it was disarmed. It was covered by the parachute. People were saying, that's just silt and mud in there, and we thought, well, you know, we couldn't leave it

there no matter what it was. Had it gone deeper into the bottom of that crevice, there would have been no way to get it.

In the process of *Alvin* sitting there, the chute billowed and got sucked into her thrusters and damn near trapped her, and that would have been disastrous.

In the final recovery, the admiral wanted three lines on the bomb, because one had failed. We got two lines on it, and then CURV, in attempting to attach the third line, got sucked into the parachute and was trapped. So the decision wisely was made, and I think it was not made by the flagship, it was made on the *Petrel*, to bring it all up at once.

So the main capstan of the *Petrel* was used to hoist the CURV's umbilical. The ASR was the best possible platform for this with its capstan, winch, and boom. We brought both lifting lines up together using the winch to raise the bomb.

The whole thing came up like a charm to 100 feet when the divers went down. It was shifted from there to the boom, and the whole bomb came up, broke water, and slick as a whistle, was hoisted on board. EOD divers had gone down and opened it and made sure it was disarmed. Then they shifted it from the lifting lines and the parachute to a sling on the bomb itself. You know, my memory is a little weak, but I guess we cut the chute away, because the bomb came on board unwrapped from the chute and hanging from the boom.

You need to know that the movie *Men of Honor* did not show what actually happened, nor was Carl Brashear involved in the recovery. He was at the scene, however, but on the *Hoist,* where he lost his leg. When the operation was over, I and Herman Kunz visited him in the hospital. We were both there when he lost his leg, but never should have. Some stupid boatswain's mate secured a mike boat across the fantail to a stanchion. As the boat heaved, it pulled the stanchion, broke the weld, the stanchion flew across the deck, and caught him right below the knee.

The most significant achievement that's been made in undersea technology covers a lot—nuclear propulsion, I mean. Most of my adult life was spent worrying about nuclear submarines. Fifty years is just about right. *Nautilus* went to sea January of '55. It's made a lot of things possible, including some remarkable things from NR1, some of which we know about, some we don't.

There's been a lot of interest in NR2. There certainly was when Rickover was still alive. The ability to remotely go deep and recover sizeable things with CURV III, not CURV I, is probably pretty remarkable. And the AUVs are pretty remarkable. I think the AUVs will revolutionize submarine warfare, because they will do a lot of things from a mother submarine that the submarine would otherwise have been called on to do.

If all the barriers had been removed during my career, I would have changed a couple things. I never would have built the *Gerald P. Lipscomb*, but this is Rickover Hall and that's another story. There were some pretty tough times with Rickover, and we had a class of submarines pretty well conceptually designed that I think would have been every bit as effective as the 688, but smaller, and I think cheaper, but that's second-guessing. It would be nice to go back and say if I had all the authority, I would probably have done that, and history may have proven me right; maybe not.

We did pretty well. I think maybe that's the answer to the question, that given the whole situation, we did pretty well. During the Cold War, we pushed those Soviets into a spending race that there was no way they could win, and they came to the conclusion finally that to have a safe submarine that was quiet, you really had to take a lot of time and spent a lot of money. That came to fruition on my watch while I was still on active duty. And that was very pleasing, indeed. But I think in terms of useful work in the ocean and understanding more about it, the instruments, the deep ROVs, and the AUVs are going to be good stuff.

In the future, I think other than something like *Monitor*, where you may not want to use ROVs and AUVs, and it's shallow enough, you

can get an awful lot of work out of saturation diving, out of the divers that you wouldn't get if they were surface tended.

There's really no substitute for some of that fragile stuff, other than to put the human being with the eyeball in there rather than a machine. I think that there will always be a place for divers. They're still being used in the North Sea, you know, where it's shallow enough. And as to ocean floor habitats, I think the logistics for a habitat is such that it's better to go up and down with an elevator, you know, the PTC.

In considering undersea technology it is sort of like the Mars Rover versus manned space [flight]; I think that you can do an awful lot without the man. I mention this here about *Alvin*, some of the final things, lessons learned, unmanned vehicles have a definite role. *Alvin* almost became entangled; CURV was, you know. And I don't say anymore than that, but it's obvious that ROVs have a role. But I also say there was no substitute for the MK-1 Eyeball, but sidescan sonar has future possibilities.

There are tremendous challenges for future advances in undersea technology. The ocean can capture a tremendous amount of imagination, but it certainly hasn't captured the kind of funding that is really needed. I don't know what it is. I thought I was on the trail. I've been doing a lot of consulting on a lot of interesting projects.

I was working over the past couple of years with one of the richest men in America, who wants to be a latter-day Jacques Cousteau and explore the oceans, and yet he is one of the strangest guys. I never did meet him.

I met his vice presidents. I asked, "What does he really want to do?" The reason I got involved: he's building a "luxury submarine," which I chuckled at—I said that is an oxymoron, but nonetheless, I'll give you the luxury submarine, 10-men, goes as deep as an SSN, but being designed by tourist submarine guys who hadn't been deeper than 100 and some feet. And so it was a challenge for us to get them on the right track.

I said, "What's he going to do?" He said, "Just look at the ocean." So I said, "Well, it's a luxury submarine; is he going to be willing to take VIPs like congressmen out and convince them they ought to put big money into the ocean?" The response was, "That sounds like a good idea." I said, "The last time we had a billionaire involved in the ocean, it was a cover for a big project—Howard Hughes." "That sounds like a good idea." I thought, "Oh man!" you know?

There's got to be some synergy, but I'm afraid it's going to be for other people. I did the best I could to try to capture it, and it's going to take something to get some real money back in the Navy to do this kind of thing.

We talked about a wet NASA 40 years ago. You know, we've really just scratched the surface, literally and figuratively. Yeah, I think there probably should be a wet NASA.

There certainly should be a national awareness; there should be a national effort, and wet NASA—NOAA was supposed to be the wet NASA, but I don't know. There's been some remarkable things done. There's been some remarkable things done that we don't know about.

CAPTAIN GEORGE W. MARTIN

I got into the deep submersible business by first qualifying in submarines. I was a chief engineer, and I served three years on the *Catfish*. We were getting ready to work up to go to WestPac for another deployment, and a message came out that Lieutenants Walsh and Shumaker, from the bathyscaphe *Trieste*, were going to be transferred, and if you qualified in certain ways, you could volunteer.

That was January of 1960, so they had already done the deep dive. They were tied up there in San Diego, in the water, and they went out to sea right there. Of course, it was sitting very low in the water.

I said to myself that I was coming up for rotation. I had three years on the *Catfish*. I might go to postgraduate school or something. But as a lieutenant, I wasn't going to do anything too

exciting. I think that by that time, it was pretty clear that I was not going to go to nuclear power school. They needed bright people and that wasn't where I was.

I put in for the *Trieste*. I also went over and met Walsh and Shumaker. They were from the class of 1954. I met Dr. Andreas Rechnitzer, who was the chief scientist. Larry Shumaker took me to the bathyscaphe. You enter through a narrow access trunk with a little ladder. I think it was about 20 inches in diameter. Larry was something like six foot four. It was a real job for him to get down through the access trunk. Anyway, we got down into the sphere in San Diego Harbor. You could look out the window but didn't see anything because the water was so turbid. He said, "I'll be right back." He shut the entrance hatch, which weighs 378 pounds, and went on up topside. I started looking around inside the sphere. My escape had been cut off and I began to feel uncomfortable. Then I said to myself, "I am 15 feet below the surface, in a watertight steel sphere that has been down to 18,000 feet and returned safely." I calmed down and looked at the rudimentary instrumentation.

This was the Wright Brothers' stage of deep submergence. Not that I was any Wright brother, but we were at that stage at which almost anything we did was an improvement, an upgrade. Well, anyway, I had this really funny feeling. I thought, "Gee, I'm in here all alone. The hatch is shut. I guess they'll come back and get me at some point."

Shumaker came back some time later, but not as soon as I thought he would come back. He must have been gone 15 or 20 minutes. If you were down there, of course, it was a long time. He may have just gone up and taken a phone call or something like that. It was a very busy place.

Anyway, I was selected and ordered to go. I was detached from the *Catfish* to report to the Navy Electronics Laboratory in San Diego, in March. At that time, you had a six- or seven-day window to report. Anyway, I got back on the *Catfish* and went over to WestPac. We did pretty much what we did before. We were in Sasebo, Japan, which is on the southwest side of the Japanese islands. I was detached, took a Japanese train up to Tokyo, and then a propeller-driven aircraft full of women, children, and crying babies. It was a contract flight.

In other words, the Navy contracted with other airlines to run these flights. They had people going back and forth every day. The passengers were dependents, sailors, and other officers of the military. Anyway, we flew from Tokyo to Hawaii, and had a two or three hour layover there for refueling purposes.

Then we went on to San Francisco. Then I got a flight on PSA (Poor Sailors Airline) to San Diego and got home. I reported to the bathyscaphe, and Don Keach had reported just a week or so before I got there. There were just the two of us assigned. He was to be the officer in charge and I'd be the assistant officer in charge. The laboratory was a fascinating place to be after six years on ships and submarines.

We were submersible pilots three and four. Walsh was one, Schumaker was two, Keach was three—Keach died in 1999—and I became operator number four.

I knew that assignment to the *Trieste* was not a mainstream thing. When you were a lieutenant, you did not know a whole lot, but I knew it was not mainstream. Mainstream was nuclear power. I was not going to be in nuclear power, so why not do this? It was sea duty. But at that time, of course, I had six years of sea duty, rather arduous sea duty. This was a shore duty for rotation and sea duty for promotion. You got submarine pay, which was unheard of in those days.

I knew it was not mainstream, but for me, it was just right. Walsh and Schumaker had made the deep dive in January of 1960. Over the next two years, they had spent money on some refurbishment of the bathyscaphe and some upgrades. They hadn't really gotten it back to sea. It was an experimental craft. Everything was one-of-a-kind, experimental. Everything took time to order, receive, install, and test.

Keach and I relieved Don and Larry. Keach told me our job was to get the bathyscaphe to sea with scientists on board. The public relations phase was over. Everybody knew who and where we were, and our job was to get scientists to sea doing ASW research because category 6.1 research funds were paying the bill.

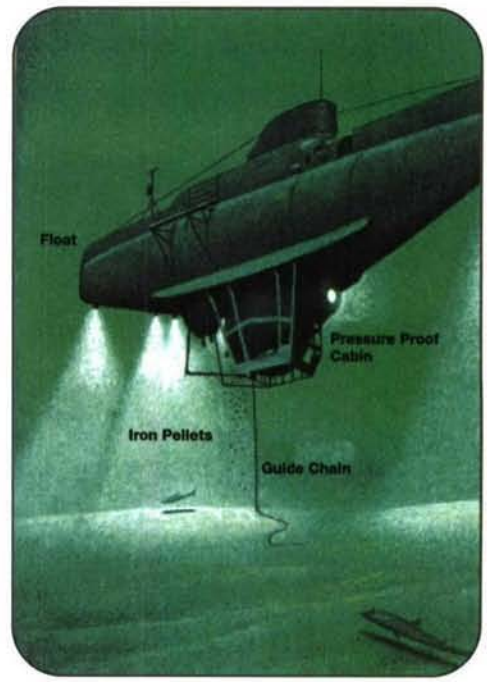
The bathyscaphe had a fair amount of financial support, compared to the submarine. The submarine had reasonable support. But on the destroyer, it was always hand-to-mouth. You would ask, "Do I want to buy this part I need for the pump, or should I buy the line I need to tie up to go alongside?" There was always a day-to-day spending question on a destroyer. The *Trieste*, by comparison, was a Mecca for people who were excited about a new venture. Hey, we were going under the sea, and it was not a warship. We were going to find out what there was to find out underwater.

There were more questions than there were answers. But that attracts a certain type of individual such as Alan Vine of *Alvin* fame, from Woods Hole Oceanographic Institution. He came about every six weeks to see what we were doing and to probe here and there to insert his thinking into our work. He also collected ideas to take back to Woods Hole for design of *Alvin*. It was an experience.

Industry was interested. How did we build a deep submersible, or a piece of it? It was clear that the bathyscaphe *Trieste* would not be duplicated. Nobody wanted another bathyscaphe. They were too clunky. They couldn't do what scientists and operators wanted. Maneuverability was something they didn't have, for example.

Everybody in American aviation and space industry wanted to get into this new deep submergence arena. They had a lot of engineers, a lot of talented guys trying to figure out how to do it better. There was competition. It was wide open because nobody knew what the Navy was going to do next. There were opportunities in commercial work for submersibles.

Everybody was anticipating a wet NASA. Those were the expectations. I reported aboard



Trieste

in March of 1962. *Sputnik* was launched in 1957. By 1962, I guess, John Glenn had spun around the earth. But even the idea of a wet NASA was actually just four years later, in the mid-1960s. The aerospace industry was anxious to see what could be done, essentially starting with a clean sheet of paper.

The staffing assigned to the *Trieste* included Keach and me, and there were eight enlisted men assigned to us from the Navy Electronics Laboratory. There was Giuseppe Buono, who was the key man, really, because he had worked with the Piccards at the Castlelemare shipyard in Italy when the bathyscaphe was built.

Giuseppe was brought along by Jacques Piccard, who sold the bathyscaphe *Trieste* to the United States Navy. Piccard had brought Giuseppe along with him. Then, when Piccard sold the *Trieste* to the Navy, Giuseppe was offered a job to become a civil servant and continue to do the work on the *Trieste*. What he did was maintain the float and sphere systems for ballasting and de-ballasting the air, gasoline, and steel shot. He was in charge of opening the vents so that we could submerge. He was in charge of closing the vents, and when we

surfaced, getting the water and air out. All of the mechanical operations that had to do with operating the bathyscaphe at sea were his responsibility.

He did it extremely well and was very conscientious. He was what you would call "old school." That is the right way to do it. You didn't do it any other way because it was faster or somebody thought it was better. No, that was the right way to do it based on experience.

There were fairly delicate things. For example, there was disposable ballast. We had two tubs that held about eight tons each of this disposable ballast. The problem was that the American shot had different magnetic properties than the Italian shot. This was the same shot that is used to sandblast the side of a ship's hull or any surface on which you wanted to take off a lot of surface material. The electromagnets controlled the orifice that discharged the shot which was discharged by gravity, but you had to open the orifice. It was an electromagnet that we controlled from the control panel inside the sphere.

We had a certain amount of the Italian-made shot that they brought with the *Trieste* when they made the deep dive. We ran out of that, so they brought American steel shot for us to use. Well, American steel shot would become permanently magnetized in the orifice and what you needed was shot with the magnetic properties suitable for the design of the orifice and magnet. The US shot didn't work to Giuseppe's satisfaction, in terms of how fast it would stop after you magnetized the orifice. If you had to let go of shot, and there were lots of cases in which you had to do that, you didn't want some magnetized shot hang-up so electro-magnetized that it was frozen. That was a very crucial thing.

Giuseppe took care of things like that. But then he had to go order the shot from Italy. Fortunately, in those days, you could do stuff like that.

The Office of Naval Research (ONR) paid about $350,000 for the *Treiste*. It was the best buy; it was a steal. Nobody in America had ever thought of building something like it. We built ships, aircraft carriers, merchant ships, and submarines. But what did we want this for? Auguste Piccard, the father of Jacques, was a true genius. His son, Jacques, was extremely dedicated, and very well trained in engineering. They were brilliant men. The United States was very fortunate to have the opportunity to buy this thing they invented.

The scientists with whom we worked were from ONR or universities. They could be either, but because we were at the Navy Electronics Lab, the scientists were already there and they had gotten the first call on it. The Scripps Institution of Oceanography was just seven miles up the street, in La Jolla. We were in San Diego Harbor. There were NEL scientists, too. Dr. Eugene La Fond had this Sea Floor Studies Group.

Dr. Ed Hamilton was one of the geologists. In one of his experiments, they were basically trying to figure out what would affect bottom bounce sonar. They came up with the idea of bouncing the sonar signal from the surface warship or later, a submarine, down to the surface of the sea floor. Then, where would it go? What was the predictability of its reflection and refraction, and how could we use that information to recover the signal? Would the return signal come back the same way? Would it go through the water instead? There were a lot of questions being asked.

Until that time, nobody had worried about it. There was a new problem. The bathyscaphe would take you down and you could stick your instruments into the sediment and bounce signals off and measure it. It was a wonderland for the curious person. The scientists were just beautiful. They were all well trained. They were focused.

Dr. Eric Barham was a marine biologist, and he was working at the lab at the time. As a marine biologist, he was concerned with discovering what all of the marine biota were and how fish showed up on sonar. There was a phenomenon called a deep scattering layer that confused a sonar signal. In other words, there was

something in the water that seriously attenuated the sonar signal. It didn't go through; it got scattered. Then you had a lot less sonar information continuing past that field of biota and you got a lot less signal back.

There were scientists pulling net hauls, trying to pull in nets. There was some kind of marine organism in the net, but what was it? What did it look like? Could we shoo it away and make it go away or something? That was the next part.

Barham went down in the bathyscaphe with instruments and net hauls to capture samples of biota. He actually figured out that the deep scattering was caused by a certain kind of marine organisms. They are called Siphonophora. A Siphonophora is like a long, twenty to thirty to forty-foot long chain that you could see through. In other words, it was almost transparent. It was like a big jellyfish, but stretched out twenty feet. It was so delicate that when you put a cast down and pulled it back out, you never found any Siphonophora in there. They had been broken apart on the way up. They figured out that Siphonophora was the deep scattering layer. Then, you could find out what feeds on them and what size they were that confused the sonar.

For a typical day of work, there was a lot of preparation work. Each scientist had his own instrument package. He had to build it himself, or get the laboratory to build it for him, and that was what they were there for. He had to promote his idea with the superiors in the laboratory and his scientific peers, that the experiment was the smart thing to do.

He would get his instrument ready. It usually involved some kind of electrical/electronic signal information. He had sensors, and they would go outboard. We would carry the sensor outboard with us. Then, he had control through electrical wires, which came through certain electrical penetrators and went through the hull into the sphere.

This was the tough part of the job. How did you safely get electrical signals from outside, through a steel hull? The wire was inside, but if something broke, you didn't want the water pressure of several thousand tons per square inch pushing that wire through the penetrator, into the sphere and through your head.

Electrical penetrators were very difficult jobs. Of course this was back in the beginning. The Piccards had one that worked down near 35,800 feet, but it didn't work for long. You were always repairing or trying a new design. The enlisted men were mostly in the electronic field, with some mechanical background. Giuseppe did mechanical work, and the crew did electrical/electronic work, and then, you had to coordinate with the scientists. We were getting underway. We wanted you to have your equipment a couple of days beforehand, to test it out, to see if it worked with our battery power supply package, and our penetrators.

Then, we were towed to sea. We were not self-propelled, so we had to be towed out to wherever we were going. The day of the trip would arrive and it could be foggy. Well, it is one thing for a ship to go out in the fog if it has to. But it was another thing to take out an ocean-going fleet tug or salvage ship to tow the *Trieste*. The towline would be a mile long! You had little control over where that tow was going. There could be a lot of Navy traffic or fishing boats, coming in or out of San Diego Harbor. Therefore, on some days, the dives would be cancelled. We only had the Navy ships for one day each, because they were very tightly scheduled. Everybody wanted those tugs for towing sleds for gunfire practice and whatnot.

We were allotted three or four days of tug service every quarter. It was a quarterly conference. You did the best you could. If it was the day to go out, you went out unless the scientist said, "Look, it's not working. My equipment doesn't work. We'd be sitting out there." That happened sometimes. We'd just pass it up. Sometimes, we weren't ready. Usually, we were.

We got towed to sea. Fortunately, in San Diego, on the western side of the continent, they're called "continental borderlands," but you don't have a shelf like you do on the East Coast. Four miles from Buoy One off San Diego, you

could dive in 2,000 feet of water. At maybe ten miles out, you could dive in 4,000 feet of water.

There were all sorts of things. You had to get the tug, you had to get the scientist. You had to get the bathyscaphe ready and then, the weather had to break for you. We got scientists out there. Once they went to sea, they were sold. They'd never seen anything like it. They'd never been able to look at the water column. What is it? What are those things out there? To go down and look at the sea floor was amazing for them. Now, scientists have been pulling up buckets of mud and dredging and things like that for hundreds of years or longer. But to go down and see the physical features of the floor was great.

We went down and took core samples, and the core samples were right there in front of you. Well, you could move the *Trieste* around to where the scientists wanted a core sample to be taken. They could make very precise measurements of the core. If you dropped it from an oceanographic ship on the surface, and it goes down to 2,000 or 4,000 feet and gets hauled up, you can lose a lot of information about the core.

It was very exciting to be blazing new territory. The people were so professional. I had never met Ph.D.s before. Where would I have come across those people? As I said, I knew it was not mainstream. But it sure was exciting enough for me. That was great.

We'd get enough scientists out there, and they were starting to get papers published. The Bureau of Ships said, "We're concerned with the physical welfare of you inside that steel sphere at 4,000 feet. Our engineers have never been able to look at it and analyze its structural capabilities. Is it strong enough? How strong is it?" Well, we knew it had been down to 18,000 feet. It was called the "Terni Sphere." Terni is a place in Italy where it was made. It was safe. But the Bureau of Ships was responsible for these things.

The deep dive used the Krupps sphere made by Krupp of Germany, to go safely to 35,000 feet. It was almost six inches thick, actually, whereas the Terni sphere was like three and three-quarters to four inches thick. BUSHIPS sent Pete Palermo from the David Taylor Model Basin, Carderock Division, Navy Lab, and he instrumented the sphere with strain gauges. We went out to dive, and he had an instrument that took the strain gauge readings and brought them back. That gave him real data to analyze.

That winter (1962–63), we had taken the sphere apart at the Naval Repair Facility in San Diego to see actually how it was manufactured and how the two hemispheres were constrained. We did that and put it back together. The flange at the mid-section had been clamped together by rivets. There was a gasket in there, and we put it back together. It took a while.

There were other things in process. We were trying to develop new electric motors. We were trying to get better batteries. We were using Sears' best automobile batteries as our propulsion source and for the external lights. Each light was 1000 watts. In the dark water, 1000 watts doesn't give you very much. You need 4000 to 8000 watts of power. You need electric power, and we didn't have very much.

Anyway, we got the sphere back together. It was about March 26, 1963. We filled the float full of gas and were getting ready to make our first post-availability dive, in April. Things were going along pretty well. We hadn't made the dive yet. *Trieste* was sitting in the water at the waterfront. The electrical/electronic equipment, the ballast control systems and depth sounders and the other equipment were in place. Everybody was doing good work to make our schedule to be ready for sea by mid-April.

Then April 10 came. It was a Thursday. I usually left work about 6:00 in the evening. That afternoon, the guard at the gate, instead of just waving me on, stopped, came over and said, "Lieutenant, did you hear about the submarine?" He said, "There's a submarine down in the Atlantic." I was a little skeptical, frankly. Submarines surface all the time and the antennas are grounded out.

But I got home and walked in the door. Dorothy was standing there in tears. She said, "*Life* magazine has called. *Time* magazine has called. They told me a submarine is sunk and they want you to give them the story. What's happening?" she asked. I didn't know anything.

They assumed that I would know what is going on. They had inducements, like, "Give us your exclusive story and we'll send you to Bermuda." Of course, we were living in San Diego. The Navy had sent us to the best home port. Nothing was going to be an improvement. But that was the way the media worked. Of course, with the deep dive, there had been a lot of press activity.

Keach called and said, "You heard the news. Be at the compound at 7:30 a.m." I went back down at 7:30. Keach and I and the chief scientist, a fellow named Ken McKenzie, were there. His boss, Dr. Curl, who was the head of the sea floor research studies and everything like that, was also there. He was a marvelous man and a dedicated scientist. The executive officer of the Navy Electronics Lab was there. His name was Captain Peterson. The Commanding Officer, Captain Mason, was in Washington at the time, at the Bureau of Ships. We were a Bureau of Ships activity. The only information that we had was that the name of the ship was the USS *Thresher*, SSN-593.

The last known location was approximately 270 miles east of Boston, Massachusetts. Ed Hamilton had brought the chart over and said, "This is where it is. It's on this continental slope, a six to ten-degree down slope. It's rugged. It's not anything flat, like we have on the continental shelf or with the deep sea." But that was all we knew.



USS Thresher

Of course, Captain Mason was in Washington. He'd been up to answer lots of questions. He called Captain Peterson and said, "Tell them to get ready in case they're called." The next day, we were called. It was Good Friday. We then had to take the gasoline out of the float, which was a big job. There were thirty-five thousand gallons of aviation gasoline. We had to tell the crew to pack up. We knew we were going. We did not know how long we were going to be there. But it was going to be a long time, we said. We didn't know. It wasn't a week or two or anything like that. We packed up everything that we could. Of course they had a wonderful civilian staff there at the Navy Electronics Lab, and those guys packed up everything.

We packed up lock, stock, and barrel, and the crew and I went on the USS *Point Defiance*, LSD, and through the Panama Canal. We arrived in Boston on April 28. They took us into a dry dock so that we could get things checked out, and that took a few days. Then, they lifted us up, put us in the water and we filled the float with gasoline. All the steel shot was replenished and we made ready to go to sea. Nothing happened. You know, everything had been rush, rush, rush. The Navy's search was still in the papers. It was disturbing, too. Not only to the Navy because of the bad press, but the families were there, of course. Most of these sailors were from New England. One hundred and twenty-nine sailors were lost on the *Thresher*, and the ship had been built in the Portsmouth Shipyard, the Navy's oldest shipyard. They had a lot of tradition there. It was a mighty blow to the national psyche. Plus the term "atom-powered submarine," which was part of the headline in the *New York Times*, was unnerving. The public's connotation of atom involved atomic bombs. The idea of a submarine running on atomic power was a new thought, and not entirely a welcome thought because of what might happen if one blew up.

The immediate effort was sending aircraft over the scene looking for debris. They sent submarines into the area to see if they picked up

any sounds of anything. That was within the first 24 or 48 hours. Of course, a surface ship picked up a plastic booty that sailors wore over their shoes when they went into the reactor compartment. There was an oil slick, too, but nothing that said, "USS *Thresher*." There was some skepticism in the press. "What is this about you not being able to find this submarine," they asked. That was carried out in the newspapers.

That was pretty close to when the *Challenger* and the *Columbia* went up. "What are you guys doing killing people?" The only asset, or capability, that the Navy had was the bathyscaphe *Trieste*. Of course, it had been down to 35,800 feet, so certainly, it could go down to the estimated 8,000 or 8,500 feet where they thought the *Thresher* was. That was true.

The only question was where the *Thresher* was. The bathyscaphe *Trieste* was not a high-powered propulsion system. We were not self-propelled on the surface and had to be towed to the dive site. When you pulled the plug and submerged to the bottom, you didn't particularly know where you were when you got to the bottom because of the water currents. We had a rudimentary compass on board.

Sears' best automobile batteries propelled us, and the electric motors had been built by General Electric and did work most times. But all the electrical wiring between the batteries, motors and control panels was going through electric wires exposed to salt water. Sea pressure at 8,000 feet pushes the water into any crack and any space, into the wires, and shorts them out. Then, you end up with nothing. The other concern was about the search capability that we had. Underwater propulsion was about one knot in speed for four to six hours. That was it. Our sweep width, or how far we could see, was about fifty feet wide. That was looking out the forward porthole of the *Trieste*. We did have experimental sonar on board. But that only worked intermittently.

There were surface ships, four oceanographic research ships, that had been sent to the scene. They were taking photographs of the bottom. They were taking samples of the sea floor to test for radiation or in some cases, dragging the bottom to see if they could pick up any debris. Some debris was found and photographed. But there was not enough evidence to say, "Here it is."

They kept us in port on standby in Boston until they thought they had enough evidence that made it worth a shot to tow the bathyscaphe out there, 270 miles. They planted a deep-moored buoy, down to 8,400 feet or so. They used that as the marker out there, in the middle of the ocean. There was one Decca navigation line. Well, the hand-held sextant was still the primary tool for navigation.

It is hard now, forty years later, to think about how primitive things were. As I said, it was really the Wright Brothers stage of deep submergence. Don Keach, the officer in charge, talked with Captain Frank Andrews and said, "If you can get us an area that is about two miles wide, two miles across, we can go down but it's a matter of luck. It's as much a matter of skill as it is of chance."

They towed us to sea. We started out on June 19th. We got there five or six days later. We could only be towed at a speed of about two or three knots. There was fog and a lot of delays. We got out there to the dive site. Don Keach made the first dive. He didn't find anything in particular. I made the second dive. I didn't find anything. I didn't see anything that could have been part of the *Thresher*.

We made five dives in that first series. After each dive, the gasoline from the maneuvering tank had to be replenished. The steel shot had to be replenished. We used about eight tons of steel shot on a dive. We descended through 8,000 feet, and that had to be replaced at sea. The bathyscaphe was moving up and down in the seaway, as was the little Boston whaler that was our transport between the dive site and the USS *Preserver*, the Navy salvage ship, our mother ship out there. Anything you're doing at sea is subject to the sea, the spray, and the waves. It's a wet operation.

After five dives, it appeared that we really didn't have much to show for it and decided to

return to Boston, to add more battery power so that we had more endurance underwater. The scientists from the Naval Research Laboratory, the electronics laboratory, and other laboratories, had put different sensors on board to detect anomalies. We had radiation counters, and things like that to detect any nuclear radiation. Nobody knew exactly what had happened. Did the submarine break up? If it did break up, what happened to the nuclear elements in the reactor? It was all unknown.

We were fortunate in that there were never any signs of any radiation above background. The subsequent dives that went on through 1993 never found any radiation above the normal background. We returned and got towed back to Boston. We had to go through the whole operation of unloading. Thirty-five thousand gallons of gasoline had to be pumped out. It was a big operation and took a lot of effort, a lot of hard work, a lot of coordination. The Boston Navy Yard was, of course, very cooperative. They had a lot of capabilities, but the bathyscaphe was a one-of-a-kind, first-of-a-kind laboratory instrument. Everything that went into it was pretty much hand-made.

We prepared to go back to sea. One of the things that Keach had installed on the bathyscaphe during that in-port period was the mechanical arm that had arrived at our facility in San Diego in January of 1963. We had tried it out several times, and it worked well as long as you were on land and nice and dry. But when you put it in the ocean, it turned into a big battering ram. We sent it back to General Dynamics and said that they had to do a better job. They did. They did what they could, and it was then flown out to Boston to meet us there. It was reinstalled. It was a very good move on Keach's part to get that.

We went out the second time. It was the middle of August by that point. In the middle of August, off the Maine coast, off Cape Cod, the summer is over and the seas are starting to build up. We knew our days out at sea were numbered, in terms of the days that we could safely get from the salvage ship to the Boston whaler and from the whaler over to the *Trieste*.

Keach made the first dive in this second series. I made the second dive. We saw some things, and some things were photographed, like a six- or eight-inch diameter valve and other pieces of debris. There were places on the seafloor littered with something. We never did understand what it was. It looked like aluminum foil all over the sea floor.

On dive three of the second series, Keach happened upon a large area of crumpled steel, obviously from a ship or something. Remember, nothing said "*Thresher*" on it, so everything at that point was speculation or hope. There were large sections of steel. As he was moving around through that area, he had to be careful. You didn't want to get too near it. A piece of that steel could have punctured the thin skin of the bathyscaphe float. The float was about three millimeters in thickness. You were very concerned over and careful about getting too close to anything that you might bump into, including rocks or something coming up or an underwater feature.

Then, Keach saw this pipe in this field and maneuvered over to it. He got the mechanical arm. There were five functions in the arm, like the shoulder, elbow, wrist, pinchers, and I think that only two of the functions were working. He got the arm through the soft ooze of the sediment, came up under the pipe and cradled it in the elbow. Then, he dropped it.

The pinchers wouldn't work. Still, he was able to pick it up and balanced it in the mechanical arm. Then he dropped the steel ballast, the disposal ballast, to rise to the surface. He called ahead on the underwater telephone and said that he had a piece of equipment and was taking it to the surface. He said that he would stop at approximately one hundred feet below the surface. He wanted divers and radiation monitoring equipment down there.

We got ready, and they got a couple of the divers into the Boston whaler, and I was there. I was the surface safety coordinator. It was after sunset by the time he told me that he was at one

hundred feet. Usually it took a little over an hour to come to the surface from 8,000 feet, but it probably took him two hours that day because, if it had gone too quickly, the pipe might have become unbalanced in the arm and disappeared. He would have never found it again. It was a long time waiting on the surface. It was probably two hours. When he sent word on the underwater telephone that he was at a hundred feet, we told him to turn his lights on. Then, we could see the lights down there. We had to move around in the whaler a little bit, but we did find the lights and the divers went down.

Johnny Howchen and Smith put a line around the pipe and brought it to the surface. The scientist was there and tested it for radiation. It wasn't anything above what you would expect. They surfaced, and life went on. That was dive three, and then I went down on dive four. I didn't find anything spectacular. He went back down on dive five and didn't come across anything.

At that point, a big concern was the deteriorating hull on the *Trieste*. That is, the very thin, eggshell float that contained the gasoline. The gasoline provided the buoyancy for the steel float that the pilot and the observer went in. So the captain, Frank Andrews, and Keach talked things through and decided it was really a safety issue to get the bathyscaphe back to port before anything serious happened to it. There were some cracks in the iron float, but you couldn't do anything to repair those out at sea. You could put chewing gum in them or something like that, but then, when you towed the bathyscaphe in the seaway, there would be waves crashing over it. The craft would be physically warped.

Anyway, it was time to terminate the search and get towed back to Boston. That was what we did. They flew Keach to Washington to meet personally with the Secretary of the Navy, Fred Korth and the Assistant Secretary of the Navy for Research and Development, Dr. James Wakelin. They were very savvy and credible people.

The Navy was very fortunate to have people like them in those positions. Anyway, a couple of days later, the secretary held a press conference. At the press conference, he essentially said that the bathyscaphe had determined that structural pieces of the *Thresher* had been located, the pipe had been retrieved, and the pipe had the words "593 Boat" and BUSHIP's drawing number etched into it.

That was the confirmation for which everybody had been looking. The attitude until then was, "They found some junk in the ocean. What does that prove?" Everybody kind of had a big, collective sigh of relief, and the secretary closed it out by saying that this ended our operational search for the year, and that it would become a research project. We'd go back and check on it, he said.

Actually, the Navy sent us over to Marseilles, France, to discuss bathyscaphe operations of the other bathyscaphe in the world, the *Archimedes*, the French navy's bathyscaphe. We exchanged a lot of information. But there wasn't anything that they had that we could use to further our search. Our job was to get back to San Diego. The Navy wanted to build a replacement float. Mare Island Shipyard, in Vallejo, was selected as the building site.

Keach and I spent a good part of fall and winter commuting to Mare Island to give them the design specifications, and cooperate with the engineers and the workmen who were building the replacement float. The idea was a design that could be towed. The original bathyscaphe, built by Piccard, had roughly a right-circular cylindrical design, which was inexpensive and efficient for containing the gasoline.

We wanted something with a slightly heavier-gauge metal, and we wanted the batteries in a safer position, not in aluminum cans on top of the light aluminum deck of the *Trieste*. We were trying to get better electric motors. The bathyscaphe, the new float, was transported to San Diego, and the Navy Electronics Lab had a nice ceremony for bringing in the new float and putting it into the water. It was very nice. Then, the work began to assemble the new float with the old sphere that we were using for the science and search operations. They got that together.

Then, Brad Mooney's new team came on board to relieve Don Keach. Larry Shumaker came back to the project to relieve me as the assistant officer in charge. They assigned a third officer, John Howland, because there was plenty of work to do. They increased the allotment for enlisted men. It went from about eight up to a dozen or so. We were getting a lot of support.

Keach was detached. We were ordered and sent from San Diego to Boston to start a second summer of search operations. I was there and helped them get ready to go back to sea. When they left port, I was detached and went back to San Diego, or was detached from the bathyscaphe project and went back as the executive officer of a submarine down in Key West, FL. Brad Mooney will tell you the rest of the story. The highlight of that was that on their dive, they actually landed on one of the pieces of the large hull section of the *Thresher*.

The really important thing that came out about the tragedy was an explanation of the causes of the disaster. What could we do about it? Several groups were formed on the engineering side and the operational side. What happened? Two well-documented and important papers were the Findings of the Naval Board of Inquiry and the Hearings of the Joint Committee on Atomic Energy.

Those are summarized in Part Two of the Naval Submarine League article I wrote. Part One essentially tells you what I just went over here, in terms of the operation on the search itself. The Deep Submergence Systems Review Group came up with a lot of good ideas. They came up with some really clever, innovative ideas. The preeminent one of that was the deep submergence rescue vehicle (DSRV), a vehicle that could go down to the submarine if it was at 2,000 feet or less. That would be within the structural strength of the hull. There was hope of recovering personnel from a downed submarine. They actually went out and awarded a contract and had two of these built.

The concept of operation of the DSRV is to fly the DSRV to an airfield near a port where a specially equipped submarine would carry it piggyback on top of the deck. The submarine would submerge and transport the DSRV to the sunken submarine. The DSRV would evacuate the crew from the submarine and return to the transport submarine. The entire operation from port to return to port would take place submerged. This avoided the dangerous air-sea interaction that can damage the DSRV or the transport submarine or cause delay in the operation due to bad weather. The men in the downed submarine had a limited number of days before the oxygen became depleted or the partial pressure of the air mix inside the submarine caused it to became toxic. Time is of the essence.

Fortunately, they've never been used in anger, so to speak, or in an emergency. They have gone out for training exercises from time to time. The DSRV-1 was put into service in 1970 and DSRV-2 in 1971. They are now thirty-plus years old. There were maintenance problems, since everything on the DSRV was pretty much one-of-a-kind when it was built. Now, thirty years later, do we have the capability to maintain them? In some cases the answer is "no." Of course everything today costs more. I only have unclassified knowledge about what the Navy is up to. I don't have any special access or anything.

As far as I know, DSRV-1 is essentially out of commission already. The second one will be deactivated, or at least no longer funded in 2005. After that, they will use a submersible suit that



DSRV

each crewman would put on. It is a combination Steinke hood and life preserver. Each crewman would pop to the surface in an individual suit. It would keep them dry on the surface.

Of course, there is no point in popping up to the surface if the water temperature is 40°F because you are only going to live a few minutes anyway. They are certifying those suits down to about 600 feet, so that is on the shallow end.

On the deep end, they have a new system, but it's not a deep submergence rescue vehicle. It is transported to the site on a surface ship, or a ship of opportunity. It will be unmanned, except for a diver. It'll be totally controlled as a remotely operated vehicle (ROV) controlled by people from the surface through sonar and underwater television cameras that locate the submarine and maneuver the ROV to it. Then, the diver will visually check what's going on in the submarine. He can open a hatch, possibly, and at least check if there is water or air inside, and that kind of thing. That is in development. It's supposed to be out in a year or two. We certainly wish them good luck with that.

You must go back and rediscover the problems with working on the surface of the sea with something that is 1,000 or 2,000 feet below. That's why I say that what we learned on *Thresher* was that it's dangerous and sometimes impossible to operate from the surface. It's difficult to be towed to the site, as opposed to being delivered on a submarine, which can put something piggyback on the exterior and take it there at maybe 15 knots. The *Trieste* got towed at two knots.

All I can say about the hard work that went into the DSRV operation is what are the lessons learned? You want to do it underwater. Avoid the sea/air interface. Avoid decompression sickness of the crew, assuming you got there in time. Just avoid all the problems of working on the sea surface, which is just a very severe operational environment, even in good weather.

As I said, why they went back to that, it is not clear to me. I guess they wanted to save money or something. I wish them well with it, because it doesn't seem to be moving forward. The operational concept is what I disagree with. The technology is probably great. I am sure it is great, actually. They spent good money on it, and that part of it will work. But whether the weather, the ocean, and the location will cooperate remains to be seen.

While it may sound like the Navy has a short memory for lessons learned, we must remember that it's been forty years. If you think of it, a Navy career is twenty years. That's two full careers for a twenty-year officer or enlisted man. That's what you lose in that time span. They have a Sub-Safe Program today, and those submarines are very, very safe. They essentially don't let salt water into the ship, or not very much of it.

But in terms of the rescue operation, of course, we've come a long way with saturation diving and can do wonderful things. I'm just saying that if I had the money, I would certainly build and improve, or at least use, the operational concept of take-it-underwater, perform the rescue underwater. Return the rescue vehicle back to the submarine. Eliminate all of the safety concerns that you have when operating from the surface.

The other thing is this ship of opportunity. Back at that symposium in 2001, there was a retired chief warrant officer who was still working in the commercial world. He said, "ship of opportunity," yes. "But having a captain on there who could lay a moor, a four-point moor in 1,000 feet of water," he said, "I doubt if one in one hundred of those skippers has ever laid a moor in one hundred feet of water." This was a man from the commercial diving industry who was familiar with not just the technology. Well, we're still dealing with humans here and they have to have a certain amount of training to do this. Otherwise, every operation and every emergency is relearning, retraining of a new crew and skipper. You are trying to do this four-point moor, or even a three-point moor out in a seaway somewhere. God forbid it be someplace in the Persian Gulf. If you're doing that on the

surface, you're going to have a lot of unfriendly people around there trying to make it more hazardous for you. Those are my opinions. Again, I don't know all of the classified plans and things like that.

The other thing we learned on the Palomares bomb operation was that you had to keep the curious, as well as the menacing, at some distance. Everybody's got these mini-subs and ROVs now. Eight Asian nations bought diesel submarines in the last four years. There's going to be a lot of company out there, and they may be unfriendly.

If I could name a role model in my career, there were a few people who made big differences in my life. My first skipper, Gene Farrell, Rear Admiral, retired, was one person. He has certainly done a lot for me, personally, and in every way. Don Keach, who was the officer-in-charge of the *Trieste*, was a mentor. He gave me a couple of hints as to how to be more effective. He did help me out. Brad Mooney, who followed me on the *Trieste*, was another. But because I was still in the deep submergence world when I left active duty for a couple of years, I was working for Lockheed. Brad was still in the Navy. He was able to guide me and provide opportunities, not that I was always able to take them. But he was always opening doors and things like that. Of course, John Craven was another individual who influenced me. John and I were good friends. He was not an operator, but he understood a lot of what was required, like what kind of people you needed and so on. Al Vine was important, too. Al Vine had come out to visit us on the bathyscaphe. Of course, the *Alvin* was just on paper then. He'd say, "George, this bathyscaphe thing you have here, this is not a submarine. This is something that needs to be loved and taken care of. It needs to be nurtured, and you need to be really personally involved with it."

Craven was moving in much higher circles, and he tried to guide me when I left active duty. You know, I didn't pay attention. But we're still friends. It was a long time ago, and I never looked back. That's useless. I had a good working career, and the Navy experience was wonderful. The Naval Reserve worked out for me very well. I was the reserve commanding officer of two submarine tenders. If the balloon went up, and in the 1960s and 1970s, that was still a pretty high expectation, that I would have become CO of a 1,000-man submarine tender. I did get promoted to captain. I started my own company called Project Engineering, Inc. in 1977. We worked mostly for NASA and the Goddard Space Flight Center. We closed in 1994, and I've essentially been retired since.

It was the American dream, to own your own business and that kind of thing. I just feel very thankful for all the opportunities that have been given to me, like the good people I met. There are lots of people that you never hear of. Captain "Ski" Dzikowski, is one such. He was an engineering duty officer. He was in charge of the deep submergence on the BUSHIPS side for several years, from 1967 to the early 1970s or so. He knows everything. He's got a sharp mind and is a good man. There were a lot of good men. There was Pete Palermo, whom I talked about earlier. He was a civilian engineer. He's still alive. Most of the others are dead by now, like B. King Couper who was our sponsor at BUSHIPS. A lot of them, like Keach, are gone. Andy Rechnitzer has been a good friend. He was chief scientist on the *Trieste* during the deep dive. I actually interviewed with him when I went through to the *Trieste*, and he then left and went to industry to work for North American Rockwell and helped them build a submersible called the *Beaver*, which was headed for the oil fields to work underwater. Andy Rechnitzer is still alive and in San Diego. There were a lot of good people.

Swede Momsen was another great man as well as Frank Andrews from over in Annapolis. Of course, I did not continue in that world after I left Lockheed. I ended up in the NASA world, which was very different, but I appreciated the chance to come back.

In 1997, I started wondering about who remembered the *Thresher*, what the lessons

learned were, and what they were doing about it. I got an invitation to speak to the Washington section of the Naval Submarine League. They were pleased with that. They invited me to speak to the national meeting that they hold in June in the Alexandria area.

Of course, in the Navy, everybody's moving around, so it's very hard to get in touch with those people. Things are a lot more complex now. There are a lot more layers with which to deal and safety requirements and things like that. We were fortunate that we all survived it, but we weren't impeded. We could do anything we wanted to do. It was up to you to weigh things and act accordingly.

Editor's Note:

When one thinks of deep diving, it usually brings up a visual of a diver in deep sea diving gear plodding along the bottom of the ocean. For the purpose of this book, we have included deep submersible work as part of this section because, as we see it, a submersible doing searches in the deep ocean is deep diving just as much as is the diver in a deep sea rig. We have selected here one of the US Navy's leading authorities on deep submersible work, Rear Admiral Bradley Mooney. RADM Mooney, a "bucket-man" in submarine school (last in his class), he went on to become the first of his class to qualify for command of a submarine, and during his career he had some exceptionally interesting assignments. Here Admiral Mooney talked about his assignment to search for the submarine *Thresher* and about searching for a lost hydrogen bomb off the coast of Spain.

RADM BRAD MOONEY

The typical search operation at the time of the *Thresher* tragedy was done with far less technology for search and navigation than we have today. In fact, by today's standards, navigation on the bottom was not existent. It was done by eye. In 1963 and 1964, they dropped three-dimensional things with sash weights. They put a window sash weight on them. They were colored various colors and they were all numbered. From a surface ship, they let them go so that they would be little avenues down there that you went around in a search. Of course, they went down through the water column much in the same fashion as leaves drop from trees. They didn't go down in an orderly fashion at all. They were all spread around the place with no orderly numbering or color system at all, and it was terrible. They impeded the progress more than they did anything else. But we, of course, were let off on the surface at a datum that they felt was the best datum possible for where the *Thresher* was.

There was a surface ship there and it dropped us off. The vagaries of the water column took us to different places between there and getting down to 8,200 feet. Once we got down there, we saw some light debris on a couple of dives, but we had a fire. We lost all propulsion power on the bathyscaphe on one of our first dives in 1964. We tried to reset the circuit breakers but they wouldn't reset.

It involved Larry Shoemaker, our chief scientist, McKenzie, and me. There was a little bit of current. Shot was a commodity in demand, because we used shot, you know, for ballast. We'd only brought so much shot with us from the West Coast, and it was hard to come by anyway. They'd steal all of our shot. The shot was like BBs.

The way you controlled the bathyscaphe I liken to a dirigible. A dirigible has a rigid gas bag. If you take the gas out of it, it retains its shape. With a blimp, if you take the gas out of it, the shape collapses. The bathyscaphe is filled with aviation gasoline. But in there, there's a silo forward and aft that are full of steel alloy shot. At the bottom of that silo is an electro-magnet. If you have a current, the electro-magnet will magnetize the current in the orifice and it forms its own valve. If you interrupt the current, the shot will flow like sand out of an hourglass and you get light. In the center of the bathyscaphe there was a tank that you could release the gasoline with. It was replaced by water, so you

got heavier. It was those two things that played to give you the buoyancy that you needed, or the neutral buoyancy.

When you went down, there was some heating by the compression of the gasoline. On the bottom, there was a degree of cooling of the gasoline, so you got heavier. We were getting heavier, and thought it was just because of the cooling. When we surfaced, we found out that we had burned a hole in the hull and it was aviation gasoline that we were losing the entire time.

In any event, we stayed down for about seven hours and let the current take us, because we figured, "Why abort the dive and lose all the shot? Hopefully the current will take us where we want to go," and it did. We got into some pretty heavy debris and thought if we got underneath it, we would not be able to drive ourselves out.

When we got into where it was big, we decided to surface. Once we got to the surface, you had to come out of the bathyscaphe, go topside and shut two ballast tank vent valves on either end of it. When we did that, we were waist-deep in aviation gasoline. We saw the electrical distribution box burned open. A big cable that was about three inches in diameter had cooked like a hot dog. The skin on it was off. We'd obviously had a very large discharge fire, an electrical fire.

We went back to Boston and I immediately called Captain Russ Bryan. He later became Commander, Naval Sea Systems Command (NAVSEASYSCOM). At that time, he was production officer of the Portsmouth Naval Shipyard. He said, "Come to Portsmouth right away. We'll help you." We got up there at about 2:00 in the morning. He had assembled a team of experts, his engineers. We told them what the problem was, and they said they would take care of it. They took the whole electrical system apart in a month. They rebuilt it, tested it and took it apart. They took it to Boston, put it on the bathyscaphe and tested it. We went to sea again in a month.

During that month my youngest daughter, Jennifer, was born. The story I have just told you is one that I mentioned several years later to a person at the Pentagon. That person said, "Well, we've got a project that we want to name, and we have just gotten the name. We'll call it Project Jennifer." If the people that read this are interested, there's a book by the name of *Project Jennifer*. It will tell them what it's about. At that time, of course, it was very classified. Anyway, we went out and made some more dives. On one of those dives, by luck, we landed on top of the hull of the *Thresher*.

After they fixed the electrical system, we started diving again. On about the 18th of August, I think, we made a couple of dives after we'd been repaired. Frank Andrews, John Howland, and I made the dive, and we landed on the hull. We then saw why they hadn't been able to find the *Thresher* with sonar. It had gone down and dug its own hole. The best way that I can describe it is that it was sort of like a sand pit, and it had swished around and come to rest up against the wall of the sand pit on one side. The other side was totally open.

When we landed, we landed ninety degrees from the axis of the hull and could see the bottom on the open side, and we wondered why we couldn't get down to the bottom. Then, we were letting gas go and so on, and we couldn't get down there. We could see it about thirty feet beneath us. We got a little bit of buoyancy, swung ninety degrees, and there was the hull. That was when we first found out what it was.

There was a big hole in the hull with a piece of metal sticking up. Of course, to us, that piece of metal was a potential can opener for our 3/16-inch hull that we had on the bathyscaphe. We very gingerly maneuvered around and got a lot of pictures of it. Then, we went down to the open side and scraped paint off the bathyscaphe on both sides as we went down in that hole. But we got salt water readings, which we brought back for radiation measuring purposes.

The *Thresher* had dug a hole, so if you were off to one side of it and had sonar, you were shooting your sonar beams right over it, across the sea floor. In any event, that was over.

We went back to San Diego and did a lot of dives for science. Then they were going to do some reconfigurations on the hull of the *Trieste*.

We lost the hydrogen bomb off of Spain. An Air Force bomber was re-fueling from a tanker and they collided and crashed. Three H-bombs went into the tomato fields of southern Spain and one went into the ocean. I was sent over there. I was the gent who had the responsibilities for searches below 300 feet. A diver named Red Moody had the responsibility for searches above 300 feet. I had the *Mizar* with a towed camera sled. I had the *Aluminaut* and the *Cubmarine*. I also had *Alvin*. They were submersibles, except for the *Mizar*.

The experience that we had with *Thresher*, of course, gave us some experience of how we should do it. Once we got over there, the first thing that was obvious was that there was no common navigation system, so there were multiple contacts that couldn't be correlated to one another. They set up a good, short baseline navigation system over there on the surface. Then we had pretty good data that had been sort of overlooked.

There was a fisherman named Simo Orts, who was sort of the head of the fisherman's union in Pompaneria or Lagartera, Spain. They were upset because they were denied fishing in the area. They thought there might be radiation and that sort of thing. However, before I had gotten there, they'd taken him to sea because he said he saw a man in a parachute go in the water. They thought that might be the bomb. He lined up the mountains appropriately and said, "It's right here." They marked that spot, but the Navy folk who were there and used to very precise navigation and cuts, not just eyeball navigation, discounted what he had given them.

The lobster fishermen in Portsmouth, NH navigate like Simo Orts was navigating in Spain. After I'd been there a couple of days, I went over to the bar in Lagartera with John Lindbergh. The Air Force gave us a Jeep to drive there, and we found Simo Orts in a bar and got him to sea on a minesweeper. We said, "Tell us again where the bomb went in." He said it was about ten yards from where he indicated the first time. Immediately, that became a firm datum.

We figured that if the parachute on the bomb did not open, it would have gone down like a rock. But if it had opened, it would have gone with the current. We figured out what the currents were. That gave us a search area, and we made some segments for that search area and started diving in them. The *Aluminaut* was not very maneuverable, so we gave it the areas that were more flat and *Alvin* got the areas that had really rough terrain. *Alvin* found the bomb.

Then we tried to recover it. We hooked a grappling hook into the shrouds and straps of the parachute. Upon lifting, they cut through those shrouds and straps. That can be done on anything. It doesn't have to be terribly sharp. You can cut through the nylon very easily when it's under tension. We dropped it and the parachute billowed and the currents took it away. It took us a couple of weeks to find it again.

One thing that I had been taught when I was in small vehicles was to never have two small vehicles in the same area. But I violated that. *Alvin* was down there. She found the bomb and was sitting beside it, but she was almost out of battery power. We sent the *Aluminaut* down and had a rendezvous at the bomb with both vehicles' lights on.

Normally, with backscatter, sixty feet is the world. Because the two vehicles had their headlights shining at each other, like on the road in a storm, they could see each other further away. They made a rendezvous and *Aluminaut* came in and babysat the bomb until *Alvin* could get squared away. Then we put a marker down beside the bomb so that we could get back to it more easily. I guess that was the first time we really used underwater markers like that. That gave us an assist. We had a cooperative target down there to go after.

This entire story is compressed. I figured out how many days we were doing this. We also used *CURV* (Controlled Underwater Research Vehicle), which was an ROV that recovered

torpedoes at the laboratory in San Diego. It went in close with the grappling hook to get a certain number of straps and shrouds on the bomb so that we had a couple hundred percent safety guard, because we were going to lift it this time. But the parachute billowed because of the wash from the *CURV*'s propellers. We could see the pictures on the surface with the cameras, so I said, "Drive it in there."

They drove *CURV* into the parachute and got it totally tangled in it. Admiral Guest, bless his heart, was an aviator, and this was all foreign to him. But he had been the one who told us how many straps and how many shrouds we should have. I could not tell him I had that number of shrouds and that number of straps, but I felt pretty confident that we did. We had totally entangled the *CURV* in the parachute, and he said, "Cut it loose."

Some of my friends at the Naval Electronic Lab, which is now the SpaWar Center, were there with the senior civilians whom I had known for a while. We had some discussions, Admiral Guest and I, as we went along. I think he respected my advice, because I was about the only guy there who had done any deep sea work. They said to go in and convince him otherwise, because they didn't want to cut it loose. Neither did I.

He didn't want to cut it loose because he wasn't assured that there were enough of the straps and shrouds to lift it safely. I went into the wardroom on the ASR. I think it was "Black Bart" Bartholomew, in his book about divers, who quoted me or maybe Alvin quoted me in his book on the Sea Baby. In one of those books, I'm quoted as saying, as I went into the wardroom, "This is dumb as hell, sir," which is what I said.

Admiral Guest and I had a heated discussion for about three hours. I was a lieutenant commander. I figured, "I'll never get anywhere after this." Finally he said, "All right, go ahead." and we lifted the bomb. Then, we had to display it before the whole world. The news media was there.

There was a lot of pressure from Washington during the operation and a couple of the sidelines were interesting. Every day, Admiral Guest had to send a secret message on the status of the operation. We knew that there were e-link stations that the media had set up along the coast of Spain. They were also listening to our UQC transmissions between the ship and the submersible. We had established a code and changed it everyday. A person on the sub that was diving that day had a copy of the code. I had a copy of the code, and a person who was in the CIC on the cruiser with Admiral Guest had a copy of the code. It was made up of the colors of the rainbow and the characters in the *Peanuts* comic strip. "Lucy-Purple" meant something, for instance. We could talk to one another with this code. It changed every day. He was sending secret messages to Washington.

The next day, *The Paris Tribune* had almost verbatim what he was sending in the secret message. Guest decided that every day, he was going to take one ID off the message. The day he took the ID for our Ambassador from France, it didn't appear in the *Tribune*. He put it back on and it appeared in the *Tribune*. He took it off and there was no story in the *Tribune*. He said, "I'm not going to send him anymore messages." Biddle Duke was the Ambassador.

At about that time, we had dropped the bomb. Biddle Duke insisted that he get the word by such and such a time, as to whether we had found the bomb or not. The day that we found it the second time, I wanted to make darned sure that we knew where it was. We had all the ships calibrate their navigation equipment and come out over the site. I was talking with this code to the submersible to find out what the slope was, and all the questions I figured Guest would ask me, and I didn't know that he had a deadline.

At about a quarter to four on the day he had to tell Biddle Duke the answer, I spurted this information into the cruiser, and he received it. Later, he got hold of me and told me how he had a deadline and we beat it by 15 minutes or he would have had to say no. That was a tangent on that whole operation.

The Soviet Union had a trawler in the area. It came through one day and a submersible was on the bottom. I think it was the ASR, or it may have been the USS *Hoist*, a salvage ship that I asked to go out, shoulder that trawler, and do everything short of a collision to get them out of the way. They did that and the trawler moved out. We didn't want them operating overtop of the submersible. That was the only evidence that there was any Soviet reaction there.

The Deep Submergence Systems Review Group, Admiral Stephens group, came out with a report on the *Thresher* and the improvements that ought to be made in search, inspection, recovery, large and small object recovery, diving, and man in the sea. My first duty in the Pentagon was to go through that report. It wasn't finished then. But I worked with the people on the report, and went through it and implemented the elements of that report.

After that, I went out to SubDev Group One and had to live with my sins. The things that I had sent out of the Pentagon were things I had to live and comply with out at Dev Group One. Before I left the *Trieste*, it had moved from the laboratory at the Naval Electronics Laboratory (NEL), to the fleet. It was a fleet asset that later became the nucleus for SubDev Group One, which is now SubDev Five.

When I was chief staff officer at the Dev Group in 1972, the United States had lost a classified package in the Pacific, and we had to go out there and find it and recover it. It happened in April of 1972, I think, at about the same time that Operation Jennifer was going on. I was Officer in Tactical Command (OTC). I didn't make the dive, but *Trieste* went out there. We didn't search for it. Navigation had improved tremendously. Fred Spiese from the Marine Physics Lab searched for it and found the item that we were to go after. He gave me the position of three transponders on the bottom of the Pacific, on the back of an envelope, literally. He said, "This is where you have to go." We went out there. The first time we got into the area the *Trieste* was being towed by the *Apache* and it was in an Auxiliary Repair Dry Dock (ARD), so that was sort of home.

We sort of skidded into the position where we thought we were supposed to be, because we wanted to make sure that we knew what the wind and currents were. The first time we pinged we found all three of those transponders. There had been a lot of advances between 1964 and 1972. After that, we were at the whim of the weather. We were just about in the place where the trade winds and the Siberian lows fought for control of the weather there. It would change in a matter of minutes. We went out in October. The weather window pretty much was shut by the time we got there, and it took until April, but we weren't out there all that time.

In April, we went down and recovered the classified package. It was at 16,400 feet. At that time, and for about ten years after that, that recovery was in the *Guinness Book of World Records*. I think it was the deepest recovery that had been made up to that time.

While I was Chief of Naval Research (CNR), we funded *Jason*. Of course, we also funded *Alvin*. We needed to have a test bed to test *Jason*. Robert Ballard and I had been friends for a long time. Ballard was over by the Azores and was coming home. We convinced John Lehman, the secretary of the Navy, that rather than build the test bed to test *Jason*, it might be wise to sort of slip by where we thought the *Titanic* was and test it there. That was all tongue-in-cheek. But on the way home, Ballard went by the place that was the most probable site of the *Titanic* and found it.

The federal government really didn't fund the search for *Titanic*. But since we were testing our *Jason*, he swung by there to see if he could find it. I met him when he got into Woods Hole.

I don't think that Bob would be opposed to my telling you this. Like most people who have achieved some of the things that Bob Ballard has achieved, there is an ego there. But people need to know the other side of that. I was at National Geographic when he gave a talk on the *Titanic* and presented the pictures he had. He got to the

stern of the *Titanic* and he stopped and changed the subject very quickly. He'd read so much about the *Titanic,* and it almost got as though he knew the personalities of everybody on the *Titanic.*

The stern was where everybody went to try to save him- or herself, so there was chaos on the stern of the *Titanic.* That was really where people died. When he found the stern on the *Titanic*, they immediately stopped and had a memorial service. That was the first time that the *Titanic* was found, but he couldn't talk about it. Later on, when I was the Chief of Naval Research, he came by the office and I said, "You seemed to choke up when you were talking about the stern of *Titanic.*" He told me that he did.

I told him that I couldn't bear to see Edna DiNola (widow of an officer lost on the *Thresher*) after I had the found the hull of the *Thresher.* The two of us sat there in my office. I cleared my schedule all that afternoon, and the two of us sat there talking about what those two events meant to us. We cried like babies, talking about it. It was really horrible for me to see the way *Thresher* went, and it was horrible for him to see the stern on the *Titanic.*

About two weeks before that, I went over to NRL to congratulate the gent who had gotten the Nobel Prize in chemistry and asked, "What obligation do you feel to the youth of this country?" He hadn't thought about that. Later on, during the National Science Fair, I invited him and he gave out all of the ONR scholarships to the kids.

Anyway, when Ballard came back from the *Titanic*, I asked him the same question. He said he hadn't thought about it. He said, "I'll tell you in six weeks." In six weeks, he came up and outlined the *Jason* program. That's still going well. Kids all over this country and other countries are able to witness things on the seafloor and control ROVs on the bottom, halfway around the world. He's really done a lot to educate youngsters on the ocean. That's the kind of person Bob Ballard is.

I've talked to a lot of people who think Bob Ballard does "gee-whiz" science. My answer to that is it may be gee-whiz science from your perspective, but since Jacques Cousteau, who has enlightened more people in the world to the importance of the ocean to mankind than Bob Ballard? Maybe he is even equivalent to Jacques Cousteau. You probably get money to do your science, so don't knock Bob Ballard.

The DSRVs, while they were in service, were the rescue system for the world, for submarines. To every nation that ran submarines, we gave the template they needed to build their hatches, and if they built those hatches to that template and had a problem, we could rescue people from their submarines. It was for more than just the United States. Of course, we've tested it on many of our allies' submarines, in transferring people and so on.

The *Turtle* and the *SeaCliff* were built for ONR as autonomous vehicles and someone forgot to put the money and billets up for people to operate them. Bill Searle used to be the Supervisor of Salvage and is still a good friend of mine. Bill called me one day and said, "You know it's going to be a real black eye for the Navy if they take the *Turtle* and the *SeaCliff* as soon as they're finished at the Electric Boat Company and put them up on the block." We were expanding the *Trieste* group and training people to run the Deep Submergence Rescue Vehicles (DSRV), so we carved out of those the people who ran the *Turtle* and the *SeaCliff.* They became the workhorses of the deep ocean fleet for a long time.

We also had all of the training for saturation divers there at the Dev Group and we had the IX-501. On one Friday evening at 5:00, I was still there doing some work and the yeoman answered the phone and said that someone wanted to talk to me. Someone got on the phone and said there was a bomb on the IX-501; it was going to go off at 7:00. We had seven divers at 300 feet, coming up from 1,000 feet, on the IX-501.

I knew where the divers in that group had their beer on Friday night. It was at the Brigantine in San Diego, by Shelter Island.

We called there and got all the master divers back. We had about seven or eight doctors, submarine medical officers, and we called their homes. Their wives were home, but they weren't home yet. We said, "When your husband gets there, turn him right around; tell him to go back to the Dev Group."

Once we had assembled all the doctors and all the master divers, I asked, "What do we do?" They had a caucus, and talked and talked and talked. Their recommendation to me was to get an ambulance to the IX-501. Get the submarine tender and their hyperbaric chamber. Have the police on the base clear all of the roads between the IX-501 and the submarine tender.

They put those seven divers on the surface. They had been at 1,000 feet for over a month and were decompressing at 300 feet, which normally would have taken three more days. They put them on pure oxygen, brought them up and put them in the ambulance. They drove them down to the submarine tender and put them in the hyperbaric chamber there. In less than twenty minutes we had squeezed them down a little bit further than 300 feet, and not one of them got a twinge.

That was the first time in my life that I sort of handed my commission to everybody else, the divers and the medics there, because I didn't know what to do. They were the guys who had the knowledge. I didn't have that knowledge. I depended 100 percent on their best advice as to what we should do. I did that and we lucked out. None of the divers were hurt. There was no bomb.

The new submarine rescue system that is presently being developed has some integration problems that need to be overcome. It can rescue people at a little bit greater angles than a DSRV system. Since we put the ASRs out of commission, we have no place to put the rescuees these days. This new rescue system provides a place to put the rescuees so that they can make a second trip down to bring up some more rescuees. In that sense, I'm not sure that whoever made the decision to put the ASRs out of commission really recognized that they were really cutting that capability. With the chambers that are transportable by air, they can put the people in and have a place for them to be while the rescue system goes out and makes a second and third and fourth trip. That's certainly something that is absolutely needed today. The limitation is that if a downed submarine or damaged submarine has people in it who are at an elevated pressure, they have to be discharged in an equivalent elevated pressure to decompress them, and we can't do that today.

WILLIAM MAC NICHOLSON

I was promoted to captain in 1960 and soon thereafter I got a call from Admiral James. He said, "How would you like to go to MIT and take the job of running the Navy program there?" I said, "I'm not sure that's a good career pattern for me. I've already had a couple of tours in education and what you move up on is fleet experience. I'm not sure that's a good job for me, but if you need me up there, I'll be happy to go." What else do you do? The next thing I knew, I had orders and I went up to MIT.

I ran the entire Navy program. I was what they called a "Professor of Naval Construction." I had charge of all of the naval officers in that course, working their programs out with them, and of the selection for officers coming in. I taught five courses, and teaching five courses was a pain because I had to create the courses. My predecessor didn't leave me anything. I had to create the courses and teach them. Unlike other professors at MIT, who all had teaching assistants working with them, I had to do the whole works. I also had to write the exams. And I had to grade the exams and the whole business. I had never burned as much midnight oil in my life as I did for those three years up there, the first year, in particular.

While I was at MIT, I was keeping my finger on what was going on and had arranged to go on a dive on the USS *Thresher*, on her test drive. Being close to Portsmouth and having an interest

in submarines, I arranged to go up there. I found out at the last minute they were going to have a large crew on board with a lot of extra people and I would not be making any direct contribution. I was just going along to keep up with the state of the art, so I called up and cancelled my trip. They never came back.

When they were searching for it, I had another finger in the pie. They took the *Trieste* down. The *Trieste* was searching for it [the *Thresher*] and they were having real navigational problems. I sent some of my top students out for the summer to work with the fleet and help them. I understand they did a good job of building patterns for navigation help and things like that.

Don Keach and George Martin were on board the *Trieste*. They were doing the diving. Bottom navigation has always been a problem. The *Trieste I* wasn't that maneuverable. Don Walsh described it once as basically an elevator. It was very slow.

At MIT, I also brought in guest lecturers for the students quite often. One of the things I did was done without anticipating what was going to happen. I knew SEALAB I was going on while I was teaching up there, so I called George Bond and got him to come up and talk to the students. I had no notion that I was eventually going to be his commanding officer. George was all over the place at the time and was hard to put a finger on. But that's background. I was then ordered to do design in the ship design division.

The *Halibut* was a part of our program that was not in the public light. It was fitted for putting a saturation diving outfit in the submarine so that the divers could exit from the bottom of the boat and do work outside. That gets into some highly classified areas. Along with the *Glomar Explorer*, we were the cover for a lot of that. Testing, for example, for the stuff that went into the *Glomar Explorer* was all done under our umbrella to keep it from surfacing.

The *Glomar Explorer* project was interesting. When that started to surface, we heard about the Soviet submarine out there. They asked me to talk about that. The idea came up to go get it. I talked to Admiral Gallien about it and asked, "Do you want us to do it? It fits within our deep search and recovery program. It's clearly part of our charter."

We had quite a big discussion about it and he said no. They decided that we were too visible to the public. There was so much "everybody was going to go live under the ocean kind of *Popular Mechanics*" thing that that visibility would have been hard to handle with the Central Intelligence Agency's approach. They took that whole thing off into a separate project, which, I think, was probably a good idea. I don't think we could have kept it quiet. We had the press looking over our shoulder all the time.

RADM J. EDWARD SNYDER

As the Oceanographer of the Navy, I dealt with a lot of reimbursable programs but sometimes never asked for payment. I remember looking for a gun in Lake Michigan at the request of somebody, and it was legally a reimbursable program. I went to the divers and said, "This is over Christmas. This is purely voluntary. If you volunteer, I'll see that you get Navy per diem, but I want 100 percent volunteers. I don't want anyone thinking the Old Man is telling you to do it." I got more volunteers than I needed. They went over there and they found the gun. I don't remember the details. I did not consider that the situation demanded reimbursement.

On the other hand, when the Air Force lost its hydrogen bomb, I was working for the Assistant Secretary of the Navy, and that was a totally different story. Dr. Harold Brown was the Secretary of the Air Force then, and I can remember very clearly what he said when I handed him the bill. He said, "Snyder, can't you just call this your Navy training?" It was a pretty hefty sum. It wasn't just the contract work. I wrote in the charges for the *Mizar* and the *Trieste*, a pretty big bill in those days. It was a long time ago, but it was a pretty big expense to send the Trieste halfway around the world.

I went to the *New Jersey* in December of 1967, and I think this was about two years before that when the bomb was lost. I don't remember the exact date, but I do remember that Dr. Morse was still the assistant secretary of the Navy, so it would have to be before Frosch came in. Dr. Morse was the acting secretary of the Navy, because Secretary Nitze was out of town on an official trip. I have a memorandum on the assistant secretary's white letterhead paper that reads, "Ed, take charge and find it," or something simple like that, "Signed, Bob Morse." I thought, "Oh, boy!" It was on a weekend and we were pulling in the whole Navy.

We were even pulling the flagship of the Sixth Fleet over there for one purpose, communications. It wasn't just R&D. I think you would call it a really operational thing. Basically, the Air Force was talking to me on the telephone. They had a one- or two-star general assigned to the problem because it was their weapon and they did not want anybody to find out why it was lost.

It was lost because some major from the general's staff suckered the pilot of the bomber to let him fly up for the refueling and, in my opinion, he didn't know what he was doing. But that was when the explosion occurred. Nobody was killed. It was absolutely amazing. But it broke the back of the bomber and it just opened up and all the weapons just dropped out.

I think there were four hydrogen bombs on that aircraft. One went into the water because only one deployed a parachute. The wind got its parachute and took it into the water. We were doing all that on the weekend, and I mean that we were really doing it. They even assigned me a place to sit in the CNO's ready room because we were really operational. It really wasn't research and development, but we were calling on R&D to use their cutting edge new technology equipment to find and retrieve the lost bomb.

ONR sent the *Alvin*, and it was the *Alvin* that found it. The *Alvin* was owned by Woods Hole, which was owned by the Office of Naval Research, which was owned by the assistant secretary, who at that time was the acting secretary of the Navy.

Anyhow, I put all of this junk that reported on what was happening on Secretary Nitze's desk. When he came back on Monday morning, he was floored. It had hit the newspapers. But it was an Air Force plane. I don't think the relationship of the Navy to the operation was clear to the secretary until he saw my report. Then, things really started to happen. The president got involved. It became the highest level thing because unbeknownst to me, certain presidents or directors in various European countries had given unofficial permission to the United States Air Force to fly over their countries with a loaded hydrogen bomb.

They basically said, "If you don't find the bomb and straighten all this out, you've got to stop your flights." Here is my good opinion, which has nothing to do with fact. I always call it the "Air Farce" because if that had happened, you would have had only one major nuclear program, and that would have been Polaris.

Many may not be aware, but the Navy couldn't have cared less about Polaris. Again, that is my opinion, and many would deny it, but the Navy really never supported Polaris, because it was eating them alive, financially. They did support it, but please know what I mean by that kind of support.

The Air Force could only have seen the incident as a threat. Can you imagine not being able to fly over in those days, when you didn't have cruise missiles in the airplanes? You had to physically fly over the target and physically drop your bomb. It became a number one problem.

The vice president of the United States was put in charge of the oversight committee. I was going over there with whoever was representing DOD, who happened to be Navy, by the way. I think it was the undersecretary. It wasn't my boss. I remember this clearly. I went over to the meetings in the White House. I stayed out of the day-to-day bolts and nuts, and the work done by our contractor, Admiral Stephan's Ocean Systems. But when I found out how deep the area was, for instance, I discovered our CURV, or Cable-controlled

Underwater Recovery Vehicle, couldn't go that deep. I called the director of the Navy laboratory on the West Coast and told him to modify its cable. I remember that he said, "Who's going to pay for this?" I said, "It's going to be your butt if you don't do it, so don't argue with me about reimbursement."

That was the bureaucracy. We had the number one problem in the United States of America, and I was getting, "I'm not going to do it until you pay me." Come off it. But that's the way life is. My tone was not exactly pleasant, nor was it official. I could not have necessarily backed it up, either. But we were going to do it, and we did.

The Air Force was absolutely 100 percent cooperative. I remember we also got involved somewhat with the land business, even though that was the Air Force's responsibility. They had to scrape acres of radiation-contaminated topsoil, and their general asked me if our SeaBees could help. He asked, "Can't we get them over there and start pulling this contaminated dirt together?" I said, "Yes, sir." I called the head of the SeaBees and the Commander of the Naval Facilities Engineering Command, but they only had one used bulldozer.

I called the general back and asked if he could buy six bulldozers and fly them over there. He bought brand new ones and flew them over for the SeaBees to operate. The Navy couldn't do that. We didn't have that kind of money. I had sailors from a heavy cruiser wading into the shallow water in swimsuits, walking to see if they could find the bomb on the bottom. I had the Atomic Energy Commission totally disagreeing as to where it was.

I talked to a Spanish fisherman, and when he told me where he thought it went into the water, I accepted his word. His location was sixty miles away from where the Atomic Energy Commission-Sandia had decided it was, but that was where we did find it.

The assistant secretary was with the CNO, who was running the operation from the Pentagon. But because Morse had been the acting secretary of the Navy at the beginning, he had put me in charge.

The CNO's office was perfectly willing to have a shared responsibility and assigned a two-star admiral to run the operational part of the program in the Pentagon. I can't remember his name. Everything was taking place in Spain. We had ONR involved, plus contract teams, so how did you communicate?

We put a heavy cruiser on the scene. Then, we said, "Well, gee whiz, can't we use some of their sailors to double check the shallow water?" Everybody was having a ball from that viewpoint. I remember it so clearly. While it was going on, Dr. Morse was called upon to testify before Congress, but he was in the hospital by then.

The Chief of Navy Legislative Affairs came in and said, "Snyder, you do it." I said, "I can't do it, sir." He said, "You didn't hear me. Go do it." I went over there, representing the Navy department, and gave this testimony and slides as to how we had recovered this weapon. A congressman, before the Appropriations Committee said, "Well, Commander, do you need more money for this kind of program? This is very important, isn't it?" I said, "Yes, sir." He said, "Do you need more money?" I said, "Yes, sir." He said, "Well, how about ten million dollars?" I said, "That's a start," or something like that. He threw it in the budget and the Senate approved it, and McNamara's staff went right through the ceiling because there was a Navy guy putting money in the budget with a directed program.

Of course, that was not the right thing to do, but I was pretty naive about that. I had been dealing in the technical sense all the time that nobody cared about. But all of a sudden, I was going before the chairman of the House Appropriations Committee, a particular congressman on the committee that was, in my opinion, a very brilliant, powerful, and honest man. I had dealt with him before on technical matters, and that shook a few people up. But it was so important to find the bomb, and we did find it, as you know. It was so important that there were a lot of bureaucracies involved, but it got done.

To this day, it would be hard to actually document how it got done, because nobody would believe it.

That was *Man in the Sea*, too, by the way, because we wanted to put a man down there when we thought that it was in shallower water. We wanted divers because we started out thinking it was in shallow water, so some of the SEALAB divers were sent to help us. It actually fell into shallow water, but the parachute stayed partially open so that the current pulled the bomb into a gully and made it three or four times deeper than it was when it first fell. That was when the *Alvin* saw it. The *Alvin* saw the parachute and followed it. For the deeper search, the *Alvin* was the nearest thing available on the East Coast. It was at Woods Hole, next to Hyannis, and the Air Force said they could pick it up at Otis Air Force Base and fly it over, which they did. As I remember, they flew it over, because it got there in a hurry, comparatively speaking. The *Mizar* was sent over, too. It also belonged to the Office of Naval Research. The CURV vehicle was on call.

At that time, the Navy was the leader in undersea technology. You didn't have all these civilian companies, and the early ones did work under Navy contracts. You had them involved somewhat. You had them involved in the shallow diving and in shallow recovery. But the lost bomb was very deep when it was finally found. I don't remember the exact depth. Also, you've got to realize our concern about charges that the Americans had irradiated Spain. The Soviets tried to exploit that.

Three of four bombs came apart and irradiated Spanish fishing grounds and the waters around them. They irradiated the tomato patches. I remember recommending to Secretary Nitze that he tell the vice president and the secretary of state he would authorize the Navy to buy tomatoes from Palomares farmers and feed them to our crews. That would prove that they weren't contaminated. Of course, we had already done the tests and knew they weren't contaminated. But the Russians would try to convince everyone that they were. They were watching us all the time. A Soviet spy ship was sitting there, pretending it was a fishing ship, but it was watching everything. That caused me to tell the secretary that if we didn't find the lost one, I had another one in my back pocket, fixed up to look exactly like the real thing, including dents. We could slip it in there and pull it up. He said, "That's a good idea, but keep it to yourself, because the Soviets are going to accuse you of just that when we do locate the real one."

I always looked at *Man in the Sea* as a function of the operational Navy, whereas most of the people on the materiel side looked at it as a toy, a Cousteau toy. It was an inner space program and so forth. I was looking at it because I thought we would need to be able to use a man, on occasion, and not just a remote sensor. I didn't know. I wasn't smart enough to know what that occasion would be. But today, it has been proved true. In the intelligence world, it is absolutely true.

I think the hydrogen bomb recovery proved to the world that the US Navy had a deep search and recovery capability; but I don't think the Navy understood that. Except for what the contractors brought, all the gear that was out there, the diving suits, submersibles, the CURV and so forth, were all in-house Navy equipment. They weren't combat ships, but they were paid for and owned by the United States Navy. The equipment was designed and developed by the United States Navy or its university and laboratory contractors and the Navy stood over it.

DR. ROSS SAXON

When I was selected for the integration program, I left the *Bugara* and went to Officer's Candidate School in Newport, RI. Upon graduation I received orders to the Officers course at the Submarine School in Groton. After completion I received orders to USS *Menhaden* (SS-377) in San Diego, where I served as Supply, Weapons, and Communications Officer.

Although I had scuba diving credentials, I really wasn't a Navy diver, per se. From the *Menhaden*, I went to the USS *Capitaine* (SS-336)

and served on her as the engineering officer and for a shorter period, as navigator. I qualified for command of submarines on the *Capitaine*. When *Capitaine* was decommissioned and transferred to the Italian Navy, I remained with the ship as Officer in Charge of a Mobile Transfer Team to the Italian government and additionally assumed responsibility for ex-USS *Besugo*, which was also transferred to the Italian Navy.

I went from the *Capitaine* to be the executive officer of the USS *Mackerel* in Key West, FL, and did a lot of diving there. Again, though, it was mostly recreational diving, diving we did on weekends and things of that nature. There was some diving associated with the operation of the boat, because we had a very experimental platform for the NR-1. From the *Mackerel*, because of the experimental nature of the boat, I volunteered to go to the USS *Trieste* and was selected for it.

The *Trieste* was the Navy's deep diving bathyscaphe. The *Trieste* dove to 38,500 feet in the Marianas Trench in January, 1960. Don Walsh was the pilot of *Trieste* at the time. The *Trieste*, at the time I was with her, was limited to 20,000 feet because of the sphere configuration.

When I joined the *Trieste*, we deployed from San Diego to the USS *Scorpion* wreckage. The *Scorpion* was one of our submarines and was lost returning from Mediterranean deployment. I'm losing track of dates, but I think it was 1968 when she was lost. Our job was to go out, locate the wreckage, and try to determine what had happened with the *Scorpion*. The crew of *Trieste* was technically seven officers, I believe, and a support crew of another 15 or 16 persons.

We transported *Trieste* and were moved on board the USS *White Sands*, which was towed by the USS *Apache*. We spent a lot of time in transit and tow before we got on station. Then, we made nine dives on the wreckage of the *Scorpion*.

The first thing was the difficulty of just getting to the wreckage, because underwater navigation was somewhat archaic in those days and some of the instruments we were using were pieced together from topside-type equipment. The first thing that we did was to plant deep sea transponders in the wreckage pattern so that we could triangulate using an on-board computer in the *Trieste* sphere to get to the wreckage. On the *Trieste*, we had underwater lights. We had still cameras. We had television cameras. We had a manipulator. All of those devices could be dropped from the *Trieste* to give us positive buoyancy in case we got fouled on the wreckage. We also had shot tubs with which we could release steel pellets, which would give us that positive buoyancy.

The primary job, basically, was to go down and take photographic evidence of the segments of the wreckage and try to eliminate, from a scenario of (I think) 23 different possibilities, why she, in fact, was lost. One of those things was the speculation that there was a circular torpedo run and it had come back and struck the submarine while she was in transit.

To try to eliminate that scenario, we inspected the shutter doors of the torpedo tubes, all of which were tightly shut. There did not appear to be that type of wreckage. There wasn't evidence that the torpedo had made a circular run and come back and struck the submarine. Most of the deformation of the metal did not indicate that type of casualty. We looked at some other things. We looked at the possibility of a battery explosion. We didn't see any evidence that one of the submarine batteries had actually exploded. We looked at the possibility of a torpedo battery explosion in the forward torpedo room, but there was no evidence of that. By "evidence," what I mean is that there wasn't any outward deformation of the hull where it was evident that there was an explosion from within the submarine. Everything was basically an implosion, which would be the pressure on the way down crushing the submarine.

Our job was really to go out and take a good look at the wreckage of the submarine and try to determine from this list of possibilities what may have taken place. We pretty thoroughly

exhausted the whole list and came back away with no really concrete reason as to why she went down. We added a couple of possibilities to the list but today, we still don't know. We have no idea why she sank.

After the search for the *Scorpion*, I was talking to my detailer about what would be my next assignment. My detailer went ahead and programmed me into becoming the first executive officer of the new class of submarine rescue vessels, which were going to be the ASR-21/22 *Pigeon and Ortolan*. But because they were both being built at Alabama Ship Building, he detailed me to the Armed Forces Staff College. I went to Norfolk, VA, and went through the Armed Forces Staff College.

Prior to joining the *Trieste*, I went through the second class Navy diver school on 32nd Street in San Diego. By then, I had picked up more diving knowledge and diving experience. The combination of that, the deep submergence activity, having been a lieutenant commander for about a year and a half at that point, and having gone to Armed Forces Staff College got me into the *Ortolan* job. After the staff college, in 1970, I went to the officers' course at Naval School of Diving and Salvage (NSDS) in Washington, D.C.

I graduated in the very early months of 1970. *Ortolan* was still in the building process and people were not yet being assigned to her, other than the commanding officer. At any rate, there was still a holding period. Following the graduation from NSDS as a deep sea diving and salvage officer, I went through the saturation training course in San Diego at the Submarine Development Group One. I had been at Submarine Development Group One in somewhat of a TAD status for a period of time between *Trieste* and going back to the Armed Forces Staff College. It was nice to go back there, see some friends and go through that particular kind of training. I then joined the *Ortolan*, which was hauled to the Philadelphia Naval Shipyard for outfitting in July of 1971. It was on July 4th, as a matter of fact.

The *Ortolan* was designed to support the Deep Submergence Rescue Vehicle (DSRV) and rescue submariners trapped in a downed submarine. The DSRVs are now being replaced with a new system called the Submarine Rescue and Diving Recompression System. Now, at the risk of having a lot of people throw a lot of things at me, I think building the DSRV was a total waste of money.

In the history of submarine rescue, we've had one, the USS *Squalus* in 1939, sink in shallow water in the Long Island Sound. It was a magnificent accomplishment and proved that we could do something. Since then, we've had no submarine rescues, per se, but we've sure thrown an awful lot of money at it. My personal belief is that we're putting a lot of money and energy into it more for political reasons than for practical reasons. We want to be able to tell Johnny's mother that we have a system that can rescue her son, when in reality we can't rescue her son. Our submarines go faster. They go deeper. They're in waters in which I don't think we can do much, in terms of submarine rescue.

I think that if we're going to have some form of a system associated with submarine rescue, it should probably be a McCann Chamber, like what was used with the *Squalus*. I think they should be relatively simple devices that are perhaps pre-staged on government-owned but perhaps civilian-operated vessels, with a given range of capability or distance that could be traveled within 24 hours to reach the scene of a relatively shallow submarine casualty, perhaps in the harbor.



ASR-22 Ortolan

But I think we're throwing a lot of money at something that, to me, doesn't make sense. I say that as a diver, a submariner, and now, a person in the commercial industry. I never felt, when I was a submariner, that submarine rescue was something with which I should concern myself.

Now, consider the emergence system developed by the British. Basically, it is a much more sophisticated Steinke Hood. I don't know that it had a great deal of value to anybody other than the application for which it was designed. The hard suit, the one atmosphere suit that can go down to 1000 or 2000 feet, depending upon its particular version, wasn't developed, at least to my knowledge, for submarine rescue. It has since been considered as one of those tools that might be used, but it was really developed for oil patch activity and is used in a variety of different ways. It can be either a suit where a man is, if you will, a diver, or in a suit that has propellers attached to it or thrusters attached to it so that it can be utilized in the mid-column or be relatively mobile. I don't know that the submarine rescue activity in which we or any other nation have been engaged has really produced any useful or meaningful tools.



US Navy atmospheric diving suit (ADS 2000) developed to assist in submarine rescue

COMMANDER DEWITT "RED" MOODY

We got involved in very diverse operations, such as locating test carcasses from ordnance, from the Air Force and the Army. The Army had some water ranges, at which they would fire some of that heavy caliber artillery into the water and we would recover it. Sometimes, if the operational tempo got too much for the people in Dahlgren, we'd go and support them in some of their underwater recovery. At Eglin Air Force Base, we had a continual requirement to come in and do a lot of recovery for them. As a matter of fact, when the Air Force called on the Navy to assist them in recovering the nuclear bomb in Spain, I had an officer who was going to Eglin Air Force Base with a lot of search equipment to find a device that they had lost there. Because of priorities, all the equipment we had ordered into Eglin for the search got diverted and ended up in Spain to look for the nuclear bomb.

I got a call early in the morning, at about 2:00 AM, and I asked the Duty Captain for the CNO, if he thought that I should respond personally. He said, "Well, I'll leave that up to you, but this is about the biggest hot potato in the world right now." I felt that, in order to support my people, it would be best if I went with them because I could interface them with the staff and outsiders to allow them the freedom to be able to do their jobs. I found that was a good thing, too. When you went on an operation like that, you needed somebody who could talk the talk and communicate with the senior p eople who may not have had any idea of what you were doing, either in the diving world or in the commercial world. I found that worked quite well.

In any case, we were asked and we responded. I believe I took about 18 or 19 people with me. They sent a dedicated AC135, which came from the same squadron as the refueling aircraft that had also gone down when the B-52 went down. They had found three bombs ashore and suspected that the fourth bomb had gone into the water. Later on, we drew a really tough

operation. It was recovered. Our people primarily conducted inshore searches from the beach out to about eighty feet of water. We were using divers of all classes. We used UDT divers. We used, of course, EOD divers. We even had some of the divers from SEALAB come out because we were going to use them for extremely deep dives.

As it turned out, it was not too practical to try to use the SEALAB divers because the old Mark 6 diving unit leaked gas, was extremely fragile, and diving at those deep depths out of a Mark 8 boat was difficult and dangerous, to say the least. Also, the oxygen transfer units that were required were pretty tender to be used in a rough environment like the beach and on Mark 8 boats. They were not very effective as deep-sea divers. Some of them were UDT-qualified and we did go ahead and deploy with our other UDT divers to conduct searches. They stayed on the scene for a while. But all the divers on that mission, regardless of whether they were UDT or whatever, were basically divers.

I got on the scene and briefed the Admiral as to my position. I told him that it was my problem, as the C.O. of the UDT-2, because we did have, in writing, worldwide responsibility for ordnance or things of that nature. It wasn't quite worldwide, but in that part of the world, we were responsible. He accepted that and I referred to the particular Navy order that specified it. Once they got that in hand, I had wonderful relations with the entire staff.

There were a couple of ways in which we were involved. I did a great deal of the planning on the lift system we used and was the Task Unit Commander for the recovery units. I was without a staff because I was a one-man show. I did a lot of personal interfacing, and also wrote quite a few Navy messages.

We laid down the second line of buoys before we did anything else, and we then searched in that area and then removed the first line of buoys and flip-flopped again so that the buoys were never removed until they had been searched on both sides. That way, we felt like we were coming as close to a hundred percent of the search area as we could, as far as our buoy system was concerned.

The underwater visibility was excellent, and on some days, you could see as much as forty or fifty feet. On the worst days, the visibility, to the best of my knowledge, never got below about eight or ten feet, and most of the time, it was excellent. One of the operational problems that we had was the mistral that used to blow up off the North African coast. It could be a balmy day in Spain and, all of a sudden, the wind would shift about sixty degrees and the jump up to about sixty knots. You had to be very alert to the weather systems. Fortunately, no one was ever hurt, although things got pretty dicey on a couple of occasions.

The rest of the force was reporting in at about that time. Of course, they brought some ASRs and some ATFs that had divers on them. We tried to deploy them to do contact identification on items that the mine sweeps and other sonar-equipped vessels had found in some of the deeper water. That didn't pan out too well because of the problems with getting into a good moor and the mobility of the divers and everything. They worked very hard, but the results were somewhat unsatisfactory. Master Diver Carl Brashear was on one of the vessels and, in fact, did lose his leg, as is reported in the movie *Men of Honor*. He was a good senior diver on the ship. I'm not aware of any problems, such as those depicted in the movie. Carl was very, very much in shape and had very strong upper body strength. He used to punch a Steve bag and do calisthenics for about thirty minutes each day.

As far as I know, the chief boatswain's mate and the diving officer had excellent rapport and ran a good, taut ship. One problem they had was that a couple of divers were bent on their first few dives. I was asked to go over and see what was wrong. In fact, we asked them, "When was the last time the gauges were calibrated?" and they didn't seem to have a good handle on it. We had the gauges calibrated over on the tender that was part of the task force. They had no problems after that.

There were other ways that the ships were employed. They would send out the "Cubmarine," which was a small research submarine, to do a visual search in some of the deeper areas. If they found a piece of aircraft wreckage, they'd sit on the bottom and we would have a diving vessel come over and send divers down with a recovery line. They would recover the aircraft wreckage.

We did have an incident, in which there were some pretty heated messages exchanged between the MSOs and the ASRs, and that eventually trickled up to the Task Force commander. I was asked to find out what was going on. It was a matter of diving safety. The MSOs really didn't understand the need for keeping that clear when the divers were down, and the COs of the ASRs were taking exceptions to it. There was a change to the way the business was done and after that, it worked well. We assigned the senior officer on the scene as the ASR instead of the mine sweep, so it worked out a lot better.

The EOD people, as they got into deeper water and had more limited bottom time, went to a tow-type search. A couple of our chief boatswain's mates took some of the old mine sweep gear with the otters and spreaders and rigged them in such a manner that they could then put divers on a sandbar between the two outer doors. We could then tow them at about a knot and a half to two knots.

The big problem that we had with towing was the double hose regulator, so we got a lot of flooding in there. That seemed to be the limiting thing that affected how fast we could pull a swimmer. Later on, I went into a couple of operations and I made sure that we got the single hose regulators. We found that we could tow them much more quickly. We had one of the vessels lay some surface buoys in eighty feet of water and we conducted a search out to eighty feet. From there, the other vessels took over.

When the bomb was recovered, one of the things I wanted to do was get the wire straps around it just as quickly as we could. Once we got it to about a hundred feet of water, we stopped the lift and had them take a braided nylon with two wire straps and strap it in front and in back of the suspension unit that was still on the bomb. It was the first time I really felt comfortable and thought that we had it in hand. The divers told me later that it was pretty exciting to go down there and put those straps underneath that big, billowing parachute.

Entanglement was a concern and, of course, if we lost the thing at that point, they were going down with that parachute. It was pretty dicey for them. They did a really good job and cut away some of the parachute so that it didn't encapsulate so much of the water. One of the problems we had as we were bringing the bomb clear of the water was that the parachute was billowing, putting a heck of a force on the entire rig. That was why we went ahead and cut some of the risers, so we could spill the water.

We got it aboard and the EOD people went to work and pulled the proper components out to save it. In pulling the components out, they had to use a little ingenuity because they found that one of the components was swollen from the seawater. In order to get it out, they put a small bolt in it and then used the Spanish windlass to a pad eye on the ship and in order to bring it out. The Air Force was watching this and they thought that was pretty neat.

DR. JOHN CRAVEN

I must talk about the fact that while we were developing the Deep Submergence Systems Program (DSSP) into all these projects, all of a sudden there came operational capabilities that we hadn't expected. The first one of those was the lost hydrogen bomb off of Palomares.

I got a call from the undersecretary of the Navy concerned about nuclear weapons. He said, "Craven, we've lost the bomb in the ocean off of Palomares and you've got to go get it." I said, "I don't have to go get it." I called Bill Searle. I said, "Hey, Bill, you're the supervisor of salvage. You've got to go get it." Bill Searle said,

"I haven't got the equipment, or the assets, or the technology to go get it. You've got to go get it, Craven." We went back and forth about this for a while and finally, one of us said, "Hey, we'll work together on this as a combined team." We put a team together with Admiral Swanson, Admiral Waters, Bill Searle, and myself. It was a committee called 'SalvOpsMed.' Our first problem was getting assets out there that would work.

The first call I got was from Woods Hole. The Woods Hole people were very proud of themselves and they believed that nothing was done unless they did it. That's a good attitude to have. Woods Hole called me up and said, "Don't worry, Craven, we'll send the *Alvin* over and we'll find it and you don't have to worry." I said, "Well, send the *Alvin* over, but we have to put it in an airplane. You can't put anything in an airplane unless you have a detailed structural analysis of the interaction between a heavy weight like that and the airframe." They hadn't thought about that. I put them in touch with the Air Force and they started to work on that. I immediately got the USS *Aluminaut* and put it in the dry dock at Fort Snelling. I had a problem with the Bureau of Ships because they refused to certify the *Aluminaut*.

No naval officers could set foot in it. But I said to the Bureau of Ships, "That doesn't look right, to go recover hydrogen bombs with only civilian personnel aboard, because it's too dangerous for naval officers to be on?" They didn't agree with me, so I went to the secretary of Navy. The secretary of the Navy wrote a letter to the Bureau of Ships that instructed them that they should allow naval officers on board. We never got any naval officers to go on board anyhow, so the *Aluminaut* had purely a civilian crew.

Then, we got CURV sent over. I sent over the whole SEALAB team because we didn't know whether it was in shallow water or deep water or what. Then, we sent over, of course, all the mine hunters, the minesweeps, and everything else. The Navy sent a cruiser in with an Admiral Guest in charge. Admiral Guest was an airdale, a flier, and he could not believe that the underwater community was so unsophisticated. I mean, he was furious about that because he wanted to know why we didn't have underwater vehicles that had the same research and development capabilities that all his aircraft had.

We had the problem that the only search doctrines we had were based on mine hunting doctrines, which I had been heavily involved with when I was working on minesweeping and mine hunting. I realized that those doctrines just weren't going to work. That was what I became famous for in *Blind Man's Bluff*, because at that time I had been going to some lectures by a Harvard professor by the name of Ryetha on subjective probability analysis. It was based, fundamentally, on the behavior of bettors at a racetrack. When the bettors go to the racetrack, they bet on the horses and that determines the odds. In retrospect, 6-to-1 horses are 6-to-1 horses and 10-to-1 horses are 10-to-1 horses. The bettors bet correctly. That means that there is something in their nonverbal knowledge brain that gives them information, which is better than a pure random guess of any kind.

This leads to the notion of taking all the evidence you've got, building up scenarios based on all the evidence, building up scenarios based on a little evidence, building up scenarios that say we disregard all the evidence, but we presume it's somewhere in that area. Then, you take these scenarios and get experts, fliers, and other people in there to make bets on the scenarios. You take each scenario and figure out a field of probability as to whether the thing would land. You multiply that field of probability by the bet. Then, you add all the probability fields together in such a way the probability of your search doctrine is unified.

When you do that, what's curious is that you almost never get to the high point of any single scenario. The other interesting thing was that in the searches that were conducted, the high point was almost always correct, or close to

correct. For the *Scorpion*, we searched that high point and it was within one-eighth of a mile of the submarine when we found it on the bottom. It was kind of amazing.

When you were amazed with it you finally said to yourself, "Hey, Ryetha was right. I didn't run them through rigorous calculations, but I hired Wagner Associates to run its own rigorous calculations because I thought that nobody would believe me unless I had somebody run it through such calculations. The net result was that the highest probability happened to be in a place we couldn't go, a deep crevasse, about 1,200 feet deep, and we couldn't get anything down there until we got *Alvin*. But *Alvin* finally arrived at Rota, and we had to get it from Rota to Palomares at the same time that the USS *Fort Snelling* arrived at Rota. We put *Alvin* on the *Fort Snelling* and took both of them over. We really didn't get involved in the search until those two vehicles were in place.

Then *Alvin* went down and found it. Because we didn't have a navigation grid of any kind down there, *Alvin* had to be relieved by the *Aluminaut* because *Alvin* didn't have the staying power. The *Aluminaut* baby-sat the bomb for a long time. If you think you're cold here, those guys were as cold as could be. They sat for the long night until *Alvin* could come down and they could put a navigation grid on the whole thing.

They then realized that it would be stupid to try to get the *Alvin* to recover it because the parachute had deployed. In our scenarios, there was one parachute deployed or two parachutes deployed or no parachute deployed. On the other scenario, three bombs were deployed but with no parachutes. Each nuclear weapon had two parachutes that slowed them down in the process. That was why we had all these different scenarios.



Naval Research

REAR ADMIRAL J. EDWARD SNYDER

To begin my story, I have to say that we wouldn't have had oceanography anywhere other than in the Office of Naval Research or the Naval Research Lab had it not been for Dr. Jim Wakelin, whose background was Ryan Aviation, I think. He was a PhD and academically inclined, but also a great gentleman. It was probably the best thing that could have happened to us.

Now someone was coming into the Pentagon following the establishment of the office of Director of Defense Research and Engineering (DDR&E). A separate line appropriation for research and development and a Navy assistant secretary who was skilled in that area were assigned to this department as well. I knew absolutely nothing about research and development from that standpoint. I knew how to manage programs, but not how you did it in a bureaucracy. In fact, I had just finished writing a paper about how there were so many admirals in the Pentagon and that they were all "no-sayers." I wrote that you could never get anything through and that was why the title of the paper was "The Five Sided No-Sayer."

Dr. Wakelin was impressed by my "Trash Developed Profusely," although TDPs were part of the new McNamara system on how you did paperwork. Nobody cared about whether you had a destroyer, but you had to prove in the paper work that it was cost effective. He and I were off to a good start in that sense, except for my language, which he continually criticized. My office was, by the way, closer to his office than his executive assistant's office. I was right outside his door and the executive assistant was in a little cubicle behind it.

His executive assistant was a Navy captain. In those days, one of the fascinating things, which I will go into later, was that the Navy, though I can't speak for the other services, refused to have deputy secretaries, deputy undersecretaries, or deputy assistant secretaries. They had naval aides and executive assistants. They were four-stripers who controlled the calendar. In fact, the CNO and vice chief didn't have civil servants to help them. They each had an executive assistant and a naval aide. For example, when Admiral Kidd was only a captain, he was the naval aide to Admiral Moorer.

Dr. Wakelin, for some reason or another, absolutely felt compelled to do something about oceanography. It was Dr. Wakelin who put money in the budget to create all the new oceanographic institutions. I don't remember exactly how many we had in 1962, but I think there were Woods Hole, Scripps, Texas, and Columbia. Columbia was the one that did bottom contour mapping up on the East Coast. By the time I left, the office had something like 15 new programs in academic oceanography outside of the military. We had no oceanography within the Navy until after I left.

When I came back, I found that the oceanographer was in charge of the oceanographic program at the postgraduate school in Monterey and of supplying ships and faculty for the program in oceanography at the Naval Academy. That was Dr. Wakelin's definition of oceanography.

I was trying to get it done. I was at the Pentagon for almost five years, and always thought it was absolutely ridiculous that you had the assistant secretary of the Navy running the Naval Academy. I would have thought the CNO would be involved.

Up until Dr. Wakelin's tenure, we had never had anybody in charge who was interested in research and development. There was no formalized Navy structure for research and development. As a matter of fact, since I had no knowledge of how you did things within the bureaucracy of the Navy, I decided that I would learn. I asked the secretary if I could have his authority to write a pamphlet called the RDT&E Management Guide, or in other words, the "Research, Development, Test, and Evaluation Management Guide." He said, "Fine, Eddie, go do it."

I called people. By that time, I had been introduced to civil servants in all the bureaus

and to all the flag officers in the Pentagon. I had learned, because of my own negative experience with flag officers, that you did not get flag officers involved with anything. I called over to various bureaus, and the Office of Naval Research and the Naval Research Lab, and arranged for designated GS-15s or above to come on over and sit in my office so that we could talk about what it was they had to do. To make a long story short, we wrote the manual.

You have to realize that at that time, none of the uniformed Navy or even the civilians really understood formal research, development, testing, or evaluation because it was only a little more than a year old. I wrote in that first edition that the assistant secretary of the Navy for Research and Development was the program sponsor and appropriation sponsor for the expenditure of RDT&E funds.

When I left the Pentagon, the Chief of Naval Operations still believed that the assistant secretary for Research and Development actually decided where that money came from, who got it, and where it was going. Nobody questioned that while I was there. DDR&E didn't question it, but it was actually not true. Nobody in Congress ever even said anything about an appropriations sponsor. That indirectly gave him and his two successors immense power, if you stop and analyze it.

The Deep Submergence Systems Review Group was Admiral Stephan's last job. He was chosen for the assignment, and he retired when it completed its work. When I came aboard, the oceanographer was a meteorologist or somebody, but it was not Admiral Stephan. I know that because it was during Dr. Morse's time frame.

When we lost the H-bomb, I got hold of Ocean Systems in New York to help us out. Admiral Stephan was the President of Ocean Systems, which was 60 percent owned by Union Carbide, 30 percent by General Precision, Ed Link's company, and 10 percent by Link personally.

That brings up another issue, the preparation of the pamphlet "Effective Use of the Sea," a product of the Panel on Oceanography of the President's Science Advisory Committee. The chairman of the panel was Dr. Gordon J. F. MacDonald of the University of California in Los Angeles, who later became head of the Environmental Protection Agency under Nixon. The vice chairman was Herb York, who was at the University of California in San Diego. The pamphlet was written during the time frame when the Weather Bureau was trying to become leader of civilian oceanography. That was supported by Wakelin, in a sense, and was certainly supported by him for years afterward. President Johnson signed "Effective Use of the Sea." It documented the Navy's first step forward to volunteer as the ocean engineer for the US. Seen by some people as a power grab by the Navy, the Navy looked at it reluctantly as something that I must have been doing.

Dr. Frosch then replaced Dr. Morse. I left the office in 1967 as special assistant to Dr. Frosch. When I returned in 1971 as the oceanographer, Dr. Frosch was still there. He served until January 1973. He was there quite some time while I was the oceanographer. In fact, he was the one who wanted me to be the oceanographer.

I can remember clearly what happened that day. I was a fresh caught admiral, or relatively fresh. Admiral Zumwalt was the CNO. I had been told to leave my job as the COMTRALANT, or Commander Training Force Atlantic Fleet, in Norfolk, at least two days a week and take over as additional duty the job of running the Office of the Oceanographer. Admiral Behrens, who was then the oceanographer, had been sent by Admiral Zumwalt to work over at NOAA, where he established the billet of Naval Deputy to the Administrator of NOAA.

That fateful day, I was standing in the hallway, having a friendly conversation with Dr. Frosch in the corridor outside his office when Admiral Zumwalt came down the hall and started to talk to him. Dr. Frosch, who called Zumwalt "Bud," said, "Bud, I want Ed to be the Oceanographer of the Navy." Zumwalt responded, "I want him

to at least try to be the Atomic Energy Commission (AEC) Director of Military Applications."

The reason Admiral Zumwalt had sent Behrens to NOAA was his great interest in getting the Navy involved with other federal agencies. The Director of Military Applications had never been a Navy job. He was the one who ran the weapons side of the Atomic Energy Commission, a very powerful position. Up until that time, this director was, by law, the only weapons tie between the Department of Defense and the Atomic Energy Commission. The primary purpose was to be sure that the military couldn't make their own weapons. Of course, it has been changed since then. I am well aware of that.

Anyway, I think somebody had told Zumwalt that I was a flag officer who had served at Los Alamos and Livermore, and that might be the Navy's only chance to get the job. Frosch and Zumwalt were discussing this issue back and forth, when one of the cute gals from the undersecretary's office walked by. I stopped listening to both the CNO and the secretary and turned my back on them to say something to her. Dr. Frosch, and I can see him now, turned and looked at Zumwalt, smiled and said, "Now, you know why I want Ed Snyder. Is there anybody else who can do bottom contour mapping better than Ed?" Everybody started laughing. Zumwalt said, "Okay, but I get first shot at him with DMA. If he fails, then you've got him." I did fail, but that's a two-hour story.

In those days, you were dealing with the Atomic Energy Commission, who decided who received what weapon. That was after the time when the Air Force had set up Dr. Teller at Livermore, thinking they could get their own atomic energy laboratory. Of course, the law and Congress and everybody else stepped in and said, "No. That belongs to the Atomic Energy Commission, period!"

We had two competing laboratories, as opposed to the original concept. The Air Force denied it, but they wanted their own bomb makers. That's another subject that has nothing to do with oceanography, but it is an interesting subject. The Air Force wanted to say that you could not build a military weapon system smaller than 54 inches in diameter. One reason for that, without being written down, was so we couldn't fly them off an aircraft carrier. Teller invented a 39-inch one with twice the yield, and that put the Navy back into the carrier business at Los Alamos.

The outside world didn't realize the things that used to happen in the Washington arena, and few people really knew what the heck was going on. You had decisions being made sometimes without any technical knowledge to back them up. I may be exaggerating, but I think it certainly was true in the 1960s. Can you imagine another weapons system like Polaris, which was built under President Eisenhower? There was no way at all. I mean, the president had a meeting with ADM Raborn, Dr. Teller, and a couple of other people. They convinced him it was important. The president said to do it. It started immediately and was completed in three or four years. It was done on an unlimited budget and finished on time.

The weapon was lower in yield and shorter in range because the people sitting at that meeting with the president each had a different version of what the word "warhead" meant. To Teller, "warhead" meant the plutonium, polonium, and uranium. To a weapons designer, it meant that, plus the fusing and firing circuit. But to the military people it also included the re-entry body. I can't remember the exact figures, but Dr. Teller said, "I will guarantee you one megaton within such and such a weight." In the end, we attained that weight, but it also included the re-entry vehicle and the fusing and firing, so that cut the range down.

There was no definition of the term "warhead." When I went out to Los Alamos, it blew my mind, because nobody was speaking the same language. You had the most brilliant man in the nuclear warhead business sitting with the president of the United States, and you had an admiral who was an aviator, not a

physicist, and you had other people who were worried about Sandia Corporation, which hadn't been working on ballistic weapons, but had been working on fly-them-away weapons. There was a big difference and it caused a lot of problems, which we did solve, but that is a totally separate subject. That was three years of malarkey.

I think the Stephan Committee gave the Navy its ability to focus together all of its recommendations. Certainly, it got the Navy moving, but it would not have moved if it were not for Wakelin. He took that report and started to implement it. When Wakelin left, Dr. Morse came aboard. Dr. Morse implemented the engineering side even more than Wakelin because Morse really believed in it.

When Frosch came aboard, you had not only a scientist, but also an individual who had a tremendous background in underwater acoustics and had come from the Defense Advanced Research Projects Agency (DARPA). He possessed knowledge that neither Morse nor Wakelin had. Both of them had to learn on the job. Wakelin had to learn how to make the office function. Morse had to learn how to deal with the bureaucracy. Frosch came from DARPA, which I have to call the bureaucracy. That was advanced research at DOD, and he really knew what he was talking about. You saw things happening.

The Office of the Oceanographer was set up because I realized that it was impossible to tie those things together as everybody wanted them unless you had somebody to tie them together. Although Admiral Stephan may say he was the first Oceanographer of the Navy, he was not. He was the Hydrographer of the Navy; Wakelin was the first Oceanographer of the Navy.

When Dr. Morse came aboard, we had a discussion about needing to get rid of a bureaucracy that talks about meteorology and oceanography and diving, and really start bringing it together. Dr. Morse was given permission by the vice chief of Naval Operations to go out and pick his own oceanographer. We went on field trips to interview various men; that was when we picked RADM Odale "Muddy" Waters. Some folks accused me of picking Waters because his name matched that of the Chairman of the House Committee, Mendel Rivers. It was Chairman Rivers and Admiral Waters. I don't know the reasons why Dr. Morse chose Admiral Muddy Waters, but he did, and made him the first oceanographer.

Maybe the one before Admiral Waters was the first legal oceanographer. It's not clear, because we didn't even have a designated oceanographic program until Secretary Nitze signed the instruction that established the Oceanographer of the Navy, the Assistant Oceanographer for Ocean Science, the Assistant Oceanographer for Ocean Engineering and Development, and the Assistant Oceanographer for Operations.

When Secretary Nitze attended my going away party, he asked me, "What did you accomplish in these five years?" I didn't answer, and he said, "You must have done something." I said, "Yes, sir. I got you to sign two pieces of paper." He asked, "What were they?" I said, "Creating the Oceanographer of the Navy and OP-95." He said, "That can't be true." I said, "Well, let's put it this way, Mr. Secretary. All the mistakes I made would fill the largest hard drive you have in the computer, and I couldn't even get my accomplishments on a little disk."

OP-95 was the creation of a czar for anti-submarine warfare (ASW) that Congress pushed on us. We were not doing well in anti-submarine warfare, and there were big arguments that submarines could sink carriers and so on.

Admiral Leydon was Chief of Naval Research when I was trying to write the oceanographer's charter. This project started under Dr. Wakelin, who gave the order to emphasize oceanography in the Navy. One of my jobs was to sit down and, in effect, write a charter for the oceanographer of the Navy. You can well imagine that was not the easiest thing in the world to do because you were cutting into the knickers of people other than the chief of Naval Research.

Under procedures current at that time, and even later when I was the oceanographer, the assistant secretary for Research and Development ran the Office of Naval Research. The chief of Naval Research did not report to the CNO. He reported to the secretary of the Navy, but the secretary had delegated that responsibility to his assistant secretary for Research and Development during the time I was there.

The Office of Naval Research ran the secretary's budget because the ONR comptroller was the comptroller for ASN(R&D). I had written in the RDT&E Management Guide that ASN(R&D) was the sponsor for research funds appropriated by Congress. I didn't know that he really wasn't, but this statement gave him a lot of clout. That meant a lot of other things were involved with it, too.

The other issue was naval development, not just basic research but development. That brought in the materiel establishments. They did not turn out to be a problem, because it was going to be a loose confederation. Nobody was going to own anything, but they all had to report.

The concept I had, which the secretary bought, was to have an assistant oceanographer for Research, assistant oceanographer for Development, and assistant oceanographer for Operations. The oceanographer for Development would be on the materiel side. In those days, the Secretary of the Navy ran the materiel offices, not the CNO. That changed later. The only problem I had was with operations, because operations came under the CNO. It was probably a technical mistake, but I chose the submarine community to be the assistant oceanographer of the Navy for Operations. That was what I had in my mind, but it took two or three years to get it signed.

This is what happened to me. I'd been in the weapons system program. I'd been at Los Alamos. I'd been at Livermore. I'd been at Sandia Base. I'd been the program manager for the Polaris warhead and reentry body on-site. The only thing I had to do with oceanography in those days was to be sure that we knew where the FBM submarine was and whether it could launch a missile through the interface of the ocean into the air. Then, all of a sudden, I was the Oceanographer of the Navy. That started really because of my job in the assistant secretary's office.

I don't think history will ever give Jim Wakelin true credit for the fact that we have a Navy oceanographic program because of him. Morse followed through and, indeed, did more in certain areas and Frosch did much more in other areas. But I'm talking about getting it started. We were dumping money in every small town and university that was willing to accept it from ONR to get involved in the ocean business. We suddenly woke up to the fact that in the Navy, certain programs, like anti-submarine warfare and submarine operations, needed to know a lot about the ocean. The Polaris program put us in the position of having to really understand something more about the ocean than most people recognize.

When I walked into the Pentagon debate on the subject of anti-submarine warfare, I remember Secretary Wakelin saying to me, "You know, Eddie, the Congress is really pushing us on anti-submarine warfare. They say we don't have any capability, and I tend to agree with them. I want to see what we should do. They want us to have a czar of anti-submarine warfare. The Navy does not want us to do that. The Navy doesn't want to push anti-submarine warfare in the same limelight as tailhooking, driving nuclear submarines, and so forth." Then he got me involved with that.

Congress really pushed us into anti-submarine warfare. I woke up as I walked in there. I was coming from command of a destroyer, and not yet aware of the SQS-26 sonar. All of a sudden, I was, in effect, advising the secretary how to do it, pay for it, train people, and get people interested in it. I should have known a lot more about it than I did. Here I was running some ASW programs, but was not up-to-date on all the new stuff.

I would say the current ASW capability was more of a scientific program than the oceanographic program because it occurred prior to the establishment of a valid oceanographic program. My personal opinion is that the kinds of things that we've done, plus what the oil companies were able to do later with it, really started at the Office of Naval Research.

The big problem, as I saw it when I came in, was how we were to move it from ONR to new ships. In other words, the question was how we were to take it from the drawing board and the bread board model to something the Navy could use at sea.

I was a sea diver. I'm a unique individual because you don't see that now. I had command at sea of three ships, and at other times, I managed three or four technical programs. Nowadays, you've got to make a decision to go one way or the other.

I was lucky in a sense, and unlucky in another because I would rather have been an operator. It was more fun. I couldn't explain or articulate to you the fun of commanding a battleship, seeing peoples' lives saved, and seeing very scary people just disappearing whenever you moved in. That was a real thrill. It was like a surgeon saving somebody's life. It got to be a real satisfaction when you knew you made the right cut or the right diagnosis. I'll never get that opportunity again, and I don't think many other people will, either.

A good question is how do you get anything done in Washington? I remember the paper I wrote at the War College, "The Five Sided No-Sayer," meaning the Pentagon. (They can't do anything but say no.) I really verified that after I got there. I would see sometimes as many as 12 flag officers' signatures on a piece of paper before it got to the secretary of the Navy. That was ridiculous.

It was also perfectly clear to me that if you really wanted to tie all of that stuff together, you had to do it within the ability to have it classified when you needed it classified. In those days, I gave everything to everybody. I gave things to the Soviet Union. But certain people in the military departments, the Department of Defense and the Navy, particularly the civilians, understood that the United States came first in my mind, but I didn't over-classify.

As a matter of fact, I remember walking into an argument that took place while Secretary Nitze was secretary of the Navy. It was over the issue of the Transit Navigational System which, by using a satellite system, played a part in telling the Polaris when to fire. Its other role was purely navigational. Well, I gave the Soviet technical people the navigational part of it. Of course, that blew a lot of peoples' minds. They didn't see Transit as just a navigator; they saw it as a Navy weapons program.

I remember throwing down a South African paper article about the Transit in front of the desk with all these admirals. I said, "Who the heck are we trying to keep it from? Here's a declassified version from South Africa. I'm talking about navigation." Before the Global Positioning System (GPS) became available to everybody in the world, Transit was a heck of a fight. But it probably set the stage so that GPS later did not have to go through that same fight. The United States Navy did permit industrial receivers the capability to use the Transit Navigational System, but again, that was over strenuous objections.

The Transit system was a satellite system used to navigate before the GPS, which we needed for the Polaris program. It was the predecessor to the GPS. The big issue was over whether we improved and increased the number of Transits or created a new system. The decision made by the Secretary of Defense was to do a new system.

I was involved with the GPS when it first came out, and I was supporting it. I think the only thing wrong with it was the altitude. The third thing the GPS can give you is absolutely accurate altitude. Well, so what? Simple radar gives you the inches you are above the building, the earth, or anything else. The GPS only gives you altitude above a geodetic position. I'm sure

they have that capability, but what good was that to me? It's a three-dimensional navigation system, but you don't need to know feet above a geodetic position.

I'm not sure that the technical details of GPS are available to the rest of the world. They will be, eventually, because you can't hide that forever. Then, I didn't see that it was that important from a navigational viewpoint. I think it's just fascinating. I remember in the early part of the Polaris program, when I was the warhead officer. I was also double-hatted to the Atomic Energy Commission and to Dr. Teller at Livermore. In addition to the other problems, you had to know where you were. If you didn't, you were going to miss.

In those days, we didn't have the smart bomb ability to sense a specific target and go after it. We had to know where we were and where the target was, and we had to determine the location of both geodetically, because we were operating in geodetic space. How do you rectify and resolve all of those issues when the Navy says to you, "We know where we are within feet?"

I had admirals asking me, "What are you talking about? That's a waste of money. I went to the Naval Academy. I know how to blah, blah, blah."

I said, "Okay, we've got a really simple problem. Let us put out an order that when the 6th Fleet returns from its next deployment, no ship can talk to any other about its position. I don't want the admiral getting the noon position from the ships. He can get that from his flagship, but not from the rest of the fleet. When we come back, we'll look at them, and I guarantee you that they will average more than ten miles part." When those ships came back, they were about 18 miles apart. That was not accurate enough for a missile to launch against a target in those days. The need for having a navigational system became obvious. Forget the business of all the old Navy guys being able to use a sextant. I think they had their picture taken with sextants, but they never really knew how to use them.

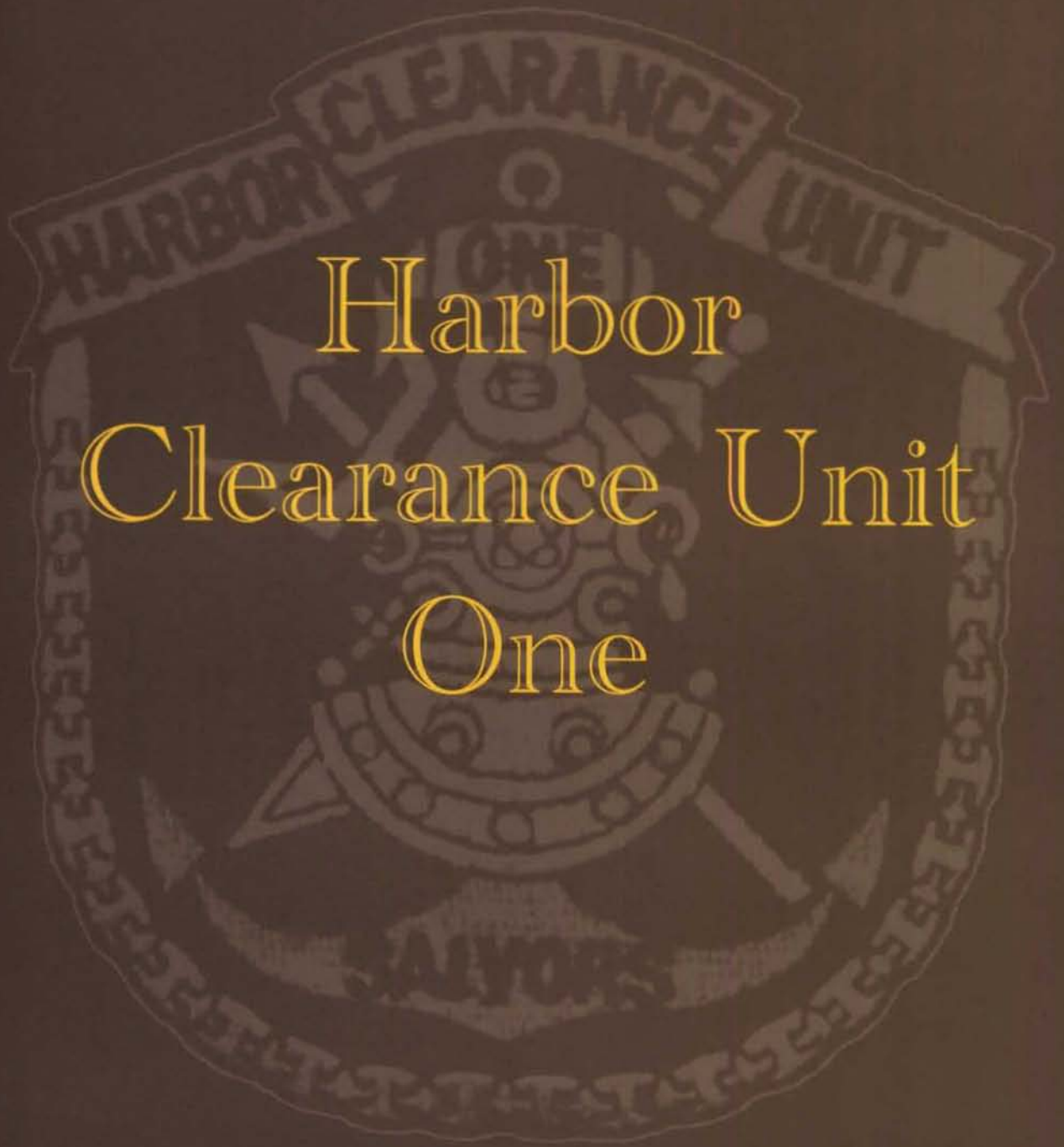
Back when I was very young, I saw the SEALs as a group of people who could accomplish the dream of putting man on the ocean floor. They could exit from a submarine to walk around. Some people shared that idea, and some people investigated it. I remember a very fine young officer who went up to Woods Hole and made the equivalent of admiral in EOD or SEALS. He was their first flag officer. But before that, they didn't have a flag officer to lead their community.

Look at a line officer like Brad Mooney. When he was a young commander operating submersibles, who was supporting what he was doing? Nobody except for me. Look at the medical people who were interested in doing hyperbaric work. Well, it doesn't mean I owned them. It doesn't mean I was their legal sponsor. I could help them in little but important ways when there was a big meeting going on. It is an important thing for the Navy to do. There are all kinds of sponsorship. There is also a dangerous sponsorship in taking the legal approach, because it then gets involved with billets.

One of the things you can do as an old man for the young people is help them plan a career path. That was one of the reasons you saw me having my luncheon reserved at least four days a week for outsiders and not for staff meetings. Somebody who was running some kind of program would want to come over and discuss a problem with me. These were people who recognized that something different was going on in my office. They didn't know what it was or how it worked, but it seemed to be reasonably successful, not only from a promotion viewpoint, but because it was successful in getting something done.

I would always let people bring their kids over if they could. I was also getting concerned that everybody wanted to be in biological oceanography, and I didn't think that was all this country needed. We needed specialists in physical oceanography, too. Don't misunderstand me. We needed biology, but not exclusively. You know that when I hired my first aide, I turned

down the aide they wanted to send me, the captain of the football team at the Naval Academy. I chose Ron Tipper instead, because he had a PhD and understood biology when I hardly knew how to spell it.



Harbor Clearance Unit One

Mobile Diving and Salvage Unit ONE (MDSU-1) was commissioned as Harbor Clearance Unit ONE (HCU-1) in February 1966 in Subic Bay, Republic of the Philippines.

The command was immediately put to test in Vietnam. During the conflict, salvage teams conducted hundreds of harbor clearance operations in Vietnamese rivers, harbors, coastal areas, and inland waterways. It was considered to be an afloat-command with in-country forces under the administrative control of the Republic of Vietnam. Its mission was classified as "providing Western Pacific harbor/river clearance and salvage capability with primary commitments to operations in the Republic of Vietnam." As will be noted in this chapter, that mission was carried out by HCU-1, which pushed, pulled, towed, lifted, demolished, patched, and raised sunken vessels, stranded equipment, and cleared harbors, bridges, and waterways.

At the conclusion of the Vietnam conflict, the command was relocated to Pearl Harbor, HI. In 1982, the name of the unit was again changed back to Mobile Diving and Savage Unit One to more closely reflect the capabilities of the unit. In 1996, with the consolidation of the SUBASE dive locker into MDSU-1 Fleet Maintenance and Dive Department, MSSU-1 became responsible for all ship's husbandry diving services of water craft, surface ships and submarines in Pearl Harbor.

It was during the Vietnam conflict, however, that the professionalism of the unit resulted in the command being awarded the Meritorious Unit Commendation and the Navy Unit Citation. Even today, when one speaks to a former HCU-1 man, there is a fierce pride in what they did as they operated in a hostile environment using only the equipment and vessels they had—for the first few years most of it left over from World War II—and the outstanding coordination and teamwork of everyone involved.

The information in this chapter is a compilation of interviews of retired Navy personnel, both officers and enlisted men, who served in HCU-1 between 1966 and 1972. During those long years, the conditions for the men varied from semi-calm periods in the conflict to stormy years of intense fighting. This resulted in some of the HCU-1 tours being much safer than other tours where extreme danger was a daily reality.

Whatever the tour, whenever it occurred, however, the tasks of HCU-1 during the Vietnam period could best be classified as "dirty, dangerous, different, and demanding, but never daunting."

The five teams who made up this unit were determined to do their assigned jobs by any means necessary, using whatever they could borrow, find, make, barter for, or obtain through other creative actions. More than the use of any craft, piece of equipment, or salvage technique, it was the untiring, dedicated, and innovative performance of the officers, enlisted men (both divers and topside personnel), who made it so successful. All of the men in this unit, regardless of rank, did arduous duties and worked long hours, usually under the constant inherent dangers of diving in zero visibility, doing salvage on vessels or objects that could contain unknown hazards, combined with the threats of enemy fire and hidden explosives.

Teamwork was the theme of the day! Two-thirds of those who were responsible for the successful ventures of HCU-1 were support personnel who were often asked to do jobs that went well beyond their training. It was not unusual to have a diver using a Jack Brown rig in zero visibility water tended by seamen, firemen, or engineers who had never been to diving school. At other times, these on-the-job trained tenders were also relaying signals to crane operators. The corpsmen aboard the vessels were also divers, who, for the most part, had attended both diving, and salvage schools and were first class divers. But these divers always had to do the last dive of the day just in case one of the earlier divers needed medical assistance.

If it were not for the hard work, willingness to take on any task, and the cooperation of an entire team, many of the jobs undertaken by

HCU-1 could never have been accomplished. It is a tribute to their resourcefulness and ingenuity that they lost less than twenty men, nearly all to enemy fire while working on a job, or traveling down the narrow rivers or along the coast to reach a job. At times, the fire from enemy guns came while they were towing vessels back to bases for repair; other times they were injured, or killed, diving to find the body of some other military personnel who had been lost in the water.

The requirements of "make do or do without" began in 1966 when the first group of 28 HCU-1 men were sent to Subic Bay. They were assigned to a barracks that had no bunks and no lockers. Furthermore, they were not given any funds to procure what they needed. Therefore, their first job was to locate the things they needed to have in the barracks. They accomplished this by "borrowing a truck" and making some "midnight requisitions." The second job was to assemble the craft they would be using for salvage operations in Vietnam. It was a British lift craft that had been in storage during World War II. They could not begin their assignment in Vietnam until they were able to assemble all of the parts of the craft and get it operational. The major problem on this task was that some of the parts they had to assemble weighed several tons and they had no tools or lifting equipment. To complete this "impossible" task, the creative men of HCU-1 "borrowed" a crane from a nearby army base, and negotiated and bartered for tools and other parts from Navy ships in the harbor.

Initially, HCU-1 had four teams, each team made up of two diving-trained officers, 22 enlisted personnel, including 14 divers and 8-9 support people, some of whom had been trained in salvage or had been to 2nd class dive school. Other support personnel were young, new, Navy seamen who had volunteered for duty in Vietnam, but had no salvage or diver training. Later, during the extended conflict, a smaller, fifth team of 6-8 men was added to the unit. Their primary responsibility was to maintain clearance of obstacles in the small canals and river tributaries of the inland part of the country. For Team 5, their assignments often meant working in waters that were too narrow to turn their boat around.

In most instances, the salvage and demolition work was done from one of three types of crafts; a light lift craft (YLLC), a small combat salvage boat (CSN), or a yard diving boat (YDB). Most often they had to use vessels, (English, German, or American) that had been in storage since World War II. It was their responsibility to refurbish this donated equipment to meet their salvage needs. Again, they often had to secure the parts and equipment using their own ingenuity and their skills of "borrowing and begging."

Some of the salvage boats in use during most of the Vietnam conflict were formerly World War II landing craft that were intended to bring a tank or two onto shore. These had to be reconfigured to hold an A-frame, and the compressors and other equipment and supplies needed for diving. The vessels had to be configured in such a way that they became the teams' "home-away-from-home," as well as their transportation, their staging area for salvage operations, the mess hall, and often their sleeping area.

As the conflict extended, the equipment and essentials of HCU-1 changed. By 1967-68, the four teams had two lift crafts, four CSBs, and 2 dive boats assigned to their unit. They had secured tremendous fire fighting equipment and were far better prepared to protect themselves. Again, much of the reconfiguration work they did themselves, and most of the supplies and equipment they managed to secure in non-traditional ways. While back at their base in Subic Bay, where HCU-1 used a large vessel as their staging point, the teams who were not in Vietnam spent their time repairing their equipment, developing items that were needed for their work, and trying to find the materials they need for successful salvage jobs.

Some of the boats had some light armor on the outside when they were given to HCU-1, but the crew found that this was sufficient when they were being shot at from both sides of very

narrow rivers. Using the material on hand and their resourcefulness, they found that if they filled the space between the armor and the boat with empty ammunition canisters, or other cans of various types (filled with sand or water) they had much more protection.

This system was also used by other military personnel who used the rivers for transportation of equipment and men. While this extra, creatively added "home-made" armor helped protect the men from enemy fire, it also meant that if a vessel was sunk or damaged, it usually turned upside down in the water because it was so top heavy. Thus, when HCU-1 crews came to salvage the vessel, their first task was often to turn the sunken vessel right side up.

Another tough job for many members of HCU-1 was returning from their salvage assignments. In many cases, a small group of men would be flown by helicopter to the site of a salvage job with their scuba bottles, swim fits, and a few provisions. After the job was finished, it was their secondary task to find their own way back to the base camp. This was often more dangerous than the salvage job.

As the only salvage unit in Vietnam, the task they were asked to do varied extensively. Sometimes the task could be done in a day; more often, it would take three or four days to do the job. Sometimes a job took several weeks, and in a few instances, several months of hard, grimy work in polluted water. Whether the job was in the southern part of the country or almost to the Cambodian border, HCU-1 was expected to find a way to complete the job.

One major job, assigned to a team in the 1970 time period, was to find a way to remove a massive concrete landing pier that had been destroyed. This pier, the main landing for ferries over the river, was preventing civilians and military personnel from going from one side to the other of a very wide river because there was no bridge across the river. The landing pier, whose concrete was crisscrossed with rebar had to be blown down, and the rebar removed by divers in muddy water in the always heavy current. One ex-diver recalled having "his hoses hung up in the rebar and having to cut himself loose to get out." As always, it was the diver's job to rescue himself; there was no one else to do it.

On another unusual assignment, one of the teams was trying to replace a generator in an LT. Because, like much of the equipment in Vietnam, the LT had been modified, in this case to make more sleeping room, the generator could not be taken out through the top of the vessel. Instead, the team of divers had to go underwater, cut a hole in the side of the vessel, and bring the old compressor out that way. They then put the new generator in underwater and patched the hole they had made. It was not only HCU-1 who had to "jerry-rig" the equipment they used in Vietnam.

Not all of the jobs the HCU-1 teams were involved in required diving skills. They sometimes had to take on other assignments. When the base at Dan Ten was being overrun, one of the teams had their vessel tied up to the nearby pier and had received no news about the emergency on the base. When they were notified that one of the tanks of fuel was ablaze, they immediately went to help as they were carrying 500 gallon of fire fighting foam and had huge pumps to dispel it. What they didn't know, at the time, was that the fire department on the base had also withdrawn in retreat. The team went right to the fire and was able to keep the second tanks from catching fire or blowing up. This was an unusual assignment, but one they willing took on.

It was the officers' job on each team to make certain that the mission was accomplished, that his men stayed safe, had food, and that the salvage techniques selected were realistic. Completing these tasks in a foreign country often required bartering, bargaining, and, if necessary, bribing civilians and South Vietnamese military for assistance, food, shelter, and water.

One afternoon, after a day-long salvage job, a HCU-1 salvage vessel hooked the sunken craft it has just raised on to its A-frame and started back to their base, towing the salvaged vessel. The pontoon bridge on the river, that had been

raised so they could pass under in the morning, was now down. The HCU-1 team was told by the Vietnamese officer in charge that the bridge could not be raised until morning. Realizing that it was far too dangerous to sit in the middle of the river all night like a "sitting pigeon," the HCU-1 officer negotiated with the South Vietnamese officer to raise the pontoon bridge in exchange for a case of frozen chicken. This turned out to be a wise decision for the team. That night Vietcong, who were laying wait, completely destroyed another US vessel who had to wait at the bridge for it to open.

On other major jobs, the HCU-1 team and their small vessels might be joined by other Navy and Army vessels and suppliers. These could include a destroyer, cameras, mine sweepers, and outside personnel. Regardless of the job, no two were ever exactly alike. Each required the ability to figure out what was needed at the moment. This sometimes involved an officer and two divers flying to a site to determine whether or not they would salvage, and returning to their home base to gather the materials needed, explain to the team what they planned to do, and then the entire group would return for as long as it took to accomplish the task.

For some of the junior offices assigned to HCU-1 the assignment was much easier than for others. After graduation from Officer Candidate School, if they were lucky they were sent to the dive school in Washington, D.C., the only first class dive school in the US at that time. They were then assigned to a salvage repair ship, such as the USS *Grapple*, for a short time to learn the basic techniques of salvage. Officers were not so lucky. They did not have this added experience, but had to reply on the advice of more seasoned salvage men, usually chiefs, to tactfully suggest what need to be done. The same diversity in training and skills was reflected in the support staff on the teams. Some had been trained as a diver with expertise in rigging, others knew about salvage and inspection, and still others were part of the on-the-job training portion of the team.

Because of political reasons, the members of HCU-1 were never officially assigned to the Vietnam conflict. Rather, they were officially stationed in the Philippines and rotated, two or three teams at a time, into Vietnam for four or five months at a time. Because of this arrangement, with all the men on Temporary Duty Assignment (TDA), the unit was never "officially" in Vietnam. Some of the men who supported these tours were long-term Navy personnel, not trained as divers, but welders, seamen, cooks, and engineers. As long as the men stayed in Vietnam no longer than five months, twenty-nine days, it was not considered a complete tour of duty. For being out of the country (TDA), the men were awarded an extra three dollars a day per diem. All in all some men were assigned to HCU-1 for as long as three years, with 16 months of that time actually spent in Vietnam. The time for each man varied as many served on different teams, as needed, and some were assigned to different teams during different periods of the conflict.

It did, however, provide an usual opportunity to be with their families. Some of the men assigned to HCU-1 brought their families with them to Subic. For long-term Navy men, this was a "chance in a lifetime" to have their family with them during wartime. There was also the other side of the coin. One of the HCU-1 interviewees, who was critically injured, spent a year and a half in the states in various hospitals while his family remained in the Philippines because that was his home port.

The TDA classification may be one reason that the HCU-1 received so little recognition for their tremendous contributions to the military efforts in Vietnam. It was maybe one of the reasons that many individual heroic actions were never officially recognized nor the men given medals. One enlisted man, who was able to get three wounded comrades, two in critical condition and one dying, out of a small boat in the middle of a river into a hovering helicopter was denied a medal. Although recommended by his junior officer, the request was denied because "he was just doing his job."

The role of the HCU-1 teams varied according to the nature of the job they were asked to do, but basically each job included travel to the location of the assigned job, survey of the sunken or damaged vessels or other structure, evaluation of the feasibility of the work that had to be accomplished to raise or destroy the object blocking the waterway, and performance of the necessary work. When a call would come for a HCU-1 team to go to a specific spot, the task would always include developing a workable salvage plan and then locating the necessary equipment to carry out the plan. Sometimes a team would be lucky and there would be an army or marine base close by, but often the crew would have to make-do with what they had. Interviewees remember that a lot of their work consisted of "jerry-rigging" equipment from scraps and various on-board parts, and doing tasks for which they had no previous training or experience.

During the long extended time the HCU-1 worked in Vietnam, there were many types of salvage jobs to which the teams were assigned. It was not only enemy fire, mines, and explosives that caused the havoc and the necessity of some type of salvage, but they also had salvage jobs that were caused by vessels getting caught in anti-submarine nets, vessels that went aground during tide changes, equipment flung ashore during the ferocious storms that struck along the coast, sunken helicopter and equipment-carrying barges, sunken fishing boats that blocked channels and river passage areas, and extraction of equipment sunk in deep mud.

During their individual trips to Vietnam, different teams of HCU-1 salvaged and raised grounded PBR, NLP, ships, stranded bulldozers, a five-ton truck, and a 155mm Howitzer. They also cleared a bride span over the Danang River, eliminated numerous civilian-owned navigational hazards, repaired holes in sunken ships, and demolished those items that could not be salvaged. All in all, interviewees estimated that they raised hundreds of small boats, did more than a dozen major dredge jobs, repaired and patched dozens of both large and small vessels, and destroyed hundreds of other objects with underwater explosives if they could not be salvaged. Many of these jobs required working from sunup to sundown, seven days a week. When they would come to the critical part, the team members often worked 24 to 36 hours straight.

The junior officers assigned to each team were often without previous salvage and/or leadership experience. One of the frequent comments of the officers interviewed revealed that their understanding to know how to do a specific task actually came for the expertise of the on-board chief, who usually had years of Navy experience and a keen knowledge of rigging and salvage. All the interviewees agreed that the work done by the junior officers of the teams would today be served only for senior officers with lots of training and experience.

Clad in shorts and maybe a shirt, when the men of HCU-1 were in the southern part of Vietnam, they had to endure 100% humidity, mosquitoes that "could carry you away" and "rats as big as cats." Additionally, the teams often encountered both above and below the water a complete assortment of water and land animals and varmints that "defied description." Of particular interest to the divers, was another danger not often encountered in salvage jobs; snakes were everywhere, and they were of a large variety. The water snakes of Vietnam are considered to be more dangerous, with more toxic poison than a cobra. Fortunately, the HCU-1 men learned this fact from an article in a *National Geographic Magazine* that someone sent to them. This information helped them be forewarned and they became fare-armed in watching for and destroying snakes. This was not something they learned in dive school or from previous salvage experience.

When asked how the monsoon rains of the area affected their ability to perform their tasks, one interviewee replied, "The amount of rain was not important to us, we were wet almost all of the time. In fact, we were either in the water

or sweating from the heat; it really never stopped. It's a wonder all of us did not rot away. One good thing is we never had to worry about keeping our uniforms neat or clean. The clothes of the day, for everyone, were shorts and shoes." The only time we were cold was when we were sent up the DMZ area in the winter. At that time, it was really cold, especially if you had to work in the water."

There were many grim dangers HCU-1 personnel had to consider on each diving job in the rivers of the entire country. One was the swift currents that kept the waters churned up so that there was nearly always zero visibility after a diver entered the water and went down two to three feet. Another danger was the possibility that there were unexploded mines or other armament housed in or attached to the sunken vessel. Of course, there was always the danger that enemy fire could catch them in crossfire as they traveled on the waterways, as well as extreme danger from the Vietcong swimmers who came after dark and attached explosives to the repair ships.

For the support personnel assigned to each team, their work was vital to the success of each diving team. As one interviewee explained, his job on one of the smaller crafts, "We did every job the divers did, except we didn't stick our head under the water. We were, however, involved in all types of tending and rigging—even those of us who had never been to dive school, those not trained in salvage, and those seamen whose prior Navy experience was less than six months." In contrast, some of the other topside support personnel, who served on a team on a larger vessel and had been to dive school reported, "We had a cook and a fireman in the boiler room on our boat. All I had to do was stay topside and take care of that space. My main tasks were to do the topside rigging, act as a tender, and help the Warrant Officer with any duties that he requested." Yet another topside seaman stated, "It was a rough learning experience for someone 18 years of age who had only been in the Navy for six months. Yet, I learned to do the teamwork; it was the best duty station I had in the 22 years I stayed in the Navy."

One of the most complicated jobs of the HCU-1 Team 5 involved the USS *Baton Rouge*, which had been hit, with at least 17 men killed and still aboard the sunken ship. That job involved diving through the black oil in the water to try to find and bring to the surface the bodies of these men before they could begin the task of salvaging the ship.

Another job remembered by this crew involved the *Jamaica Bay*, which had been partially sunk by enemy fire. After patching up the holes, it had a crew of 7, including some HCU-1 seaman, riding the ship back to the Philippines, escorted by a civilian tug. Somehow, during the middle of the night, the ship got into a collision with a Chinese ship and had to return to Vietnam. On the way, the ship sunk and the team member telling the story noted this was a scary adventure as, "I was the last one out of the engine room. This required that I tread water in the dark for a while." Of course, he added, "The good thing about working on the *Jamaica Bay* was the cook was able to find good food and we got to sleep in warm beds in the staterooms on the ship for many nights." The pleasures that the men reported appreciating during this tour of duty were often small and ones usually taken for granted.

All the dangers that were present in working in Vietnam were present in another major job undertaken by HCU-1. This entailed the four-month-long task of raising a sunken sandpumper in the Mekong River section of the Mekong Delta. To raise this heavy vessel required running lines under the sunken craft to lift it, in a type of cradle. The size and weight of the sandpumper required the coordination and use of two of the heaviest lift crafts in the area and hundreds of dives. It was at times like this that the inventiveness of the men came into action. They not only had to design a system for lifting a craft of this size, but they also had to design and develop the equipment they needed to do it.

As always, the teams stayed in Vietnam until the specific job to which they were assigned was completed, even if this necessitated staying beyond their allotted time for a TDA. An assigned task had to be completed "by hook or crook," no matter how long it took.

Food for the day was always one of the concerns of the officer in charge. If the team was lucky, they would be close enough to a base camp that they could eat hot food in the mess halls. They consider the luckiest times as those when they were housed near the 9th Army Base, which had a mess tent, cooks, and hot food. Other lucky times remembered by some of the interviewees were those when they could buy fresh vegetables and fruits from the markets as they passed up and down the rivers. In some of the larger vessels, they could carry teams and their locations were not as lucky.

Sometimes, the major challenge was how to get food. The crafts always had sea rations and usually adequate supplies of Long Range Reconnaissance Patrol rations (pronounced Lurp), but sometimes they had no water to mix with the food. One team remembers trading sea rations to civilian trawlers for water for their bilge. This bilge water was pumped into native boats for wells; the sanitary conditions of the bilges was a question that would have been posed under better conditions.

Another team remembers that their favorite diet consisted of LURP rations smothered with small Vietnamese onions, eaten on good French bread that was always available in local villages. For those team involved in finding their own food supply, they sometimes had to live on their boats for several months. Fresh vegetables were nearly non-existent. To those men, the most frustrating part of the food search was having cases of dehydrated food supplies but no water to mix with it.

In retrospect, many of those interviewed could think of things that are now funny or actions taken that helped them cope with the stress and seriousness of the times in Vietnam. One officer recalled the dogs they had as pets. These were rescued so they wouldn't be eaten, as dogs are a delicacy to the Vietnamese. They provided some entertainment and companionship in a very lonely, dangerous situation.

Another interviewee recalled the time that a hand grenade was accidentally dropped on board the vessel instead of being thrown overboard as intended. As the story goes, one of the major dangers for ships at anchor during the night were the enemy swimmers who would come up to the boats and tie on explosives that had the power to sink the vessels. It was the practice of the HCU-1 teams to randomly toss grenades into the water, about three times an hour, to ward off these enemy swimmers. One night, the man whose turn it was to toss a grenade let it slip out of his greasy hand. He just calmly reach down, picked it up and tossed it overboard, where it promptly blew up in the air. A funny story now, but not at the time.

One of the heroes of the diving personnel of HCU-1 was Dr. Paul Linaweaver, a career medical doctor who volunteered to go to Vietnam. When Dr. Linaweaver learned that the Mark I Saturation system, which had been leased by the Navy from Ocean Systems, was to be sent to Vietnam to help with salvage operations, he was concerned that there were no officers in Vietnam who had his degree of experience in working with this system. Because he was worried about the health and welfare of the divers using this system, he persuaded the admiral, who he met at a dinner party in Washington, D.C., that he should be allowed to leave his current duty assignment and accompany the equipment. Temporarily reassigned to Vietnam, Linaweaver first spent the summer of 1967 training 20 men to use equipment of the system; he then accompanied the system to Vietnam to ensure that it operated safely. The use of this equipment significantly changed the capabilities of the diving operations for diving teams in Vietnam by allowing them to use saturation diving for the first time.

As a result of the ingenuity the teams used in salvage operations, many operations that are

still in use today were invented. They figured out how to use hoses to trench under ships, to raise heavy partially sunken ships using a cadre of ships and personnel from different branches of the military, to raise an 8.4 ton piece of equipment using salvage balloons, to perform many intricate types of rigging not utilized before, to attach patches in unique ways, and to do diving salvage jobs that had previously been classifies as "impossible."

During the later years of the conflict in Vietnam, starting in about 1970, some of the teams were involved in frequent fire fights. In that period of time, all salvage jobs were extremely dangerous, both traveling to and from the site, and while the team was working. Even if the HCU-1 teams were not actually involved in the exchange of gunfire, they could hear fierce fighting going on nearby.

About the same period of the fighting, a great deal of emphasis was being placed on increasing the salvage capability of the Vietnamese Navy by training them in salvage techniques, the proper operation of the salvage craft and its machinery, as well as the US system of diving operations. In fact, it was the goal of the US military that the salvage crafts of the HCU-1 mission that occurred during this period involved a trawler that had sunk off the coast. A team from HCU-1 was sent out, with a Vietnamese team, to determine how the Vietcong were getting supplies onto land without being seen. There was speculation that the trawler was a key player in the operation, but no one could quite figure out how or why. The US divers, but not the Vietnamese divers, were able to figure out that the trawler had been putting supplies into fishing nets and sinking them. Small crafts would then come by, lower hooks on lines, catch the fishing nets full of explosives and supplies, and take them to shore.

As many other military men who served in Vietnam, the men from HCU-1 received little praise or recognition after their years of service. Those who were interviewed, however, were all quick to point out that they felt they were a crucial asset in the efforts to win the war. All their missions required a team effort, with courage, skills, perseverance, and complete devotion to duty to keep the waterways open so that civilian and military crafts and equipment could move up and down the waterways, a critical part of the transportation system used in Vietnam.

The phrases they used to describe the work they did and their accomplished tasks included these: "We used initiative and hard work, plus our ingenuity and enthusiasm for getting the job done"; "We were resourceful, professional, and worked tirelessly until the job was done—sometimes as long as 24 to 36 hours at a time when we were in the process of raising a piece of equipment"; and finally, all agreed that it was the exemplary "team work" that did it. No one officer or enlisted man was about doing what ever needed to be done." As one diver explained, "We made decisions and did with our enlisted personnel and junior officers operations that today only senior officers are allowed to do."

In spite of their hardships and lack of recognition for the job that they did during this unpopular conflict, many of those interviewed said that it was their favorite Navy assignment, and they still remember the good friends they made and the harmony with which they worked. Because, for the most part, they were young and in great physical condition, they did not consider the arduous, grueling tasks to which they were assigned to be a burden. Instead, they looked at each job enthusiastically as a challenge that merely tested their resourcefulness, professionalism, and endurance.

All the interviewees gave the impression that they looked forward to responding to each salvage commitment with fierce pride. The fact that they had to "manufacture" or "obtain" most of their equipment, food, water, and other supplies was not a concern to them in those days. They noted that the awesome responsibility that was given to them, combined with the chance to think for themselves only increased this sense of pride in what they did.

NEDU Celebrates 75 Years

Established in 1927, the Navy Experimental Diving Unit completed 75 years of pioneering diving and hyperbaric research in 2002. Among NEDU's accomplishments over the past three quarters of a century are ground-breaking work developing standard decompression tables for air diving, helium-oxygen diving procedures, recompression treatment tables, surface decompression procedures, saturation diving, early sea-floor habitats, diver thermal protection, and submarine rescue.

Experimental diving began in the Navy in 1912 at the Brooklyn Navy Yard under the direction of Chief Warrant Officer George D. Stillson. His small group developed the first standard Navy diving equipment, tested Dr. John S. Haldane's theories on staged decompression, and extended the maximum diving depth of US Navy divers from 60 to nearly 300 feet. Stillson's group led the salvage of the submarine, *F-4*, lost off Honolulu in 1915 in 304 feet of water and made the first experiments with helium-oxygen diving. The venerable Mk V diving helmet and dress were developed and tested by Gunner Stillson and his team of divers.

Navy diving stagnated immediately after World War I with the closing of the Diving School in Newport, RI, but additional experiments with helium were conducted in cooperation with the Bureau of Mines in the mid-twenties. The loss of two more submarines, the *S-51* in 1925 and the *S-4* in 1927, highlighted the need for better diver training and advances in diving equipment and technique.

To answer this need, the Navy Experimental Diving Unit was formally established in 1927 at the Washington Navy yard adjacent to the reestablished Diving School. Captain, later Fleet Admiral, Ernest J. King—who had commanded the Naval submarine base at New London, Connecticut, and had supervised the salvage of the *S-51* and *S-4*—wanted the two units co-located so that advances in diving technology could be rapidly incorporated into diver training. The relationship between the Diving School and the Experimental Diving Unit would be an enduring one. In the early days, it was common for one officer to serve concurrently as the officer-in-charge of both units. In the 1970s, both commands were relocated to Panama City, FL, where they presently form, with the Coastal Systems Station, the center of diving excellence. The first officer-in-charge of NEDU was Warrant Officer C. Tibbals.

Editors Note:

Coastal Systems Station is now officially called Naval Surface Warfare Center, Panama City.

NEDU's early focus was on submarine rescue and experiments with helium diving. In the mid-1930s, Doctors C.W. Schilling, A.R. Behnke, and O.E. Van der Aue became the first medical staff at NEDU. Their early experiments demonstrated the usefulness of oxygen for treating decompression sickness and proved conclusively that breathing high-pressure air caused physical and mental performance decrements. They also developed surface decompression procedures for submarine rescue. It was thought that helium, because of its small molecular mass and low density, would permit shorter decompression times. Though using helium did not provide for shorter decompression, as hoped, it did eliminate the problem of nitrogen narcosis, allowing divers to work at greater depths.

The first operational use of helium was during the salvage of the USS *Squalus*, which sank in 243 feet of water off the Isles of Shoals near Portsmouth, NH. Equipment and procedures developed at NEDU, including the McCann Rescue Chamber, were essential to the rescue of the 33 crewmen who survived the initial sinking. Divers from NEDU, led by CDR Charles B. "Swede" Momsen and using NEDU's recently developed helium tables, salvaged *Squalus,* which was refitted and fought in World War II as USS *Sailfish*. During the salvage effort, NEDU divers also tested the first surface decompression tables. Submarine rescue remained an enduring focus of NEDU research and later prompted the development of saturation

diving. Through the late 1990s to the present, NEDU has been developing oxygen accelerated decompression tables for rescuing submariners from disabled submarines using the Submarine Rescue Diving and Recompression System.

During World War II, NEDU began work on early oxygen rebreathers, investigated oxygen toxicity, and tested captured enemy diving equipment. The unit also tested breathing systems and pressure suits for aviators and investigated altitude bends, a new phenomenon observed with the advent of high performance, high altitude aircraft. During the war, the use of scuba was limited by inadequate thermal protection. In those days, divers and combat swimmers relied on thick coats of grease or beeswax and woolen underwear for insulation. In the 1950s, NEDU experimented with aviator's exposure suits made of neoprene and adapted them for diving use, gradually improving the form, fit, and function. Diver thermal protection continues to be a key area of study for NEDU. Recent experiments have evaluated hot water suits, microscopic-encapsulated phase change material and liquid thermal liners for wet and dry suits, closed circuit tube suits for circulating warm water around the diver, and a hydrogen catalytic heater for possible use in SEAL delivery vehicles.

In the 1950s, NEDU developed surface decompression tables using oxygen for air diving. In 1956, NEDU developed procedures for air diving that became the basis of the Standard Air Decompression tables, the Surface Decompression Using Air table, and the Repetitive Air Dive tables. These air tables became the standard worldwide. Throughout the 1950s, NEDU tested numerous scuba devices, which proliferated after World War II. Interestingly, when the Navy adopted scuba, many divers were poor swimmers, so the Navy established the Underwater Swimmers School in 1954 in Key West, FL.

In the late 1950s, CAPT George Bond, Medical Corps, began the first early experiments in saturation diving, named Project Genesis, at the Submarine Medical Research Laboratory in Groton, CT. He and his team of aquanauts conducted their first manned saturation dive, Genesis D, to 100 fsw at NEDU in the spring of 1963. The loss of USS *Thresher* (SSN 593) in 1963 highlighted that, in the era of the nuclear submarine, Navy diving depth limits were inadequate for submarine rescue, just as the *S-51* and *S-4* tragedies had exposed the inadequacies of diving technology in the 1920s. The *Thresher* tragedy led to a keen interest in saturation diving as means to rescue trapped submariners and to recover items of interest from the sea floor. CAPT Bond's experiments gave birth to the Man-in-the-Sea and the SEALAB programs as well as other classified projects. The SEALAB program continued through 1969 and pioneered techniques for permitting saturated divers to live in sea-floor habitats. Much of the training was conducted at NEDU.

Editors Note:
Genesis Project got underway in 1957.

Saturation diving progressed dramatically through the 1960s and 1970s. New diving records were set and broken, including the first 600 fsw dive in 1964, the first 1000 fsw dive in 1968 in a joint venture with Duke University, and a 1,600 fsw dive in 1973 at Taylor Diving and Salvage in New Orleans, LA, which was then the world's largest hyperbaric facility. In the 1960s, NEDU developed recompression treatments that would become know as Treatment Tables 5 and 6, still in use today.

In 1975, NEDU relocated from the Washington Navy Yard to its present location on the Florida panhandle in Panama City. It was commissioned as a shore command under Naval Sea Systems Command. The new unit included the Ocean Simulation Facility—the largest manned hyperbaric facility in the world—and the Experimental Diving Facility for unmanned testing. The OSF complex can be pressed to 1,000 psig, the equivalent of 2,250 feet of seawater. Divers can live in the five connected chambers that make up its dry habitat, which is



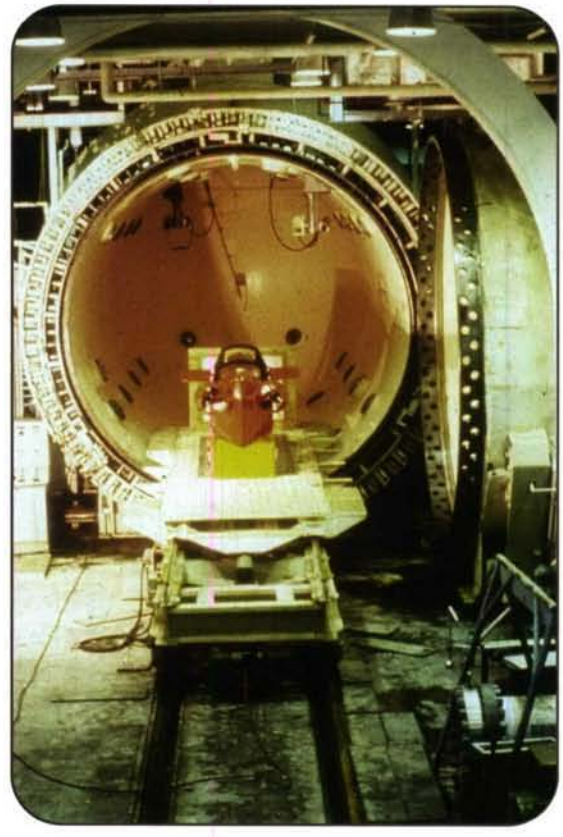
Navy Experimental Diving Unit in Panama City, FL.

connected to the 55,000 gallon wet pot by a trunk. In addition to manned diving, the OSF has been used to test a variety of atmospheric diving suits and small submersibles. Most recently, the OSF was used to hydrostatically test one of the Deep Submergence Unit's Submarine Rescue Chambers. The OSF can also serve as an altitude chamber, simulating altitudes up to 100,000 feet. CAPT Bond oversaw construction of the OSF before retiring in December 1975. The complex was renamed in his honor as the Dr. George F. Bond Ocean Simulation Facility in recognition of his contributions to Navy diving.

Through the 1970s and 1980s, NEDU tested a great variety of diving equipment and achieved new records for depth and duration in saturation diving. Among the equipment tested was the Mk-12 Surface Supplied Diving System (SSDS), which replaced the Mk V that George Stillson had tested in the 1920s, and which would be replaced by the Mk-21/Superlight 17, also tested at NEDU. During this period, NEDU did extensive testing of the EX-14 closed circuit Saturation Diving System and the Mk 15 and Mk 16 constant partial-pressure-of-oxygen closed circuit UBAs. NEDU completed evaluation of the Unlimited Duration Saturation Excursion Diving Tables in 1976. In 1979, NEDU made a record setting 1,800-fsw saturation dive in the OSF.

During the 1980s and 1990s, NEDU did a large amount of saturation diving to evaluate diving equipment, examine deep saturation diver thermal protection problems, test active and passive diver thermal protection, validate decompression algorithms, test various carbon dioxide absorbents and scrubber systems, develop Treatment Table 7, and conduct mission-specific training for various special projects. The Mk 16 HeO_2 table testing in 1984, with 1,413 man-dives, was the largest decompression table validation ever conducted. Other projects included developmental efforts on explosive ship sectioning, evaluation of scuba regulators for cold water, testing of diver propulsion vehicles, and testing of one-atmosphere diving systems, with a manned test to 2,200 feet in the OSF. A 1995 project to create a Navy dive computer was completed in 2001 and approved for use by the Naval Special Warfare SEAL Delivery Vehicle Teams.

In 1998, the diving biomedical research and development functions from the Naval Medical Research Institute (NMRI) in Bethesda, MD, were consolidated with NEDU, as mandated by the 1995 Base Realignment and Closure Act.



Ocean Simulation Facility (OSF) Wetpot

This shifted 42 billets to NEDU and resulted in the construction of a 14,500 square-foot building that includes a physiology laboratory and an environmental chamber.

From 1999 to 2002, NEDU conducted two warm water diving studies to address concerns of the Naval Special Warfare community regarding critical gaps in the Navy's knowledge of warm water diving physiology. The studies focused on determining optimal and minimum acclimatization schedules and the physiological effects of various wet and dry garments. The guidance is particularly relevant to special warfare units operating in the warm waters of the Arabian Gulf and the North African littoral, where summer water temperatures can exceed 95° Fahrenheit. Related to these studies was the development of a physical performance battery used to measure a diver's performance decrement after exposure to thermal stress. The battery, which includes assembling and firing a service rifle modified with a compressed-air recoil simulation, and laser targeting, tests strength, dexterity, and cognitive function.

In 2001 and 2002, NEDU divers made essential contributions to the ex-USS *Monitor* salvage project. The mission was a three-year, joint National Oceanic and Atmospheric Administration and US Navy expedition to recover artifacts from the historic site 16 miles south-southeast of Cape Hatteras Lighthouse off the North Carolina coast. This salvage effort resulted in the recovery of the *Monitor*'s steam engine, revolving gun turret, 11-inch Dahlgren guns, other artifacts, and human remains from 230 feet of seawater, where they had rested since December 31, 1862. The initial surface supplied efforts in 2000, which culminated in the recovery of the *Monitor*'s four-bladed screw propeller, demonstrated that accomplishing significant work at that depth would require much longer bottom times. In 2001, Naval Sea Systems Command leased a Global Industries 1504 commercial saturation diving system embarked on the Manson Gulf barge, *Wotan*. Mobile Diving and Salvage Unit Two and the Supervisor of Salvage assembled a team of saturation divers, over half of which were from NEDU. Other NEDU divers and diving medical officers contributed to surface-supplied dive teams, which worked alongside the saturation divers. Their efforts culminated in the recovery of *Monitor*'s vibrating side lever steam engine in 2001. The third and final recovery mission was focused on raising *Monitor*'s 241-ton gun turret, the first rotating turret on a modern ironclad warship. The saturation divers, who were less vulnerable to weather delays and did not require lengthy in-water decompression, were able to log 641 hours of bottom time compared to the surface supplied side's 286 hours, demonstrating the enduring value of saturation diving for deep work. Two NEDU saturation divers together accounted for 175 hours of work. The recovered artifacts were sent to the Mariners' Museum in Newport News, VA, for conservation and display.

In 2002, NEDU completed the final open-water demonstration dives for certification of the Mk 16 Mod 1 UBA to 300-foot of seawater (fsw) in the Gulf of Mexico. The 300 foot open-water certification dives completed a four-year product improvement process that included: extending the working limit from 200 to 300 fsw, developing 1.3 atmosphere constant partial-pressure-of-oxygen decompression tables for nitrogen (N_2O_2) and helium (HeO_2) diving, providing an HeO_2 repetitive dive capability for dives shallower than 200 fsw, testing an emergency breathing system (EBS) with integral communications, adding an integral buoyancy compensation device, and adopting an improved full face mask. The extended depth range fulfills the Explosive Ordnance Disposal community's requirement to conduct mine counter-measure diving in depths shallower than 300 fsw. The new 1.3 tables are the first Navy tables constructed on a probabilistic vs. deterministic model to better control risk of decompression sickness and were validated with 1,600 man-dives in the Ocean Simulation Facility. The KMS-48 full face mask is a hybrid design in which the diver's mouthpiece is mounted in a

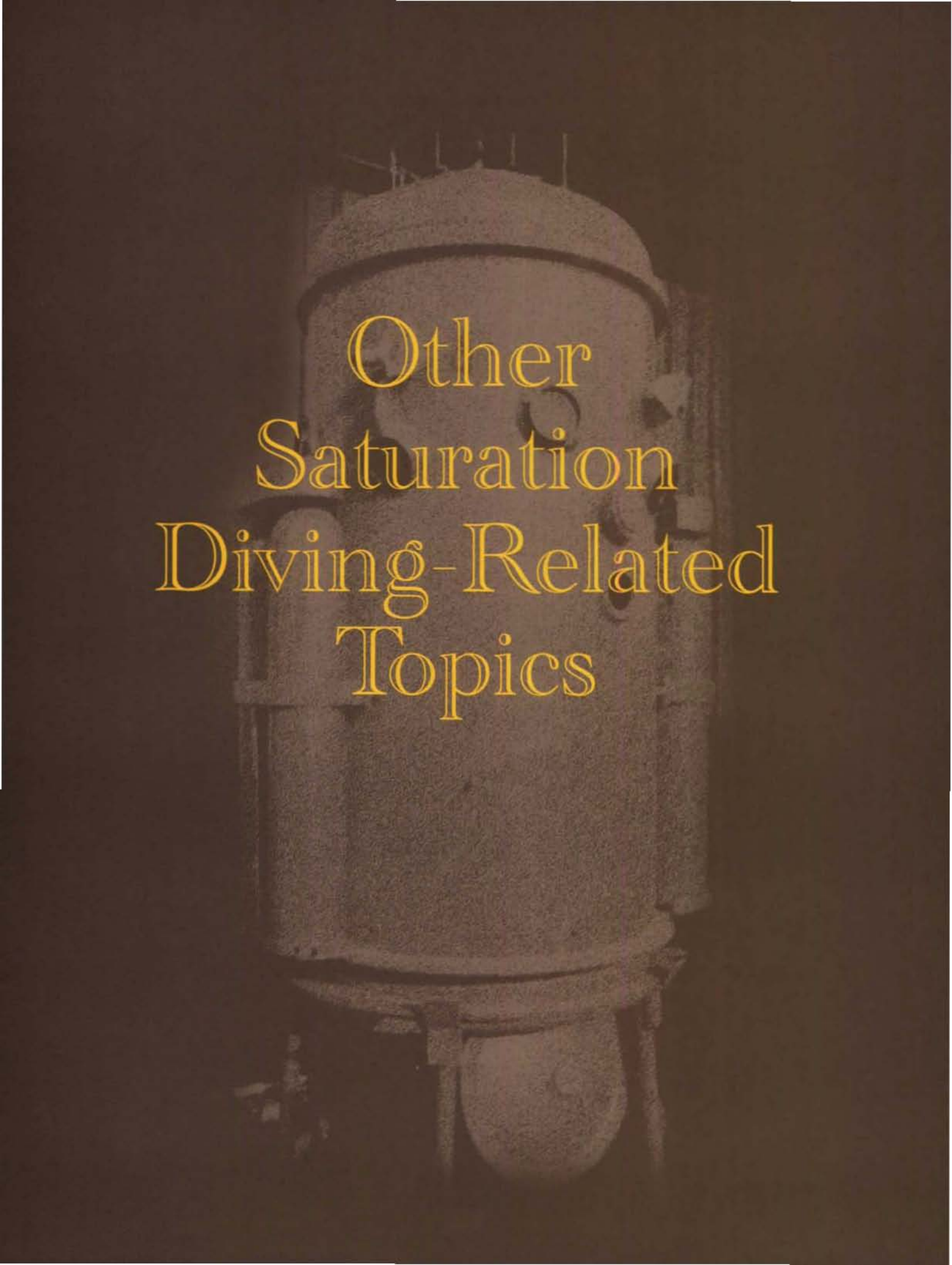
detachable pod, alleviating the need to ditch the entire mask to breathe from the EBS. The mask has a communication whip that plugs into the EBS, allowing the diver to speak directly with the dive supervisor on the surface. Another version of the mask is being tested for the Special Warfare community and other applications.

Over the past 75 years, NEDU has evolved from a small team of Navy divers to a diverse workforce of over 150 people, including military divers from the fleet, EOD, SEABEE, and SEAL diving communities; Ph.D. scientists and engineers; diving medical officers, physiologists, and research psychologists; and many talented technicians and support personnel. NEDU's mission has evolved from Gunner Stillson's original assignment to evaluate diving equipment and procedures to a much broader mandate that includes a wide range of undersea and hyperbaric biomedical research and development. NEDU also conducts accident investigations for civil and military agencies on diving equipment involved in fatalities. As NEDU looks towards the immediate future, we foresee research focused on procedures for contaminated water diving, advances in diver thermal protection, furthering our understanding of oxygen toxicity and decompression illnesses, and preserving a Navy capability for saturation diving.

Written by

LCDR MARC G. TRANCHEMONTAGNE, USN.

The author wishes to acknowledge that much of the information on NEDU's early history was taken from a 50-year retrospective written by LT R. C. Carter, MSC, USN and published in the Fall 1977 Faceplate as "NEDU Celebrates 50th Anniversary 1927–1977," and as NEDU Report 1-77, "Pioneering Inner Space: The Navy Experimental Diving Unit's First 50 Years."



Other Saturation Diving-Related Topics

Saturation Diving

Nothing in diving history took the world by storm as did saturation diving. Many commercial diving companies took it on as their primary mode of operation, and thousands of saturation diving systems were fabricated and used around the world. George Bond, CAPT, MC, USN (Ret) is considered the "Father of Saturation Diving." Dr. Bond hailed from Bat Cave, North Carolina and entered the US Navy after a successful career in the hills of North Carolina, where he built a community health center and praticed medicine "the old fashioned way." Entering the Navy provided him opportunity to research some of his ideas, including that of saturation diving. Many others followed Dr. Bond's lead and embarked on research in this unfolding field of diving.

Along with his fellow Navy doctors, Robert Workman and Walter Mazzone, Bond conducted a series of experiments on saturation diving, first on animal subjects and then on humans. Bond, Workman, and Mazzone tried different gas mixes, discovering that a helium-oxygen mixture that delivered a partial pressure of oxygen approximating 22% was an optimal mixture. These experiments, called Genesis, were conducted beginning in 1957. However, work was performed previously on what would eventually become known as saturation diving. Dr. James Vorosmarti, who was involved in the SEALAB programs, relates this history of saturation diving prior to the Genesis experiments.

DR. JAMES VOROSMARTI

In 1962 it was my great fortune to apply for and be accepted into the Navy submarine and dive training program. Unbeknown to me at the time, this was the beginning of the recent "Golden Age" of diving with the advent of saturation diving.

This concept was not a new one. Haldane, Boycott, and Damant, in their 1907 report, were well aware of the fact that saturation would occur. At pressures up to 45 psi, or four atmospheres of absolute pressure, there appears to be no substantial objection to keeping men for six hours, or even more, continuously under pressure, provided that the mode of decompression is safe.

However, there is no clue in these writings that they ever considered the practice of saturation diving. I think that the most obvious reason is that there was simply no foreseeable need for this technology at the time. Most diving was done at less than 50 feet and was not excessively long. Even in tunnel work, decompression time was not overly long except when working at the highest pressures. Another reason was that Haldane et al. were concentrating on surface supplied diving for the Navy. No equipment for this type of saturation diving existed then, although construction of an underwater habitat would have posed little problem with the engineering knowledge of the time. Atmospheric control, however, would have posed an almost impossible problem because of the inability to easily and accurately monitor gas composition. Temperature control also would have proved to be a problem.

Another clue to their awareness of saturation diving was shown in an exchange between Damant and Haldane in 1935 in a discussion of caisson decompression. Damant commented on Haldane's idea of extending shifts to eight hours. He stated that "a complete table from hour to infinity is the thing (required) as you have drafted it." Again, there was no real need to extend the tables for long bottom times, but the idea was certainly there.

Another close miss with saturation diving is illustrated by the underwater diving station proposed by Davis. [Sir Robert Davis of the UK developed the Davis Submerged Escape Apparatus, the forerunner of closed-circuit rebreathers, circa 1910.] Unfortunately, there is no date attached to this idea, but it was probably devised in the 1920s or 1930s. It is obvious that Davis was thinking ahead to having divers live, at least for short periods of time, under the sea. The problem here is that the habitat is maintained at one

atmosphere so that the diver would still have required decompression. Why was this not adopted for staying or living at ambient pressure? Again, probably because there was no real need.

The first intentional saturation dive (although not called that at the time) was done in December 1938. It was planned by Dr. Edgar End with Max Nohl as the diver. The dive was done because of problems with animals, not humans. At the time, tunneling operations were underway in Milwaukee, and mules and donkeys were used for hauling material. They were kept under pressure for weeks and months at a time. However, whenever decompression of them took place, they died. The details of the decompression schedules used are unfortunately not available.

Therefore, this dive was planned to demonstrate that animals (and humans) could be decompressed after extended periods of time at pressure. Nohl entered the chamber at 1100 on or around December 19th (the record is not clear on the exact date) and spent 27 hours at a depth of 100 feet breathing air. End spent about 11 hours in the chamber doing physiological testing, the results of which are not available as no report was ever published. Decompression took about five hours and resulted in Nohl suffering decompression sickness on reaching the surface. He recovered fully after recompression treatment, except for feeling bad for several days afterwards. We now know that this was probably due to a combination of the decompression sickness and pulmonary oxygen toxicity from the long period of breathing a high partial pressure of oxygen. Two conclusions reached by End were that 27 hours was the limit for staying under pressure without risking life, and that helium substituted for nitrogen in the breathing mix may reduce diving hazards.

A few years later, in 1942, Dr. Al Behnke stated the first clear concept of saturation diving with excursions. In an article published that year in the *Medical Clinics of North America* discussing working at 50 psi, he wrote, "It would appear advisable therefore to keep men at work on a job continually under pressure. Following a work shift at maximum pressure, the pressure could be lowered rapidly to between 20 and 30 pounds and maintained at this level during the rest and sleep period. The final decompression prior to emergence into a normal atmosphere would be uniform over a period of 8 to 24 hours." He also made a statement in this article that prolonged exposure for up to seven days at pressures of 30 psi gauge had been made repeatedly. Presumably, he was referring to tunnel or caisson work.

The term "saturation dive" was used for the first time in 1945 by Dr. Otto van der Aue. He was working at the USN Experimental Diving Unit conducting a large series of experimental dives in order to produce acceptable surface decompression schedules. These dives were done to test the still-used 2:1 ratio for safe decompression. The decompression schedules were the first in which a tissue half-time of 120 minutes was used in their calculation. Tissue half-time refers to the hypothetical time required for a tissue to gain or lose one-half of the inert gas dissolved into it. It is a concept used for the mathematical construction of decompression schedules not for correlation with any specific anatomic tissue and does not correlate to any body tissue. As part of this series, four dives were done, which were called, and actually were, saturation dives. All were done in October 1945 with air. The first was to 33 feet for 24 hours with direct surfacing. No cases of DCS resulted in the four divers. The next two dives were to 33 feet for 36 hours with four divers in each exposure. Two of the divers developed bends. The last dive was to 99 feet for 12 hours followed by decompression to 33 feet for a stay of 24 hours. Both of the divers using this schedule suffered decompression sickness (DCS). The conclusion was that for decompression from longer dives, long tissue half-times needed to be assigned lower ratios than short half-time tissues. In other words, the 2:1 ratio for decompression did not work (as Haldane had already discovered).

No more was heard about saturation diving until 1954 when, for reasons that are obscure, a diver named Ed Fisher stayed underwater at 33 feet for 24 hours beginning on August 21st. This event took place in Florida, and he did this without the benefit of anything but his wetsuit, an inflated inner tube anchored to coral and the support of friends who brought him replacement air tanks and food from a support boat nearby. He reportedly also speared a fish and ate it raw for dinner. He decompressed at ten feet for 15 minutes, although he did not think this was necessary, and reached the surface with no problems. In an interview, he said the only problem he had was the pain when he had to remove his wetsuit. Surprisingly, he did not peel off any skin with his wetsuit.

High Pressure Nervous Syndrome

As saturation diving became commonplace throughout the world, some divers began to experience a strange phenomenon during compression, especially if they were rapidly compressed to a deep depth. Medical scientists named the condition "high pressure nervous syndrome" (HPNS). HPNS is a condition in which a diver visibly trembles and usually loses short term memory. In severe cases, a diver can be completely incapacitated. Treatment for HPNS is bed rest and time. It is reported that this condition can be life threatening, and because of this potential danger, the condition is considered a serious one that can completely stop compression of a dive team until the injured diver recovers. To be sure, HPNS is a show-stopper. Research into the causes of HPNS was funded for several years but, unfortunately, there still is no known cure for this condition. Below, you will read what one of the world's experts had to say on this debilitating condition during the taping of his oral history (complete oral histories can be found on the enclosed CD).

DR. ARTHUR J. BACHRACH

At the Naval Medical Research Institute we started getting into diving research and one of the first areas that we got into was high pressure nervous syndrome (HPNS). We also had a Memorandum of Understanding (MOU) with the Royal Navy (RN). Peter Bennett was still in England at the Royal Naval Physiological Laboratory (RNPL) in Alverstoke and we established a collaboration with Peter. We had a MOU that the US panel would meet with the RN panel. We had this project going on with HPNS.

We had a very fine group with George Tresansky. His group built an intentional tremor device. I had one while I was doing some tremor research at Arizona State. We had a middle European machinist named Lazlo, who was a marvelous machinist and used to put jewelers' rings on everything. I said to him one day, "This is going to be in a case. No one is ever going to see it." He said, "I'll know it's there." It was like the ship model builders of the 16th century and forward who closed the hulls. If you look through fiber optics in Annapolis, as they did some years ago, inside a lot of the ship models they found fully carved figures, cannons, bunks, and everything. Well, Lazlo was like that. He would do jewelers' rings. We had a model for a tremor device. The machinists and technicians at the Naval Medical Research Institute (NMRI) built an intentional tremor device. That was some of the first research that we got into. That was in cooperation with the RN.

With high-pressure nervous syndrome, generally, the first symptom is tremor. That was why we were interested in measuring tremors. It was so that we could see if we could pick it up early. Well, it could get as far as seizures, but it's generally a matter of imbalance and just neurological symptoms that interfere with perception and work. It's usually a factor of depth and compression. Slow compression seems to be a lot healthier.

HPNS has the potential of endangering a person's life. I think that was what happened



JIM suit

when we started getting into deep diving. At one time, people were talking about 2,000 to 3,000-foot limits. Well, I think it was proven on the University of Pennsylvania dives in the 70s and in the deep dives at Duke University. At depth, there were signs of HPNS, like tremor. It could be endangering. We still don't know the long-range effects of high-pressure nervous syndrome.

I'd like to see the term "inert" banished from the English language. Inert gas is not necessarily biologically inert, and we did some studies with helium. I think Steve Gruenau was the one who did these studies at NMRI. He took EEGs and found that there were definite changes with helium at depth. "Inert" is not a biologically sound term, and I think it has come true that human exposure to depth is not needed. Now, the human diver has been replaced with remotely operated vehicles (ROVs) and submersibles, and submersibles have become more fuel efficient, so they are much more usable. But there is no point in exposing a human diver to the pressures of a really deep depth.

For example, when inspecting pipelines now, they don't use divers that much. They just run an ROV over the surface and sit up with bourbon in their hands, watching the screen and seeing what happens. This idea, actually, plus the HPNS and the exposure to physiological pressure and damage, led me to think that there has got to be an alternative to deep diving and made me receptive to the one atmosphere suit called "JIM" and other one atmosphere diving systems when I first became aware of them.

I think the work on HPNS was a very significant advance, because it brought reality to what we thought about undersea habitats, living cities, cities under the sea, and people still want to talk about those things. I think HPNS told us that there was definitely a physiological barrier. We could not really expect to dive below 1500 feet, probably. I remember a MK-14 dive out off San Diego during which they were at 1400 feet, and that was a remarkable depth. I think HPNS taught us something about what physiological events were happening with deep diving. It taught us a lot about compression and gases and human potential.

DR. ROBERT BORNMANN

Saturation diving was essential. Actually, saturation was essential, but not in the way its creators envisioned it. I don't want to get sucked into the debate about who was the creator of saturation diving. If you go by priority, Haldane mentioned it as a possibility, though he never did anything about it. In my book, George Bond, a Navy Medical Corps officer, brought saturation diving into the Navy.

I was associated with Ed Link when he did the first at-sea operational helium-oxygen saturation dive. Ed's vision was to reduce the cost of diving by decreasing the amount of decompression for a given amount of work underwater. George's vision was of people living and working under the ocean. That was how

the three SEALAB projects were envisioned. It made it possible for the Navy to take on long, deep diving.

Even if you made a thirty-minute dive to 750 feet, you might not have been saturated when you left 750 feet, but you certainly were saturated before you reached the surface again. They changed it to make the divers' residence in a deck decompression chamber, rather than in a habitat on the ocean floor. Commercial diving companies all around the world adopted that process, procedure, and equipment. But we lost out in the race with the engineers who developed the remotely operated vehicles, autonomous vehicles, and the armored diving suit.

Deep human diving is becoming more and more infrequent. As I understand it, the specific requirement for the Navy, for a human diver, is to be able to dive to 350 feet. Curiously, that was what we could do in 1957, when I came on active duty in the Navy.

COMMANDER SCOTT CARPENTER

When I try to visualize the future for undersea technology, I see this brick wall at 2,000 feet for the free-swimming diver. I don't hold out a lot of hope for any progress in depth or duration. We're not in the business of saturation diving anymore. I don't know where we're going. It seems like we have lost our way. Even in responding to the critics who say that the recovery operation from the TWA 800 disaster could have been faster and safer, I must think, "Where was the need for doing it faster? We didn't lose any divers in the way it was done."

DR. EDWARD FLYNN

In my last year in college, something happened. I had to figure out what to do and wrote the Navy, asking them what opportunities they had in marine biology, thinking that that was something the Navy was probably interested in and I would be interested in. I waited a long time and got a letter back from none other than Bob Workman.

Somehow, the Navy had forwarded the letter down to him, and he responded, "Well, I don't know anything about opportunities for marine biologists in the Navy, but this is what we're doing." He started talking about all the decompression work and all this other stuff. He wrote, "Why don't you consider going to medical school and joining us in the Navy?" I started thinking. I said, "Well, this is a good idea. This is probably what I should do." I switched over from biology to pre-med. That really didn't take much of anything because the curriculum was virtually identical. It was just a name change.

In my fourth year at Trinity College, I was interested enough in decompression that, in conjunction with the engineering department, I built a small hyperbaric chamber out of a cast iron flange-T that was used for transporting gases and whatnot under pressure. We milled out some Lucite windows for that on the three flange faces. We bolted those windows on with a metal retaining ring and put a screwed-in pressure gauge in the top window and some inlet and outlet hoses. I had a hyperbaric chamber that would go down to about 200 feet safely. We tried it out and everything seemed to work. Then, I got some mice. I started doing mouse decompression experiments with that during my senior year as part of a senior thesis. I started getting some experience doing animal decompression work with that chamber.

The third medical school to which I applied was the University of Pennsylvania. I went for my interview at 10:00 in the morning. I didn't know anything about Chris Lambertsen. I had no idea that there was a lab there, or what he did or anything. But during the course of the interview, I said I was interested in diving and they dragged me over to meet Lambertsen and he then showed me through the whole facility. He told me what he was doing and all this stuff. I said, "Oh, this is really neat." They offered me a full-time scholarship. When I got there, I

immediately teamed up with him and he gave me a spot in the lab. I started doing mouse decompression experiments there.

It was about 1964, and they were doing the offshore saturations with Ed Link. Those were done at around 400 feet in that little rubber Goodyear habitat, the submersible one. Joe MacInnis was there in the lab and so was Mark Bradley. Mark was on active duty, doing a fellowship. Jim Summit was doing that, too.

In addition to working with Ed Link's rubber habitat, Lambertsen had Joe MacInnis looking at high pressure nervous syndrome in mice. Ed Link had made a chamber that was essentially an eight-inch diameter pipe with threads on both ends and two heavy heads that you screwed on, and there was a little window in each head.

When Joe finished up doing those experiments, I inherited that chamber and I then rigged it up for doing mouse decompressions. I started looking at the things that I reported in a 1971 paper, about how fast mice saturate, the possibility that multiple inert gases might be better than just single gases, and that helium was basically better than nitrogen. That was what I did, more or less, all through medical school in the lab. Of course, going to school was pretty much a full-time occupation.

I attended the Navy's School of Submarine Medicine at the submarine base in Groton, CT. After submarine school, I went to the Navy Experimental Diving Unit (NEDU). Jim Summit and Jerry Heron were lieutenant commanders there, and John Alexander and I were lieutenants. We really had a fabulous time. I was at the NEDU from 1969 to 1971 on the first tour. We did an incredible amount of stuff amongst the four of us.

I started off by doing an evaluation of the submarine escape immersion suits that the British had just developed. We did 500-foot compressions in the old wet pot, a 16-second compression to 500 feet. That was followed by a nine-foot per second travel rate to the surface in that suit. During these fast compressions the subject's ears either cleared or busted, but we didn't have any busted eardrums, actually. You just started on that compression and, boom, your ears were open. I know that, subsequently, they've had problems. The Royal Navy has had some problems. But in that particular series, we didn't have any problems.

We did four depths. We started at 33 feet to get used to things, and then went to a hundred. Then, we went to 240 and then 500. There were not a lot of dives. It was a proof of concept thing. We proved we could do it and everything was fine. It looked like it was fine. A couple of interesting things came out of that. One thing was, of course, the heat. It was a hydraulic compression. You knew you doubled the pressure every few seconds. The heat of compression was so hot that the guys were inside with air blowing on their faces and the air was literally burning their faces.

They were submerged in water but had an air pocket in the front of their faces in a stole and it got incredibly hot during compression. The water couldn't take the heat away quickly enough. They didn't get physically burned. In other words, they didn't come out with second-degree burns or anything like that; but, the intense heat was a big problem with that suit. The second thing was the narcosis. They would hit the bottom at 500 feet and would be perfectly clear headed because the circulation from the lung to the brain hadn't yet delivered the nitrogen load. But on the way up, at about a hundred feet, they'd have an overwhelming wave of narcosis come over them as the blood shot through the brain. By the time they hit the surface, it was waning. About thirty seconds after they were on the surface, they felt fine again. This series was written up in NEDU Report 469.

That was the beginning of the Navy's evaluation of that suit. Then, Dave Hall, who was a Medical Service Corps officer, who also trained at the University of Pennsylvania, was up in Groton. He was pushing to get the Navy to adopt the British Submarine Escape System. He pushed and pushed and pushed but was never successful. Over the years, we kept pushing it and were never successful. Interestingly, about

two years ago, the US Navy finally decided that it was going to use the technology.

The second thing we were looking at was excursion diving from helium-oxygen saturation from depths of a hundred feet to as deep as about 500 feet or so. We wanted to make those downward excursions without decompression but with no decompression sickness. Bob Bornmann had been talking to Bob Workman. He looked at one of his calculations and calculated all these excursion diving schedules. Then, we tested them at the Experimental Diving Unit and, as I recall, we did roughly 1,100 excursion dives and never had a single case of decompression sickness or any complaints. The tables were wildly successful. However, we missed the mark by a country mile, which we would later find out when we did the unlimited duration excursion studies during my next tour at NEDU. But during this tour we had these schedules that just worked incredibly well.

The tables were so conservative that they never produced any decompression sickness at all. We should have been tipped off that we were way out of the ballpark on these things because we never had any problems with them. But we were not. We were very complacent and said, "Oh, these things work great." It was a vindication of Bob Workman's decompression model and everybody was really happy about that. Bob Bornmann, who then was at the Deep Submergence Systems Project office in Chevy Chase, MD, was the author of these experiments.

There were only three Medical Corps officers at the NEDU and at any time one of us was out on the West Coast with the Mark I diving system. The other two guys were standing port and starboard watches. I recall we did 44,000 man-hours of saturation diving in two years. We'd surface one dive and a couple of days later, the next dive would go down, and the dive after that would go down a couple days afterward. It was 'round the clock diving.

The other thing we did during that first tour was look at revised surface-supplied helium-oxygen schedules, and those were calculated by Heinz Shriner at Oceans Systems. They were for the partial pressure tables. It was done as a replacement for the partial pressure tables. Bob Workman had more or less provided Heinz the input that was needed and Heinz then cranked out the schedules on the computer in Tonawanda, and they looked pretty good. I'll have to admit that. We started testing them. This happened in 1970.

We started right off with a pretty aggressive bottom time. As I recall, it was something like sixty minutes, and we ended up bending 33 percent of the guys. We said, "Okay, these tables look good. The model looks good. Everything looks good. But hey, they don't work." That was the end of that evolution. Of course, we stuck with those surface supply tables with minor modifications back and forth, right up to the present time. We still haven't really cranked out a whole new set of schedules based on any modern model.

The Duke University dive we did during my first tour at NEDU was pretty successful, and that was where I really learned respiratory physiology and how to do a manned experiment. I learned a lot about thermal physiology. We even experimented on that dive with hot water suits, Apollo tube suits, and underneath the dry suits to provide heat. We even used nitrogen as an insulating gas, as opposed to helium.

During the Duke experiment, we also discovered that when you were immersed to your neck, your alveolar arterial oxygen gradient increases by about ten millimeters of mercury due to shunting through the bases. We saw that on the experiment. There was a fellow at Duke who came along shortly thereafter and did a surface experiment that showed the same thing. Then, I did another surface experiment at Duke shortly after that and confirmed it again. We were pretty confident that there was an increase in the alveolar arterial gradient when you sat in water up to your neck.

During this same period of time on the West Coast was the Mark I deep diving system, which was a flyaway saturation system with two deck

chambers that would hold two guys each, a transfer lock, and a three-man diving bell. All of it was flyaway and could be assembled on a shipof opportunity. We assembled it on the fantail of the USNS *Gear* and went out to Anacapa Island. Essentially, our goal was to do an operational evaluation (OpEval) on the thing down to 850 feet.

Anacapa is about twelve miles offshore from Port Hueneme. I was out there for long, long stretches at a time while we exercised that system through its various paces. But the culmination was diving down to 850 feet with a twenty-foot excursion using the Mark 11 semi-closed circuit UBA, which was basically a successor to the Mark 9. That seemed to work reasonably well. The Mark I system worked beautifully, and we did those dives. That was a big triumph, because we had put everything together and made it work at sea.

The Mark I dives on the West Coast were operational evaluation dives, and the operational test and evaluation forces wrote those things up. They weren't medical experiments. They were verifying that that system would do what it was supposed to do. However, in the early stages, I modified our surface-supplied helium-oxygen tables so that we could use them with bell diving. We did a number of non-saturation bell runs using those tables with some modifications, and those also seemed to work pretty well. We were confident that we could dive to 850 feet or any shallower depths with that system and do so with either sat or non-sat. That was a good feeling. Everything really came together there.

DR. WILLIAM SPAUR

I worked a long time with underwater breathing apparatus for combat swimmers. We were developing ways to use the oxygen-add rebreathers, reducing the breathing resistance, extending the carbon dioxide scrubbing capability, and doing simple things like human factors. For instance, the oxygen valve button and the diluent valve buttons on a rig were the same on the initial specifications. I think Rob Carter was our psychologist at the time. He worked out that one should feel pointed to the gloved thumb, and the other one should feel like a hole in a circle.

It is terribly complicated to figure out mixes, diving procedures, decompression tables, and breathing apparatus for combat swimmers who operate for long periods in the water at variable depths. Protection against cold is difficult. Those operations will always be problematic.

I published the results of a saturation experiment in the *Undersea Medical Society Journal* and went on to put it in the diving manual. By the time I got it in the diving manual, I'd made some adjustments. With further experience, we had shortened the distance at the deep end a little bit, I think. After I left the Navy, Ed Thalmann worked on it more. Now the limits are a little bit different, overall. It absolutely changed the way saturation diving was done. The idea that you could put a chamber down, store the divers at a depth, work up and down through a distance of 100 or 150 feet and not have to worry about how long they went down, or how long they were below the personnel transfer capsule (PTC), that was an extraordinary change. It resisted all kinds of M-value calculations. It didn't have anything to do with them. I don't know now whether any theoretical mathematics have been appended to the results. I think that was a great achievement.

I don't know whether the Navy has made a mistake in limiting diving research to shallow diving, because I don't know what the mission is at the present time, so it's hard for me to talk about that. I don't know what our platforms and capabilities are now, but I think that the US Navy is the biggest experimental group that exists. Nobody else can match it in its facilities, the ocean simulation facility, the number of subjects they can get, and the enormous brain power of the diving medical officers and the engineers that are in that business.

I think the Navy should always be looking at all aspects of underwater work, whether it is deep or shallow, helium or nitrogen, or anything

else that is going on. The equipment always will be advancing as technology advances.

When I started out, there were no oxygen sensors. We had a project going at General Electric Company to make a unit that was called the "Mark 10." It was the first closed-circuit oxygen-add unit. All the oxygen sensors were hand-made. The units were hand-made. They were very expensive. My understanding is that when that project ended, General Electric got rid of the single middle-aged lady who could make those sensors, put the membranes on them, and make them by hand. That was almost the end of the technology for a while. Arterial blood-gas studies really hadn't been possible in the beginning.

With the deep saturation diving out of submarines sitting on the bottom, it is an incredible technology that opens up the whole sea floor, at least down to 1200 or 1500 feet or so, where people are reasonably comfortable diving. You have to have the capability to put people out at every depth possible. I don't know of any advances in the capability to put divers deeper than 1200 to 1500 feet and have them able to work. I myself was a subject on a 1400-foot dive. It was like having the flu for a month, or for the weeks that we were that deep. Subsequently, we made an 1800-foot dive, on which the guys didn't think, or feel, very well. Everybody had tremendous weight loss.

DR. MARK BRADLEY

I spent close to eleven and a half years at the Naval Medical Research Institute in Bethesda, MD. I arrived there in late August or early September of 1973 and retired in December of 1984. In one form or another, such as heading the diving group, I was in charge of the diving lab the entire period of time that I was there. It kept morphing into different things while I was there. It started off as the Diving Physiology Division, then the Environmental Biosciences Department, and then morphed into the Diving Medicine or Hyperbaric Medicine and Physiology Department and then into the Hyperbaric Medicine Program Center.

When I first arrived, there were no diver billets. I mean, there was no one to maintain and operate the chambers except for Wally Bent and Chet Langworthy and people of that sort. I managed to get a couple. They weren't diver billets but just basically enlisted billets. I accumulated billets in a number of ways over a period of years.

One of the things that I think facilitated getting the billets to operate and maintain the chambers was the fact that at that time, the Navy was short on shore-based saturation dive facilities. They had the Navy Experimental Diving Unit and that was it. When the Naval Medical Research Institute came along with that requirement, people were out on the various platforms, such as on the USS *Halibut* and the other platform at the time.

There were some trained people out at the Submarine Development Group. They had the *Elk River* at that time, but it was waiting for the USS *Pigeon* and the USS *Ortolan* to be built and for them to become operational. Those would have been considered sea billets, too.

Anyway, we accumulated a lot of the diver billets by hook or by crook. I think one of the ways that we picked up about twenty billets was a senior diving medical technician, Chris West, struck up a friendship with a congressional staffer. He managed to convince said staffer and things trickled down from Congress to the Navy. They decided that maybe they ought to put some billets out at Bethesda.

That was one thing. Certainly, one of the things that helped financially was that Bob Bornmann and Jim Vorosmarti had both been very supportive when they were down at the R&D command. After that, I managed to, or had some influence in, getting people who had been at NMRI become program managers down in the R&D command. It was very helpful to have graduates of the diving program at NMRI as program managers down at the R&D command. That was how Chris Green, Del Evans, and Al

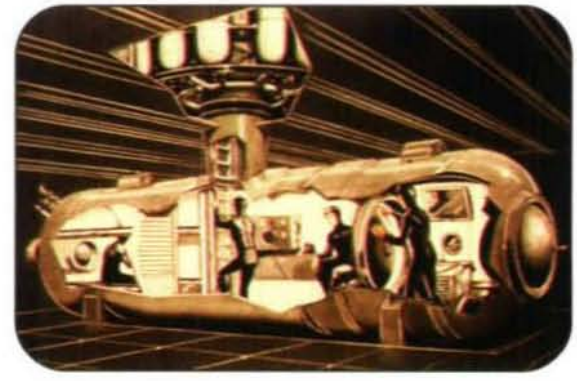
Manalaysay ended up down there, and they were all very supportive. There was a little bit of political maneuvering that was going on.

Today, I don't think there is that much in the way of diving left in the Navy to recommend it as a career path for a young medical officer. If asked, I would not only say "no," but "heck, no." I don't think the support is there, either monetarily or facility-wise in any way. For somebody who is on active duty, I think it's a dead end path. The Navy Medical Department continues to be run by clinicians, for clinicians.

In years past, one of the things the Navy did was pioneer the work in saturation diving. The Navy carried it along for a considerable portion of the way. It proved to be extraordinarily useful in a number of things, particularly with some of the black programs out there, and then they dropped it. The last platform was decommissioned this year. Only some of that capability will be maintained with the ASDS, the Advanced Seal Delivery System.

Deep Diving Operations and Developments After SEALAB

When someone mentions the term saturation diving, it conjures up visions of divers exiting a Personnel Transfer Capsule (PTC) and going to a job site in very deep water. Visions of the deck decompression chamber that these brave divers call home for the length of the task at hand also come to mind. But what about all the support that is necessary so a saturation diver can do his best work? What about the crew who "drives" the support ship under the command of a skipper who is experienced and schooled to handle any emergency the diver may encounter? That, too, needs coverage. This look at undersea Navy technology would not be complete without some words about those who transport the divers and stay on station while they do their work.



Deck Decompression Chamber (DDC)

CAPTAIN RUSTY MIRICK

I got to the USS *Pigeon* after graduating from the Navy Dive School in Panama City, FL in 1983, having finished the basic diving officer course, the salvage officer course and the mixed-gas course. All that was left for training for me was to go to SAT school. When I reported to the *Pigeon* in 1983 as first lieutenant, I relieved an officer who was removed for cause months prior and took over a department that hadn't had a junior officer to lead them in a number of months. We were in the yards to boot. SAT school was local and about two months in duration. It didn't take me too far from my unit except that I was not undergoing the rigors of shipyard duty.

I graduated from SAT school at the end of the summer and was reassigned to the *Pigeon*. Soon, we were out of the yards and ready to finish what we had begun before the yards, which was what we called "sliding 850." It is basically a progression of deeper and deeper dives to demonstrate the full design capability of the ship. It had never been done before with the *Pigeon* class. The *Pigeon* class was comprised of two ships back then, the USS *Ortolan* and the *Pigeon*. The *Ortolan* was following our progress closely, because they were next. We were going to break the ground and they were going to certify faster and in less time with less money, hopefully, than the lead class ship.

We were successful in conducting dives progressively deeper off Point Loma, off the southern California coast. Eventually, I was

responsible, as first lieutenant, to put us in a moor in a thousand feet of water for the final certification dives to 850 feet under the Naval Sea Systems Command certification authority. We were on board for the final demonstrations of the conventional diving suit with mixed-gas capability and the saturation system.

I supported, as a watch-stander, some of the certification dives and demonstrations, which included a submarine rescue chamber (SRC), rigging and deployment and recovery, both the port and starboard deck decompression system (DDS), the chambers that were resident in each hull of this catamaran ship.

The one atmosphere was called the "observation mode" for the personnel transfer capsule (PTC), which was a design thing that was rarely used. But it was an initial capability, so we had to demonstrate it. Of course, to do any real world water excursions one needed to use the PTC and its principle function to get divers in the water column, which we demonstrated at 850 feet. We also had to demonstrate surface recovery of a Deep Submergence Rescue Vehicle (DSRV) and underwater mating and all of that procedure. It took a lot of time and a lot of effort. It began way before I got to the ship. The timing of my arrival was neat, because I got to see it all come together.

As for diving, I don't recall any significant contributions as a diver. That was more the chiefs' and first-class petty officers' chances to shine, and they did great. The saturation-qualified officers were very few. It was just the commanding officer (CO), the executive officer (XO), the deep submergence officer, the ops boss, the engineer and myself. That was it for the whole ship. We were dedicated to the topside watches.



Submarine-mounted DSRV

We were in and out of San Diego a lot. The "Mole Pier" at 32nd Street was the home of the *Pigeon* and the home of Operational Mark II, Mod I saturation system operations. We did everything right out of 32nd Street. We'd get liquid oxygen load top-offs from Ballast Point, the submarine base. We might get some oxygen clean level work done by the tenders. We had both the *Dixon* and *McKee* in port at that time. We were a SUBPAC asset, belonging to the Submarine Development Group One.

After we were certified, we weren't too sure what operations we would get into. We were busy with the certification cards that were issued by NAVSEA, which were not showstoppers but discrepancies. That ship's force was responsible to correct them, some of which would take a lot of money and a lot of time at the Long Beach Naval Shipyard. Others were more administrative in nature.

That consumed a lot of the work. When we did get underway, it was to keep ship's force and the ship's divers trained up and to augment the *Elk River*. Within 12 months of certification, it just so happened that the *Elk River*'s main propulsion machinery went down, which required a C-4 casualty report. The *Pigeon* was the only surface saturation platform to qualify the students. We took over that additional role.

By that time, I was deep submergence officer and attendant. I had been relieved by a fellow named Mike Donch, who's also a Navy captain, 1140. As deep submergence officer, I suddenly became the schoolmaster, something I hadn't anticipated. The training requirement was significant, but the operations are also what made the job special. The operations that I recall sometimes involved the conventional diving mode, typical of salvage ships in the Southern California area. It all came together for us when the Mark V system failed one day off of Point Mugu and a telemetry round of some

significance, and certainly some serious monetary value, was lost.

There was a general location, but the Mark V recovery system failed because the seal had a cold. The Department of Defense (DOD) gave SUBPAC a call and the Navy had to go to its next best thing. "If the sea lions aren't working, maybe saturation divers could," they figured. With the Mark V systems, the sea lion Marine Mammal Systems were recovering deep objects.

Our only rescue in my one and a half years on the *Pigeon*, before I got moved early to be executive officer on the USS *Bolster*, an old salvage ship out of Long Beach, was the rescue of one of our own assets. We were aware of mother sub and deep submergence rescue vehicle operations in the Southern California operations area. We were assigned to be topside support. There is a backup procedure that requires a ship with a recompression chamber to be on standby in case a real emergency occurs because of some emergency procedure that a submarine crew will have to employ if something goes wrong. It is not routine or planned for, but we were there if the plan went awry.

To our surprise, in the middle of the night, we got an SOS call from the DSRV, which was on the surface. The submarine directed us to a position where they last held the DSRV. They were starting sub-miss, sub-look procedures, which the USS *Thresher* accident made famous, at least within our own Navy, if not internationally, because of the international protocols of sub-miss, sub-look. It was an agreed upon thing with our allies.

Suddenly, we found ourselves really missing a submarine. It was our own DSRV, either the *Mystic* or the *Avalon*. I think it was *Avalon*. Both had their home ports in North Island. The officer-in-charge was a Lieutenant Commander Bill Pigg, a well-qualified submarine officer, a nuclear power officer. The DSRV was in great shape and operated with the mother sub that day. It was routine training for them. They had built up for it and looked forward to it.

Anyway, the submarine communicated with us and we transited the five miles or so to get to the exact point, conducted some basic searches and made sure the mother submarine could hear us. We had the ability to make some noise, so we did. We tried the underwater telephone to hail the DSRV, but we didn't have any update on her.

We were two hours into sub-miss, so we knew the Chief of Naval Operations was being personally briefed, if not higher, and the "pucker factor" was getting up. Suddenly, the aft lookout, and I'm not kidding, the good old Mark I Mod O Eyeball spied this light that didn't fit in with the rest of the fishermen and the stars and whatever was out that night. It was a strobe from the DSRV's sail.

We closed the distance and tried to establish communications. We were in a sea-state three and a half. We realized that after we exchanged information, we had to do an emergency surface recovery of the DSRV. Emergency surface recovery had never been demonstrated before. It wasn't a part of the sliding 850 Mark II, Mod I saturation system certification by NAVSEA. It was simply an untested emergency procedure (EP) that was theoretically supposed to work.

To NAVSEA's credit, some of the design considerations for the *Pigeon* and the DSRVs took into account the emergency surface recovery, but it had never been tested. It wasn't even practical. In fact, the plastic mock-up of the DSRV for rehearsing watch standing and handling training of sailors was only built after this incident. It was pretty early on in the DSRV days of operation.



DSRV



DSRV Mystic

Anyway, to get back to that night, it is a story that ends well. The point is that we were outside of our parameters for conducting the emergency procedure. It required a NAVSEA waiver to conduct it. I made my recommendations as thedeep submergence officer to the CO that we could recover the DSRV safely. I made them aware that we were outside the specifications and let him handle communicating with the chain of command. I really can't speak to that.

The CO at the time was Commander Bill Shotts. But it quickly became apparent that it was a specialized task and had never been done before. The people on deck who knew how to do it were me, my weight-handling officer, Chief Warrant Officer Steve Miller, and BM1 Dehart and the rest of the pirates. Steve Miller specially selected that group. They were their own division, called the "weight handling division."

The ship had a condition one recovery, which was their general quarters (GQ) for this contingency, much the same as a destroyer might go to condition one for ASW operations to defend itself from an attack submarine. We had a condition one for rescue of our own DSRV. We manned that and went to work.

Getting lines to the DSRV, getting her situated and using the ship's propulsion because she was dead in the water were quite challenging in the middle of the night. We called the DSRV a "pickle," by the way, because Lockheed Martin's design was rather cigar shaped and the green color scheme that was adopted in the space age years of the seventies. Everything had a certain look to it back then and a certain design or flair because of the aeronautics industry, which was just booming at that time, in the late 60's and early 70's. We inherited something that would do just as well in space as underwater, I think, and the sailors termed it the "Pickle."

The Pickle's skin was dinged in a couple places as we manhandled her with hausers and tended the line into a specially formed cradle dolly that deployed to forty feet underwater, which was the normal mating regimen for the DSRV. Once we secured the cradle dolly, it was recovered by four points, four wires, up into the center well area. That was why the catamaran design was suited for the DSRV. Except the cradle dolly wasn't behaving correctly. In a sea-state three, it was rough. The ship handling was difficult. The Pickle itself was not particularly patient with us.

I skirted around the deck, yelling at Steve. Steve skirted around the deck yelling at his people. We were primarily concerned with the safety of the operation, and it was pretty unsafe. We had people in the way of lines, because by the design of the ship, there was no way to get out of the way of tension lines. The lines had to be tensioned to keep the DSRV under control. Things worked well enough that we were able to get her into the cradle dolly, recover up to the deck level, which meant that she was high and dry and we could start dealing with her problem.

It turned out the emergency surface recovery decision was about the only option we had, other than letting her sink, because her life support had failed, or failed enough that she had to surface. Once on the surface, the sea-state was so rough that having the hatch open was needed for the climate control and oxygen for the inhabitants. But the hatch also was an entrance for water. Because she didn't have propulsion, which would have taken away from life support, she couldn't manage the sea-state. She was taking on water, the lesser of two evils, instead of having her crew expire from lack of oxygen.

We were working against the clock. We were out of our league, in terms of the sea-state, but for

all that, Commodore "Bullet Head" Mauer, from Submarine Development Group One, came down to the ship the next morning. I think we were asked to return to Ballast Point so that the safety investigation could be done more efficiently. At Ballast Point, the commodore came aboard ship the next morning and looked at my dragging, tired, unkempt-looking batch of sailors of the weight-handling division and wanted to hug them all, but ended up putting a Navy achievement medal on Steve Miller's shirt. The rest of it is probably unspoken and unwritten history, except for this reporting.

Although the DSRV was in trouble, like anything else, once she was recovered, things quickly went back to routine. I'm sure the CNO and others started worrying about more pressing issues. Frankly speaking, I think for the chain of command, it was something they preferred to just handle as an operation and as a win, and not self-flagellate over it. There was no self-flagellation and very little written about it. The story needed to come out. The heroes of it were the people in the weight-handling division of the *Pigeon* in 1984, Steve Miller and company. Hoo-ya! As for the other salvage operations, I'll just give you highlights.

The USS *Hoist* safely recovered the USS *Bone Fish*, which surfaced after a severe fire in her battery room. Sailors, tragically, were lost in that fire. The ship would have been lost were it not for the *Hoist*. It is an example of a salvage ship conducting what submarine rescue ships were designed to do. That was in early 1990, before I took command.

Another significant operation that happened while I was in command of the *Hoist* in 1991 and 1992 was the handling of the mass conflagration fire on the Tunisian flagship *Inkhad*. She was in her homeport at the time. A fire broke out in her deep fat fryer. The crew abandoned ship. It's not clear that everybody was on board at the time anyway, but whatever crew was on board that weekday evening abandoned ship. The *Hoist* went to work when the quarterdeck watch spotted orange smoke and orange flames emitting from one of the mid-ship windows on the Tunisian flagship.

That flagship, by the way, was an old US Navy Destroyer Escort (DE). We sold it to the Tunisians in the 80's and it was reconfigured to meet Tunisian Navy standards, which included tons of wood veneer and fabric, which would never be allowed on a US Navy ship. But they were part of the culture and the tradition of the Tunisian navy, a very proud navy with exploits in World War II. I'll let somebody else tell that. But the point is that they were proud of their DE, the *Inkhad*.

The fire that ensued would be what our Navy calls a "mass conflagration." It took all the resources of my ship, my hundred man crew, in terms of fire parties and de-watering parties. All the workboats were in the water. I commandeered two harbor tugs to control the skin temperature of the ship, which was peeling paint. We had whatever Tunisian ship's force we could find and we communicated in our best French, English, and Arabic derivations. We explained to them that they had to offload small arms, so the ship's company deserved credit for putting themselves in harm's way by offloading ordnance that could have cooked off.

Meanwhile, the *Hoist*'s crew was busy with the business of fighting a fire for six hours, a bravo fire that had turned into a huge alpha fire throughout the ship. The ship was saved. She took on a list because of the firefighting water we put in and on her. We de-watered that.

We helped solidify Mediterranean allies during the Cold War, when examples of the US reaching out to northern Africa countries were slim and enemies far outnumbered allies in that part of the world. It was not looked upon as a great salvage feat, but at least it was a huge diplomatic coup at a time that our government needed it. I was also the salvage officer for the terrestrial disaster of KAL Flight 801, which crashed on Guam on Nimitz Hill in 1998.

I'm respectful to those lives lost, but I want to add an editorial comment. The experience prepared me for being a salvage officer once

again for the crash of Alaskan Air Flight 261, which was a maritime crash in the Channel Islands preserve off of Port Hueneme, CA in 2000. When I was chief staff officer for EOD-GRU in San Diego, I found myself TAD, as the fleet salvage officer, and in charge of salvage assets once again.

When the Supervisor of Salvage, Captain Burt Marsh, came on the scene, we were already one or two days into the operation. He was delayed getting there because he was still dealing with three salvage operations: TWA 800 off Long Island, Egypt Air, and Swiss Air. Of course, the operation was seven times deeper than TWA 800, which crashed in about 120 feet of water. There was over 700 feet of water where that Alaska Air flight crashed in 2000.

The heroes of that, again, were the members of Submarine Development Group One. It had been renamed "Submarine Development Squadron Five." Submarine Development Squadron Five still had its unmanned vehicle detachment based out of San Diego and had, from what I remember, new and improved equipment. The sailors were up to the task of deploying.

The ROV *Scorpio* and the remote vehicle *Deep Drone* eventually showed up. We had motor vessel *Independence* under contract with NAVFAC. We had the USS *Cleveland* as our command and control ship, and we had a Federal Aviation Administration-patrolled bubble by the Coast Guard. We had a great staging base at Port Huneume. We contracted a crew boat to run back and forth at the site.

With M/V *Independence* and ROV *Scorpio*, we were able to recover the famous flight data and cockpit voice recorders in short order. The suspected jack screw flaw that caused the stabilizer to make the plane crash was all surmised in guesswork in the first 36 to 78 hours, but was confirmed when the unmanned vehicle detachment picked up the smoking gun, if you will. The helical piece of brass from its mating fitting on the stabilizer was still intact. There was amazing piloting done by the young enlisted man at the helm of this ROV. He recovered the item from 700 feet, so that the materials scientist and the National Transportation Safety Board and other experts could really get a first good feel, within the first couple days, of what went wrong on that flight.

It took a year of investigations, as all such investigations do, but it bore out that the initial hunches were right. The whole fleet of MD-80s and military variation of the civilian aircraft, which were widely in use, were all grounded. But they were restored to carrying commercial passengers to the United States within days. It came down to a compatibility of lubricant with the helical screw and how frequently one checked it or did the lubrication.

That is a highlight of some of the major salvage jobs in my career. Some were just pulling on lines, labor intensive, and needed brute force. They were not very high tech. Others, at the other extreme, were all high tech. But for the grace of God, the weather cooperated and our resources got there in time, so we were able to meet the missions that we did meet.

I was one of the few 1140 officers that went through master diver evaluation. The decision was made in the early 1990s that the master diver selection process had gone through so many iterations. The master diver selection process had been scrutinized at so many different levels. Some who attained it and those who didn't attain it had criticized the master diver selection process. There was a really close look by the community itself at how to best pick the next crop of master divers. Everyone knew the process wasn't perfect, but we thought we had a good handle on what was working.

One part of the refinements was to remove the diving officer evaluator from a group of four or five and replace him with someone of the same skill set as the other four or five. That's the current requirement today, by the way. All qualified master diver candidates of esteemed reputation, who are recommended by their COs and can get off and go to Panama City for two weeks should go. Master diver evaluations are conducted three times a year.

I was privileged to serve as, if not the last officer, probably the second to last officer on a master diver evaluation. But the decision, when it was made, also grandfathered those officers, those master diver evaluators who had already been on the schedule. They grandfathered that schedule to honor those people who were already committed. I knew, going in, I had to do a good job as an evaluator. I knew that I was the next to the last officer to perform such a duty, if not the last. I took it very seriously. It's one of the high points of my diving career in salvage operations but an unrelated kind of contribution, a giving back to the community that I desperately feel I owe. After all, it's the master divers who brought me along as a junior officer. It was the first-class divers and master divers with whom I interfaced when I first learned diving in Panama City.

To add icing to the cake, one of the master diver candidates, who we all felt qualified and who was made a master diver when I was an evaluator, came back to work for me when I commanded Mobile Diving Salvage Unit One in Pearl Harbor some six months later. There's an example of being very proud to have a candidate work for me. I never second-guessed this gent's capabilities, and he certainly performed to everybody's expectations.

I see Navy diving being a unique and irreplaceable, but perishable, skill that needs continued attention and resources, but maybe a smaller, slimmed down version than the kind of operation and outfits we had in the Cold War. I think that those who do special warfare combat diving and EOD diving have always been doing most of the diving anyhow. That was true even during the Cold War and even given the saturation diving and all the dollars in that program and my loyalty to it, and all the other surface supplied work we did.

Since the Vietnam War, the EOD and special warfare have done the lion's share of the diving in terms of numbers of dives-per-day kind of accounting. But I think it has taken us a while to come to the realization that it's time to outsource and give to the more efficient organizations, like contractors, some of that ship's husbandry work that, historically, Navy divers have found themselves doing.

Ship's husbandry works out great to keep the skills sharp and honed for divers who are committed to and have resources for salvage, but it is not the case the other way around. Too often in the last decade the perception has been that divers do salvage, or call themselves salvage divers, for the occasional times when they leave their real jobs, which is underwater ship's husbandry, and go do salvage.

The point is that it's completely opposite the perception. The Navy requirement to conduct towing of disabled ships in war and conduct basic battle damage repair and emergency salvage is well-formed and written in blood, and Navy doctrine should be reviewed on a periodic basis. But that is the basic requirement. Ship's husbandry is that which the divers do to keep their skills up because, thankfully, these emergencies and types of operations don't occur very often. It's like a firehouse. Right now, the US Navy is trying to figure out how many firehouses they have and how many they need.

I think that is probably a good answer to the question about the future of Navy diving. But we've got to make sure that as we trim down firehouses, the fire trucks are the best we can get. I really think the Submarine Rescue Program has latched onto a mostly commercial, off-the-shelf, mostly Norwegian-inspired submarine rescue system and it will work very well. I think the salvage piece needs to be exercised and looked after with vigilance, but I think it's doable. I think training can sustain the necessary level of salvage confidence we need with an ARS 50 class and shore-based salvage units.

I'm a proponent, if you're going to label me, of a lesser but better quality kind of salvage team. We need to be less parochial. We have great salvage assets and capability with the Army, believe it or not. We have great salvage capability with our Seabee friends. We have to recognize that the divers who do most of the diving are special warfare divers or EOD, not salvage

types, and piggyback off lessons learned from spearheading state-of-the-art organizations like Navy Special Clearance Team One.

I think we ought to continue to invest money in national assets like the Navy Experimental Diving Unit. I think you've got the gist of what I'm after. My experience has made me a product of many, many organizations that call themselves "salvage" that may or may not have been able to really do the job. I've grown up with that. I'm now advocating more specialized assets, fewer in number, better maintained, better equipped, and better manned kind of equation.

Deep Submersibles and Submarines Used in Clandestine Operations

The book *Blind Man's Bluff* broke the news that deep submersible vehicles and submarines that transported and supported saturation divers were used in clandestine operations. Here is a short excerpt from the interview with the man who was head of that program and was in charge of SEALAB III, and after its tragic end moved that entire operation into the black. Here is some of what Dr. John Craven had to say about this topic.

DR. JOHN CRAVEN

The *Trieste II* disappeared when we took the *Scorpion* out of the closet. By taking it out of the closet we used it as a decoy to distract people from the possibility that we had the *Halibut*. In other words, we felt that the Soviets had no idea, which was true. They had no idea that we had the *Halibut*.

We always felt that, in the whole business, whenever you got a system that the Soviets had no idea you had, you had to display the system that would be used to do what that new system is doing. You had to do it in such an overt way that the Soviets were sure that you were not carrying out that mission. I hope that makes sense.

We were playing dominoes one way or another. You saw that when we brought the *Trieste* out, and when we brought some other systems into play. We were then working on the *Halibut* with the idea that it was going to go out there and watch nose cones and the guidance systems fall into the ocean, observe them and collect them and do things of that nature. There was absolutely no notion as to what was going to come up with the Russian submarine, none whatsoever. Also, maybe if there was a nuclear weapon of some sort, we could go out, find it and search it and do things.

We decided to use the phantom *Trieste* for recovery in the deep ocean whenever it came down. We had alternate missions for the DSRV, but I deliberately designed the DSRV to have as much alternate mission capability as you could possibly imagine, by postulating almost ridiculous scenarios under which we would have to rescue people. I knew that we were going to get as much money as we needed. In addition, we used that money for cover-up money.

As the *Halibut* developed, we had many more problems with it. We finally sent it out on a mission that had two purposes. One was to try to get some information on the Soviet missiles they were dropping in the ocean. The other was to see whether the *Halibut* could be detected or not. We told all the surface ships that a US submarine was going to be in the vicinity and they were encouraged to see if they could detect it. They didn't detect it.

We saw that we had a good clandestine capability with the *Halibut*, although we didn't have any good results. By that time, as it came into port, we were repairing all the weaknesses with the cable that had too high a strain around her shiv.

We could put in a great big fish. When they had the fish, though, we had a cable that had to go down 20,000 feet. The space was such that we had a shiv that was only of a certain maximum diameter. That cable had to go over the shiv and we couldn't find any other way of doing it. We

made very careful calculations and discovered that the cable that we were getting couldn't make it.

We failed to realize that the cable had welds along the way and that the welds could not take the stress. The welds would snap and, when they snapped, the wire would just spring out. When they sprung out, you couldn't reel it back in. There were terrible tales of sailors getting up on the high seas and pulling it in on the deck in order to pull the cable back up and get it in place. The only way to finally solve that was by getting the cable manufacturers to make cables that had 20,000 feet of wire with no welds. The big joke was that Bob Frosh was talking to the cable manufacturer and the guy finally said, "You know, Bob, please tell me, for what building is this elevator?"

We solved all those problems and we knew we had a working fish. We came back into port and got word that the Soviets had lost a submarine.

The fish had sonar on it. It had optics. We had color cameras that, in my opinion, produced color that was as good as the best color produced today. I suppose they are now using our technology. We had some fabulous new technology on the whole thing and we also had some sonar that was extremely good. We had just about everything on the fish you could possibly imagine.

Think about it. The Soviets were chasing for their submarine on the surface. When you lost a submarine you made no pretense about where it was. You went right down the path on which it was supposed to go. It went down the usual path that the Soviet submarines took when they went on station. Ballistic missile submarines go on station. We were trying to find it on SOSUS, but could not find it. Finally, Captain Joseph Kelly called me up. Captain Kelly was our SOSUS man. That guy was a hero. I mean, he knew everything there was to know about it. He was just a gentleman. He was also an Irishman. He was proud of being an Irishman. He was just a great guy.

He called me over. He said, "Hey, Craven, I think I've found the Russian submarine." I said, "Really? Let me see the record." He didn't find it on SOSUS, but he found it on a hydrophone. SOSUS was no good for finding single explosives or single devices because SOSUS was continuously breaking everything down into frequency bands. Unless you had additional hydrophones, you wouldn't find anything. You could use the SOSUS hydrophone and just take the wrong measurement on it.

Until the *Scorpion* came, we didn't really do that. After the *Scorpion,* we had isolated hydrophones everywhere to pick up those measurements.

He said, "Look, I think I found it," and showed me a single blip. I said, "Hey, Joe, there are single blips like that all over the ocean all the time." He said, "Yeah, but look at the location of this one. It's 180/40 and 180/40 was not an accident of nature. It was a product of man. It had to be." I said, "Well, gee, that's interesting." He said, "Note that 180/40 is 300 miles away from where the Soviets are looking for their submarine." The blip might have only been a trace, because it might have made that noise and went on somewhere else, like a rogue. Suddenly, that changed the whole nature of whether you wanted to go look for it.

A rogue is a submarine that was operating contrary to the orders it had received from its command. If it was a ballistic missile submarine that'd been sent out by the Russians, it'd been sent out in order to be on station. You knew that, because that was why they were hunting for it. If it was 300 miles away from where they were hunting for it, then you knew that there was no way the guy could have made a navigational mistake of that magnitude, and particularly if he was going to a spot marked 180/40. Even if you didn't know what that meant, you knew that there was something magic about 180/40.

It was hard to come up with a scenario that said it was not a rogue, unless it was a hostile scenario of some sort. Some of the admirals said, "Craven and Kelly, are you smoking pot?" We

said, "Well, maybe it was on the surface, had all the ports open, and went down." They said, "Even if it went down, there are all sorts of containers and vessels on board the ship that are going to implode anyhow. You're bound to get a bunch of firecrackers under any circumstance, and you didn't." We finally took a diesel boat out to the area in question, opened up all the hatches and sank it with all the other tanks there. There was dead silence. We didn't pick up anything. That made it plausible that the one blip might have been the submarine.

Then, the question arose. How serious was it? It was taken up to the president. You said to the president, "Hey, do you think this is serious? Is there any possibility at all that this is a rogue ballistic missile submarine?" That went right to the heart of national security.

The president at that time was Lyndon Johnson. It was toward the end of his term, but Johnson took it seriously and said, "Yes, go out and look for it." We went out to look for it and nobody in the crew knew what we were looking for. The navigation was screwed so that they didn't know where they were. The only guys who knew the nature of the mission were the executive officer and the commanding officer, and Gary Lang, a lieutenant who was an Air Force intelligence officer, who was along on the cruise.

They went out and took these photographs. All of a sudden, the photographer came tearing into the cabin and said, "Captain, you'll never believe what I saw. There is a perfect image of a sail. It is just absolutely perfect." There was a picture of the part of the sail that had blown up, which was right by the missile compartment, probably, if you can believe *Blind Man's Bluff*. The interesting thing to me was that the call numbers of the submarine were clearly marked. The captain told him, "Well, you know, you've got to develop all the pictures from here on in." *Blind Man's Bluff* says there were 23,000 pictures. I don't believe there were 23,000 pictures, but there may have been. I don't know, but all the pictures were taken.

Then the *Halibut* came back and I got to see the pictures because I was the project manager. I met the *Halibut* when she came in. Whether I had a need to know or not, I made an interpretation as to what it could possibly be. At that point, it looked to me like something was happening with the missiles and the warheads. It was not clear what it was.

COMMANDER JIM BLADH

I think there's a definite place for saturation diving. I think the commercial world is moving faster than the Navy because of our regulations. I would think that except for classified areas, we would be better off putting money into the commercial world to do the deep saturation diving. Now, I recognize that there might be some projects that are classified and we can't do that. I think there's a fantastic amount that could be done with an ocean floor habitat. Now, I think it's awfully expensive and probably pretty risky.

REAR ADMIRAL BRADLEY MOONEY

The Navy has contributed a lot toward the offshore oil industry. Since the first half of the century, the Navy was the world leader in diving and underwater exploration. Many of the people who were hard-hat divers in the Navy were exposed to saturation diving. Some of them became saturation divers. They went to work for civilian dive companies when they retired from or got out of the Navy. They became instructors and became part of the leadership of those civilian dive companies.

CAPTAIN GLENN "TEX" BREWER

Being assigned to PMS-395 brought me into saturation diving. I had a lot of responsibilities. I was the special projects officer who sort of had a finger in everything. I brought my operational experience to this engineer's bureau. It was a whole new learning curve in how to employ

saturation diving in an operational mode outside of the old submarine rescue ships (ASR). That was when we had two catamaran ASRs, the USS *Pigeon* and the USS *Ortolan,* designed and built. Plus, the saturation diving systems were installed on the new ASRs. The PTC, or personnel transfer capsule, was being designed and worked on, too.

In 1972, Don Walsh, Don Keach, and I made a trip together to attend the International Conference on the Oceans held in the Hague, The Netherlands. Don Walsh had his Ph.D. in oceanography. He had also made the deepest dive to the bottom of the Mariana's Trench in 1959 in the Navy's research submersible *Trieste.* Don Keach had piloted the *Trieste* later, when it located the sunken submarine *Thresher.* It was a great team to visit each of the allied navy's deep submersible programs in Europe for an information exchange tour.

The trip was not primarily of an intelligence nature. We weren't connected with the Office of Naval Intelligence (ONI) at all, except that there were a few things we observed that were reported back to them. It was to be an exchange of information and capabilities, a discussion of just what we were doing to explore the ocean. It was truly an international effort with a lot of cooperation. We visited Marseilles, Toulon, St. Tropez, Nice, and Monaco. In Monaco, we had lunch with Jacques Cousteau at his Oceanographic Museum and visited the French bathyscaphs and talked to their operators.

Cousteau liked having his photograph taken with Don Walsh. We took our wives with us and it was a real social exchange also. We rented two Mercedes to carry the three couples and all our luggage. We couldn't do it with one car. Don Walsh said in a very sensible way, and we all agreed, that rather than spend our liberty and per diem money on booze in the bars, we should use it for four star restaurants and fine foods. That was how we made our whole trip. I think we had just a cocktail before dinner and a little wine with dinner. We certainly ate well.

It was a marvelous trip for Jeanne also. Joan Walsh and Betty Keach were two of the loveliest people, and we were really the most compatible sextet there could be. In fact, I was about to get my name changed to Don Brewer. We could have been the three Dons. If Kenny Wilson could change my name to "Tex," then someone else could change it to Don. When Bob Kutzleb was commissioned, his first skipper told him there were already too many Bobs in the wardroom. His name got changed to "Sam." We continued on to La Spezia and to Naples in Italy to visit the Italian navy submersibles and commands.

Ocean Simulation Facility

MR. JIM McCARTHY

In the same time frame that the SEALAB III program was in operation, the Navy planned to build a facility to safely dive in a chamber to simulate the pressure and depth of seawater. The NASA organization had the financial support to build facilities to test in a simulated mode, but the Navy did not have the financial resources, so testing of new equipment was done at sea.

When a new diving rig was introduced to the Navy, they had to take it out to the ocean to see if and how it worked. The same thing happened during the SEALAB program. If we had a place where we could have tested the equipment prior to actual operations, it may have turned out different. The Navy Experimental Diving Unit in Washington, D.C., was the testing agency and the facility by which they did all the basic testing and diving at the time.

At the time, when I was on the SEALAB program, I had only heard of the Navy Experimental Diving Unit. But, after the completion and the shut down of the SEALAB program, the Navy found the funds to do it right, and design and build a large testing facility that could simulate the depths of the ocean in a

controlled environment without physically going to the ocean.

The Navy Engineers at the Mine Defense Laboratory drew up the basic design for the facility. The initial design was accomplished by Sanders and Thomas for the Naval Facilities Engineering Command. The entire program was funded and managed through the Southern Division of the Naval Facilities Engineering Command. They issued the Request For Proposal to large companies like Lockheed, North American, and Northrop. I think there were about seven large companies that submitted proposals and cost bids on the contract. With a stroke of luck and I guess a sound proposal, we won the contract. I was fortunate to assume the Engineering Manager task and John O'Brian was the Program Manager. He was an engineering manager with a solid managerial background.

The initial task after being awarded the contract was to pick a team and start the designs based on the conceptual designs provided as part of the contract, with the system operating parameters of 2,250 FSW depth and wet chamber temperature range of 34°F to 90°F. The entire package was divided into several major segments.

The gas storage system was sized to support the intended use of the facility during the dives, providing sufficient volume of air, helium, and nitrogen for pressurizing the chamber, and oxygen and mixed gas for breathing.

The piping system from the air compressors, helium, oxygen, nitrogen, and mixed gas pumps to the gas storage flasks was sized and routed through the new trench system. The shelter for the gas bottles was designed for protection of the environment as well as strong enough for 120 mile-an-hour wind storms.

The gas supply system from the storage flasks to the chamber was designed to enter the building to the gas control console on the first deck. The gas control console contained pressure regulators to reduce the stored gas and air pressure to 1200 psig. Analysis equipment was installed to verify gas purity, and control valves were installed to route the gas to the chambers.

A gas mixer system (Mix Maker) was designed and installed to blend different gas mixtures of oxygen and helium or oxygen and nitrogen and pipe it through a mixed-gas Corbin diaphragm pump to the mixed-gas storage flasks, or directly up to the chamber for breathing purposes.

Air and gases were routed from the gas control console to the headers on the third floor, to the second floor portable water sanitary tanks, and to the wet chamber pressure control station. The gas headers on the third floor were plumbed through the remote operating control valves directly into the five upper chambers and a second set of lines through five manual operations panel. These panels were located directly in front of each of the five upper dry chambers and were designed to operate the chambers manually in the event of a loss of electrical power.

The electrical power required to operate the entire facility was routed through the Navy base power station. We installed a 500 KW backup generator to provide enough electrical power for the entire facility in the event of a power loss situation. Should a major storm or a hurricane occur while a deep dive was in progress, we would place the emergency generator on line to prevent a power outage and harm or injury to our divers.

The chamber fire suppression system consisted of five 600-gallon pressurized water reservoirs located directly above each of the chambers. The water was pressurized with helium for deep dives or nitrogen for shallow air dives. The tank had a tracking regulator for pressurizing the reservoirs and maintained 60 psig over the chamber pressure, during both pressurizing and depressurizing the chambers. The original requirements for the wet chamber were to use salt water or fresh water and chill the water to 34°F and heat the water to 90°F. After much consideration, we decided not to use saltwater because of the corrosive effect it would have on the HY80 steel pressure vessel.

The heat exchangers for cooling the water in the wet chamber were designed as a single pass, "tube in shell" assembly working with two high capacity chiller units, which circulated brine water. The size of the heat exchangers was based on chilling the 55,000 gallons of water in the wet chamber for ambient 80°F down to 34°F in less than five hours. The heater heat exchanger was required to heat the water to 90°F also within five hours. A large filter system was installed into the water circulation system to maintain water clarity.

The design of the piping system considered the effects of the wet chamber increasing both in diameter and longitude during pressurization and depressurization. This required the piping be run as a torsion bar specifically dictated by the stress analysis programs.

The environmental conditioning system was designed to remove the gas from the chamber, dehumidify by cooling, scrub the carbon dioxide, remove odors, reheat to original temperature, and add oxygen for metabolic makeup.

As part of the environmental conditioning system, the gas within the chamber was continuously analyzed for oxygen, carbon dioxide, and other contaminants. Through this system the makeup oxygen was designed to automatically be added in the environmental control system (ECS) loops. We designed the entire interior of the dry chambers for habitability, noise control, and creature comforts, using all consideration of elevated oxygen levels within the chambers.

We performed burn and ignition tests on all materials to be used as wearing apparel and bedding and paints. We designed new toilet seats of stainless steel; this was cold to sit on but it would not burn. The potable water system was designed to provide water for showers and toilet use. We designed the potable water tank to hold 50 gallons and to withstand the operating pressure of 1000 psig.

The sanitary tank was sized also at 50-gallon capacity and pressure rated at 1000 psig. The tanks were physically located below chambers B and D, and the water drained into the sanitary tanks by gravity. The Ocean Simulation Facility (OSF) sanitary system was designed with interlocks to prevent injury to the inside personnel.



Ocean Simulation Facility

As a footnote to the use of saltwater in the wet chamber, we designed a large container, installed it in the wet chamber, and filled it with saltwater. We then filled the wet chamber with fresh water to surround the salt water container. The saltwater in the container was plumbed to a chiller system at ambient pressure and was cooled to 28°F with the fresh water cooled to 34°F.

A unique problem in building the OSF was the paint used in the chamber, especially the wet chamber. On the very first series of dives that we had in the OSF, when we came back to the surface and opened up the door, we had large pieces—I'm talking like 20 foot pieces of paint that peeled off the wall—fall down to the deck. We discovered that the chamber would expand and the paint would not, so as soon as the water found a tiny crack in the paint, the water would get behind the paint, and it would peel.

We contacted paint manufacturers to find a paint that would take the expansion; their response was to try the Corvette paint. The paint that General Motors uses on the Corvette was a very pliable paint, called "Imron," manufactured by Dupont. We ran off-gassing studies and flammability studies on the paint. We applied it to the wet chamber in 1973.

Another problem was the requirement to fly the chamber to 50,000-foot altitude. This requirement made for a specific design on the viewports so they would not be pulled by the internal vacuum.

The Government contracts to design and build the Ocean Simulation Facility was issued to three contractors. The building contract for $1,116,505 was issued to Dyson & Co. of Pensacola, FL. The Pressure Vessel contract for $2,468,387 was issued to Hahn and Clay of Houston, TX. The Life Support contract for $3,740,000 was issued to Northrop Corporation of Anaheim, CA. The Life Support contract was started in early 1971 and the first dive was recorded in 1974. We were honored to have Captain George Bond to be the first person pressurized in the OSF.

The first design of the huge wet chamber door was a unique design that we knew wouldn't work because of the number of times the door must be opened and closed, and to get that 15-foot-diameter door to make a good seal every time was a major issue. We went back to Mr. Larry Megow of Hahn & Clay, who was the manufacturer of the pressure vessel and had some of the greatest engineers in the world, as far as large pressure vessels. We sat down with Larry, and Larry said, "Now, look, I've got one that we use in the nuclear field for closing a door, and it's a double seal. There are two 'O' rings." And, that's all there was, and we decided that because of the sealing mechanism being basically tongue in groove type mechanism, we had to keep that door from blowing open. So we decided that the design had to have a series of mechanical pins that locked into place, which held the door closed. It was calculated that we had to have somewhere in the neighborhood of a hundred pins; it ended up being 96 pins.

To this day, which is so surprising, we have never had a leak—not one drop of water ever came out of that door. That door design was so good that, to my knowledge, in 30 years we replaced that "O" ring once.

The dry chambers are built as all living quarters, and there are five chambers. We designed a life-support loop for each chamber, plus a spare. The spare loop provided us a method of disconnecting one loop and valve in the spare for maintenance. In the original design, we had a big positive displacement roots blower, or compressor system that had a compressive flow. The major problem was the noise we encountered when they were operating. When the blowers operated you could hear them inside the chamber, like being in a big brass drum, and you almost had to wear hearing protection while you were inside. It was more like a compressor than anything else. We could run it slow, but even at night it was very difficult for the divers to sleep.

The second part of the problem was that the pressure seal between the motor and the positive displacement blower had to be changed every fourth dive, and in emergencies sometimes had to be changed during a dive to save the divers from freezing.

In 1976, we attended an OTC meeting for large equipment in New Orleans and discovered a magnetic drive blower unit. The design was a complete forging with a centrifugal impeller driven by an external motor and connected with a magnetic drive interface. When operating even at full speed, the noise was about 75dba inside the chamber. This was a godsend for the divers inside, and after the new blowers were installed we never changed them out in over 25 years of operation. We bought two of them, which were aluminum construction, and requested the same units to be manufactured of stainless steel.

There were no penetrations into the unit. We found that the magnetic drive was extremely quiet. A Canadian firm built the blowers of stainless material. The company built six of them; no actually, they built eight of them. Mr. Chips Hurley came to NEDU and discovered how quiet our units were by comparison to their units. NEDU loaned two units to the Naval Medical Research Institute in Bethesda, MD.

Another problem we encountered was mixing the environments inside the chamber. We were using helium oxygen mixture and blended the gas in the life support environmental conditioning system and returned it into the chamber. You could see gas layers inside the chamber; it was cold at the bottom and warmer at the top where it was entering the chamber. We had to build a big plenum to move the gas around and to make sure that everybody was nice and comfortable inside.

The diver-winch design was one that we enjoyed working on. The winch had to be electrically controlled up and down from inside and the motor located outside. We made a penetration on the outside that pierced the hull of the upper hatch on the trunk. We designed the cable housing located overhead inside the trunk with a gearbox, with a shaft penetrating the chamber, driven by an electric motor outside. The shaft seal was a pressure bearing using the pressure from inside the chamber, which would equalize. The pendant control with up/down control could not have any electricity. We used two "sensor" magnetic relays so that when the operator would press the "up" button, magnetically it would close a contact on the electric relay outside on the motor, and in reverse, a second magnetically operated relay would run the motor to the down position.

The chamber lights were another design challenge. In the chambers of days gone by, the electric light bulb was located inside, in the overhead. We contacted John Canty to design the new lighting system with the light bulb located outside the chamber, and the light was reflected by a mirror through an acrylic rod to the inside the chamber. This design was the basis for today's hyperbaric lights.

The next challenge was the fire suppression system, which must include a detector system that will work at high pressure. The forth system we installed would activate the automatic fire system even if it saw a simulated fire of a movie with a fire in it. The sensors were redesigned and changed and have had no problems since.

CAPTAIN BRYAN BARRETT (RN)

The Royal Navy medical officers who came over here all undertook unusual research tasks and completed them. It was a major benefit to the US Navy and a wonderful experience.

I like to think that I made a contribution to the Navy Experimental Diving Unit while I was there. I was the program manager, as well as a diving officer for the Ocean Simulation Facility and the saturation diving program. Bill Spaur, our senior medical officer, was running it, of course.

I actually started a program for the development of a push-pull breathing system for work on the Mark II deep diving systems in San Diego. I initiated that program. I got it funded by the Naval Sea Systems Command (NAVSEA) and was the program manager for it both here in Washington and while I was down in Panama City. I know that I made a substantial contribution to the Mark 14 diving system that was used in saturation diving operations.

There were people who influenced me to some extent. Some of those who influenced me most when I was young lieutenant under training were probably the people who tried to dissuade me from doing it in the first place. I'd always had a great deal of respect for some of the senior members of the diving branch. I received encouragement from some. I received a lot of encouragement as I got more involved in it, and the more I read about experimental diving and saturation deep diving, the more and more I became fascinated by it. I suppose the person who encouraged me and gave me the most influence was John Rawlins.

When I first became a diver, he was a legendary figure. He was an enormously well known, well-respected, and well-loved figure. You will be talking more about him, I'm sure, in your book, as a medical officer, but not as a clearance diver, or even as aviation medicine specialist for years and years. He knew every



MK II PTC

single person in the clearance diving branch. He knew every able seaman, every E-2, by nickname, and who the seaman was, and where the seaman was working. He was absolutely phenomenal. He was a sort of father figure to many of us in the branch. I got to know him before I became a clearance diver (CD). Then, once I was a CD, I came across him quite a lot. Indeed, I did some experimental dives with him in the chamber in Alverstoke at the Admiralty Experimental Diving Unit (AEDU). I'd always had a huge regard for him and still do. I think that of the people in the branch, he was probably the one who had the most influence on me.

I also got to know David Elliott. I didn't work much with him. He was across at AEDU. I was more involved with the sort of operational Navy, so I didn't see that much of him.

Before I came here to the United States, I did about six months attached to the HMS *Vernon*, working at the Royal Navy Physiology Laboratory (RNPL) and AEDU, really learning a bit about saturation diving. I did a couple of saturation dives to really get my feet wet, as it were, so that when I came out here I'd at least have some understanding. In fact, at that time there were two US officers on exchange with whom I worked. One was Stan Kwiklinski. The other was Jim Vorosmarti. I worked with Jim and Stan a bit.

DR. EDWARD THALMANN

The Ocean Simulation Facility (OSF) had been under construction for some years, and I forget when it started, but it was instigated by George Bond, and from the *Man in the Sea* program. That was totally separate from NEDU. The OSF was to have nothing to do with NEDU. It was to be a totally separate facility run by the guys in Panama City. The *Man in the Sea* program, I wasn't an expert in it, but with Berry Cannon's death, there was a lot of political stuff, and George Bond got put in Panama City.

I think George's being assigned to Panama City was kind of a purgatory to him. He had been appointed to a lot of highfalutin communities, but they wanted to kind of get him away from Washington, so he had been dispatched to Panama City. The OSF was supposed to be some kind of a simulation facility in which aquanauts would train and eventually go out into the real ocean and do wonderful things.

I don't know how it meshed with SEALAB. As we all know, after Berry Cannon died, the whole program folded. I know little or nothing about SEALAB except what was written down. I had no personal interaction. At any rate, somewhere along the line, I guess it was decided that they were going to dedicate the OSF in Panama City and then mothball it, because they had to let the contract finish, but they didn't set aside any operating budget.

Captain Gene Mitchell, the Director of Ocean Engineering (NAVSEA-OOC), decided that NEDU should go have a look at the OSF and see if the facility would meet their needs. Captain Mitchell then dispatched a guy named Don Chandler to go down to Panama City to see if the facility was suitable.

Don Chandler was an MSC lieutenant at the time and a diving officer at NEDU. He was sent

down to see if the Panama City facility would suit our needs. I was not privy to all these conversations. All I knew was from what I could gather by being there and listening to different people talk. But the bottom line was, yes, the facility seemed to have many of the things NEDU wanted, but no, it wouldn't exactly suit their needs. NEDU was instructed to go down there and look at it and try to get it buffed up so they could use it.

That was in 1972, right after the 1600-foot dive. I made several trips to Panama City with Bill Spaur and Bill Brathwaite to look at the facility, and it was about that time that Ed Flynn came back from SUNY Buffalo and ended up at NEDU. Ed had completed a two-year physiology post-doctoral fellowship. Some years later, he did an anesthesia residency at Bethesda.

NEDU moving to Panama City was a political issue and commenced because the lab in Panama City, at that time known as the Naval Coastal Systems Laboratory (NCSL), envisioned that NEDU would come in and provide the people to operate the OSF, but they, in fact, would be in charge of it and direct NEDU as to what should be done with it.

Of course, NEDU had different ideas. They said, "Oh, we're our own command. We will be in charge of it. We will be in charge of diving it, and we will be in charge of scheduling it, and we will be in charge of it, period." A lot of political fighting went on to decide who was going to be in charge of the OSF, and at the end of the day, it was decided NEDU was. The lab had to get all their people out of there, and that was the end of it, although NEDU was instructed to work closely with the lab, because NCSL was in the business of developing certain kinds of diving gear.

George Bond was still around at the time. We'd go down to NEDU and he was there. George retired and went back to Bat Cave, NC.

At that time, we had begun to do these things called "saturation excursions," in which we were trying to develop tables. If a diver was saturated at some depth, how shallow could he go without getting bent, or if he was saturated at some depth, how deep could he go for a given time and still return to his storage depth? We had done a bunch of dives at NEDU (north) for that, and the first dives in Panama City were a series of dives to look at the saturation excursion dives. That was a project that was already in the mill and was suitable because it already had prescribed a bunch of dives at different depths down to whatever. Bill Spaur had mapped out a plan at NEDU in which we would begin going deeper and deeper to the maximum pressure of the facility, which I think was 2,000 feet.

They did a 1,000 footer, a 1,200 footer, a 1,400 footer, a 1,500 footer and culminated in the 1,800 foot dive, which was the deepest dive that they ever did in the OSF. Because as we were pushing deeper and deeper, the politicals in Washington were fighting amongst themselves and eventually decided that the Navy's maximum depth capability only needed to be 1,000 feet, or something like that. I'm not sure what went on. I have no idea what drove the decision. Nobody asked me.

My first tour to Panama City was short, and the reason is that while NEDU was in the throes of deciding on Panama City, I had been accepted into a post-doc position at SUNY Buffalo. The original plan was that I would finish up at NEDU in July of 1975, go to Buffalo for two years, and then come back to NEDU. Well, somewhere before 1975, and I'm guessing it was July of 1974, moving to Panama City became a fire drill, and all of a sudden it was very important to move down there at once.

I thought I was just going to mark my time in Washington until I went to Buffalo. But around July, Ed Flynn, Ken Mihwa, and I went to Panama City and we began going through the throes of getting the medical department moved to NEDU. Spaur was still the senior medical officer. Flynn had decided he didn't want to go to Panama City; he wanted to stay in Washington and made kind of a big fuss about it. In the end, he ended up going to the dive school.

The helium tables were actually finished before the air algorithm was done. Those got published and were based on the 75-meter heliox tables for the Royal Navy EOD when I was stationed in England for two years. Speaking of England, while I was there we had the opportunity to finish up saturation excursion dives. The other big study we did over there was the thermal garment study for the Royal Marines, who had gotten themselves some SDVs and admitted that they really couldn't do 12-hour missions, as some of their scenarios called for, and stay warm.

We did a fairly extensive thermal study, mainly with dry suits, looking at the various under and outer garments and different kinds of gloves. We used the test pool with an SDV mock-up in it. The divers went down and sat for many hours, and they were instrumented with a bunch of heat flow transducers. It was a 12-point model, so each one of the transducers was at a certain anatomical position on the body, like a forearm, upper arm, thigh, back, et cetera, and the nice part was that we wanted to make modifications to the garments. They could take them over to a wet suit shop in Portsmouth and get the stuff done right off the bat. In the end, we did pretty well.

We came up with a very nice thermal garment, which was based on a rubberized outer garment, one that was fairly thin but very flexible, and a Thinsulate undergarment. I guess the main thing we did was a set of gloves. We used Thinsulate ski gloves underneath what were then sold as windsurfing gloves. We got very large windsurfing gloves and pulled them over the Thinsulate gloves. We made up a sealing arrangement at the wrists, and that didn't put any pressure on the wrists but kept the hands pretty warm. The Royal Marines were pretty happy with that garment and went out and had a whole bunch of them made up. They used them for quite some time, I understand.

When we got back to NMRI, I found myself in charge of the Decompression Research Group. I found, and maybe I expected it, that really nothing in decompression had progressed since I had left NEDU, at least in terms of operational procedures. One thing that had happened was that Paul Weathersby and Lou Homer had come up with this probabilistic decompression modeling technique, which they were using to incorporate large numbers of diverse dives. They also used it to compute parameters for decompression models based on a lot of different dives.

Looking at this while I was in England, I didn't quite understand it and, when I got to NMRI, I immersed myself in it to the point at which I began to understand what was going on. I will admit that in the beginning, I didn't thoroughly buy off on what they were doing, but after a while, I began to see what was going on. At the time, they were using exponential models, the typical Haldanean exponential uptake and offgassing models. Based on those models, they went in and did risk analyses of Navy tables, DCIEM tables, and various and sundry other tables.

They would take this exponential model and calibrate it against a bunch of man dives, of which they knew the profiles and whether somebody got bent. Once they had a good set of parameter values, they could go ahead and turn around and take any dive profile and put it through the algorithm. It would spit out a probability of bends. Basically, once they were done, they could take any profile they wanted and compute the theoretical probability of decompression sickness. They did that for air tables, among others.

Looking at their effort, and reflecting on the fact that at NEDU our exponential uptake on an off-gassing effort really led us into a brick wall, I injected the V-val 18 model into it, the exponential uptake and linear off-gassing model. Now, in order to convert this to a probabilistic model instead of using M-values, we used time integration, the super saturation ratio. It was a difference between the theoretical tissue tension and the ambient, so it was a super saturation difference, or the super saturation itself, and we

said the time integral of that somehow related to whether you got the bends. We took all the dives that we had done at NEDU and any other dives we could find and came up with a new set of parameters. Some actually fit better than anything that had been tried previously.

Therein began the NMRI effort looking at what we called the LE model. Now, once this happened, I began to wonder if we shouldn't go back and have another look at the air algorithm dives, those we did at NEDU that were not quite as satisfactory as we wanted. I was told that there wasn't a lot of NAVSEA interest in doing this. Well, I went down and saw Captain Chuck Bartholomew, and in the end, he agreed that we should begin pursuing a revised set of air schedules, but he didn't want to link it to a piece of hardware.

The reason he didn't want to link it was not because he didn't want a decompression computer, but because he didn't want new air tables to be held up waiting for a decompression computer. If the tables had been ready to go before the computer, they would have done that.

He gave us the go-ahead, and we wrote some routines that allowed us to actually compute the tables in real time, which was a bit more complicated than the V-Vals because of the math. Without going into the details, there are a lot of iterative techniques involved.

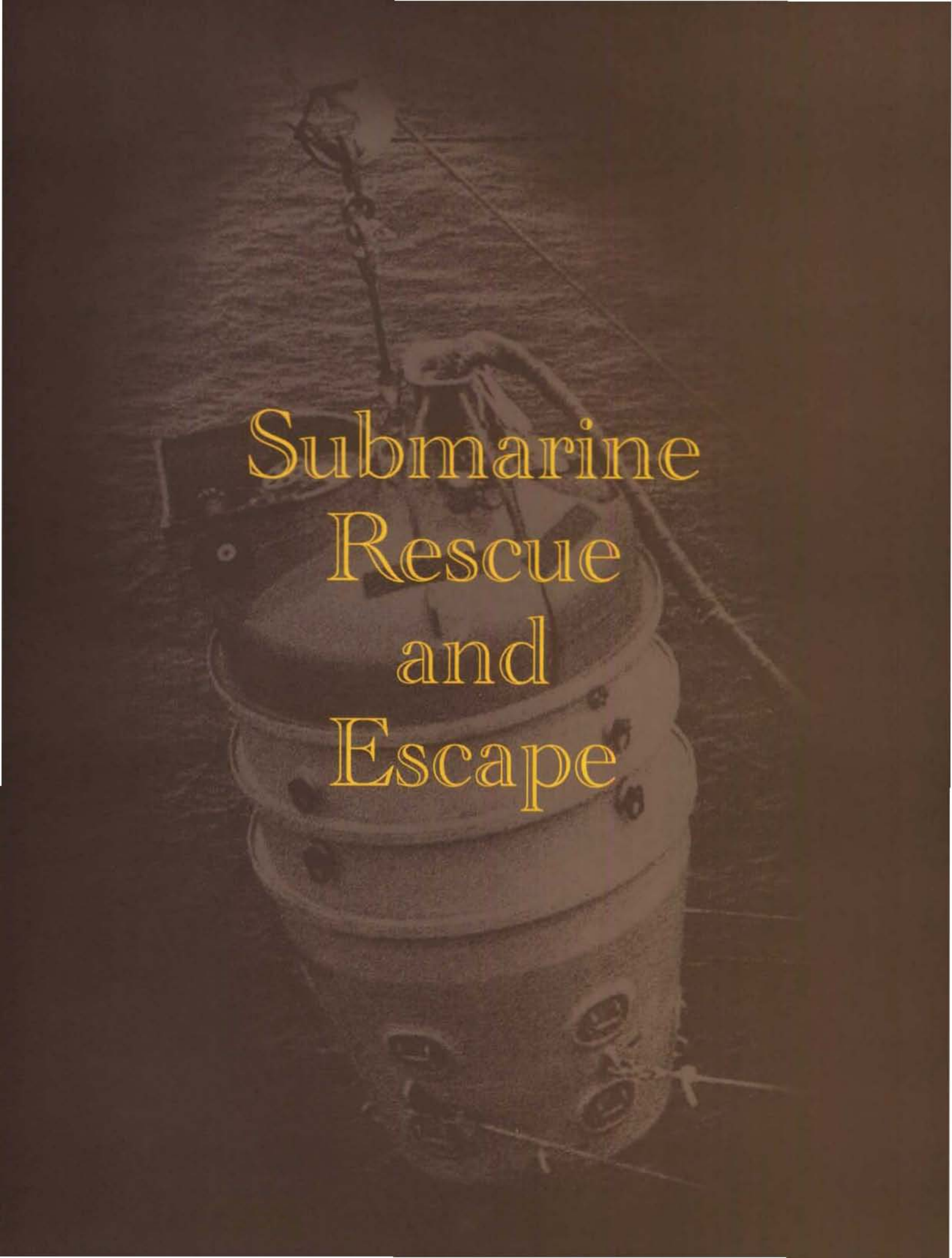
The people working on this project included a computer contractor named Shalani Shurvansi and a guy named Eric Parker. They were the two main efforts at NMRI, in terms of getting the software up and running. A big dive series started out with NMRI doing small numbers of dives to see if it would work. Basically, the idea was to see how the algorithm would work prospectively. In other words, we had gotten a set of parameter values that again would predict certain decompression sickness probabilities for certain dives. Then, we went out and dove those profiles to see how close they were. In the end, we had something called a NMRI 93 model. The idea was to then sell this to NAVSEA.

Well, the problem with the model was that the longer dives predicted very, very long decompressions, and I had my misgivings about whether the fleet would buy off on it. It turned out they didn't. In the end, they looked at it and said, "We're not having a lot of trouble with our air dives, and we're not really interested in having these incredibly long decompression schedules when we don't think we need them."

I think the "we" were the master divers, mainly, who complained loudly to NAVSEA about it. There weren't any specific complaints. They would say, "Hey, these things are long," and "We don't need them that long. It's going to hurt our ability to dive." When we went back and tried to show them that they would very rarely dive long profiles, it didn't make any difference to them.

The no-stop limits were fine, but the repetitive procedures turned out to be pretty complicated because of the profiles we were computing. Rather than having a procedure in which you came up from a dive, you had a repetitive group, and used that to calculate some amount of time you added to the bottom time of your second time; you actually came up with a repetitive group based on the surface interval that would decay. Then, rather than compute residual nitrogen time or some such thing, you actually picked up a new set of tables so that there were eight or ten volumes of tables.

Now, I didn't think this was a bad thing. There were more tables, but you didn't have to do any math. In the end, the fleet divers, I guess, didn't buy off on it. At any rate, the whole thing slipped to the back burner. Eventually, the Navy did turn around and allow a contract to build an underwater decompression computer. Cochran built one, and the V-Val eventually got installed in that. The operators had some misgivings about it. If you look at some of the profiles on paper, there are some that have much longer decompressions than you would utilize for other procedures.



Submarine Rescue and Escape

Submarine rescue and escape is of foremost importance to US Navy submariners, maybe because relatively few have actually escaped from a submarine. In the past, most submarines have gone down in water too deep for rescue, and very few submariners have survived such dreaded circumstances. Indeed, if it weren't for the need for submarine rescue, deep diving may never have been a priority for the US Navy—altering worldwide diving history and technology research today. However, the U.S. Navy has always attentively investigated ways to rescue their own, and for most of the last half of the 20th century, they maintained Deep Submergence Rescue Vessels (DSRV) intended to accompany a "mother" submarine. The U.S. Navy designed DSRV's to deploy quickly within the crisis vicinity and attach to a downed submarine such that survivors could transit from the submarine to the DSRV, ideally at one absolute atmosphere of pressure, and proceed to the surface. Since the late 1920's, rescue operators have also used the McCann bell to free trapped survivors. This system proved its value when Navy ops used it to rescue 33 survivors from the USS *Squalus* on May 23, 1939. Today it remains a very simple yet capable rescue system. While submarine rescue and escape drove researchers to move deeper and deeper into the ocean, other devices such as deck decompression chambers and personnel transfer capsules thrust technology forward, generating spin-offs that deep diving technology could use for other Navy projects, such as submarine-based clandestine operations. The following oral histories contain some of the stories of those who were involved in these terrible missions and who can be credited with many extraordinary contributions to Navy undersea technology.

MR. CLAYTON DECKER

My name is Clayton Decker. I was born December 12, 1920 and raised in Paonia, CO; my grandparents had a cattle ranch there. In Colorado we have the Rocky Mountains running right down through the middle of the state, and so we experience all four seasons fully. As a matter of fact, the little valley in Paonia that I came from is referred to as North Fork Valley. My grandparents settled in that little town in 1882.

Growing up on a cattle ranch was a great experience. When I look at the experiences that I had as a youngster, I often think, "Oh, how I would love to have had my youngsters grow up in that very same environment." It was slower living, but we had everything. We had a great school system and a hospital about thirty miles away. We experienced everything that people did in the big cities, but that country living was great, and I missed it after I left.

In 1940, I graduated from high school. I married a high school sweetheart right after I graduated. The young lady that I married, her father was a coal miner, and they lived up the river about ten miles in the little town of Somerset, CO. After we were married, we lived with them. We moved in with them in Somerset. I got two years of college in. But in the summertime then in order to make some money, I had to mine coal. The only money that really you could make of any consequence came from working in the coal mines. The two summers of the years that I did attend college I worked in the coal mine there at Somerset.

That was one of the things that helped me get in the submarine service, too. If you work in a coal mine, you certainly can't have claustrophobia.

I attended agriculture college in Fort Collins, CO, for two years. When the war broke out and Japan bombed Pearl Harbor, like many of the other college students, I wanted to go and fight for my country. I discussed it with my wife, and it was agreeable with her. At that point in time, we had a youngster who was a year old.

Then, I had to make the decision as to what service I should join. I used to think about the Army. I thought, "Well, I like hiking, but I didn't know whether or not I wanted to do that much hiking." The other thing that I had heard about the various services, if you were going to

join one of them, was that you had to take two main things into consideration. One was a nice, warm bed, and the other was the chow, and I thought, "Well, now, if I join the Navy, I'm going to have both of them right along with me wherever I go."

I selected the Navy. In Colorado Springs, we have the big air academy there and so forth. I said, "Well, here I am on a cattle ranch." I'd never ever flown in an airplane. The closest I'd ever come to riding in an airplane was a roller coaster ride.

I joined the Navy with the recruiter who came to Paonia, there were four of us who joined at the same time. He gave the four of us "chits" to ride the train into Denver, and we signed up when we got to Denver. It was Christmas Eve, 1942, when I got on a troop train to go to Faragut, ID, to boot camp. It was a brand new camp that they had set up there.

As a matter of fact, at Faragut, there were actually seven camps in the complex. The camp that I was in was called "Benyon." I don't know who it represented, but probably someone who was a naval officer would be my guess. I can't remember. But I was there for three months.

Then we were asked, "Have you given any thought about what you want to be?" Back in those days, right arm ratings pretty much meant activities in the Navy, that pertained pretty much just to either boats or ships. I say "boats" because we called submarines boats. Left arm ratings, you know. I just wasn't that well acquainted with it, and I went with the right arm rating and asked to go to torpedo school.

I didn't understand it well enough. After all, what did a torpedo man do after he got out of the Navy? Who was selling torpedoes or buying torpedoes, you know? I ended up being a left arm rating, but I did select a right arm rating. I selected torpedo school. From Faragut, Idaho, I was sent to Norfolk, VA.

Going there on a troop train was a good experience. I enjoyed that. I really did because, again, I was from a little cow town like Paonia, CO. I was on the train with all these guys and was treated royally. We would stop and get lunch, wherever we might stop. Oh, we made one stop overnight in Chicago, coming out of Faragut, going east, of course, and two of the lads who were in the group going to Norfolk had parents in Chicago. We got invites to go with them to their homes, but they didn't go. We just pretty much stayed around the train there and spent the night there in Chicago.

Then, we went on to New York City. Again, we had a little delay there. It was the first time I had ever seen any big city like that. The biggest towns I had seen up to that point were Denver and Grand Junction, CO. But I mean, seeing Chicago and seeing New York was, for this cow town boy, a new experience.

Then, we went on to Norfolk and got involved with the torpedo school and the torpedo class, which was interesting. It really was interesting. There again, we would say, "Hey, we want to do our part." We were at war with Japan. We said, "Let's get with it." Of course, the one thing that I did do that I probably wished I hadn't done in Norfolk was get one tattoo on each arm. Down the line, I'll tell you that those tattoos worked out favorably for me, and I'll tell you about that experience a little later.

The other thing that was exciting for me at Norfolk was that the torpedo class I was in was a class of 26 men, and believe it or not, I came out number one in the class. I had the top score in the class, and that gave me a rating of torpedo man third class from Norfolk.

While we were there, the steam torpedo, the Mark XIV, was the only one that we worked on. I didn't become acquainted with the electric torpedo until after we had made at least one patrol. But the steam torpedo, we learned all about it. We could tear that motor down and put it back together. We learned everything there was to know about that steam torpedo.

The classes were all day sessions. Of course, there were no classes Saturday, and of course, no classes Sunday. I enjoyed Norfolk. I made several liberties to town in Norfolk with the boys. Back in those days, you could get one of two things;

most popular in the pubs was either Valentine's Ale or beer. We'd go to town and have our share of that and then back to the base. It was late summer before that class was over.

We were given an opportunity then. The submarine service was strictly voluntary, but we could ask for submarine service, PT boats, Navy air, as far as torpedoes were concerned, and I believe the other option was destroyer duty. Destroyers had torpedo tubes at the time. It was one of the four. Well, there were three other lads with whom I became very well acquainted, both in boot camp and at torpedo school. We decided we would volunteer for submarine service, and we did. Of course, that was just the beginning. They sent us from Norfolk, VA to New London, CT.

The very first person who interviewed me at New London, at the submarine base, was this chap who, right off the bat, said, "Why do you think you're qualified for submarine service?" I told him, "Well, maybe I've got a pretty good answer. I worked in a coal mine, and I think that would prove that I don't have claustrophobia." He said, "That's a good thought. That's a good answer."

I found out later that, as a matter of fact, they absolutely did check to find out whether I did, in fact, work in that coal mine. They found out that I did. Anyway, I was accepted. I was accepted into the school to become a submariner.

There was a lot of classroom time in submarine school. It's interesting to talk to submariners from back in my era. They can remember the S boats and the R boats pretty well. By golly, when I went to sub school they had the old O boats, and I trained on an old O boat.

We would go out on an O boat about once a week during the time we were going to school at the sub base. One of the lads asked me, "You don't have claustrophobia because you worked in a coal mine, but are you fearful that maybe one day that iron tube will wind up being your tomb?" I said, "Well, absolutely." I think that with every submariner, it has to go through his mind. It certainly did go through my mind that very possibly that that could happen. But my goodness, I really looked forward to my very first experience making the escape at the hundred-foot tower.

One name I can remember from the sub base was a man who was very interesting, Chief Petty Officer Charles Spritz. We called it "Spritz's Navy." Now, he was a Navy man. As a matter of fact, he was one of the divers who went down for the USS *Squalus*. He'd take the new recruits coming in, like us, and he had a battery of Marines. They had a brig and everything else, and believe it, he was a tough one on the young guys. Really, I've thought about it since those days with Spritz, and that man really made men out of a whole lot of young lads like myself, a young man off a cow ranch in Colorado. He really did. He knew what he was doing and how to control men and tell them to get up, brush their teeth, get going, and that sort of thing.

I remember one lad from the barracks at New London. His father was one of those guys who, when they built the Holland Tunnel, were called "hoggers." It was interesting to him, because before they would allow us to actually go in and make the escape, we had to go into a decompression chamber. He used to tell us about his dad being a hogger, and that while working in the Holland Tunnel, they had to do that very same thing before they would go and put in a shift to work down there. The thing that we discovered in going into that decompression chamber was that you got a bang when they put that pressure on you. It's a misnomer to the average layman. You say, "Decompression chamber," but they put pressure on you, even though they call it a "decompression" chamber.

Anyway, when that really got hot and heavy, you looked at somebody else and if they just smiled at you, you thought that was the silliest thing you had ever seen. The other main thing about it was that we were told the reason it was done. Let's say that maybe you went through the procedure just yesterday and overnight you developed a cold or a little ear infection or something like that. It would show up as soon as they put you in that

decompression chamber. Well, that told you not to put that man in there and put a hold on him, because something was not right.

But the training in the chamber itself, man, I have to tell you, was the thing that saved my life, absolutely. The training in that escape chamber was what saved my life. You were standing in that room, in the escape chamber at New London. You were standing in water. The thing that dropped down the center was what they called a "skirt" and it came down just about chest high. It filled you up with water up to the bottom of that skirt. When they opened the hatch and dropped that column of water, it was a little scary. You were standing there and it came up and then settled back down. It was the same experience as you got up in the escape chamber when you made it on your own.

Even though you built up the pressure inside to exceed the outside pressure by five pounds, when you opened that hatch, that water wanted to come in. The water right there would come up under your chin and settle right back down again. That was kind of a hairy experience.

There was another thing that really fascinated me at the time, the early summer of 1943. I was going through submarine school in New London. There we were, with our lungs on, mouth pieces in, nose clamps on, and we'd wrapped our legs around the line, stopping at every knot, every fathom, every six feet, exhaling, inhaling, as we were told to. You had these lads who were instructors swimming around you, just in their swimming trunks, and there were blisters on the side. They could swim into those blisters and get a breath of air and come back. Little did we know then that it was going to be the procedure down the line, the free ascent, or "blow and go."

It was interesting to me, because I would be looking up, letting the knots pass through my hand, and I stopped and hesitated, and exhaled and inhaled. Then, there would come one of those instructors right up to me. Of course, when you talk under water, the bubbles just come out. They said, "You're going too fast," or they might have come up and said, "Slow down a little bit." You could hear them. They'd come right up to your ear and then boom, they'd scoot back in for another breath of air, but they'd be right there watching you. It was a great experience, oh my. After my first time, I said, "Hey, let's go again."

It is interesting that during the time you're making that ascent, there are bubbles coming up from that exhaust valve all the time. It's because that external pressure is decreasing, so there are bubbles coming up out of it all the time.

During submarine school, we'd go out on the O boats about once a week to get the feel of a dive and being down. On a couple of occasions, even after guys would say that they were accepted, they went out on a boat, on a run like that, and they would came back in and say, "It's not for me." There was one lad, in particular, in the same barracks that I was living in at New London. He just said, "Hey, it's just not for me. It's not for me."

After you were in and assigned to a boat and made a patrol, all you had to do was go to see the chaplain after a run and say, "Hey, mentally, I can't take it." There were no questions asked. You were out.

On my first assignment, even though I had a third class torpedoman's rate, they'd say, "Hey, when you go as an enlisted man, I don't care if you've got a rank or a rating of any kind. You're going to do your share of peeling the potatoes and everything else. You can rest assured that on a first patrol, you're going to do it. Now, that's all there is to it."

I knew that was going to happen when I went aboard the *Tang*. Back in those days there were not very many boats that had boatswain's mates aboard. They had a boatswain's mate. We had a first class boatswain's mate aboard the *Tang*. I went aboard and I met this lad. Remember that I was off a cattle ranch in Colorado, and I swore that man must have been related to Hitler. He cracked a whip and basically, it was right arm ratings. We not only had a boatswain's mate but we had a boatswain's mate

striker and he was kind of cocky, also. The first class boatswain's mate knew the Navy manual and he could quote it. I mean, you'd ask him what was on page so and so, and I think he could tell you. That nice guy was one of the nine survivors, by the way, and we became very close friends. But I did my share of potato peeling.

I stayed out of the way of the boatswain's mates as much as I could, and I didn't ask to get off the *Tang*. But after that first patrol, I asked the executive officer if I could become a seaman first, and go back to the black gang. That boatswain's mate is a wonderful guy, and we have a great rapport yet today. We email back and forth, and he knows my wife, I know his wife, and he's got a beautiful home up on Palamar Mountain out in California. He stayed in the Navy and retired as a full commander.

Anyway, a very good friend of mine on the *Tang* told me, "Clay, if you break down first class, come on back to the black gang." I broke down, went back in the black gang and learned about Fairbanks Morse diesel engines. They were beautiful things, beautiful pieces of equipment in both engine rooms.

When I arrived at Mare Island to report aboard the *Tang*, I couldn't go aboard. She hadn't been commissioned yet. They put us in the barracks and we'd go down, daily, to the *Tang* to do various chores and so forth, and we had oodles and gobs of civilian people. For instance, we had a Westinghouse maneuvering panel, so we had people from Westinghouse there. We had Fairbanks Morse diesel engines, so we had representatives from the Fairbanks Morse. We would just go down on a daily basis and acquaint ourselves with the boats, help wherever we could, stand watch down there, and that sort of thing.

That was where I first met the chap who I mentioned to you about changing my rate. His name was George Lofkin, and he had just completed five runs on the USS *Tunney* before being assigned to the *Tang*, and he was a First Class Motor Machinist's Mate.

George looked me up in the barracks at Mare Island, and he said, "Clay Decker, I understand you're married and you have a son who is two years old. I have a son who is two years old. Clay, I just bought a home at 67 Stoney Ford Avenue in San Francisco, and it's on one of those steep hills." Today you'd call it a condo, because if you go out to San Francisco and look, you'll see that 67 Stoney Ford is still there, but the house is split with next door with a common wall. A common wall divided this house from that house, and when you stepped out the front door, you were on the sidewalk. It had a back yard about the size of a postage stamp, but it had two bedrooms. He said, "Clay, I bought this house for $5,200. I don't know how I'm going to pay for it." My wife was out there in California. She was a secretary to the chief executive officer at the Kaiser Ship Yard, and she had hired a babysitter. He said, "Clay, how about you and I getting together? We're going to go out on the *Tang*. Your wife and your youngster could move in with my wife. We've got two bedrooms. My wife, Martha, is strictly a housewife. She could baby-sit the boys and take care of them. You and I are going to be on the *Tang*. Your wife could be out bringing in some of the beans." Boy, it just worked out perfect, and we did that.

When George and I went to sea on the *Tang*, our wives were living together at 67 Stoney Ford Avenue in San Francisco. Like I said, George was the one who helped me out then, rescued me from the Boatswain's Mate, and we laughed about that, we really did. When we got into the prison camp, we got to know one another very well.

Anyway, George asked for this arrangement, and it worked out great, and we put the *Tang* into commission. We were out at Pearl Harbor, at the sub base on Christmas Eve, basking out on the deck of the *Tang*. In January, I was looking up at the moon and the stars and said, "Gee, back in Colorado there's got to be a foot of snow on the ground, and here I am out here in beautiful Hawaii, on the *Tang*.

The *Tang*'s skipper was Richard O'Kane. I first met him when he called us all topside, even before the commissioning, and chatted with us, because we came from all walks of life. Like I said, George Lofkin already had five runs on the *Tunney*, but he was brand new to O'Kane.

Dick O'Kane, I think, was an officer and a gentleman. There's no question about that. But O'Kane definitely used the chain of command. In other words, he didn't want just everybody coming to him with any problems, you know. He wanted us to go to the chief of the boat or the executive officer, and rightfully so. I mean, he had enough on his mind.

I'm sure that you've heard that Richard Heatherington O'Kane was a Medal of Honor holder. I don't know where the title came up, how it ever came about or who started it, but he got the title of "Killer." As a matter of fact, at the Naval Academy one day, one of the leading officers said to me, "I'll never forget the first time I met 'Killer' O'Kane." People ask me about that and I say, "Hey, look, I don't know." They have to mean it jokingly. The man was married just like I was. The man had two youngsters and I had one. He didn't want to die any more than I did, but he was going out there to do a job. He had a job to do. I think we all have to agree that he and the *Tang* did one heck of a job.

Tang only made five patrols, but hey, the *Tang* only fired torpedoes on four of them. On our second patrol, the Battle of Truk Island, we didn't sink a ship. In order to get a star and your combat pin you had to sink at least one ship. We never sank any ships on that second patrol, but we picked up 22 flyers out of the water.

This year the VA made me a 100 percent VA patient. The Disabled American Veterans, the DAV, helped do the paperwork for me. The lad who did it said, "Mr. Decker, are you aware of how many medals you're entitled to?" I said, "Well, you know, I have the Silver Star and the Prisoner of War, and when I go to conventions, I wear them on my little vest. I'm proud of them." He said, "You're entitled to sixteen. If you don't mind now, one of the things that happens when you become a 100 percent disabled veteran is that the Navy Department will send you a copy of every medal you're entitled to," and they did that. One of them I got, believe it or not, was because of that second patrol, picking up all those flyers. It is black and white. I am a recipient of the Navy Air Medal. Now, how in the world does a submariner get hold of a Navy Air Medal? But, fellows, I have one. It's there. They tell me I'm entitled to it, and so it's there.

On my second patrol, I really saw more of the skipper than I did on the first patrol. Back in the black gang and particularly in the forward engine room was where I had my station on second patrol, when I went back to black gang. That was where we had our two water evaporators below decks, in the forward engine room. During most of the second patrol, I got to the point at which you could blindfold me and I could take one apart, clean it and put it back together. I don't think I ever did have both of them going at the same time, because one of them had to be down to be cleaned and so on and so forth.

That was one of the other things that put me on one hundred percent disability. So many people aren't aware of it, but hey, those World War II boats were just loaded with asbestos. The metal covering around the evaporator, when you pulled it off, showed a thick covering of asbestos around the hummer, you know. I cleaned one at least once a day, but more often twice a day.

Anyway, Dick would come back, call it a white glove inspection, if you wish, but he noticed things. He would tell you, "Good job, sailor, good job, good job, looks good, sailor, looks good." But he was all business. There was no "ding donging" around. Never did I see him come into the crew's quarters and sit down in the galley or sit down on the table and just chit-chat. The executive officer, Murray Frazee, did. Bill Ballinger, who was the chief of our boat, put five runs on the *Tunney* before he came to the *Tang*. Bill was one great guy with the crew. I mean, Bill Ballinger was just one of the greatest, as far as a chief was concerned.

On that second patrol, I went to Bill first and told him, "Bill, I really think I want to be a motor machinist's mate." "Okay," he said, "I'll get it set up for you to talk to Murray," and I talked to Murray Frazee. By the way, on the very first patrol, we took turns at bow planes and stern planes and that sort of thing, for some reason or another. Murray Frazee was executive officer aboard the *Tang* and he made four patrols with O'Kane. It was Murray Frazee's job to select permanent bow planesmen and stern planesmen on the very first patrol. Anytime we were called to battle stations submerged, and it didn't make any difference where you were or what you were doing, you'd drop what you were doing and go to the battle stations to which you were designated. He selected me. Murray is now retired. He lives in Gettysburg, PA.

About four years ago, my wife and I visited him, and I asked him, "Murray, how come you selected me as bow planesman?" Remember that I came off a cattle ranch, and the term, of course, is "catching the bubble." We had an arc about as big around as your finger, the glass bubble and, for some reason or another, there I was, off a cattle ranch. He said, "You had the sense before anybody else. When that bubble started getting away from you, you knew to tell the diving officer to ask the man to pop some weight." You remember the movie *Das Boot*? Remember how they shifted weight and sent men forward or sent men aft? Well, I apparently sensed it more quickly than other guys did. I was not going to be able to catch it with the bow planes. I'd say, "Give me some weight aft or give me some weight forward, or whatever."

I told Murray, "Murray, by making me permanent bow planesman on the *Tang*, on that first patrol, you really saved my life." When we hit that convoy on the fifth patrol, one of the first things that O'Kane called for was for everybody go to battle stations submerged. It was 2:00 a.m. and we were still on the surface and everything. That has been the thing that's been so confusing to a lot of people. What the heck happened? You were at battle stations submerged but were doing everything on the surface. That was exactly what the situation was.

But I told Murray Frazee, "Murray, you saved my life because I was back in the forward engine room on the throttles. I was standing watch on the throttles in the forward engine room." Word came over to go to battle stations submerged. I turned the throttles over to Zofkin and went forward. There I was, sitting at the bow planes in the control room at the front row seat whenever action took place on the *Tang*. I could open the hatch and go up in the conning tower. The ladder was right here. I could reach out and touch the ladder. There was the chart desk right there in the center of the control room. The Christmas tree was nearby. The man on the water manifold was over on the starboard side. I just sat right there, not going anywhere. We had not called for a crash dive or anything. I was listening to everything that was going on up there with the fire control party. I knew exactly what they were doing up there. I had a front row seat.

On a submarine, before you would ever see a target you'd see smoke, because most of those ships were either oil burners or coal burners. If they were bending it on at all, boy, they'd give off a smoke stream that you could see for miles. If you were up topside, up on the periscope or as a look-out, we were told that our distance was seven miles to the horizon. As a matter of fact, on that fifth and final patrol of ours, at 2:00 a.m., the targets were picked up on the radar, originally.

Like I said, I was sitting there in a front row seat. They called a fire control party, of course. I had been a torpedoman, the thing for those who are qualified and have their submarine-qualifying dolphins. On the O boats, we were told that you had a good 5,000 lines, valves, gauges, or something. When the qualifying officer went through that boat with you and he pointed to something, you'd better have known what it was. If it was a valve, you needed to know what the valve was for and what it did. If it was a line, what went through that line? Was it air, hydraulic oil, water? Fortunately,

I was exposed to torpedoes, and the fire control party would go up there and they'd talk about putting the data in the torpedo, "Run so deep and blah, blah, blah." That all meant something to me, probably more so than to a lot of the other guys, having been a torpedoman.

By the same token, the thing that used to interest me the most was why the fire control party was so concerned about turning the gauges until they put data into the torpedo. I didn't understand it until it was really explained to me. What they were doing was figuring out how much water a vessel drew, because we knew how important it was to try to get the torpedo you sent to hit it as close to the keel as it could.

Oh, the torpedoes. What a nightmare we had, really. Only on one patrol did we bring back a torpedo, and it had to be an electric one, too. But we had torpedoes. The sad thing was that on a target, maybe close to shore, the torpedo would go under the target and explode over on the beach. Our immediate boss, who was in charge of the submarine fleet out there, was Admiral Lockwood. Oh, we felt so sorry for him. Boy, he was pulling his hair. If I remember correctly, one of the trips that he used to make pretty frequently was to a torpedo factory. Lockwood, bless his heart, was a wonderful man. He was a great guy. Admiral Lockwood, our boss, never missed being right at dockside any time we'd come in off patrol. He was right there to greet us, right there to shake hands with every man as he got off that boat.

Getting back to the fire control party, I was told that when Richard O'Kane was executive officer on the USS *Wahoo* he did most of the periscope searching. He did so aboard the *Tang*. We really took our hats off to Admiral O'Kane. Those destroyers would be coming in right down the throat and he'd hang right in there and lay it to them and blow them out of the water.

Many people have asked, "How well did you know Admiral O'Kane?" and I say, "Hey, look, the Japanese used to throw us in a tub with a bar of soap once a month. I took baths with him." On one patrol, we brought one torpedo back.

From our standpoint back then, we didn't want anyone, particularly Tokyo Rose, knowing where we were going. Until we cleared the torpedo nets, why, we didn't open the orders to know where we were going.

When they opened the orders, the skipper would come on the intercom and tell us all where we were headed, where we were going on



Topedoes

that patrol. He did so, even though we stopped at Midway to top off our tanks before we went on to the Formosa Straits. Submariners, back in those days, absolutely hated to patrol the Formosa Straits. Today it's called "Taiwan" or the "Taiwanese Straits," but they were the Formosa Straits back in those days. I tell people, and anyone who knows a little bit about the geography of the Pacific knows, that the Formosa Straits have, probably, the shallowest water in the whole Pacific Ocean. We knew, all of us, regardless of our rates or how many patrols we had made and so forth, about the Japanese, as far as their depth charging was concerned. It was just common knowledge. You took a 55-gallon drum, filled it half full of TNT and dumped it out in the water. It took in a little salt water, but it would only gain so much weight, and anything so heavy will only go so deep. They were not self-propelled.

The thing that we were most fearful of, however, involved the pressure hole and flood valves. You had your vent valves on your bow tanks. When you were maneuvering and shaking down and you were back at port and so forth, you would use the flood valve and the vent valve both. But when you went on patrol, flood valves opened and locked open. The thing we feared the most was a depth charge going off below us, blowing those ballast tanks clear out of the water and popping us to the surface like a cork. That was the thing we used to fear most. We didn't mind them—too much—going off to the side or right above and so forth. I want to tell you something. The crew on the *Tang* went through some long, terrible depth charging experiences. We really did.

Just before the depth charges went off, they went click, click. You could hear them on the sub. They went click, click, and bang. Some people ask, "What did it feel like?" It was as though you were in a 55-gallon drum with somebody beating on it on the outside with a hammer. Like I said, there were some guys, who, with depth charging in particular, just could not take it. They'd get in, go to see the chaplain, and that was the end of it for them. They weren't belittled or anything like that. It was just routine to be able to do it that way.

There was no panicking or anything. It is so interesting. I haven't had anyone explain this to me, but it's interesting. Last year, in August, that Russian submarine went down on the East Coast of Russia. The media got in touch with me immediately and, as a matter of fact, you might have seen me on Tom Brokaw's program. Anyway, they were asking whether those guys were panicking down there. Well, I told them, "Look, if they were trained like we were trained, they weren't panicking." Even in that kind of a situation, they weren't panicking. We didn't panic. But the thing that confused me was that they were talking about those guys freezing to death. In many, many depth charge attacks on the *Tang*, if the bottom was 400, 500, or 600 feet below, we went to the bottom and shut down everything. There would be no air conditioning, no refrigeration, no nothing. Talk about silent running. That was silent running. But you could sit on the edge of a stool and bend over, and the sweat would run off your nose. It was hot, you bet. The only thing I can come up with is that on the boats that I served on, when we dove, they put pressure in the boat. They don't do that today. Is that the big difference, the fact that they put pressure in the boat? I understood we put pressure in the boat. The *Tang* was supposed to be called a thick-skinned boat, but I understand it was still less than an inch thick. There was the pressure hole. Pressure in the boat may have been the reason for it. Sure, it was hot. You would think that if you were down there 600 feet, sitting on the bottom, it would be cold. The water would be cold. Well, I'm sure it is outside, but not inside. You just sat there and didn't move a muscle and the sweat would just run off of you.

On our shakedown cruise to San Diego, the *Tang* got away from us and we went down almost 700 feet. We didn't have any problems, thank God. We had a few little leaky lines and gaskets. It wasn't planned.

We got to San Diego and I think we tied up next to the USS *Holland*. I can't remember for sure what ship it was. They didn't have a sub base, per se, back in those days, so we tied up and were there just overnight. No one got liberty or anything, and we went back to Mare Island. That commissary chief, he was going to go over, and he was telling the chief of the boat, "I won't be back because we accidentally went down almost 700 feet." He was going to leave.

Murray Frazee, the executive officer, said, "You'd better be back here tomorrow morning, or I'm going to put you before a firing squad!" The chief did come back, but that was the only run that he made. He made one patrol on the *Tang* and got off her. You bet, we sat on the bottom many times and let them just go ahead.

Have you ever had the experience of someone telling you about using CO_2 absorbent? That was a five-gallon can. You opened it, and it was vacuumed just like a can of coffee. You'd get those mattress covers, and excuse me for the Navy expression, "fart sacks," get them good and tight, and put that crystalline material on there. Hey, we not only did it once. We not only did it twice. We did it at least a half a dozen times. I mean that air just got so bad that you could just watch it. You spread it out on the mattresses and it started to get light yellow, dark yellow, light brown, dark brown, and then it almost turned black.

Of course, you could bleed out of your air tanks. You could bleed a little bit of air into the spaces then, which, as a motor machinist's mate, was one of the biggest things that we were trained to do. Believe me, it was so bad that George Zofkin never made it, because he was a Navy-trained man, and he didn't go to sub school. They needed men so badly that he got aboard submarines without having sub school training.

We were told that a diesel engine and a gasoline engine needed two things to really function, air and fuel. Of course, ignition on a gasoline engine is a spark plug. Ignition on a diesel engine is compression. It's combustion by compression.

That wasn't in the *Blue Jacket* manual. George had a big, heavy ball peen hammer, a good eight- to ten-pound hammer. It was a heavy baby and painted solid red. He fixed a clip on the starboard side and right there was that ball peen hammer.

On the Fairbanks Morse diesel engines, the main fuel line going to each one of those engines came right up near the throttle controls. It came up and made almost a right angle turn to go down to feed your engines.

One of the things that we feared was a runaway diesel engine. George taught me something. He said, "Clay, I got it figured out. In theory, they either have to have air or fuel to run. If I get a runaway, all I've got to do is grab that ball peen hammer, make one swing this way, and hit its copper tubing. If I hit that baby right there, it will bust it. There's the connection, right there, a right angle connection. If you break that connection, there's no more fuel going to that engine. If you swing that way, and back that way, there will be no more fuel."

When both those engines were running top speed, the force of the air going into the main induction would nearly knock you down. Of course, I belonged to this club. They wear one plug in each ear now, but back in those days we never had earplugs. We never had muffs or anything else. When both of those engines were at top speed, if you came into my engine room and wanted to talk to me, you nearly had to do sign language or get right up to my ear and talk.

When that diving alarm turned red, and if I didn't have those throttles down right then, each of those engines would only have to make about ten to twelve complete revolutions and they would break every man's eardrums on the boat. It would suck. It would take in that much air with that main induction closed. It would take so much air to run those engines that it would pull the air out of the boat just like that. We never tried it, believe me. But there was the thoughtfulness of George Zofkin. He said,

"Boy, listen. When I go back like this and those babies don't respond, I'm grabbing that hammer and I'm raising heck with those fuel lines." He was a great guy.

Like I said, we got the orders. We were going to go to the Formosa Straits. None of us were particularly happy about that because of the depth of the water, but as it all turned out, it was in our favor that the water was as shallow as it was. On the morning of October 24, 1944, at about 2:00 a.m., they picked up tips on the radar screen.

We were on the surface. I was a bow planesman, all the time. We attacked during battle stations submerged, and many times, we did it both from underneath and from above. We fired torpedoes submerged, and we fired torpedoes from the surface, but for the most part, I could really watch everything that was going on when we were on the surface. I was sitting there at the bow planes. In that particular case, the one thing that struck me the most was that in previous convoys that we struck, we'd find two ships abreast. They would "zig" X number of minutes, "zag" X number of minutes and, of course, the job for the fire control party was to figure out those zigs and zags and time them, put the information into the torpedo, and send it on its way.

In that particular case, there were 35 targets up there, 35 ships, end to end, and they were all apparently going full blast. I mean, all of them, as I said, were either coal burners or oil burners, and the smoke was just rolling out of their stacks. Well, it was like shooting ducks in a shooting gallery for O'Kane. I was told whenever they'd hit a convoy, they'd fire six tubes forward and four aft. We carried 24 torpedoes when we went on patrol.

When they cleaned out the torpedo tubes, forward and aft, they usually got away from the action. O'Kane did it much differently. He got right in the action and would get close enough to the ships that the boys on the bridge said, after we'd fired all the six torpedoes forward and the four torpedoes aft, that some of those ships in that convoy were firing at each other. There were shells flying back and forth over the top of the *Tang*.

Remember that if you go aboard a submarine today, practically all of it is done mechanically, in terms of loading the torpedo tubes. Back in those days, those boys had to do it with a block and tackle. Be it on the surface or be it submerged, you had to have the boat level. You had to give those boys a break. You couldn't be going up angle or down angle or doing a lot of maneuvering because it took them a little while to get those tubes loaded again. When we got in there on that first round, O'Kane decided that the hunting was great. It wound up that in that convoy of 35 ships, we sank 13 of them. The thirteenth was a troop transporter.

We found out later, after the war, that the convoy wasn't two abreast and wasn't zigging and zagging. If you check the time data, it was just prior to our landing at Leyte, back in the Philippines. We understood that all of that convoy was heading towards Leyte with supplies and troops. We had fired all but two torpedoes. We had two torpedoes left in the forward tubes, numbers 23 and 24, and we were on the surface. Dick O'Kane had sunk 12 of the ships, had the 13th one up there in his periscope. It was light enough that they could actually see the targets. It was a big troop transport. He estimated that there were about 5,000 Japanese troops aboard. Normally, as on previous patrols, we'd fire from 1,000, 1,200 or 1,400 yards. Picture yourself, there you were out there. You had this luscious target and two shells left.

You know, I'm a big game hunter out in Colorado and have been since the war, and I just quit big game hunting about three years ago. But I could see myself with one shell left in my gun, and there's a big bull elk trophy. I might even go so far as to lay the barrel of my gun across a tree limb to get a good shot. Dick O'Kane's strategy was to go in about 700 yards of that target, broadside, and he called for an "all stop." We talked about it in the prison camp afterwards, and I asked Dick about it. He said, "Well, Clay, yes, that's right. I did call for an all stop."

Normally, when we would fire, be it submerged or surfaced; we would have two or three knots on the screws. We were not moving very quickly, but in slow motion.

Anyway, he called for an all-stop. He fired the twenty-third torpedo, and she went hot, straight, and heavy, and she did away with that target. I mean, there were 5,000 Japanese, and without a doubt, 4,000 of them didn't make it. He had two men on the bridge with binoculars verify that the twenty-fourth torpedo went out of the tube. They followed the wake. It went out about 300 yards and he said it was like if you were going fishing and caught a fish on your line, and you were pulling the fish out of the water, and it was up dancing. He said, "That torpedo stood on its tail, dropped back into the water, and doing a hard left turn on itself." That was when he started pounding on the bridge, saying "Full speed ahead," pounding. If we had managed a knot or two we would have made it but, of course, that is hindsight. That torpedo hit us after making that circular run. It came around on our port side. It hit us right at the maneuvering panel, which was located just before you stepped through the hatch into the after torpedo room. We would have had the length of the after torpedo room to have gotten out of its path, had we had any forward motion. But we did not.

Anyway, we had such good success. We sank all those ships, and the crew was really starting to feel jubilant. We were told that after the fifth patrol we were going in for new construction, stateside. As a matter of fact, we had several members in the crew on that fifth patrol who were part of the relief crew back at the sub base in Pearl Harbor. They knew that or had heard stories, and boy, they just busted their legs to get aboard the *Tang* because they knew that she was going to be going back.

One of the torpedoman up there said, when he padded that breach and the twenty-fourth torpedo was fired, "Let's head for Mare Island." He said no more than that and boom, that baby hit us. Picture this, if you will. There are so many people who aren't familiar with submarines, when I tell them this story, I say, "You know, you have to picture this." The *Tang* was 300 feet long. We were in 180 feet of water, so we hit ourselves in the stern and started to sink from the stern. Picture yourself at about a 45-degree angle with the stern resting on the bottom. We knew that the bow was out of the water because we could hear the waves splashing on the hull. There I was, sitting at the bow planes, and they were big planes.

I was sitting on the bench in the front of the bow planes' steering wheel, and I didn't move four or five inches. I never got a scratch. I wasn't hurt at all, period. But picture this. Right there to the right of me, toward the forward part of the ship, was the ladder that went up to the conning tower. You had the man on the Christmas tree. You had the diving officer standing right side of the chart desk, which was, on the *Tang*, in the center of the control room. The lighting all went out. We lost all hydraulic pressure. I immediately flipped the control for the battery-powered lighting. Because I had completed my training as a qualified submariner on second patrol, I was very familiar with the fact that immediately above the chart desk in the control room, from the overhead, was the big lever that ran forward to aft. At the aft end of it, there was a pin. If you pulled that pin and let the lever swing down over the top of the chart desk, it opened all the vent valves for the forward part of the boat.

Everything that worked hydraulically on a World War II submarine could also be operated manually. The chief of the boat was on the Christmas tree. He, the diving officer, and the man on the hydraulic manifold that pumped water forward and aft for us were clear over on the starboard side. Those men, when that torpedo hit, were just literally thrown. The chief of the boat wasn't knocked out completely, but when I got the lights on, I got over to him I said, "Chief, let me help you." He knew who I was, but he was really stunned. He was the one who told me, "Clay, here we are now, at a 45-degree angle. We've got to get this boat leveled. There is

no way we're going to get to that forward torpedo room with this angle." That was the thing that prompted me to then crawl up on the chart desk, roll over on my back, throw my legs up around that lever on the overhead, pull the pin, and drop it down. Immediately, we started lowering. The boys up in the conning tower were thrown around also, but the normal way to come down from the conning tower to the control room was feet first.

Now, if you had seen guys come off a watch, they wouldn't touch a step. They'd come down and put their feet sideways, and just grab the handrails. They'd grab it and slide right down. You've seen firemen do that on fire drills. They can do that. We had two men come down, and they were the first two men to come down out of that conning tower headfirst. They dove for that hatch, and they came down. They hit that steel deck, coming straight down. They never touched a rung on the ladder or anything.The first man broke his neck. The other man who came down broke his back.

The third man who came down was this little red-headed lad. Most all the hatches on the *Tang* that opened upward were spring loaded, so that when you would un-dog and release one, it would go up itself. It had a lanyard on it, and at the bottom of the lanyard was a piece of wood about as long as my finger and as big around as my thumb. A lot of times you could just grab that lanyard and run the line through it. You'd just grab that and pull the hatch right on down, and then you'd dog it. This lad did that. He came down feet first, and he stepped on the ladder as he came down because he was in a hurry, believe me. He came down and just grabbed the line, and instead of coming down and getting hold of the wood, he just grabbed the line itself. When he grabbed that piece of wood at the end of that line and pulled the hatch to dog it, it got caught up on the gasket where the hatch came down. Even though he got it down and he got it dogged, we had a stream of water about the size of my wrist coming into the control room. That was when I went over and helped the chief. The stern planesman got up and helped the boys who were injured.

We had a man with a broken neck and we had a man with a broken back. We had a man sitting on the helm. We had a helmsman in the control room also. Now, he wasn't doing anything. He was just there in case they wanted to switch from the conning tower down to the control room. He had a broken arm. I opened the vent valves and started to level the boat to take her on down. Unbeknownst to me, during all the firing and everything, just prior to the torpedo hitting us, my buddy, George Zofkin, to whom I turned the throttles over when I went forward to the control room when called to battle stations submerged, turned the throttles over to his oiler. His oiler was a well-trained lad. Hey, we had sunk ships. We were going to be out of torpedoes. We were going to be headed home. George had gone up to the galley for a cup of coffee.

He was standing right at the galley. You stepped through and there was the radio shack and then the control room. He said, "I was standing right there, Clay, when the torpedo hit. The passageway there is fairly shallow. It shook me around a little bit, but I just stepped through and pulled the hatch closed." That closed off the after battery compartment from the control room. I was gone and didn't know that had happened, but later on, I'll tell you a little bit about what happened in that after battery room. Unbeknownst to me, George Zofkin, my buddy with whom I had left my family back in San Francisco, was among the survivors in the control room. I didn't know that until we got up in the forward torpedo room.

By that time, I was getting the chief up and helping him. He was bleeding from his head a little bit and so forth, but he was conscious and knew what he was doing. He said, "Okay, let's all move forward now," knowing that we were going to have to help those boys. We had to carry the boys with the broken back and the broken neck. We went through the officers' quarters and the forward battery compartment.

In the wardroom was Ensign Ennis. He got all the codebooks. He knew where to go to get the books and everything, and he was folding them up, taking pieces of paper and folding them up a little bit. Then, he touched a match to them. God, he was going to burn them! By that time, Ballinger and I were coming through and saw Ennis do this. We stopped him and said, "Let's not do that." That was the last thing we needed. We did not need to burn off our oxygen with a fire.

You see, the opening in the wardroom going down to the forward battery compartment was a good size. Of course, there was that opening in the top of those batteries, and you know what was in there. It was sulfuric acid. If you took a piece of paper, wadded it up like that and put it in there, zoom, it was gone. That sulfuric acid would do a number on it, so that was what we did. We got all the codebooks, opened up those batteries, and put them right down in that sulfuric acid. We figured if the Japanese ever got to the sub, they wouldn't get the codebooks. We got that done and we moved on forward.

Ennis was on up forward then, and so was another officer. He was Lieutenant (jg) Hank Flanagan, a torpedo officer. As of then, nobody had even started to get groups of four together. When Ballinger and I got up in the torpedo room, right away the chief said, "Hey, I'm going on this way." Just as he and I got up there, there was a group of guys standing right below the hatch and they were talking. One was a chief torpedoman, and the other guy was a first class motor machinist's mate, and his name was McMeryl.

Anyway, Chief Ballinger and I didn't see it, but were told about it. Both McMeryl and the chief torpedoman crawled up in the escape chamber, closed the hatch and flooded it down. That was how you knew whether that hatch up in the escape chamber was open. There was a lever in the forward torpedo room that, when the hatch opened out to sea, came down. It automatically came down. In other words, it worked like this. The hatch opened, the lever came down, the lever came up, and the hatch closed. That was the way you closed the hatch after the four people escaped. You closed it, pushed it back up and closed that hatch. Then, you drained the water down, let it just go down into the bilges, opened up the hatch, went back up, and got four more men up there.

Those two dudes got up in there. That was another asinine thing that happened. Those two dudes got up in there and they never let the buoy out, fortunately for us. I thought about it many times afterward. It was fortunate for us, because we used that buoy and that line. I did, anyway, and they were gone. I'm not sure it is even questionable that, if they went out that way, they would have hit that opening in the deck. Anyway, they were gone. Somebody was telling Ballinger about what happened and Ballinger said right away, "Clay, you want to go with me? I'm going to be in the first group." I said, "You bet. I'm going."

That was when I first discovered that George was up there. He rolled over to the side of me. There was George Zofkin. I said, "Hey, George, where did you come from?" He told me then about being there at the galley when the torpedo hit, and he just stepped through. We got the new Momsen lungs out and opened the cellophane. They were in the cellophane pack. I put one on and got the mouthpiece and the nose clamp. George reached down and took the wire clip that was on the rubber exhaust valve. He took that clip off for me and saved my life; I would not have taken that clip off.

Back at sub school, they once brought a brand new lung into class, because when we'd go through the escape chamber at sub school they had just a rack down there. You'd just grab a lung off the rack, one that somebody may have used just two hours before. It didn't make any difference. You could use it over and over.

Anyway, we had the brand new lungs. Why in the world did they ever have that thing? It was flat rubber. It was like when you were a kid, took a raspberry and made it so that water couldn't get it but air could get out. That was the



Escape lung training

principal of the thing, because the lung wanted to keep getting big like that. Even when we'd use it on the escape chamber, there were air bubbles constantly coming up from it.

Anyway, George reached down and took that clip off me. Right away, I grabbed another one and I said to him, "Come on. Let's get this on." Remember that he was my buddy with whom I left my family back in San Francisco. George said to me, "Clay, I have a confession to make." "God," I thought, "George, why are we talking about confessions? Let's get out of here. What are you talking about, a confession?" He said, "I can't swim." I thought, "Oh gee."

Since then, I've thought about it. I think about when we'd go on rest and relaxation between patrols. We'd go to the Royal Hawaiian Hotel. George and I had roomed together. We'd go out on Waikiki Beach and frolic and everything. I have pictures of us in our swimming trunks and so forth, but George never did go in the water. I had never even thought about that before then.

I told him, "George, look, you and I both know if you close that valve properly on that mouthpiece, that thing acts just like a Mae West life preserver. Let's worry about that after we get gone." He said, "Clay, do this. You go with this first wave of four, and I'll come up with the next wave." I thought, "Well, that's fair enough." Ballinger was there and ready to go.

If you've seen a submarine escape chamber, you know it was really "togetherness." You had four men standing in there and were allowed maybe a 12-inch step to step out. Remember that when you stepped out, you were looking at the aft of the ship. When you stepped out, you were on top of the pressure hole of the submarine. The height of it was about shoulder high. Believe me, Ballinger knew every step that we needed to take. There was no panic. The four of us had our Momsen lungs. You had, in the escape chamber, a gauge giving you the outside pressure of the water.

Fortunately, we didn't have any harm done to our air supply. We had air, which was a very important factor because, on your lung, you initially charge it with an air hose, just like you'd fill a bicycle tire. That was the initial charge. There was the hatch, and it opened that way, and I was standing next to it. Ballinger was that way from me, and the other chap was on my left shoulder. Immediately behind Ballinger was the reel with the buoy and a line attached to it. As I remember, it was about the size of a soccer ball, but maybe not as large as a basketball. It had a lanyard around it that was stapled ever so far so that you could get a handhold on it. Ballinger said to me, "Now, we all have our lungs on." We flooded down with water up to our shoulders. Ballinger opened the air pressure five pounds to exceed the sea pressure. "Now," he said, "Clay, put your mouthpiece in and your nose clamp on and just duck down in the water and try it once in your mouthpiece." I did. I said, "It works well, chief. It works okay." He said, "Okay, good. You're ready. Now, we're going to open the hatch." We did that. I tell people that it was the same situation as the escape chamber. Water did want to come in a little bit. It was a little scary. You opened that hatch and the door swung pretty freely, but the water did want to come in a little bit. It rose up to our chins and settled right back down.

Then, he handed me the buoy and said, "Now, Clay, when you let the buoy out, do this. It's simple mathematics. Count each knot." I did. I was letting the buoy out, and it wanted to go right to the surface. It went right out and straight up and I was counting the knots. I knew

when that buoy hit the surface, because the line was jumping in my hand. It was riding on the waves. I told him that and he said, "Okay, hold it."

By the way, we had battery lighting in the escape chamber. Outside, it was totally pitch dark black. He said to me, "Clay, let me hold the line." We were loaded. I've forgotten where the gunner's mate kept the gun, but whenever you went on topside watch, you'd go and get a .45 from the gunner's mate. I've forgotten where the locker was that he kept the .45s in, but he brought some up there.

We knew that we were in shark-infested water. We all had .45s. We each had a shark knife. We tied our pant legs down because we had sea rations stuck down in our pant legs. Ballinger said, "Now, count the knots," and I did, and it came out right on the nose at 180 feet, and that was what the gauge was reading. Bill just said to me, "Clay, go ahead, put your mouthpiece in and go for it." He wanted me to cut the line. He said, "Clay, let me hold the line. You reach back over here and cut the line from the spool, but leave enough loose so that you then can take the loose end while I'm still holding the line."

We were down at the bottom of the ocean and the hatch was open. We had three ladder steps on that escape chamber out there. It was a piece of welded steel not as big around as my thumb. But there were steps, and you came out and got hold of one if you were going to go up. On the *Tang*, the opening in the deck was three feet square, the size of a yardstick. That was the opening immediately above the escape chamber. He said, "Tie that out there for us, Clay." I don't know whether I tied a square knot or not, but I can remember I tied about three knots in it. I didn't want it to get away from us, you know. But I was just reaching out here. I was still inside the chamber and just reaching out there and tying the knots on it. I put my mouthpiece in, my nose clamp on, and proceeded on out myself. I grabbed the line and I followed the line up. It was totally dark. By that time, it was probably 6:00 or 6:30 in the morning. It was definitely daylight, because as I started getting toward the surface, I could see the water getting lighter and lighter and lighter.

As I broke out of the surface, my head popped out and immediately I said, "Oh boy. I made it." Remember that the nose clamp was strictly to keep you from breathing through your nose. I reached up to take my nose clamp off and as I did, I could see that I was bloody. There was the buoy and I was holding on with one hand, and I reached up with my other hand and saw that I was all bloody. I spat that mouthpiece out like that and asked, "Why am I bleeding? I didn't strike anything coming up. I didn't get the bends."

When I was interrogated, after I got out of the prison camp, this lad told me, "Mr. Decker, what happened was probably this. It's almost like when you go to a high altitude. You get a nosebleed or something. You have little superficial blood vessels in your cheeks. If you came up rapidly enough, they burst, because the bleeding stopped almost immediately." There was no pain. There was no aching sensation or anything. But the asinine thing that I did was spit that mouthpiece out before I reached down there and turned that valve off. Had I done that before I took the mouthpiece out, it would have acted as the Mae West life preserver. Well, I goofed. The interrogating officer asked, "Well, did you panic, then?" I said, "No. I would not say I panicked. I just didn't know why I was bleeding."

At about that time, when I was through with all of that, and I hadn't taken the lung off yet, Ballinger came to the surface. He was over from me just a little bit more than arm's reach. I could have held on and reached with both arms stretched and grabbed Ballinger. That was what that interrogating officer told me. He was a Navy man, too, but I can't remember names or his rank. I said, "You know, something told me, 'Don't do it.'" Ballinger was drowning. The man was there. His face was bleeding. I could see. He was bloody. He didn't have his mouthpiece in. He didn't have his nose clamp on. He was screaming, and water was coming out of his

mouth. The man was drowning. The interrogating officer told me, "It's a known fact that a drowning man can pull a horse under the water. If he had touched any part of you, you would have been with him. You wouldn't be here talking to me today. He was grasping. The man was dying. He was grasping for straws. If he had grabbed you, you would have been down with him."

Anyway, like I said, something told me not to do it. He was screaming. He was right there, and I did not reach out and grab him. The two bodies of the other two boys never did come to the surface. The only conclusion we could come to, when trying to theorize, was that those two boys, no doubt, when they came out of that hatch, did not get a hold of the line. Remember that it was pitch dark. We were down at the bottom of the ocean there. Picture that. If you were down there, had your lung on and your mouthpiece in but stepped out of the chamber and varied just a little bit, you were going to miss that yard stick square opening in the deck. That was what we called the "superstructure area." They wouldn't have known whether to turn right or left or what. Their bodies, no doubt, hung underneath that deck. They surely panicked and then drowned.

In the next wave of four, only one man made it. No other bodies surfaced. There were five waves of fours, and only one man made it out of each wave of those waves. There were five of us up on the surface around this buoy. The sixth man finally showed up. He was a first class and his name was Larson. He wasn't in as bad a shape as Ballinger appeared to be, but the man was drowning. He wasn't bleeding, but he was spitting water and so on and so forth. Had we had him on a beach, we could have taken Larson and pumped him dry, no question about it. As a matter of fact, we were in the water between four and five hours before we were picked up, the five of us hanging around that buoy.

We took turns hanging on to the buoy with one hand and swimming with the other. We took turns holding Larson up because he couldn't do it for himself. He couldn't swim for himself but was still alive. Two of the youngest lads were named Trukke and Norwanski. Both of them were torpedomen and both had just come onto the *Tang* for that fifth patrol. They came out of the relief crew. They were the ones who said, "Hey, we're going to go back to the States with this baby."

Anyway, those two young guys told the rest of us that we were right straight off of Fuchow, China. By that time, it was light enough that we could look over and see the Chinese coast. In the morning, the tide was coming out. You've heard the old lesson that you can't swim against the tide; believe me, you can't swim against the tide. Those two young lads were both young, husky lads. They said, "We're going to try it." They threw their lungs off and started out. They didn't get twenty yards. They were back with us at the buoy. There was no way you could swim against that tide.

If it had been afternoon and the tide had been going in, maybe those two boys could have made it. Besides, they were loaded like the rest of us. We were in the water between four and five hours before the Japanese picked us up. But in the meantime, we all unbuckled our .45's and let them go. We dropped our shark knives, shoes and everything we had. We were down to just our skivvies. That was all we had on when we were picked up. In the meantime, we were holding Larson. We were keeping him up, and a Japanese destroyer escort dropped anchor about 1,000 yards from us. We could see it in the open sea there. It was broad daylight.

They dropped a whaleboat, a rowboat with two men. They were armed. They rode over to us. We all crawled in that rowboat. We got Larson in. One of the Japanese had his gun on us. We were sitting in the back of the boat. He was telling us to sit down and so forth in Japanese, but he was motioning. We could tell what he wanted. The other guy was up in front in the bow, trying to get the buoy in the boat. He finally gave up. He couldn't get it in. We didn't tell him it was tied to a submarine.

Anyway, they rowed us back to the boat, and they had a rope ladder down the side of the ship. I was the last one to go up that rope ladder. I looked back over my shoulder, and those two guys were dumping Larson's body over the side. They didn't even try to give him any artificial respiration, they just dumped his body over the side.

It was a hot day. The sun was shining. We were on a steel deck in our skivvies. We had not been exposed to any sunlight for a long time. We were surprised, right away, to notice that the skipper and three other men had been picked up in the water. That made a total of nine of us. That was probably the roughest treatment we received the entire time we were prisoners of war. That ship probably picked up a good number of the survivors from the ships we had sunk.

Now, picture yourself on one of those ships, down in the boiler room, when that torpedo hit. With that hot steam, some of those guys were like lobsters. They were scalded, almost to death, you know. Well, they looked at us and said, "Here are the poopers that did this to us." They'd grab us by the hair and take a live cigarette butt and stick it up our noses. We spent five days and nights on that hot steel deck with no water and no food.

The Japanese word for restroom is "binjo." They took us to the binjo whenever we had to go relieve ourselves and brought us back and sat us on that hot steel deck. Believe me, by then, we were all blistered. Our lips were blistered. We all even tried drinking our own urine.

After those five days, they pulled into Taipei. They put black hoods over our heads, tied our hands behind us, and tied us one to another in a line. They marched us, probably in the streets there. We couldn't see, but we could hear and feel little old ladies and little kids coming up and hitting us with sticks and so forth. We had to carry a sign. It probably read, and we theorized about this, "Here's an example of your 'superior race'" or something, because little kids and old ladies were hitting us with sticks and so forth. Well, they took us to an army post just outside of Taipei, in the main town there.

At that time in the Japanese military, when an officer talked to a subordinate, even two feet away, instead of using a normal volume he would scream. He screamed an order to the man to take the black hoods off our heads and we found that we were standing in line. They were screaming these orders back and forth to each other. We thought, "Uh-oh, this is it. This is the firing squad. There's no question about it, because these guys are standing here with rifles." They were screaming but that was just their nature, we found out later.

They threw us in a potato cellar that night and gave us some polished rice. Whether you're aware of it or not, when you polish rice, you do away with a lot of the nutrients. They loved their polished rice. Well, they fed us. Here in the States, we call it "meal," or "chicken feed." It grows on a stalk similar to a corn stalk. The shape of their heads was like little pellets. Actually, that had more food value to it than polished rice. Our only problem was that we'd never get enough of it.

Anyway, we did get a little ball of food that night, and the next day they put us on a train and sent us clear to the north end of the island to get us prepared to go on a boat ride to the mainland of Japan. They put us down in the hold on a ship loaded with sacks of sugar in a rough sea. We were down in the hold clear up to the bow. We all got so seasick that you wouldn't believe it. We said our prayers. We said, "Jesus, I hope our submarine Navy is not on the ball and does not sink this baby before we get to Japan," because that did happen to Japanese ships. We made it. They landed at Yokohama. It was nightfall when we got into Yokohama. They put us on one of those fast trains. There we were, still in our shorts, and it was cold weather.

The first camp we were in was Ofuna. It was inland from Yokohama, right at the foot of Mt. Fuji. When we got off the train that night, it was raining. We were walked in the rain for about two hours before we got to Ofuna. It was an interrogation camp. We were interrogated and put one man to a cell, isolated in a solitary

confinement sort of thing. The Japanese navy, army, and civil defense interrogated us. You name it, and they interrogated us. As a matter of fact, it was interesting. One of those interrogators we finally nicknamed "Handsome Harry." He would show up every once in a while in a tie, white shirt, and suit. If you closed your eyes, you wouldn't know that you were talking to an Oriental; he spoke perfect English.

As a matter of fact, the first time he interviewed me, Handsome Harry said, "Mr. Decker, where did you join the Navy?" I said, "Denver, CO." "Oh," he said, "Then you're familiar with the Brown Palace Hotel in Denver?" "Oh yeah," I said, "Very much so." He said, "Mr. Decker, I lived in the Brown Palace Hotel for two years while attending Denver University." I thought, "You think those poopers weren't planning Pearl Harbor a long time before it came to pass?"

Anyway, one of the things that Dick O'Kane immediately told all of us was, "Guys, don't take any undue, unnecessary punishment, okay?" The other officers were Larry Savadkin and Hank Flanagan. Larry Savadkin was a lieutenant, and Hank Flanagan was a lieutenant (jg) torpedo officer. There were three of them. The rest of us were enlisted men. If you got caught stealing or lying, it was definitely cause for a beating. He said, "Don't take any undue punishment because you guys don't know anything that they don't already know. I'm the guy they're after, so don't do it." My God, Dick took some awful beatings.

Anyway, to prove that point, one of the guys who interviewed me questioned me about Fairbanks Morse diesel engines. I went by what Dick had told us, and, you know, he was our skipper. We got through with our interview and the interrogator brought in a catalog, a book that was published with the engine at the factory where it was made. God, he could have caught me in a lie just like that, so Dick gave good advice. There was an officer and a gentleman. I mean, that man graduated from the Naval Academy in 1934 and went out to do his job, and he did it well. Like I said, he absolutely showed his colors with his men there.

He told all of us who were not of officer status in the prison camp, "If any of you guys who want to make the Navy a career, follow me when we get out of the prison camp. When we get back to the States, if you want to stay in the Navy, I guarantee you, you'll go wherever I go, and I'll guarantee you that you're going to raise a rate a year until you become an officer. Then, you're on your own." Two of the guys took him up on it. The boatswain's mate was my friend, Bill Leibold. Bless his heart. Bill and his wife, Grace, live on Palomar Mountain outside of Escondido, CA. Even today, we have a great rapport. The other guy who took O'Kane up on the offer was Floyd Caverly. He was a first class radar technician. Savadkin and Flanagan were also career Navy men.

Of the nine of us who did survive, Hank Flanagan was the first man that passed away. Trukke, one of the younger lads, was the next one that passed away. This is almost unbelievable, but Skipper O'Kane passed away on a Sunday in 1994, in Santa Rosa, CA, in a nursing home, with Alzheimer's disease. Pete Norwanski, who was one of the torpedomen who came aboard the *Tang* on the last patrol, in Baltimore, passed away that same Sunday evening. That boils it down now to only four of us still living, out of the nine. No, excuse me; another has passed away, and he was one of the five who came up from the bottom. He just passed away a year and a half ago in Los Angeles, CA. He was a young chap.

One of the prisoners who was already there when we arrived was the ace Marine pilot, Pappy Boyington. Pappy had been shot down about a year before we were captured. He was working in the galley in that first camp. How he got thrown in with the *Tang* group, I don't know, but he did. The Japanese never allowed us to be POWs, or prisoners of war. They contended that on the freighter we sank, about 90 % of the cargo was munitions. They also contended that 95 % of the crew was civilian. Therefore, we were at war against their civilian population and

weren't entitled to be POWs. The consequence of that was that we only got half the food rations. The second camp we were sent to had 600 prisoners. We weren't entitled to mingle, fraternize, or speak to them or anything. We were kept segregated.

The second camp was on an island in Tokyo Bay called Omari. It had a wooden causeway leading out to it and was just on the outskirts of Tokyo. But like I said, we weren't allowed to speak or fraternize with the military prisoners. That was the other consequence; we only got half the food rations that the other prisoners got.

Another thing that involved me, and, of course, Skipper O'Kane, was that they never notified the Red Cross or our government that we were captured. In my particular case, after I got out of that prison camp, my wife was remarried. Mrs. O'Kane waited for Dick. Anyway, that happened to me, and it happened to Pete Norwanski. He was another one who was married. His wife had also remarried.

We spent our time through the winter months at Ofuna. A lot of people don't realize it, but Japan can get a good foot of snow on the ground and zero degree weather. The cells that we had at Ofuna were solitary confinements. We were issued three blankets that were the same as our Army blankets, but there was no heat in any of the buildings. As a matter of fact, in that interrogation camp, we never minded being interrogated that much, because when an interrogating officer would come, they had a room set up for it.

The Japanese weren't sitting in chairs like we were. They sat on the floor, and what would be your coffee table at home was their main table. The interrogating officer came and put a blanket over that table, and they put a hibachi underneath. From your butt down you know, it was nice and warm. I would say, "Let's just keep talking. Ask me all the questions you want." In the cells, the way we kept from freezing to death was by learning how to take those blankets and wrap them around ourselves. Most of the time that we slept in the winter, we did so sitting up. You started wrapping the blankets at your feet and ankles and came clear up, just as though you were a mummy and got right back in the corner. You'd get in a sitting position and could keep from freezing to death. That was kind of a tough one.

We had allies of ours in that camp. There were some Dutch, British, and Royal Navy guys. We called the English "limeys." Now, they were our allies and they were in this thing with us, but that was just what we called them. Anyway, we had some limeys in that camp. It was interesting in Ofuna, in that camp. We had limeys there, too.

There was Boyington, our ace Marine pilot. He shot down 28. We'd just go up, pat him on the arm, wanting to touch him, you know. "God, here was a hero," we thought. Well, let me tell you something. If you stole, what you did steal was food. Anytime you could steal some food, you did. Believe me, I think the worst thing a person can die from is starvation. Anyway, Boyington got caught and had to take a beating.

What the Japanese did was line us up out in the compound, Americans and limeys and all. There was a foot of snow on the ground. By the way, by that time, we did have some kind of clothing. It didn't amount to much, but we had some clothing, and they allowed us to take one blanket, wrap it around ourselves, and stand at attention while a Japanese soldier beat him. They stripped him to the waist.

They'd tie your hands and put them over a hook on a pole, and this guy started beating you until the blood and everything else was running down your back. When this guy got through beating Boyington, and he was practically in Boyington's face, he cut him down. Boyington was standing at attention, and the guy was saying, "Do you understand why I just beat you?"

We were all standing at attention, watching this go on. Everybody was just as sober on their faces as they could be. Boyington was standing there, at attention, and he said, "Go screw yourself, little man." I have to tell you something. From that point forward, those limeys had a number

one respect for Pappy Boyington. He didn't have to shoot down 28 planes. When he said that, nobody broke rank or changed expression on their faces.

Of course, the Japanese didn't know English. There he was, standing there in the snow with blood running off his back. He was a heck of a man, a heck of a guy. They took us down to Omari about the last week of February of 1945, and in the barracks there, my cellmate was Pappy Boyington. I could tell you a lot of stories about that. Over there, we'd always call him "Pappy," but for the most part, you called everybody by their last name.

The way the Japanese work it, the names are reversed. In other words, instead of "Mr. Weir" you'd be "Mr. Gary" I was called "Deckersan," and Pappy was "Boyingtonsan," and so forth. Pappy always called me Deck, which was short for Decker. Do you know something else? It was probably because of the Geneva Convention or whatever, but all the officers got paid every month in yen. They had no place to spend it. They'd come to our cell once a month and pay Pappy. He probably had enough yen to buy half of Tokyo.

Every morning at the second camp, they would take crews of men out and send them either to the shipyards or the steel mills to work all day, and they'd be back in the late evenings or late afternoons. The only ones who would remain behind were officers. Officers didn't have to go on work details.

Boyington finally convinced them to let us do something, just to get out of the barracks. He used to tell me about the Corsair that he flew. "Deck," he said, "the government never built that baby right." He would moan about it. His buttocks and the back of his calves, when he was shot down, were not loaded, but he had several pieces of shrapnel in him. We got no medical attention whatsoever. But you can take a piece of green bamboo and a piece of glass and sharpen that bamboo so that it is as sharp as a razor. Well, we'd sit out in the compound in the sunlight and he would work a piece of that shrapnel out of the calf of his leg. He'd reach down and hold it. There would be puss and everything. He gave me this really sharp piece of bamboo, had me just cut it open, dig the shrapnel out, let it bleed there, and then he'd just hold it in the sunlight. How he ever kept from getting gangrene, I'll never know.

They finally wound up taking us out while our B-29s were overhead. We were close enough to Tokyo there, and practically every house in Tokyo was made out of bamboo. The B-29s would come over and drop one incinerary bomb that would wipe out six blocks. Those bamboo houses would just go up like fire paper.

Anyway, we were finally taken out on work detail after the B-29s would bomb out an area. Back in those days, all of their vehicles were charcoal burners, you know. They burned charcoal, and they'd capture the gas and run it through the carburetor to run the engine. We went into the bombed out areas, and we'd load the dead bodies on a flat bed. I don't know if you've ever loaded a dead, burnt body, but when you grabbed the skin, it was sticky. God, it wanted to come off on your hands and so forth. We didn't have any gloves or anything, but we had to load the dead bodies and get them out of the way. Then, we'd gather the rest of the debris that was around, put it in piles, like bonfires, and burn it, and then they let us till the soil and plant a garden. It was just something to do. That was the main thing.

Boyington had a nicotine fit that wouldn't quit. He'd get caught smoking every now and then and he'd take a beating for it. When we'd be marching to those areas, he was constantly looking down at the ground. He'd find Japanese cigarette butts, and by about the time we'd get back to camp that night, he'd have a handful in his pocket.

The next day, if we didn't go out, we were there in our cells. We had an opening about 12 to maybe 14 inches square in the cell, just right so that during the day, the sunlight would be coming down through the opening.

You could take a convex lens from a flashlight and start a fire with it. Well, Pappy

would take this tobacco, and he'd roll it in yen. He'd get about five of them and have me hold the lens. You got up there like that and he'd get one going. Well, he'd have to smoke all five because the sun would change and I couldn't light another one. He'd just chain smoke all of them. God, what a character he was.

The second camp that I was in was the last of the camps I stayed in until the war ended. I've got a picture of me the day I was liberated. By the way, in the Navy Yard Museum in Washington, you can see it. Oh, it's a picture four feet wide and five feet high of us being liberated out of Omari and holding the flag there, the American flag. There's a guy right in the front row with his hand up. That's me, and that's in the Navy Yard. I've got a book. Let's see. What do they call it? Oh, it's called "VJ Day." I've got a fifty-year anniversary book. It's a hardback and it's got that picture right on the front cover of it. That's me. There I was, naked. I had just a pair of shorts on.

When that picture was taken, we had already been liberated. The Japanese pulled out about a week before. They pulled out and all they left were four guards at the main gate. We had a general, a one star general from Australia. Military-wise, it was the chain of command, but everybody voted for Boyington to be the top dog when we got to take over the camp. You know, his boys of Baa Baa Black Sheep, they didn't realize that he was still alive. We got up on the roof and painted "Pappy is here." Oh, Jesus, the Black Sheep squadron went bananas, you know. Bull Halsey came into Tokyo Bay with the 5th Fleet, and he had the hospital ship, the USS *Benevolence*. He came to the island with Higgins landing boats and picked us up. That's where that picture was taken.

Bull Halsey then, like I said, was there with the 5th Fleet. On the very day that picture was taken it was on the front page of the Bulletin in San Francisco. My first wife was working there, and she saw that picture. She went down to the Bulletin's office and asked them, "Could you possibly pull the glossy of the actual picture?" They blew it up, and there were Clayton Decker's tattoos on both arms. I have a big newspaper article all about it, too. By then, my son was pushing four years old. In the pictures, he's sitting right there by his mom, and she's looking at that newspaper, and sure enough, there are my tattoos, right in the front of that picture.

There's a nice flag in that picture. One of the prisoners embroidered it. His name was Slim. Slim has since passed away. He had the American flag. Slim Landron was a sailor off of the USS *Grenadier*; the *Grenadier* went down. They scuttled her and the whole crew was captured. There were some of those boys in that same camp. Why they mingled and did things, and the guards isolated the *Tang* guys and didn't let us become POWs, I'll never know. I've never found out.

I don't know that much about aircraft, but I'm told there was about a five-day interim before the Higgins boats came and picked us up. Hey, we broke into one warehouse in that camp. There were 10,000 Red Cross packages. Those jerks never issued them to us. The B-29s had come over and that was the first time we had ever seen them. They were dropping foodstuffs to us in 55-gallon drums on parachutes, trying to hit the beach. The Japanese pulled out, but they left, at the main gate, four guards. Two of them faced one way and two had their backs there. They sat there with their guns and just a lean-to shed. A 55-gallon drum of peaches came right through the roof of that shed and killed all four of them. It surely did. Our planes dropped a peach bomb down and killed them.

I was on the very first flight and among the first 21 prisoners of war of Japan to return to the United States. I was on a C-54 with no seats. It had benches down the side, and it contained only officers. I was the only enlisted man, so I asked Pappy, "Did you get me on this flight?" He replied, "Deck, I didn't have anything to do with it." Well, I know he did have something to do with it. I was on the first flight of 21 prisoners of Japan and I have pictures in my scrapbook at home that were taken when I

landed. We landed in Guam, refueled, and went through a chow line. The next stop was Hickam Field, Pearl Harbor. They took us to the hospital, issued us a complete sea-bag of Marine clothes, and after one night we took another flight into the naval station in Oakland, CA. They checked us into the naval hospital there.

Dick O'Kane was in bad shape, physically. I doubted that Dick would have lasted another two or three months had we not been liberated. Most of us had what they called "dry rot." What happened was that you took your hand and pushed it on your skin and it would stay indented for a while because the lack of citrus food, vitamins, and that sort of thing. They immediately started treating us for that. I didn't get my discharge right then. I got a ninety-day liberty leave. I went home to Colorado and went big game hunting. I then went back and got my discharge.

I have this oxygen thing that I'm on. A little over a year ago, the VA went into my right lung and after they came out, they said that I had a nodule in there. Everything was benign. But the first thing they asked me was, "Clay, have you ever been in a bad automobile accident?" I said, "No, I never have." They said, "The only conclusion we can come to is that your right lung is a mass of scar tissue."

The only conclusion we can come to is that it happened because the Japanese would beat us, and that right lung probably took more beatings than it could handle. Of course, during my younger years, one lung was good enough, I guess, for me to get along with, but it just showed up recently. The main reason I have to be on oxygen is that my lungs aren't putting enough oxygen into my blood stream. If you don't have enough oxygen in your blood to get to your brain, you're finished business.

You remember me talking about using the Momsen lung. One of the things that instructors would tell you was that the biggest factor in using a lung, back when we were trained, was that no two individuals had physical setups that were completely alike. That was the thing that used to bother us. In the 100-foot tower, when we were down 180 feet, you said, "Well, look, I can breathe free oxygen long enough to make the 100 foot ascent, but can I breathe it for too long?" They told us that if you breathed free oxygen long enough, you'd get a bubble in your blood stream, and when it hit your heart, you'd be gone.

That was what we were told. One of the guys was commenting about that when we got ready to put the lungs on and everything. I said, "What other choice do we have when we're sitting at 180 feet in the ocean? Let's go for it."

WILLIAM R. LEIBOLD, SR

The summer of 1940 was coming to an end and my impending return to high school studies was not something I looked forward to. Following completion of the eleventh grade, I had no sense of real accomplishment and completion of my senior year would not, in my opinion, have been a challenge.

My interest in submarines led me to the Naval Recruiting Office in downtown Los Angeles, CA. I was given a written test and advised that parental permission was required in that I was not yet eighteen. My parents opposed my leaving school to enlist but I was able to convince my father that it was the route I wanted and he gave his permission. About three months elapsed before I was notified to report for further tests and a physical and this was followed by my enlistment on 30 November 1940.

Recruit training was completed at the Naval Training Station, San Diego. While on one of the few "liberties" given while in "Boot Training," I went to the fleet landing to watch the "old salts" coming ashore. A strange little boat made the pier and discharged a group of sailors, the captain saw me eyeing his boat and invited me to ride out to his submarine. His sub was the *Dolphin* (Dl); I spent the weekend on board and was even more convinced that submarine duty was for me.

I completed boot training in February 1941 and received orders to ComMineBatFor in Pearl

Harbor. Transportation to Pearl was via the USS *Relief*, a hospital ship. A large draft of recruits was being transported and was kept busy in the deck divisions, chipping and painting as they rolled and retched across the Pacific. Arriving in Pearl, the *Relief* berthed at 1010 dock where the recruits were assembled. There were a number of ancient ships at berths nearby and the group I was in was marched to them. A chief then began calling out that he needed so many men for the various ships. When he called out "I need three men for *Pruitt*," three of us standing together stepped forward and were directed to our new home, USS *Pruitt* (DM22), last of the WWI four stack destroyers. She had been converted to a light minelayer and was undergoing upkeep at the shipyard. We were directed to place our gear (hammock, mattress, sea bag) on deck until we were assigned to a berthing space. A petty officer took me in tow and put me on "fire watch" for a shipyard welder. The welder completed his job and left. Not knowing any better, I continued standing watch until a petty officer came by and asked, "What are you doing here kid?" I informed him that I was the fire watch, when he stopped laughing he introduced himself, Fergus, GM2c. He then saw to it that I got some chow as the evening meal had already been served and got me squared away with a bunk. The next morning, we were introduced to the executive officer who advised us, amongst other things, that we would be allowed to wear dungarees while the *Pruitt* was in the shipyard. Dungarees were available in the ship's canteen and we could pay for them on the next payday. At this time, dungarees were only authorized for engineers and side cleaners.

I was assigned to the deck force and promptly started submitting special request chits for assignment to submarine school. After my second or third request, my division officer told me to knock it off, I had to have a year at sea and be Seaman lc to be eligible. At that time, advancement to Seaman 2c from Apprentice Seaman was automatic after four months service. I completed the training course and practical factors for Seaman lc in short order and spent $8.50 of my monthly pay of $29.40 (after insurance & medical deductions) for a *Knight's Modern Seamanship*. I spent much of my free time with that book and passed the seaman exam as soon as I was eligible. This was quite a pay boost to $54 per month. The Navy was expanding, consequently, advancement opportunities were increasing and required time in rate was being decreased. Many of the old timers were not pleased seeing youngsters pass an examination for advancement on their first try and then actually being advanced regardless of vacancies.

One has to understand the era and circumstances. Our country was emerging from many years of depression, the Navy was expanding both in men and ships, preparing for war following years of limited funding and advancement opportunities. In *Pruitt*, the crew was primarily composed of "old timers" who had kept their ship going during those austere times, it was understandably difficult for many to accept the rapid changes taking place. It was easy for me—I didn't know any better. The Bureau of Navigation (later BuPers) published a small booklet of "Circular Letters" (later notices/instructions) periodically. Information contained therein was not generally made available to enlisted personnel but our Yeoman showed me a letter calling for volunteers for submarine duty and I promptly submitted a request chit for submarine school. After several chits and no action, I was ordered to report to the executive officer who wanted to know where I got off putting in all the chits. I told him that I was requesting submarine school in accordance with the Circular Letter calling for volunteers. He informed me that I had no business reading circular letters; his policy was not to train men and then transfer them to something like submarines and I was not to put any more chits in. Bah Humbug!

I decided to strike for quartermaster and spoke to the chief signalman about getting into the bridge gang. He was encouraging and told me that if I did a good job, he would let me put a course in for third class after shipping over on

my second cruise! This seemed to be too far off so I spoke with the chief bosun's mate who told me he would put me up for third class as soon as I was eligible. I promptly went to work on a course for cox'n.

Pruitt was a good training platform and I became a competent seaman while serving in her. This was the "old Navy" indeed. The anchor windlass was steam driven but, we broke the anchor out with capstan bars and "Swedish Steam" from six deck hands on a quarterly basis, just in case. We also hoisted the whaleboat manually periodically. Our refrigeration consisted of an icebox on the main deck, above #2 fireroom and when the ice melted, which did not take long, so went our "fresh" stores. I was always intrigued with part of the ships armament of six cutlasses that were carried by the officers during our annual military inspection; the blades were meant for business and large brass knuckle guards were fitted on each cutlass.

We operated out of Pearl Harbor laying practice mine fields off Lahaina, Maui and general operations such as underway refueling, replenishment, and gunnery practice. Quarters for muster and inspection was held on weekdays followed by calisthenics. Captains personnel inspection was held on Saturday morning when in port followed by liberty for the non-duty sections commencing at 1300 and expiring at 0700 the following Monday. I can only recall two married men below CPO and liberty parties were not large.

December 7, 1941 brought an abrupt change to our daily routine. *Pruitt* was at Berth 18 in the Shipyard, undergoing overhaul. The duty section was on board with the remaining crew berthed at the receiving station barracks. All ammunition, fuel, et cetera had been removed from the ship. A shipmate and I had just returned to the barracks after breakfast and were discussing what we would do on this sunny Sunday when I thought I heard an explosion. I went over to the window—we were on the second deck—and looked out just in time to see a plane, at low level, passing by. It had a large red "meatball" on the fuselage! I yelled out, "It's the Japs," and headed for the stairway with several shipmates. We double timed it back to our ship where the duty chief told us that the duty section could handle damage control and directed my group of four to go to the *Pennsylvania* (BB38) where they needed men. *Pensy* was in the main dry dock with the destroyers *Cassin* and *Downes*. As we crossed the brow, strafing was taking place and the OOD directed us to take cover in the Marine's compartment off the quarterdeck. I was sent to a 5"25 AA gun on the starboard side where the gun captain put me in the ammo train. We fired many rounds, there was a hit just aft of the gun I was on and a shipmate from *Pruitt* was killed. The two destroyers ahead of us took hits and were both total losses. It was a busy morning and as the regular crew had largely returned to *Pensy*, men such as myself were released to return to our ships about 1300. I had been hit with a small piece of shrapnel in my right hand, it was removed by our chief pharmacists mate and I kept it as a souvenir but lost it somewhere along the way, possibly on *Tang*.

Back on *Pruitt*, we went into a two-section status and started loading ammo and supplies while the yard birds worked to put us back together. We were given instructions in a password system that had been instituted. I had the 20-24 watch and when relieved, two shipmates and I headed for the barracks, it was starting to drizzle and we could hear someone walking ahead of us. Suddenly, "Halt, who goes there?" rang in the darkness, the three of us froze but the person ahead kept walking. A shot rang out and the guy ahead of us stopped walking. A marine was patrolling the area and after he checked us out, we all went over to the guy who had been shot, he was dead, a casualty of war. One of my shipmates was a very black mess attendant named Lonnie Joe Nelson, when the shot was fired he grabbed my arm and exclaimed, "Is you dere boy, is you dere boy?" Later he told me that he didn't know who had been shot but thought it had been one of us.

Lonnie Joe was a few shades lighter when we reached the RecSta that was under construction. We mustered in at what later became the Navy Exchange. Groups of men were gathered under signs with the name of their ship, mostly battleships. It was rumored that the water supply had been contaminated so if you were thirsty you were given half a cup of Coca-Cola.

As soon as *Pruitt* was ready for sea, we were put on offshore patrol, then the entire division went to work laying minefields. I was still pursuing submarine duty and had lined up a swap with a man on the *Argonaut*. My exec finally gave in with the provision that he would approve the swap when we returned from an upcoming operation. This operation took us to the Aleutians for the Attu/Kiska occupation. Following this, we tangled with a very severe storm. Pruitt suffered considerable damage including the parting of all stays to the 97' wooden foremast. Without support, the mast was really unstable and looked as though it would come down. I hauled lines up the mast and secured them. My good shipmate "Chick" Triplett, GMlc was below feeding the lines to me. It was cold, everything was coated with ice, and the ship was rolling heavily so working was difficult. After we got the mast secured we both went below to try to get warm and a messenger (*Pruitt* had no loudspeaker system) told us we were to report to the captain on the bridge. Now what had we done to get into trouble this time? We went right up and the captain and exec were waiting for us by the flag bag. The storm had either abated or the ship had reached the safe semi-circle of what I suspect was a typhoon. The captain told us to stand at ease and said, "You men may very well have saved the ship!" He looked at me and said "Leibold, as of now you are advanced to bosun's mate first class," he turned to Chick and advanced him to chief gunners mate. The captain then stated that he would look into recommending us for a commission, then looked at me, winked, and said, "Leibold, you can have your choice of duty." Chick and I were fair-haired boys for the rest of that trip.

We went into Dutch Harbor for repairs, then on to San Francisco. Upon arrival, I was told to stay on board until the captain returned from a meeting. That evening, I was summoned to the quarterdeck where the captain told me that I could pack my bag, I would have orders to submarine duty by the next morning. The orders came in that night by dispatch, I still have a copy of the dispatch that read in part: "Transfer W.R. Leibold BM1C to Commander Submarine Force Pacific Administration, Mare Island, CA for assignment to submarine duty." My life on *Pruitt* had come to an end and from what I could gather, *Pruitt* was to be inspected to determine her fitness for continued service. The storm had taken a toll on that fine old ship. So, on 8 July 1943, I was finally on my way to submarine duty. I reported in at SubAd, Mare Island and was promptly given a job as "Master At Arms" and told that in as much as I had been at sea for some time, I would have a tour ashore. This was not in my plans. I snooped around the shipyard and found the *Tang* being readied for commissioning; this was going to be my boat one way or another.

I was given leave and went to visit my parents and especially the girl I had gone to school with, Grace Fiskin. I had proposed to her while I was still on *Pruitt* but we had no firm plans. We were married in North Hollywood, CA and enjoyed a short honeymoon in Laguna Beach, CA. I returned to Mare Island and Grace soon followed. We lived in a hotel—we could not afford—then moved in with another couple in Navy housing for a short while. A shipmate at SubAd, Bob Barbee, GMlc who was waiting for assignment was also in need of housing as he and his bride were in a rooming house. We teamed up and started hitting the Navy housing office twice a day. Finally, the lady in charge at the office notified us to come in. She raked us over the coals for bugging her so consistently, we figured that we would never get housing when she softened up and said, "If you two promise never to come in here again, I have a three bedroom unit you can share." We had a

home! It was not furnished and we had no furniture but our brides went to Sears and bought bedroom sets and Bob and I bought a used table and chairs and we set up housekeeping. Grace and I had acquired a 1938 Ford coupe and the four of us had some good times together going to San Francisco for nightlife.

On occasion, I would make a guard mail trip to submarines in the Bay Area and on one trip to the *Grayback* (SS208). The captain kidded me about the soft job I had. I told him it was only temporary, that I would be assigned to a submarine soon. He replied that he would take a bosun's mate on *Grayback*. I thanked him and said that I was going to a new boat, the *Tang*, under construction at Mare Island. An officer nearby, taking all this in asked if I had orders to *Tang* and I replied, "No sir, but I am going to serve on her." He then introduced himself: LT Frazee, prospective executive officer of *Tang*. I've forgotten how I wiggled out of that one but about a week later, I was directed to report to the *Tang* office and when I arrived LT Frazee introduced me to LCDR O'Kane, the prospective commanding officer. After a brief "quiz" session, O'Kane stated that he too had served on *Pruitt* while it was still DD347 and that he would take me on *Tang*.

Grace had gone to work doing clerical work at the shipyard administration and expected me to be ashore for a while. I told her that I had been drafted to submarine duty and would be leaving shortly. Bob got orders to *Tilefish* and planned to take his wife, Gena, to their home in Texas. This worked out for us in that Grace did not have a driver license and they drove her to Los Angeles.

Tang and company headed west in January 1944, we operated out of Pearl Harbor and Midway making five successful patrols. In July 1944, I was advanced to CBM. Unfortunately, at approximately 0230, 25 October 1943, during a surface attack in the Formosa Straits, our last torpedo ran erratic, circled and hit *Tang*, quickly sinking her. Of nine men on the bridge, three, including me, managed to stay afloat for approximately eight hours. One officer, LT Savadkin, in the flooded conning tower, made a free ascent and survived. Thirteen men attempted escapes from the forward torpedo room starting about four hours after the boat was on the bottom, five men survived. Of the nine survivors, four are alive today. 78 fine men were lost in *Tang*. Even though it was very dark, the erratic torpedo could be seen, porpoising and curving back on the port side, maneuvering to avoid failed and the torpedo struck near the maneuvering room/after torpedo room. On impact, the stern started to drop slowly and I could see the water covering the after deck, suddenly *Tang* went down by the stern and I went down for quite a distance, I felt a bump, or explosion, then started up to the surface where the bow was out of the water, at an acute angle, I tried to reach it but the current was too strong and I slowly drifted away. I heard voices, Jones and Rector, but they also drifted away. I recall first tossing my binoculars, then got my jacket and shoes off. I took my trousers off and after tying the legs, tried to inflate them for flotation but no success so I tossed them. I stayed afloat by treading water and floating for some time and suddenly became aware of something splashing and sputtering nearby. It was Floyd Caverly, RTlc and we stayed together figuring we would head for islands off the china coast at daybreak when we could see them.

Tang had wreaked havoc before going down; the Japanese were picking up survivors from their own sunken ships and I am sure were surprised at finding us. Caverly and I were picked up at the same time by a pulling boat whose captain kept saying "Deutch-ka." Caverly thought the captain figured we were Germans and blurted out "Heil Hitler." As the boat returned to the ship, another man was spotted and it turned out to be our Skipper who was hanging on to what appeared to be a wooden door. I screwed up by saying "Good morning, Captain, do you want a ride?" as we helped him aboard. The captain must have recognized "Captain" as he had the Skipper come to the

stem and sit on a thwart. Caverly and I remained in the bow. When we got alongside what appeared to be like our destroyer escort type ship, the boat was hoisted to the main deck level where we disembarked. Caverly noticed one of the nip sailors had a wristwatch and took his arm to see what time it was. Wham! He learned the hard way but knew it was just past 1030. We were promptly bound and made to sit on the port side of the main deck, soon thereafter, LT Savadkin joined us. Then Flanagan, Trukke, DaSilva, Norwanski, and Decker joined us. We learned later that another man, Chief Pharmacists Mate Larson was also picked up but started convulsing and lost consciousness when the boat came alongside, he was never seen again. I was between the skipper and Hayes Trukke, TM2c, who had come to *Tang* just before this patrol. Following hours in the water, Trukke's excessively long straw-like hair was covering his face. The skipper nudged me and asked who was next to me and I told him, "Trukke," to which he exclaimed "Was he on my boat?"

The nip ship (#34 painted on bow) had a number of survivors from the ships we had sunk, some were burned and bandaged and they rightly figured we were responsible of their misery and proceeded to spread the wealth. We were on the ship for three days, confined in their "hot tub" room that was very small and uncomfortable. On the third day we entered Takao, the southern port on Formosa where hoods were placed over our heads and we were loaded into a truck. We spent the night in what appeared to be a warehouse, a very uncomfortable night with our hands tightly bound and our arms pulled above our heads. During the night, we were interrogated, given some water and worked over. The next morning, the hoods were put back on our heads and we were paraded through town. This must have been a real sight, in my case. I only had what was left of blue and white striped under shorts and a shirt on. My shipmates were similarly dressed. I could see a little through the hood and there appeared to be quite a crowd surrounding us. Our treatment indicated we were not the most popular kids on the block.

We ended up at a railroad station and were put on a train. The hoods were removed and each of us was given a window seat with a guard sitting alongside. The train ride was actually pleasant, we saw the countryside but every time we pulled into a station, we could see people on the platforms getting food and drinks, but none for us. We reached our destination late in the afternoon that turned out to be Kiirun and were bussed to a nip army installation where we were put in a cell that we called the "Kiirun Clink." This place was out of the dark ages, our cell was a large room about two feet above the adjacent passageway. The bars were hard wood about 6-8 inches in diameter, the entrance was small requiring a person to crawl into the cell. A hole in one wall about 3' x 4', provided access to the head which was a slit in the deck with running water several feet below. The ceiling was high, about ten feet, and there was a barred window at the top of one wall that appeared to be plastered. We were all in the one cell and, soon after our arrival, nine bundles were pushed through an opening in the bars with cups of hot tea. The bundles appeared to be wrapped in some sort of leaf and each contained rice and a pickled vegetable. This was the first food we had since capture. Our stay lasted three days and we were fed three times daily.

On the third day, we were loaded onto a bus, each with his own armed guard, we were not bound or blindfolded. The bus was propelled by a charcoal fired boiler of sorts mounted on the rear end and soon after leaving it stalled. Several guards got off the bus, leaving their rifles leaning on their empty seat to push the bus, when it started, the driver failed to stop and the guards ended up chasing it down the road while the remaining guards laughed. When the bus finally came to a halt, the pushers came back aboard and got a good laugh about leaving their rifles with their prisoners. Our destination was the port where our officers were each put aboard a

destroyer, the enlisted aboard a cruiser. The ships got underway soon after we boarded. We—the enlisted—were put in a hold with two guards. The hold was loaded with what turned out to be sacks of cane sugar and we were on top of them. It was apparent that we were making high speed. From time to time, nip sailors would enter the hold and after punching a hole in a sack, they would appropriate sugar into little bags. This trip lasted about four days and we arrived in Kobe, Japan, on a rainy, cold morning. We were taken ashore at what appeared to be a naval training station and all nine of us were lined up for inspection by a nip admiral. He asked me in excellent English, as I shivered in the cold, if I was frightened and I replied, "No, I am cold." He then said, "Of course, stupid, no shoes," and I figured the old boy would see to it that we were issued some clothing. That didn't happen!

Our next adventure was a train ride; we had a private coach this time, each with his own guard and an officer in charge. We were not bound or blindfolded, it was a long ride and we arrived at what we later learned was Ofuna station. It was a cold, rainy night and we were marched down a dark muddy road for some distance to our new home—Ofuna. Upon arrival, we were allowed to take a bath, were given some worn out clothing and each of us were put in an individual cell. Caverly and I were singled out to follow a guard to the galley where a familiar looking man put a wooden bucket of food, a pot of tea and bowls/cups on the deck before us. No words were spoken until our guard told us to pick the items up and we returned to our building. The guard instructed mostly by hand signals to put the food, which appeared to be a mixture of rice and vegetables, into the bowls, then pour the tea and place a cup and bowl on the deck outside each cell. The cell floor was about one foot above the passageway deck. When this was done, we were directed back to our cells, the guard then proceeded to open each door and the occupant was allowed to take the food and eat. Following our meal, we were allowed to bed down for the night.

Each cell was about 5'x6' and had a tatami mat on the deck. A glass port allowed the guard, who patrolled the passageway, to keep a check on the occupant. We were provided with two blankets.

In the morning, we were fed again and then an American prisoner gave us a rundown on camp routine in the presence of a guard. The prisoner was Knutson, RM1c of USS *Grenadier* (SS210). We were then herded out of the building to another part of the camp where we were told we would be given a lesson in Japanese. A slight built prisoner was brought out and after a lot of shouting by the nip in charge, the man was beaten senseless. We all thought that he had been killed. We were returned to our cells in what we learned was a building called "Eku." Later we learned that the man that had been so badly beaten was LCDR John Fitzgerald, the Skipper of *Grenadier*. There were three people from *Grenadier* at Ofuna when we arrived and they were all transferred to another camp soon after our arrival.

Ofuna consisted of one building that housed the CO, guards, interrogation rooms, and galley. It was "L" shaped and connected to "Eku" where new arrivals were incarcerated. Three additional buildings were in the compound, "niku," "sanku" and a one room structure, "yanku." The entire facility was enclosed with a high wooden fence, Eku was separated from the rest of the facility by a high fence.

We were informed early on, that we were not "prisoners of war" rather, we were "captured enemy" and therefore, not covered by the Geneva Convention governing Prisoners of War. Initially, we were kept in solitary confinement and interrogated frequently. The interrogators were always in civilian clothes, spoke English very well and had been educated in the U.S. Although a guard was always present during interrogation, I was never mistreated during the sessions but sure got whacked afterwards.

On Christmas day 1944, several guards came to Eku, opened our cell doors and gave each of us a Red Cross food package. The box

was about 12"x12"x6" and contained tins of corned beef, pâté, powdered milk, chocolate bars, etc. as well as two packs of cigarettes. There was also a small folding can opener. We were ordered not to open or use any of the contents as we were going outside to celebrate our Christmas with other prisoners and, to leave the packages in our cell. We were taken outside and the gate leading to the other buildings was opened allowing the other prisoners into our compound. This is when we learned that the *Grenadier* survivors were gone and that the man that had been so badly beaten on our first day in Ofuna had been John Fitzgerald. I also met the familiar face from the galley on our first night. He was Major Gregory Boyington who I had read about in either a Life or Look magazine during our final patrol. There was a full-page photo of him in the article and this is why he was familiar to me.

We found that all of the prisoners were either flyers or submarine men. There were three people from the British submarine *Stratagem*, all the rest were flyers. We also learned that in the eyes of the nips, we were criminals, for entering their Empire skies and waters. Following the "social hour" we were returned to our cells and found our packages near empty or gone altogether. Mine was gone. We all did a lot of shouting and beating on our cell doors, the guard was concerned about the racket we were making and finally showed up with a basket of hot sweet potatoes. He gave two potatoes to each of us.

As time went by, more prisoners were brought in, all flyers captured by the nip navy. Ofuna was run by the UN and supported from the Yokuska Naval Base. As eku filled with the new arrivals, *Tang* men were released from solitary to do chores in and around eku. Floyd Caverly (aka "Friar Tuck") was singled out to do some work for the "kongo-cho" who was equivalent to a chief pharmacists mate. A tall, muscular man who spoke English fairly well and appeared to pull a lot of weight with the "quiz kids" and officers from Yokuska. His name was Kitamura. After a short time, Kitamura wanted another man to do work for him and Friar Tuck suggested me and I got the job. Friar and I did odd maintenance jobs around the camp. One of the flyers brought in was badly burned, and had been bandaged. I was given the impossible task of washing his bandages, both original and subsequent bandaging. After washing and salvaging what I could, I would hang them on a line to dry. The flyer, a B-29 pilot by the name of Hunt, was kept in a cell in eku. He deteriorated to a point where Kitamura and the guards would not go into his cell due to the stench. O'Kane interceded on Hunts behalf with one of the quiz kids and we were allowed to provide care for him but he died. We carried his remains to yanku, the small building reserved for the dead and Kitamura (a self styled carpenter) made a wooden coffin. Late one night, Hunt was buried across the road from the camp in an area reserved for such things.

Some of the guards would flaunt items from the Red Cross food packages so, we knew there were more in the camp. Friar and I were cleaning the passageway in sanku when we discovered what appeared to be a locked storeroom at the far end of the building. There was no guard in sight so we forced the sliding door off its track and got a peek at what appeared to be stacks of Red Cross packages when a guard appeared at the far end of the passageway. We quickly staged a fight, I hit Friar and he fell against the door, by then the guard was there, broke up our "fight" and raised heck about us knocking the door loose. We hastily got the door back on its track and the guard made sure we finished our work and left the building.

Friar and I were in adjacent cells and were able to communicate when the guard was down the passageway. We felt certain that we now knew the location of the food packages. But how to get to them? Eku was built about 18" above ground and after examining the deck under the tatami mat we agreed that by lifting the floorboards, we could go out under the building,

make our way to sanku and go in through the window. The floorboards were nailed down but there was enough space between boards to get ones fingers in and grip the board. Our plan was to loosen the boards and nails, then pull the nails and cut them off with a pair of side cutters that Friar had "borrowed" from Kitamura's tool-box. Friar did his boards first while I kept watch for the guard, the following night, I did mine while Friar kept a lookout. By inserting the shortened nails in the nail holes, the boards appeared to be nailed down if the tatami was lifted. We now had a means to leave and reenter our cell but we had to be careful that the right guard was on watch.

On our first trip, all went well until we got to sanku, the window had wooden bars but we were able to pull a couple loose. Once inside, we found the Red Cross boxes, they were large and bound with metal straps that we could not budge. It appeared that each large box contained four of the smaller packages. We left, put the bars back in place and got back to ours cells, it was well past midnight. The side cutters were needed again if we were to get into those boxes. A few nights later, we made another try, this time with the side cutters. We took two small boxes and switched the large box to the bottom of the stack with unopened boxes on top. The boxes were kept under our cells and we tapped them at night. I found out years later that other prisoners were also getting into the storeroom.

In early April 1945, it all came to a head when all the prisoners were assembled and the camp commander—the "Mummy" said there were Red Cross food packages missing and he wanted to know who had taken them. We were all worked over but none of the prisoners admitted anything. That night the nip CPO's worked the guards over and I guess they finally figured it was impossible for the prisoners to have gotten to the packages.

Soon after this, all *Tang* enlisted men, some flyers, including Greg Boyington, were taken to the POW Camp Omori, near Yokohoma. This camp was run by the army and had about 600 prisoners. There were 21 in our group and we were again locked up as a group. We were kept in a room at one end of a long barracks type building, completed fenced. A guard was posted in the room and another just outside the door. We were now "tokobetsu hoyo" or "special prisoners" and were kept in the room about a month when the nip top sergeant told us that we would go on work detail and be given 2/3 of a prisoner's ration of food. This is when we learned that we had been getting 1/2 of what the prisoners got. Most of us had no shoes and pointed this out; the sergeant said he would take care of this. The next morning, there were several pairs of shoes outside the door, loaned to us by prisoners who stayed in camp. We worked outside the camp in bombed out areas clearing wreckage and also dug caves.

We had a guard that we called "Gimpy" who was a civilian that had been badly wounded while in the army. He spoke English and made no bones about his distaste for the war. One day he was talking with an older nip woman, as we worked, she left and then returned, gave him something and he called us all together, handed the item to Boyington with instructions to divide it. The item was a "mochi" something like a donut; there were 19 of us that day and Greg managed to get 19 pieces cut. The next day, two old ladies showed up carrying a tray of candied carrots for us. Gimpy told us they were concerned over our appearance; we did not look like the POWs who wore better clothing and appeared healthy. When we returned to Omori, Gimpy marched us to the commandants building, he went in and returned with the commandant and top sergeant. There was a lot of discussion and we ended up being marched to the bathhouse where we were allowed to get cleaned up, the first time since our arrival at Omori.

Air raids were increasing and that is the only time we were left unguarded, the guards would go to a shelter and we were able to watch the fireworks that were impressive. In June, a group of prisoners, including *Tang* officers, was brought to Omori and locked up with us. The room

we occupied was now full. Additional prisoners were brought in and locked up in a room adjacent to ours. These were all flyers, recently captured. We were able to communicate through the wall, when the guard was goofing off.

I think it was August 9, 1945. We were digging a cave into the side of a hill near Yokohoma, loudspeakers could be heard and about mid-day and, from the way the guards acted, something was up. The interpreter told us to bring all tools out of the cave and unstring the lights. I had come out with some tools and was told to sit down and was given a cup of tea by the interpreter. My right foot was in bad shape after a guard had redesigned it a couple of weeks before and the interpreter told me that soon I would get medical treatment in a hospital. Our group was formed up and started the march back to Omori. As we marched a couple of truckloads of prisoners passed us and shouted, "The war is over." When we got back to Omori, the guards put us in our room and left us, without a guard. There was a lot of shouting in the camp and some of the prisoners came to our building and told us the war was over but cautioned us to remain in our room and they would stand guard outside the building. Some of the guards were drinking and could pose a problem for us. One drunken nip soldier did try to get into our space but was permanently put out of his misery by Top Sergeant Ogura.

Most of the nips left the camp, leaving the commandant and Sgt. Ogura. They stayed in their quarters and the prisoners got organized. CDR O'Kane was the senior officer, Maj. Boyington became the provost marshall. I was put in charge of a barracks with 103 men. It wasn't long before our planes, Navy and Air Force, were flying over Omori dropping all kinds of goodies. The B29s would drop 55 gallon drums, lashed together in pairs, attached to small chutes. I got khaki shirt and trousers and a pair of shoes as did the other *Tang* people.

At the end of August, a landing party came to Omori under the command of CDR Stassen. He told us that they were there to make arrangements for our evacuation that would take place in the next couple of days. After looking the place over, CDR Stassen told us to get any belongings we had, he was starting evacuation immediately.

Someone put a tag on me that was stamped "non-ambulatory" and I was taken to the Navy hospital ship *Benevolence*, anchored in the Bay. After initial treatment, I went to LSD *Ozark*, also anchored, to await air transportation. I ended up at the Naval Hospital, Oakland for a short period, then to Long Beach Naval Hospital where I remained for several months.

I returned to duty and was assigned to the NROTC Unit at UCLA. While there, I was advanced to warrant bosn. Although the duty was great, it was not for me and I requested a change and was ordered to Mare Island for duty on USS *Pelias* (ASI4), the accommodation ship for ComSubGrp PacResFlt. Grace and I moved to Vallejo, now with our young son Bill. One afternoon, I received dispatch orders to "proceed immediately" to Tokyo, Japan for duty in connection with the War Crimes Trials. I was not enthused over this but the next day Grace drove me down to Alameda Naval Air Station where I got a flight to Japan.

In Japan, I was assigned to the Legal Section, SCAP (Supreme Commander Allied Powers). They had most of the Ofuna gang in Sugamo Prison and I was out there to provide testimony and assist the lawyers in Ofuna cases. They required live witnesses for death penalty cases. I did not want to be out there and it appeared that everything was taking too long. I got a ham call back to O'Kane to apprise him of the situation, In a few days, O'Kane showed up and raised a good bit of hell. Things started to move and after some of the trials were completed, I figured it was time for me to leave. I made my departure call on the colonel in charge of the legal section and he promptly informed me that he had not authorized my leaving. O'Kane was with me and he told the colonel that his authorization was not required, CornNavFe had endorsed my orders and made travel

arrangements. Soon after that O'Kane returned to the States, where he was the chief staff officer for ComSubGrp, PacResFlt, effectively my boss.

In 1948, I received orders to USS *Nereus* (AS17), home ported in San Diego. We packed up and moved to Chula Vista. Our daughter Ericka arrived the following year. At that time, warrant officers had their own quarters and mess. I recall that there were eleven warrants on board and we led a good life. *Nereus* and *Sperry* (AS12) were in two point moors adjacent to the Coast Guard Air Station and each tended a squadron of submarines. So as not to settle down on coffee grounds, each tender would get underway for three days monthly to conduct drills, gunnery practice etc.

The LDO program was just being instituted and I took the exam for it. Just before being notified that I had been selected for ensign, I was selected for promotion to chief warrant officer. I had been a warrant for six years and was not sure about "stepping down" to ensign as opposed to being a CWO. My skipper and exec (Karl Wheland and REM Ward) convinced me that I had a far greater future by accepting a commission as ensign. In 1951, I was promoted to ensign and received orders to the Naval Station, Tongue Point, Astoria, OR. I reported in and we were assigned very nice quarters on the base. My job (a LT billet) was security and ordnance officer. The Station was originally commissioned as a Naval Air Station and bordered the Columbia River. It was now utilized to support the Columbia River Group, PacResFlt. While my job was challenging and I rattled a few cages while there, I felt it was a dead end. Most of the senior officers were on their twilight tours and it showed. I called the submarine detailer in BuPers and requested assignment to Diving School. I received my orders and after six months at Tongue Point, my family and I were on our way to Washington D.C. I completed a six-month course at the Deep Sea Diving School in October 1952 and was ordered to USS *Florikan* (ASR9) in San Diego. We again settled in Chula Vista and I had various jobs on *Florikan*. Operations, communications, navigator and diving officer. While serving in *Florikan*, I was promoted to LTJG. We did a good deal of recovery work during missile tests off the California coast as well as the usual WestPac deployments.

Following my tour in *Florikan*, I received orders to USS *Volador* (SS490) also home ported in San Diego. Again more WestPac deployment and interesting special ops. I was primarily on *Volador* to qualify (Officer) in submarines and spent a lot of time working on this in addition to my primary duties. I was promoted to LT while on *Volador*. After *Volador* I received orders to the Submarine Escape Training Tank, Pearl Harbor where I served as OinC. After a short stay in Navy Housing, Grace and I rented a new home in Pearl City, we were the only "round eyes" in the neighborhood and enjoyed living there.

Shortly after my arrival, we started conversion from training in the S.E.A. (Momsen Lung) to the buoyant ascent method of submarine escape. The Tank at New London, CT was farther along in this new procedure so, in company with Master Diver Milo Holecek and Diver Bob Sheats I made a trip there to learn from their experiences; it was a worthwhile trip. In addition to submarine escape training, we provided diving service to the Submarine Base, conducted Diver 2nd Class and SCUBA training for PacFlt and provided treatment for many civilian SCUBA divers in need of recompression. ComSubPac headquarters was located across the street and we were called upon frequently, to provide tours and demonstrations for visiting dignitaries.

In 1958, after two years at the Tank, I received orders to USS *Coucal* (ASR8) as executive officer where I served in this capacity for one year, then fleeted up to command. This worked out well for my family in that *Coucal* was home ported in Pearl Harbor and a move was not required. During my tenure, *Coucal* provided services to submarines, diver and submarine rescue training and of course, a couple of

WestPac deployments. All hands worked hard in this ship and it was awarded the coveted "E." During a deployment to WestPac, *Coucal* was assigned to work with the Japanese Maritime Self Defense Force and their new submarine "*Oyashio*." Basically, we were on detached duty and spent most of the deployment operating with the nips. We carried two nip officers on board, one a doctor and the other a line officer, the latter, LCDR Fuji, had been in their Navy during WWII and we got to know one another very well. The trial skipper of *Oyashio*, CAPT Hashimoto, was also an ex-naval officer in the IJN and had been the skipper of the I-58 when it sunk our cruiser *Indianapolis*. These officers made it a priority that we see the Japan that "tourists" did not see and we went into several out of the way ports where we were given royal treatment. One excursion took us to Tokushima where our ball team was invited to play a game of softball. We were all shocked when we arrived at a large stadium and were introduced to our opponents. We were to play the high school national champion girls team and they beat our pants off. This was quite an affair, complete with TV coverage and local dignitaries.

In Pearl Harbor, *Coucal* was given the task of rigging and towing the decommissioned submarine *Tinosa* as a submerged target for aircraft ops. Given the nickname "Asonit," a manifold was installed topside so the hull could be submerged and suspended from four salvage pontoons. While towing her in rough weather south of Kauai, pad eyes welded to the hull with suspension chains attached, pulled free and Asonit made her last dive in some 2000 fathoms. I reported the loss to ComSubPac by dispatch and fearing the worst returned to Pearl. Upon arrival, I learned that the boss was mighty pleased with our loss, as he was not too enthused with being the custodian of a target hull.

Our son Jim arrived while I served in *Coucal* and rounded our family out.

In June 1960, I received orders to the Bureau of Naval Personnel in Washington, D.C. My new job would be in Functional Training where I administered Diver, Explosive Ordnance Disposal, Underwater Demolition and Underwater Swimmers training. Grace and I bought a new home in Alexandria, not far from Mount Vernon and we enjoyed living there. During my time in BuPers, President Kennedy directed the Navy to institute a "clandestine capability" and put a time deadline on establishment. I inherited this job and establishment of the SEAL—sea, air, and land—Teams was initiated. Getting money reprogrammed and people for this was quite an undertaking. Most of the initial people had UDT backgrounds. Another project was authorization for a metal insignia to replace the embroidered diving helmet then authorized for divers. The supervisor of salvage, Bill Searle, was energetically pushing the concept and I made the presentation to the Uniform Board. All went well and our divers finally had a pin type diving insignia.

After two years at BuPers, I received orders to command of USS *Greenlet* (ASRI0) home ported at Pearl Harbor. We left our home in the hands of a property management company and headed west. The incoming OinC, Experimental Diving Unit/Deep Sea Diving School, Charlie Hedgepeth rented the home. Upon arrival in Pearl, many old friends including my squadron commander, to be, greeted us. He informed me that they were holding *Greenlet* up on getting underway so that I could ride her while she stood by a submarine making a deep dive. Great, I had not planned on this but was assured that my family would be well taken care of, and they were. Grace and I rented a home in Aiea Heights and enjoyed living there.

Greenlet like her sister ships left something to be desired in crew comforts etc. Soon after taking command, I started a "rehab" program. Arrangements were made with the Subase repair officer to allow *Greenlet* men to use the shops at night and they manufactured bunk lockers to replace all such items in *Greenlet*'s berthing compartments. The spaces were completely refurbished and a recreation

room/library was provided. Destroyers were being modernized in the shipyard and many goodies could be "appropriated" from them. *Greenlet* was fitted with the old six dog watertight doors and some of the topside doors leaked badly. Again, our shipfitters came to the rescue alld installed quick-acting doors from the destroyers. Our bridge was in need of modernization; we cannibalized part of a destroyer bridge structure and rebuilt ours. The bridge wings were extended out to the sides, thus giving the conning officer full visibility on either side. This alteration necessitated relocation of the port/starboard running lights; I was a little hesitant to do this but had already made so many unauthorized alterations, one more wouldn't hurt. Our final bridge structure now sported tinted glass windows forward, a radar repeater, rudder angle indicator etc. I know the crew was very proud of their "updated" ship.

On a deployment to WestPac, our first port of call was Sasebo, Japan where we went alongside the USS *Ajax*, a repair ship that carried a Flag Officer. This turned out to be a submarine officer (RADM Williams) who I knew from my days on *Nereus*. I made the usual call and the Admiral invited me to lunch, during which he mentioned that being familiar with ASRs, *Greenlet* appeared somewhat different. I told him that a good deal of work had been accomplished to improve the ship and invited him to look her over. I was surprised when he responded that he would inspect *Greenlet* right after lunch. He looked the ship over thoroughly and when he walked into my cabin, he exclaimed, "My God, you live better than I do!" The cabin was paneled with teakwood veneer, carpeted and nicely furnished. When we arrived on the bridge, ADM Williams looked everything over very closely and said, "There has been a lot of recent work done here, is all this authorized?" I could only answer truthfully, "Yes sir, the commanding officer authorized every bit of this work." He just nodded and I escorted him to the brow where he thanked me and left. That evening my exec and a LT—George Riefler & Bob James—were ashore at the "O" club. Williams was also there and my officers decided to have a drink delivered to his table from the *Greenlet*. In response, the admiral sent a cocktail napkin to them inscribed as follows: "I have sent the following message to ComSubPac; I inspected your *Greenlet* today, what a magnificent little ship." I breathed a little easier when I learned of the message. J.W. Williams was not one to fool with.

Like *Coucal*, *Greenlet* operated out of Pearl Harbor providing services to submarines, conducting diver training, submarine rescue exercises and six-month deployments to WestPac. The submarine rescue chamber had a max working depth of 850' and a test depth of 1300'. Seldom was the chamber operated at depths greater than 300' and my concern was: What if a boat is down in l000'? Prior to deployment to WestPac, I called on ComSubPac—ADM Clarey, who I had known for some time and held in high esteem. I explained my concerns and told him that I would like to lay a four point moor and operate the chamber in 1000' in Sagami Wan soon after our arrival in Japan. On arrival in Yokosuka, I explained the planned exercise to the Flotilla CDR and got the green light. In *Greenlet*, many calculations and preparations had been made, including testing the chamber to 1350'. We were assigned an area in Sagami Wan and proceeded there on a miserable rainy, January day. Laying the moor went well but the spuds were barely watching, while holding all the weight to the anchors. We centered in the moor and went to work lowering the false seat to the bottom. Initial soundings indicated we had 1000' of water but the actual seat was made at 942'. Lowering the false seat required close attention and was accomplished without incident. The chamber went over the side manned by CPO Davidson, GMI Smallwood, and LTjg James. A couple of "glitches" occurred that resulted in the issuance of alterations based on our recommendations.

Following the bell run, I sent a message to all concerned and naturally expected to hear

something in return but only silence followed. CDR "Bo" Coppedge who had commanded USS *Tang* (SS-563) was on duty at the CNO and, noting the silence, originated a message from CNO congratulating the officers and men of *Greenlet* for their accomplishment; this was followed by several messages down the chain of command. Upon our return to port and checking in with the boss, he stated that he did not know whether to order a board of inquiry or pat me on the back for a job well done, His concern was that we had exceeded the working depth prescribed for the rescue chamber. I pointed out that I had told him personally of our planned operation and asked the question, "If one of our submarines was on the bottom in 1000', what would you order me to do?" Putting your boss on the spot is not the smart thing to do, but then, I never was a "rocket scientist!" On return to Pearl, ComSubPac backed me up on the operation during my debriefing over the objections of his chief of staff (CAPT Walt Small) who had been "needling" throughout my presentation.

Greenlet was in WestPac when I received orders to the Experimental Diving Unit in Washington. D.C. My old friend, LCDR Lyn Clark, a survivor of *Grenadier*, relieved me in Naha, Okinawa and I was soon on my way back to Pearl. Grace had taken care of shipping our household goods and car and we enjoyed a short vacation at the Kahala Hilton with Jim and Ericka. Bill had previously returned to the mainland after graduating from high school. We had two cars, so Grace drove one and I drove the other across country. We did the usual house hunting and rented a place in Alexandria. I reported in to NEDU where my boss was Charlie Hedgepeth, also my tenant. About six months after reporting to NEDU, I was promoted to commander and then received orders to relieve Charley Hedgepeth as OinC of NEDU and DSDS in early 1966. The Hedgepeth family left Washington. Grace and I, with our children, moved back to our own house. DSDS was under BuPers, the OinC had additional duty to Bushipsas OinC of NEDU and BuMed had an active interest in both activities. This was a poor command structure and was resolved by CDR Gene Mitchell being ordered in as OinC, NEDU. DSDS was designated a command and I was ordered to that post. The two activities continued to share the same building and some facilities. The pressure facilities in both facilities were old and tired and defects were apparent in the school facilities. Unable to get the BuPers people to recognize the severity of the situation, I finally sent a CASREP, effectively shutting the school down. This created havoc and the Chief Of BuPers directed me to meet him at the school for his personal inspection. The old boy was really mad over my message. I showed him pressure lines et cetera that were ready to rupture due to years of deterioration and explained how we could have fatal casualties. He got the picture and cooled down considerably; we ended up getting a complete overhaul of our pressure facilities.

Late in 1968, CAPT Nicholson summoned me for an interview/briefing at his home on a Sunday morning. The briefing covered a classified project that involved divers and submarine operations being developed on the West Coast by the Deep Submergence Systems Project and administered by the projects technical office at the Submarine Base, San Diego. I had orders to DSSPTO so we sold our home and Grace and children headed for San Diego where she purchased a new home in Del Mar and got the kids started in school. I remained in Washington until December, when LCDR Billy Delanoy arrived to relieve me. Grace came back for the change of command and then, we drove out to California.

The SEALAB III project was being pursued by DSSPfO, the OinC, CAPT Walt Mazzone was well versed in all aspects thereof and I was not, thus it was decided that I would relieve when the project was completed. In the meantime, I would acquaint myself with other DSSPTO activities in Long Beach and San Francisco.

The SEALAB III habitat was placed on the bottom in 600' off San Clemente Island, I had just arrived there by air and was promptly advised that an accident had occurred. Upon

boarding the support vessel, I learned that two divers, CBOSN Bob Barth and Berry Cannon, a civilian participant, were in the PTC and that the habitat was flooding. Bob had brought Berry, who was unconscious, back to the PTC and communicated the problem to topside. A lot of discussion was going on among the senior officers, none of whom were line officers. They wanted to put additional divers down but CDR Jack Tomsky was reluctant to do this. Jack and I conferred on the subject and it was decided not to put more divers down but to get Bob and Berry to the surface as quickly as possible. I received dispatch orders to collect all evidence and put it in safe keeping and stand by to be a member of a Board of Investigation headed by Capt. Chase who was coming in from the east coast. The death of Berry Cannon, caused by an empty CO_2 canister in his diving gear, was essentially the basis for bringing the project to a halt. The underlying classified work could go forward with hardware and procedures thus far developed. Upon completion of the investigation, I relieved Capt. Mazzone. DSSPTO was absorbed by Commander Submarine Development Group One and the finest and most dedicated group of divers, the Navy had ever assembled, began dissolving.

By this time I was nearing retirement, our son Bill had just completed four years in the Navy on USS *Haddock* (SSN621) and the two of us took on opening a new service station in Del Mar. Bill was the first to recognize that this was not for us and went off to diving school, then on to work for Taylor Diving. I kept the station for a short time then sold out. I then managed an automotive service/parts dealership for about ten years. During this period, Grace and I had a home built on Palomar Mountain in 1975 and retired to it in 1981.

MR. GERALD McLEES

I was born in Richmond, KS, in 1914. My folks had a farm there and of course, I was a farm boy. We lived about, oh, six and three quarter miles from Richmond. My transportation to high school was a horse. I rode a horse morning and night, to and from high school. I graduated in 1932.

Times were really rough then. There was no work or anything, so this friend of mine with whom I ran around said, "Why don't we go out and join the Navy?" Without even telling my folks or anything, we hitchhiked up to Topeka, Kansas. I think we had about fifty cents in our pockets. When we got up to Topeka, the chief at the recruiting station was just about ready to go home, but we talked him into giving us the pre-examination and everything. I zoomed right through it, but my friend's eyes were bad. He flunked out right away.

After we came back, my folks were just happy that we did come back. About a month later, I got a call to go to Kansas City for my final exam, and I went. That evening, I was on a train for San Diego. I picked the Navy because that was the first recruiting station we came to. I didn't know one from the other, the Marines or the Army. The kid that I went with was kind of in favor of the Navy, too. That was one reason. As far as I was concerned, I didn't know one from the other. Joining the Navy was just something to do. I think it was in August of 1934 that I left Kansas and headed for San Diego.

After three months in recruit training, we were put in the transfer unit waiting for orders. One day, we came in from our work detail and found quite a group of names on the bulletin board, including mine, of guys who were being transferred to Pearl Harbor. We were running around like crazy, trying to find out where in the heck Pearl Harbor was. In those days, nobody had ever heard of Pearl Harbor. We found out. We got on a transport, and that was how I ended up at Pearl Harbor.

Of course, being just a boot, they put a lot of us on mess cooking duty. One day, I got acquainted with one of the guys who was mess cooking with me, and he was on a submarine there, an S-30 boat. He said, "Why don't you come down in the boat? The chief is looking for

another seaman." After we got our work done there, I went down. That evening, I had a .45 strapped on me and was on topside watch, on the submarine. I was assigned to the S-30 boat.

I guess submarine duty was voluntary then, and normally most everybody was going to New London to submarine school. I always said my folks couldn't afford the tuition and that was why I didn't go to submarine school. In 1938, the S-30 came back to New London.

Our typical day on the submarine was that we just went out from the submarine base in Pearl Harbor. Maybe once a year we would go over maybe to Lahaina Roads for gunnery practice and anchor off of Lahaina. Lahaina was nothing in those days. Now, it's a big tourist center. The diving was for short periods of time. It was not like it is today, where they go down and stay underwater for days at a time.

Living aboard a submarine in those days wasn't too comfortable. We had no air conditioning. Everything was kind of crowded. We had sleepers, but I think our bunks were four-tier high.

I never went to submarine school, but I went through the escape training tower in Pearl Harbor. Before I qualified, I went through that. In those days, I think our submarine pay was $30 a month and that was pretty good money at that time.

When I first enlisted in the Navy, my pay was $21 a month as a recruit seaman. Then, it went up after three months. It went from $21 to $35 or something like that. Then, you had to make a rate before you could get up to seaman. First it was $56. I think the highest rate there was paid to chiefs, at $99 a month.

We came back to New London on the S-30 boat. After I was in New London for a short while, the squadron got a request for four third-class electricians' mates to go to the USS *Raleigh*, a light cruiser. That was over in Europe. It was supposed to get relieved over there by the USS *Omaha*, another cruiser, but on the way out there, the *Omaha* went aground and had to go in for an overhaul. They had several people on the *Raleigh* whose time was up and had decided they were going to get out of the Navy. They wanted replacements for them. I figured I had about a year to go on my enlistment and it would be a good chance to get some overseas duty, so I volunteered and transferred to the destroyer, the USS *Claxton*. Then, we met the *Raleigh* over in Gibraltar. I went aboard the *Raleigh*. I made second class on the *Raleigh*, second class electrician's mate.

I think that just before my enlistment was up, we were relieved and came back to the States. I decided that I didn't want to stay on a surface craft. I wanted to get back to submarines. I'd already agreed to extend to go over my enlistment for two years to go over to the *Raleigh*. But when I got back to Norfolk there, my enlistment was not quite ready, so my extension hadn't started. I gave them a big line of baloney that I'd been offered a big job with Standard Oil or somebody, and I got my extension cancelled and got out of the Navy.

On the way back to Kansas, I stopped in Washington. There was an ex-skipper there who told us when he left the submarine that if there was anything he could do, were he at the Bureau, to stop by and let him know. I stopped there and told him I was out of the Navy, but I wanted to go back for submarines. He said, "You go on home. When you get ready to ship over, give me a call. I'll send a letter to the recruiting station." That was how I got back on submarines.

There was the extra pay and the social relations on submarines. You knew everybody and they knew you. You were family and all that business. It was really more homelike. On the cruiser, I didn't know more than just the group in my division.

I signed up in Kansas City, at the recruiting station. Then, I transferred right back to New London. I got on another submarine. I got on an R-boat, the R-14.

The R-boats were smaller than the S-boats. The O-boats were the smallest, followed by the R-boats and then the S-boats. While I was in New London, they started building the fleet boats and I put in for the USS *Squalus*. I got transferred to it in February of 1939, or so. It

was still being built in Portsmouth. When I came to the *Squalus*, it was quite different from the R-boat or the S-boats that I was on. I had to re-qualify.

It was a modern submarine. It was really something to get on one of those fleet boats, or what we called the "fleet-type" boats. While I was in New London, I went through the tank and the pressure chamber and all that.

I was not too aware of submarine rescue equipment at the time, but we did take the lung training and all that. We had that in the tank. We used the lungs to come up from a hundred feet. That was the only thing that we had. To be able to come up from a hundred feet was an achievement. The tank had an escape chamber at its bottom, and you went on in there and opened the hatch and came up through the hundred feet of water.

I was sent to Portsmouth, where the *Squalus* was. I was a second class electrician's mate. We went out and operated one day, and the next morning, we were supposed to make this crash dive, or whatever they called it. It was putting full power on the main engines and then shifting the motors and trying to get down to fifty feet in fifty seconds, or less than a minute, I think. That was one of the Bureau's qualifications, to be able to go down to periscope depth in so many seconds.

I was assigned to the forward battery. It was going to be a one-hour full-power discharge on the battery. I was to take gravity and temperature readings every five minutes during the hour-long discharge. Bryce was on the telephone in the forward battery. He was the one who received the word that the aft engine room was flooding. I think I was down in the tank at the time, down below the deck.

You couldn't stand up down there in the tank where the batteries were. I think I came right out of the tank and passed the word, but Chief Gaynor was taking readings from the individual boat meter up on deck. Of course, he was a little more qualified on submarines because he'd been on them for quite a while. He rushed right down to the tank and pulled a big disconnect switch to disconnect the battery from the after battery. The after battery was flooded and the forward battery was discharging fully into the after battery. He had one switch on each side. When he pulled one, the arc didn't break on it until he pulled the other one.

As I said, I was down in the tank, and as soon as Bryce got the word that the engine rooms were flooded, the word came that we were to secure the after battery, forward battery, and go into the forward torpedo room. They figured that we might start getting chlorine gas from the batteries.

We went in the forward torpedo room, and then got word to conserve all the oxygen we could. I crawled into one of the bunks there and lay down and covered up, because it was cold. Later on, it got really cold. We had no lights or anything.

The emergency lights went out when Gaynor pulled the disconnect switches in the forward battery. Of course, that was one of the things that were changed. After the *Squalus* accident, when you pulled the disconnect, you still had emergency light. We had flashlights and battle lanterns but we didn't want to use them unless we had to.

There was no panic on the *Squalus*, or anything that I knew of. You never heard anybody start hollering and then snap. I, at least, sort of figured, "Well, what the heck, maybe we are on the bottom, but we'll get rescued in no time at all."

The majority of the crew then went to the forward torpedo room. They went there after they got settled down and everything. Everybody who was in the control room secured the control room and went into the forward torpedo room. In the meantime, Maness closed the bulkhead door between the control room and the after battery when that started to flood. He got that closed. I think there were two fellows who came from the after battery who got into the control room before we closed the door.

I think that after the boat was raised, they found a first class electrician's mate who had

been assigned to the after battery to take readings. His body was still in the after battery, and a mess cook was also still in the after battery. They never found the body of a third class cook, Thompson. He got into the skirt of the after battery hatch and was trying to open the hatch. He got it undone, but the pressure held it shut. He passed out after the air was all gone in the normal space in the hatch there. When they first raised the *Squalus* and it went back down, the pressure pushed the hatch open and they figured that his body went out through the hatch. They never found it.

It was just the luck of the draw that I wasn't in the after battery. Badick and I were sitting in the crew's mess and having a cup of coffee when the diving alarm went off. He said that he wasn't finished with his coffee yet and for me to go on forward. Because he was first class and I was second, I went forward and he was to take the after battery. That was why he didn't finish the after battery compartment, where he hadn't finished his coffee.

Most of the things written in Nat Barrow's book, *Blow All Ballast*, are really true to what happened. He was right out on the USS *Falcon* all the time. They said that after the boat sank, the *Falcon*, which was a salvage ship, was there. He got some boat from Portsmouth to take him out to the salvage area. They weren't letting any of the small boats into the area, but he talked the guy on the boat into taking him up by the *Falcon* and he jumped onto the *Falcon* and made them pull the boat and shove off. Then he got acquainted with the admiral and lived right aboard the *Falcon*. He was later killed during the war, in a plane accident or something. He was a war correspondent. At the time, he was with the *Boston Globe* or the *Boston Post* or something.

Getting back to the *Squalus*, I guess it was Captain Naquin who was the one who told us to secure the forward battery on account of the chlorine. I don't think it ever had chlorine in it, but they were afraid it would get in there. After we got that secured, the people in the control room decided to vacate the control room and go to the forward torpedo room. I guess there must have been 33 of us, because the number of those rescued was 33.

The forward torpedo room was a large space with only a few bunks. It wasn't flooding, but had some water in it. Of course, a little water got in when they first opened the hatch. When they blew the water out of the bottom of the bell, before they opened the hatch, a little water got into the escape drum there, and when they opened the lower hatch, some got into the torpedo room.

Actually, we must have all been in the torpedo room when they made the first bell trip. We must have been. I won't say for sure as to whether we were all up there then. It was probably the next morning sometime, the next forenoon that the first trip was made. It took about 24 hours before the first trip was made. Nobody was saying much and it was pretty quiet. We laid down one of the sheets or something, a mattress sheet or something, and spread out the carbon dioxide absorbent. It was a white powder.

I don't think anybody had any breathing problems. I think there was one person who was getting sick. I don't know whether it was on account of his breathing, or whether it was just nervousness. I didn't know what it was, but it was only one person. They had one of the enginemen, the machinist's mate, carry him off when they came out of the bell. They had to carry him off. His health may not have been too good anyway. He was one of the oldest fellows on the boat. They put us all in the hospital after they got us off of the boat. They put us all up in the hospital, which was against our wanting to go there.

We hadn't been down too long before the sister ship, the USS *Sculpin*, came out. We could hear her screws and her engines running when they finally located us. First, they picked up our marker buoy. When they brought it on deck they tied the line around the railing and the boat swayed away from us and parted the cable. That was one of the things that they showed in the movie. It seems that the cable broke. Swede

Momsen was diving over the side, trying to get the other end of the cable.

They had just said "Hello, Naquin," and this and that. That was about as far as they got, just a few words. Of course, the *Sculpin* started to use their sonar. We could hear them pinging, and we were signaling back by hammering on the hull using Morse code. At that point in time, spirits seemed to be high, very much so.

I guess someone thought of having to escape. In fact, the skipper or whoever it was had us put on the lungs. We had the lungs strapped on. It was done just to be prepared. They figured that at a hundred feet or so there, with the temperature of the water, we wouldn't have much chance. I don't know what the temperature was, but it must have been forty degrees or less. It was really cold down there. I was lying in a bunk. In fact, there was another guy lying in the bunk, too. We had a big cover and blankets over us to keep warm.

The *Falcon* wasn't there yet. The *Sculpin* was the only craft that was there. I think the *Sculpin* located us the first day. The *Falcon* arrived the next morning sometime with the bell.

I think as soon as the *Falcon* arrived and they made the mooring over our area, the crew from the *Sculpin* actually went out in the small boat and used the grappling hook and located us after the cable for the small buoy had broken. The grappling hook so happened to hook on the railing of the forward torpedo room hatch. Of course when the diver came down on that line, he landed right by the hatch, which was where he was supposed to be. It made it very easy to hook onto the hatch area.

I can't remember exactly what time it was, but it must have been around noon or before noon when the first bell run came down. It was about 28 hours after the sinking. When they came down to put the cable on, you could hear him walking on the deck. It was easy to hear because divers wore those big lead-loaded shoes. He went clunk, clunk on the deck. Another good feeling occurred when they opened the hatch and the guy from the bell hollered down. In the movie, it showed Swede Momsen was the one who took the bell up and down, which he didn't do.

In fact, the guy who was operating the bell was a Polish fellow, Mihalowski or somebody. I forget what his name was. In fact, I did a television movie with him. It was called *Place the Face*. It was just like one of the game shows. I was a guest. That was after the war. I was in New London in the 16th Fleet then. I got a call from Hollywood, and a guy wanted to know if I would come out and do the movie. I said I would if my wife could come with me. He said okay. Anyway, I went out there and did this movie. I was on TV there, and they were asking me questions about this and that. They had this fellow. You saw his picture as though it was in a picture frame. You just saw his head. They were asking questions, like from where I knew him and all that. It just so happened that he was one of the divers who had made the dive to the *Squalus*. His name was Mihalowski.

When the hatch was opened in the movie, things were said like "Did you bring down a steak?" and "What took you so long?"

The captain was the one who assigned guys to go up. He'd say, "You, you, and you," just like that. I think Lieutenant Doyle was the first officer to go up. In fact, I'd been with Lieutenant Doyle before. He was on the S-30 boat when I came back to New London.

I forget how many could get in the bell. It had room for four or five. I guess there must have been eight or nine in there, plus the operator. Then they'd close the hatch going from the escape place down in the torpedo room. They closed the lower hatch. Then they would flood the chamber and open the upper hatch into the bell. The people down in the torpedo room, with a big lever they had there, could close that upper hatch of the submarine after the bell had left and they could then drain the escape chamber and open the lower hatch so that people could go back up in there again.

It probably took no longer than 15 or so minutes to go from the *Squalus* to the surface, or that was what it seemed like. We moved right

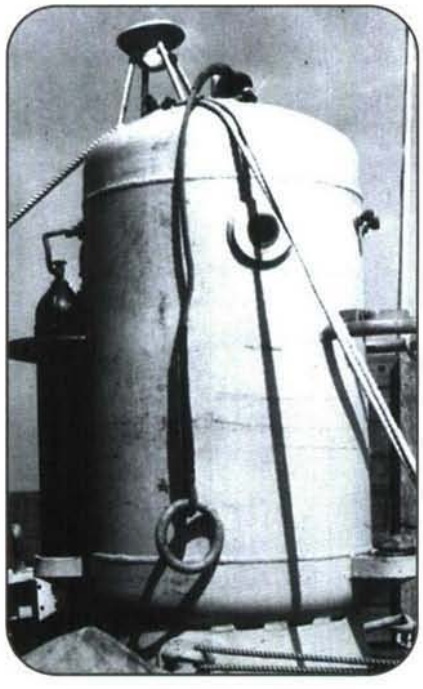
along. We didn't have to stop for decompression or anything like that. We moved right on up, slowly. When I got out of the bell, like it said in the movie, I said something about the fresh air and the sunshine. It was a bright sunny day.

We weren't aboard the *Falcon* too long. I think that after they got the first two trips aboard, the Coast Guard took the first two loads of us to the hospital. I was at the hospital when they had trouble with the fourth run. Bryson, Pierce, Persico, Naquin, and I don't know who the rest were that were on that fourth run. Naquin was the captain, so he stayed until everyone else was able to go up.

Editor's Note:

The fourth, and final, chamber run consisted of eight men including LT Oliver Naquin, the commanding officer; LT Walter Doyle, the executive officer; and crew members Charley Kuney, Allen Bryson, Donny Persico, Carol Pierce, Gene Cravens, and Charles Powell.

I think that right after we got in the hospital, Harold Prebel, the civilian naval architect, started to get on the phone and we had more food and stuff coming up to that hospital. He actually ran the Navy Yard, almost, I think.



Submarine rescue chamber

What he said really went. We got more stuff coming up there. People were bringing stuff in.

Right after we got out of the hospital, the press was trying to get to us. They had so many telephone lines running in there, from the outside into the Navy Yard and to the main building.

After we got out of the hospital there, we weren't allowed to leave the area until after the inquiry. They had the inquiry there, and they found out the accident was by no fault of the crew or anything.

I had bought a car from the first class electrician named Bland, but I forget what kind of car it was. It was probably a hundred bucks, and I probably gave him a $10 down-payment on it and was supposed to give him so much every payday. I don't know whether I said it or whether he just made it up as a joke. The first thing I supposedly said to him when we got together after getting off the *Squalus* was, "Gee, you would have to be one of those who were saved," because I owed him money. He made quite a joke out of it. Every time we had a convention later on, he'd tell that joke.

The crew stuck close together after that. We've had several reunions. Right after that, they had a big memorial for us out around Rye. Yes, it was right around Rye or someplace that they had a big memorial service. Some big shot had a big mansion out there. They had a big orchestra playing and all that, right there on the beach. The brewery in Lowell, MA, the Harvard Brewery, threw a big party for us. That was shortly after, before anybody got transferred. I know there was about a dozen or so of us who went down to the Harvard Brewery. They gave us a big dinner and all the beer we could drink. I got a kick out of it.

When we got ready to leave, I had my car and was driving. A couple of us had cars. We got ready to leave. We gave the guy heck, you know, because we were trying to get about three or four cases to take back with us. We were calling them cheap and everything else for not giving us any beer.

It probably wasn't long after they first started the salvage operation before they sent us out.

We'd come in at night and go back to sleep in the barracks and go back the next morning via the Coast Guard. They had a small Coast Guard boat that operated back and forth.

We'd go out there, and they had us handling the hoses, because they had all of these hoses hooked up to different salvage compartments, fittings, and buoyed out. We got to bring them back in every day. They'd hook them up to the air manifold and check the pressures to make sure they still had pressure on them. That was our job. A lot of times we'd go out in the morning on the Coast Guard freight boat, stay aboard there and come right back in with it. Out there, nobody really knew who we were.

When I went down to Annapolis, I had quite a talk with Admiral Brad Mooney. I didn't know who he was; I had never heard of him. He was telling me about some of the experiences he used to have up here in Portsmouth, NH, and asked whether I knew this gal or that gal.

There were a lot of boats around during the salvage operation. There were planes flying over. People were getting with reporters. A lot of times, the Coast Guard boat would pick us up in the morning and take us out to the area. We'd actually go aboard the *Falcon* and make sure the skipper and some of the others saw us and then we would get back aboard the Coast Guard boat and hide down in the engine room and ride that back in. Lieutenant Sharp was the skipper. He was pretty good. But in the movie, *The Terrible Hours,* it showed him with a chief petty officer signature on his hat. That was one of the things that I noticed that Hollywood messed up.

The *Squalus* went down on the 23rd of May. I think it was September before they got the boat back into the shipyard. I was there. The skipper was going to have all of us go out there and ride the boat back in. Of course, they never got her out of the water far enough that we could ride her in. We were going to clean the deck all off and everything else when they brought her in.

Anyway, we were there when they brought the boat in. We were right at the pier at the Navy Yard. As soon as they brought the *Squalus* in and tied it up alongside the pier, they had these big tripod cranes on the pier. It seemed as though the deck was half underwater. They hooked it onto the sail, cut a hole in the sail and hooked the cable in there to straighten the boat, and as they pumped the water out, they brought it up. As soon as they got the bow out of the water, we opened the torpedo room hatch, and I went back down as far as the after battery but didn't go in the control room.

That was a stressful experience. We were living in the barracks then, I guess. They sent us all off the boat before they started taking any of the bodies off that night. None of us were around there then. All of the bodies were still in there after three months. They said that the bodies were in good shape because they were in that cold water all that time.

I escorted Ciphers' remains back to Abingdon, VA. He was the first class electrician's mate. I think the only relative he had was his mother. I remember when we got into the funeral home there, his mother couldn't get it through her mind that was her son, because the caskets were sealed. Actually, I saw her point. After I left the funeral home and went to my hotel room that night, I think she finally convinced the undertaker at the funeral home to open the casket so she could make sure that was her son in there.

The surviving crewmembers escorted the bodies to their hometowns. Each person escorted someone different. We left Portsmouth by train to Boston. Then, they had to go from North Station over to South Station and you had to make sure the casket got on the train that you were on and everything.

As the surviving crew of the *Squalus,* all we had to do was go in and get all of the personal gear off the boat and all of the portable equipment, like typewriters and stuff like that. We took all of that stuff off and put it in a storeroom. We went through all of the lockers and got all of the personal gear of the deceased so that we could give it to their dependents. That was kind of scary.

After the *Squalus* was refurbished, it was renamed the USS *Sailfish* and sent back out. I fought hard to go back aboard and finally got it. There were three of us who went back on it as the *Sailfish*. The three were Gunner's Mate Cravens, Torpedoman Maderas, and myself. I made the first several war patrols on it as the *Sailfish*.

Also, I wanted to get back up to Portsmouth, because I was due to get married shortly. In fact, I came back to Portsmouth in 1940. I got back in toward the end of 1940 and got married in January of 1941. The boat left again in February. We left for Pearl Harbor then. My wife was supposed to come out to Pearl Harbor after we got settled, because that was going to be our home base for the *Sailfish*.

Of course, sometime around October or November, the *Sailfish* got orders to ship to the Philippines. We had to cancel the idea of my wife moving out there. We were in Manila when the war started. We went out right away; we went out the next day. The first day after the war started, we lay on the bottom of Manila Bay while the Japanese were bombing Manila.

Then we went out and started to operate, and right about the second or third day of the war, cloaked in the dark, we started out to someplace and contacted Japanese destroyers. We fired on them and got a hit, an explosion, but we couldn't see what happened because we had to go deep. An underwater sound started. The officers had been told the Japanese didn't have underwater sound equipment, so the captain got it in his head that maybe he had fired on one of our own destroyers. He cracked up. The executive officer had to bring the boat back into Manila.

We came in about midnight and, of course, everything was blacked out. When coming into Manila, Baylor flashed a light on one of the buoys for a few seconds. We headed for that. Then, on the next buoy down, he flashed a light. I know I was on the controllers in the maneuvering room and was getting an "all ahead full" and "back down full" all the way through there.

We finally got into there and tied up. The next morning, they called us all up to quarters, and the captain had big tears in his eyes, and he told us that he had cracked up and the exec had brought the boat in. We were then given the captain of the *Sea Lion*. The *Sea Lion* was being overhauled and wasn't able to get underway. When the Japanese bombed, they got a direct hit on the after engine room and sank it right alongside the dock. They lost several of the crew. We got the skipper, Lieutenant Bogey, and he became skipper of the *Sailfish*.

The *Sculpin* was our sister ship and when she was sunk the crewmembers were taken prisoners of war. They were put on a Japanese aircraft carrier to take back to the mainland, I guess. While they were headed there, the *Sailfish* came in contact with this aircraft carrier, not knowing that there were any Americans prisoners of war aboard, and sank it. A good friend of mine, George Roceck, was one of the only survivors. I still contact him all the time. He is down in Florida, but he's in pretty bad shape. His legs are all banged up and everything else. He used to come to all of our conventions, but I haven't seen him for several years.

I was on the first seven war patrols. I wasn't on the *Sailfish* when it sank the carrier. I had already gotten off. That must have been on the eighth or ninth war patrol. I don't know which one it was. I got off when the boat came back to Hawaii for an overhaul after the first seven war patrols.

We were due to get an overhaul in Pearl Harbor. We came into Pearl Harbor one day and that afternoon they transferred all of us but one section, up to the Royal Hawaiian Hotel. We probably got there in the evening. On the next morning they called us back to the ship. The overhaul at Pearl Harbor had been cancelled and changed to San Francisco. We got to San Francisco and after we'd been there about maybe four or five days, I got orders to go to Portsmouth to commission the USS *Crevalle*.

I put in time on the *Squalus*, the *Sailfish*, the *Crevalle*, and the *Sea Leopard*. The *Sailfish* was

the 192. The *Squalus* was also the 192. They didn't change the number. I went to the *Crevalle*, the 291. When it first started out, the *Squalus* was the S-11. Then they changed the hull number to 192. I think that one of the TV movies, the first one, showed it as an S-11.

Going back to those war patrols, we got depth charged on the first trip out. After we went out and fired on the destroyer, we got depth charged. But it wasn't too bad. In fact, I think before the war we didn't get any depth charges. I didn't remember any, anyway. In Pearl Harbor they would take a boat out and tell it to dive to maybe a hundred feet. They had this destroyer dropping depth charges. But you could barely hear them; they were so far off.

We had several pretty close depth charges during my time. I made three runs on the *Crevalle*, so I had a total of ten patrol runs. On the third run on the *Crevalle*, we were operating someplace off the Philippines. We got word to go into some bay or something and pick up some American survivors. We pulled into the bay and they told us if everything was clear, there would be a big white sheet on the side of a mountain there. We saw that, pulled in, and then surfaced. We were surfaced for no longer than about five minutes when what we called "bug boats" headed out toward us, and we took aboard thirty-something passengers. They were American women and small kids. We took them aboard and brought them to Australia; I forget where in Australia. During the time that we had them aboard, we got one of the worst depth charges I took in all ten war patrols.

During depth charges, you were down there. You were hanging onto something. The old boat shook and water started dripping in here and there; a valve ruptured or something. The kids were getting a big kick out of it. They were hollering, "Did we hit them? Did we hit them?" every time a depth charge went off. The kids weren't afraid at all. They didn't know the difference.

To this day, at our national convention every year, several of those people that we picked up attend. They are all American citizens. They say their husbands were out there on business or something. They spent days out in the wilderness trying to get away from the Japanese.

After three patrols on the *Crevalle*, I came back to Portsmouth and put the *Sea Leopard*, 483, into commission. I was on the *Sea Leopard* in New London training, ready to head for the war zone, when the war ended.

Of my 22 years in the Navy, all but about 8 months were spent on submarines. In fact, even then I didn't have enough. After I retired, I went back to Portsmouth and worked for 13 years in the shipyards.

My wife is from here in Portsmouth, so this is where we settled. In 1948, when I got out of the Navy, I had this house built, and I retired from the Navy, for good, in about 1956. In about 1960, the state decided it was going to build a new highway through where the overpass is there, and that was where my house sat, right on the corner where the overpass is now. I had to pick the house up and move it to here. I've had a very good career, I think.

I'd like to say when I got invited down to Washington, the producer, the guy who produced the show, was the one who invited us survivors down. In fact, it was only Bryce and me. My daughter and I went down and we had dinner at the White House, out on the White House lawn. They had tables set up. We sat down out there and the guy started coming around asking, "Do you want a beer or wine or anything?" We sat there and had a few drinks, and there were several senators and representatives with whom we shot the breeze. Then, President Bush came out and we had dinner. We had a very nice visit with his wife. That was in June of 2001.

DR. ARTHUR J. BACHRACH

To submarine rescue, I contributed nothing, but I think I contributed to diving with my interest in diver panic, which was less applicable to the Navy than it was to the civilian community,

Squalus Salvage Operations







but Dr. Glen Egstrom and I really got into the whole business of diver panic. I feel that was a contribution, to start getting some analysis of accident methodology.

I subscribe to the school of accident methodology that argues an accident is an unforeseen event. It's not preventable. "Accident prevention" is a meaningless term. You can get accident mitigation. If you have a hard hat, you're not going to prevent an accident. But it could mitigate the consequences. I think that was something that I kept pushing for, accident methodology.

The aviation industry is much better at accident reporting than the diving industry is. They report near misses. We never do, and I think you could learn more from near misses than you can from accidents. An accident is something you're not going to prevent, but it is something you can prepare for in training. I think that was something I pushed hard for and maybe had some impact with. But I've got a lot to be modest about. One small thing: our research with JIM-4 demonstrated you could link up a down cable from a DSRV to a stranded submarine.

DR. ROBERT BORNMANN

I think the one atmosphere diving unit, or diving suit, and the submarine escape and immersion equipment, the British submarine personnel escape system, were marvelous accomplishments. Well, you're talking about submarine rescue and escape. Forget about the one atmosphere diving suit, because that's being used commercially right now. It's a balance of objectives, resources, and trade-offs. It's about whether you need it, whether you can afford to put it aboard, and whether that energy and money could be better spent to avoid the accident that disables the submarine.

DR. EDWARD T. FLYNN

When we started experimenting with deep diving exposures, it was for submarine escape. We started at 33 feet to get used to things and

then went to a hundred. Then, we went to 240 and then 500. There were not a lot of dives. It was a proof of concept thing. We proved we could do it and everything was fine.

A couple of interesting things came out of that. One thing was, of course, the heat. It was a hydraulic compression. You knew you doubled the pressure every few seconds. The heat of compression was so hot that the guys were inside of a stole with air on their faces and the air was literally burning their faces.

They were submerged in water but had an air pocket in the front of their faces in the stole and it just got incredibly hot during compression. The water couldn't take the heat away quickly enough. They didn't get physically burned. In other words, they didn't come out with second-degree burns or anything like that. But the intense heat was a big problem with that suit.

The second thing was the narcosis. They would hit the bottom at 500 feet and would be perfectly clear headed because the circulation from the lung to the brain hadn't yet delivered the nitrogen load. But on the way up, at about a hundred feet, they'd have an overwhelming wave of narcosis come over them as the blood shot through the brain. By the time they hit the surface, it was waning. About thirty seconds after they were on the surface, they felt fine again. You could almost measure the circulation time from the lung to the brain by that experiment.

The experiment was written up in NEDU Report 4-69. That was the beginning of the Navy's evaluation of that suit [the British Submarine Escape Immersion Suit (SEIS)]. Then Dave Hall, who was a Medical Service Corps officer, also trained at the University of Pennsylvania but up in Groton, was pushing to get the Navy to adopt the suit. He pushed and pushed and pushed but was never successful. Over the years, we kept pushing it and were never successful. About two years ago, the US Navy finally decided that it was going to use the technology.

Editor's Note:

NEDU Report 4-69: Simulated Submarine Escapes from 33, 100, 240, and 495 Feet of Seawater, by Summitt, Herron, Flynn, and Hall.

I think the reasons that it took the Navy so long were two things. First of all, submariners have a fatalistic attitude—"if we sink, we die." Escape was not considered a viable option so there was no sense in getting all excited about it. Second, it was always the problem with them not wanting to retrofit any boats for that capability because it was going to cost too much money. We said, "We'll do it on new construction." Well, every time new construction came up there was always some reason not to do it.

It could have been done long ago but the Navy just didn't get excited enough about it, literally. Even though the British have been using it for years and years, we only picked up on it about three years ago.

In this particular case, we did the trials in 1969. Thirty-one years later they finally woke up and said, "Yeah, this thing probably does work." That was the very first thing I worked on at the Navy Experimental Diving Unit (NEDU).

The second thing we were looking at was excursion diving from helium-oxygen saturation at depths of 100–500 feet. We wanted to make those downward excursion dives on a repetitive basis without decompression but with no decompression sickness. Bob Bornmann had been talking to Bob Workman about how to adopt his model to this application. Bornmann calculated all these excursion diving schedules. Then we tested them at the NEDU and, as I recall, we did roughly 1,100 excursion dives and never had a single case of decompression sickness or any complaints. The tables were wildly successful. However, we missed the mark by a country mile, which we would later find out when we did the unlimited duration excursion studies during my next tour at NEDU. But during this tour we had these schedules that just worked incredibly well.

They were so conservative that they never produced any decompression sickness at all.

We should have been tipped off that we were way out of the ballpark on these things because we never had any problems with them. But we were very complacent and said, "Oh, these things work great." It was a vindication of Bob Workman's decompression model and everybody was really happy about that. Bob Bornmann, who then was out at the Deep Submergence Systems Project office in Chevy Chase, Maryland, was the author of these experiments. There were only three Medical Corps officers at the NEDU and at any one time one of us was out on the west coast with the Mark I diving system. The other two guys were standing port and starboard watches. We slept at NEDU every other night.

I recall we did 44,000 man-hours of saturation diving in those two years. We'd surface one dive and a couple of days later, the next dive would go down and the dive after that would go down a couple of days after that one surfaced. It was round the clock diving and an incredible amount of work. The other thing we did during that first tour was look at revised surface-supplied helium-oxygen schedules calculated by Heinz Shriner at Oceans Systems.

These were for the partial pressure tables. It was done as a replacement for the partial pressure tables. Bob Workman had provided Heinz with the algorithm and Heinz then cranked out the schedules on the computer in Tonawanda. They looked pretty good. We started testing them in 1970.

These only went down to 300 feet. They weren't the really deep ones. But we started right off with a pretty aggressive bottom time. As I recall, it was something like sixty minutes, and we ended up bending 33 percent of the guys. We said, "Okay, these tables look good. The model looks good. Everything looks good, but, hey, they don't work." That was the end of that evolution.

Of course, we stuck with those surface supply tables with minor modifications back and forth, right up to the present time. We still haven't really cranked out a whole new set of schedules based on any modern model.

Late in my tour at the NEDU, we did a 1,000-foot saturation dive in stages, starting at the surface and going progressively to 200, 400, 600, 800, and 1,000 feet. At each one of those depths two divers breathed freezing cold helium-oxygen while exercising on a bicycle ergometer at various workloads, including up to near maximum workload. We measured the inspired-expired temperature difference and the respiratory minute ventilation. From that, we computed the respiratory heat loss. We also simultaneously measured the core body temperature and the subject's ability to do forced vital capacity maneuvers.

The purpose of the dives was to confirm the earlier theoretical prediction by John Rawlins and John Tauber at the Naval Medical Research Institute that if you breathe cold gas deeper than 600 feet more heat will be extracted from the body via the lungs than can be replaced by metabolism.

With helium, you start losing body heat right away. You're losing heat through the respiratory system right here, on the surface, but the loss gets bigger and bigger the deeper you go because the product of the gas density and the constant pressure specific heat steadily increases. For a given differential temperature between expired and inspired, each breath that you take at depth contains more heat. We pretty much confirmed Tauber and Rawlins' theoretical prediction that beyond a certain depth you could not keep up. In other words, your respiratory heat loss could be as great, or greater, than your metabolic heat production.

That depth is roughly 600 feet. If you are deeper than that, of course, you go into a whole body net heat loss. In fact, you go into a net loss even shallower, because you're also losing heat through your skin. You're extracting all the metabolic heat produced by the body via the respiratory system and extracting additional heat from body stores via the skin to the environment. The core body temperature literally plummets.



Decompression studies at NEDU for surface supplied divers.

As a result of that experiment and an experiment by Mickey Goodman at Westinghouse, NEDU published the first curve showing the minimum allowable inspired gas temperature at depths from 0 to 1,000 feet. The curve spurred the development of inspired gas heating for deep dives. That first curve stayed in effect for about a decade until Claude Piantadosi did another theoretical analysis. He made the temperature limits more conservative than what we had proposed.

One of the interesting things that we found on that 1000-foot dive was that in addition to respiratory heat loss, there was tremendous bronchial constriction associated with cold gas breathing and a tremendous bronchorrhea as well. The divers were literally choking on thick, ropey bronchial secretions. They couldn't spit them out into the mouthpiece fast enough to keep ahead. The stuff was just pouring out of them. There were major effects on the respiratory system that would render divers non-functional on deep dives if they didn't have gas heating.

Our dive was a single dive to 1,000 feet, but as far as I know it was the first dive that ever verified the devastating affect that breathing cold gas at depth could have. Subsequently, of course, there were other studies. Mickey Goodman did one very shortly after ours at Westinghouse, essentially confirming exactly the results that we found. Our study was dry. His was done in the water with the hot water suits, so it was a little more realistic about the thermal environment than ours was. But with regard to the respiratory system, the findings were pretty much the same. Our cold gas study was a seminal piece of work.

Another thing worth mentioning was the development of a new helium-oxygen saturation decompression schedule. The diver ascends at six feet per hour from his saturation depth to 200 feet, five feet an hour from 200 to 100 feet, four feet per hour from 100 to 50 feet, and three feet per hour from 50 feet to the surface.

This new schedule was something that I came up with in conjunction with Jim Summitt and Bob Bornmann. Up to that time, we had been ascending at a constant rate of 4 feet per hour and inserting four-hour holds every one hundred feet during saturation decompression. That seemed to work fine, but it was not really totally satisfactory because those holds came at odd periods of time.

Also, the more we looked at saturation decompression, the more we figured we could travel faster while deep, but had to slow up in shallow water. We shaped the new decompression schedule to look like a hockey stick. You had a long pull at six feet per hour up to 200 feet, but then, you got onto the curved part of the hockey stick and the rate really slowed down.

We inserted the holds at the same time each day—overnight from midnight until 6:00 in the morning to permit sleeping and again in the afternoon from 2:00 until 4:00. There was a total of eight hours of breaks each day. That became the Navy standard saturation decompression schedule for helium-oxygen diving and, as far as I know, it's virtually the same today.

USS *SCORPION*

MR. WALTER BERGMAN

In the late 1960s Ocean Systems, Inc. had a general servicing contract to help with salvage, diving services, engineering assistance, and management, a really broad brush. When the *Scorpion* went down, I was up at the funeral for my father-in-law. I whipped back to Washington, and Ed Wardwell said, "I want you to go down and take charge. This is what we're going to do. We're going to take an ARS and rip off the

gunwhales. We'll put the deep diving system on board with an ADS 4 type, and we're going to put Ed Link's submersible on. You're in charge. Let's get it done. If you find something, go after it full bore. We're going to send John Harter out, too. He'll be your technical engineering support and you can take anybody else you want."

We headed to Florida and were mounting out there at an airport, and Ed Link was very, very, very upset that he could not go. He was a ten percent minority owner of Ocean Systems. He had no confidence in Walter. He didn't know Walter from a cord of wood, and how was he going to run the submersible operation?

I had Joe MacInnis there, and Denny Breeze was going to be the submersible operator. We were having a devil of a time mounting out and getting everything together. We were taking C130s, with the ramps down, and pulling the submarine up right when Ed Link was there. The bloody chain broke and all of a sudden, you saw Ed Link's submarine on the ramp, slowly going down and rolling on the runway. That was not a good start. We did finally mount up, and we brought divers from Louisiana and California, from both Ocean Systems.

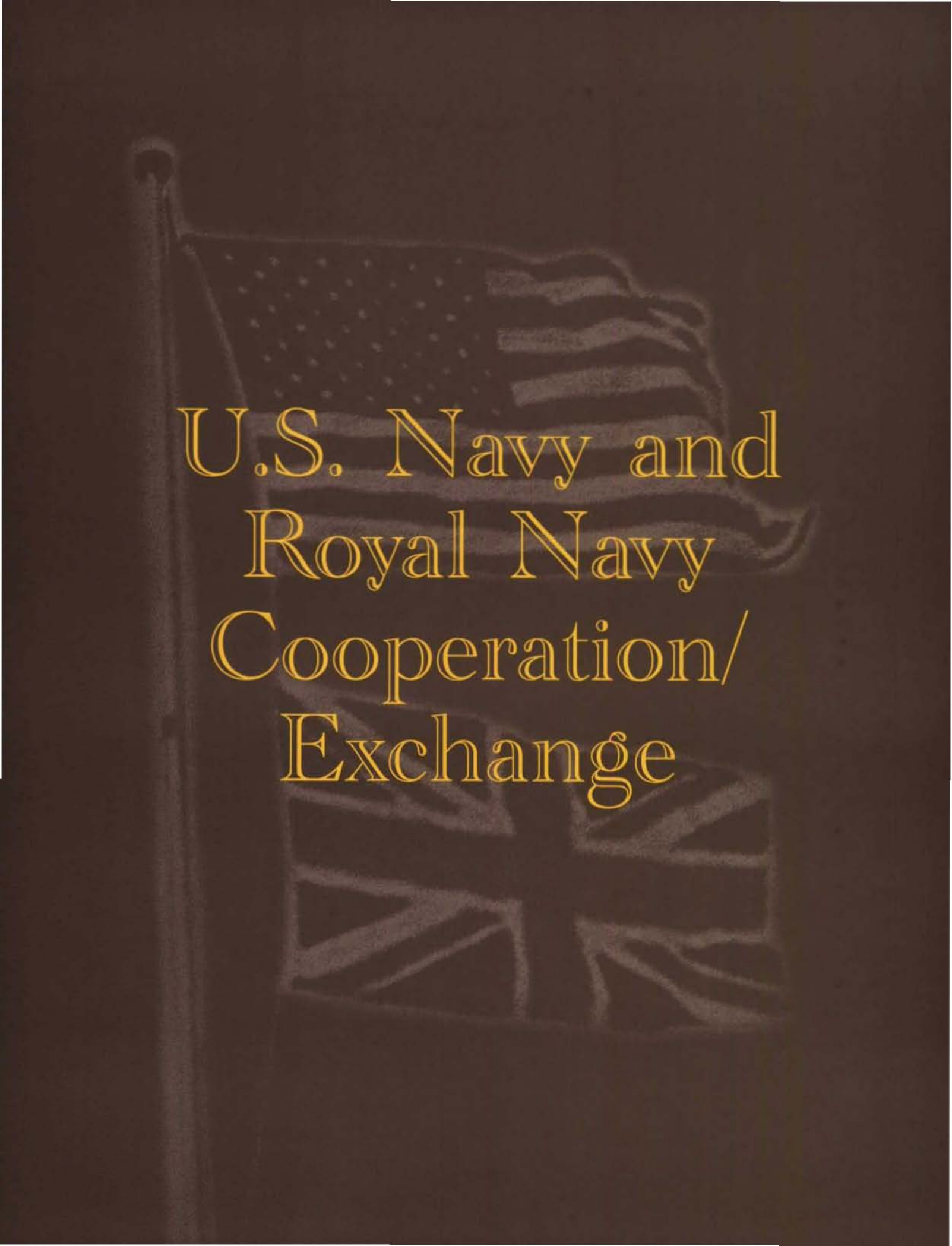
The Link submersible didn't have a diver lockout. It was one of the earlier ones. I was all ready to go, and I got a phone call from Ed Wardwell. He said, "Walter, we've got a real problem." I asked, "What's the problem?" He said, "We've got the wrong material in the hull of that submersible. If it's cold water and it hits anything with any impact, it has the potential to almost shatter." I said, "You're kidding?" He said, "No. The results of the Sharpey V-notch test were just disastrous. But you cannot tell anyone else." I said, "Whoa. You're sending me out there with a loaded gun." His reply was, "You've got to go, Walter. If it's life and death, we'll take the risk if we can save the *Scorpion*."

He said that he would go to SUPSALV and confide to Bill Searle that we had this problem. We took the submersible with us. It took a while to take the ship apart and get the divers all together, but finally, everything was loaded and we went. We were ready to start searching. But where were we to search?

We got to the best area to search and were out there with the ARS. We were fully equipped and ready to go, but I wanted to dive only on something that looked like a very good target. Joe MacInnis was a delightful fellow, but he just really wanted to get the submarine in the water and ride. He and Denny Breeze said, "What's the hesitation, Walter?" and I couldn't tell them. I had to keep the thing a secret. It was tough, because they knew that I was usually more aggressive than that. They probably thought, "Why doesn't he want to just put the boat in so that we can take a look?" Well, I just wouldn't and there we were. This is the crazy part of the story. We were back in port and going to go out again. They called us back in. I never knew what that was all about, but they said, "Hey, they've got a guy who knows where the submarine went down. He saw it, the *Scorpion*. He saw it go down."

Bob Kutzleb was on the Palomares bomb recovery. Some fisherman said he knew where the parachute had gone in. He had done triangulation with trees and shore features. They ignored him for a time, but sure enough, when they went where he said, that was where the hydrogen bomb was. I said, "Hey, it's worth a shot," and I rolled out to find this guy. I bought a bottle of wine and we sat down at the table. We had an interpreter there. All of a sudden, what came out was that he had a dream in which a submarine ran into an underwater mountain. Not having consumed any wine, I left the bottle with him and went back to the ship.

Then, all of a sudden, we got a re-call to the United States and it was all over. We knew where the *Scorpion* was, and it was nowhere near the Azores. The rumor I heard was that it was really the Russians who told us where it was. On a national television show, it was said that the Russians had information that they passed on to Washington. But John Craven contradicted that and I never knew the true facts. It didn't matter to me, but I was pretty upset, being sent out there with an inferior Sharpey notch product.



U.S. Navy and Royal Navy Cooperation/ Exchange

Early in the Industrial Revolution, research was usually performed by individuals such as Thomas Edison. But as technology and research subjects became more and more complex, "research by committee" became the norm. This trend applied to diving and diving medicine research as well. The United States and Great Britain began collaborating on diving research as allies during World War II. The joint research proved so useful that the cooperative efforts continued after the war ended. Several exchange programs have allowed American, British, and other researchers to gain from each other's knowledge and experience. Following are the recollections of personnel, both American and British, who took part in this valuable exchange of information.

DR. ARTHUR J. BACHRACH

We had projects at Naval Medical Research Institute (NMRI) with the Royal Navy, and with Sweden, Japan, and France. I had the chance to meet people in England, people like David Elliott, who was an exchange officer. David, to me, was one of the great scientists and one of the finest people I have ever known. I also met John Rawlins, who was at the NMRI. I got to know John pretty well, and we still keep in touch. I go over to the Historical Diving Society in England every year.

In England, I also met people like Peter Barnard, who was excellent. He was very quiet but a superb researcher and a fine physician. He and David Elliott stand out as the people at Alverstoke and the group at Deep Trial Units (DTU), and the people in Farnborough. Mike Borrow, who was one of the early people working on the one-atmosphere diving suit (JIM) project, was an excellent, excellent person.

COMMANDER JIM BLADH

Filling the exchange billet in England was my twilight cruise. It was a great job. The British navy fully accepted me into their group. I made a deep chamber dive. I guess that at my age at that time, my late forties, the US Navy would have never allowed me to do that. It was just a great experience. I was the first US military type who was put in charge of a Royal Navy team. I also have permanent mess number on the HMS *Vernon*, which is a considerable honor when it comes to the Royal Navy.

DR. ROBERT BORNMANN

Gunner Stillson and Dr. French came out with their report on deep diving, and then the first modern navy diving manual in 1914 or 1915. When they did that, they thanked the Office of Naval Intelligence for providing them with information and reports on what was going on in the United Kingdom and Europe.

Today, we have exchange officers. We have information exchange programs. We have a memorandum of understanding. The Office of Naval Research has contacts in almost every European laboratory, navy and otherwise. Our associations, like the Undersea and Hyperbaric Medical Society, are not parochial organizations but international societies. Our meetings are international exchanges. When we talk about what has been accomplished in the latter part of the century, we're talking about international program accomplishments, not the parochial successes of the United States Navy. I think that has been the biggest change during the 20th century.

Editor's Note:

Deep diving in the US Navy would not have progressed as rapidly as it did without the assistance of loyal allies in other navies, primarily those of the United Kingdom and European countries within the membership of the North Atlantic Treaty Organization (NATO). For a number of years the US Navy maintained Data Exchange Agreements (DEA) and/or Memoranda of Understanding (MOU) with several countries and these agreements have remained in force for many years. The affect of such international agreements was that it

permitted an open assault on the knowledge of people in other navies who were working on similar problems. Much was learned over the years and much was gained for the United States and for the countries where the agreements existed. One person from the United Kingdom who was selected to do a tour of duty as an exchange officer with the US Navy was Professor David Elliott, O.B.E. Dr. Elliott was one of the first exchange officers from the UK and was pleased to express the history of his involvement (and that of his Navy) as is presented below. We are grateful for the assistance these several countries gave to the advancement of undersea technology.

DR. DAVID ELLIOTT

The first thing I did once I finished my Ph.D. was to go down to the Naval Physiological Laboratory in Alverstoke. Eric McKay, who did a lot of work with the HMS *Reclaim*, was one of the doctors there. When I joined in 1964 he went on to another job and his number two, Peter Barnard, who was a couple years senior to me, became my boss. I took the junior job. As a diving medical officer in those days, I went off and did the clearance diving course and all those sorts of things. We were at the forefront, which would sound grand if you judged that by today's standards. We were at the front line of what was a very small organization. We had a diving team to work with. We had the Royal Navy Physiology Laboratory (RNPL), which was doing all the physiological research. We were two uniformed doctors in a civilian research unit that was using naval divers to do the work. There was nothing else.

There was really no recreational diving in the UK, other than a few mad enthusiasts. There were no other operational chambers in the UK. There were one or two in dockyards that could be called on if needed, but nobody ever wanted to use them. There were perhaps one or two cases of civilian decompression sickness each year in the whole country, and there would be people diving in dockyards and things like that. They weren't recreational divers.

In the RNPL we had two things happening. We had the development of submarine escape, and all the hard work for that had pretty well been done. The other activity, of course, was the development of the deep dive program. The Royal Navy was looking at 600- and 800-foot dives for maximum durations of an hour each. You'd have to look into other archives to answer why, but that was what we were interested in. In fact, as far as the development of diving was concerned, that was really quite important, because you guys, by whom I mean George Bond and the US Navy, had a different focus. With participation from Ed Link and so forth, the US Navy was much more focused on saturation diving and probably habitat diving at that particular stage. Ours was based on a submersible bell going down, doing something and coming back. At that particular time, industry, for what it was worth, mostly in North Sea oil, was doing hardhat bounce diving at 400 to 500 feet. The kind of work that we were doing at RNPL and with the *Reclaim* was of interest to the then very small diving industry.

The focus of our dives was progressing the deep diving research. Dr. Taylor was then the superintendent of RNPL. Later, when he retired, and after an intermediate individual, the job was taken on by Dr. Hempleman, who, at the time I joined, was the person working on the theory of decompression. It was he, Peter Bennett, who was at the lab, and various other characters there. We can go on for hours with this discussion. We were producing tables, or trying to produce safe tables, to do dives at 450 and 600 feet for durations of thirty to sixty minutes, and an 800-foot dive for twenty minutes. That was pretty much our work in that field.

Peter Barnard and I, and the whole of the HMS *Reclaim*, went to Le Lavandou on the south coast of France. We were based at Toulon Navy Base and started to do bounce dives on sea trials, having already cleared them. The laboratory work had been going on for years before I

joined. I get no credit for the research. I was just part of the medical cover. But we then found that having the medical cover was quite a responsibility.

That would have been in 1965. In that period, we had the various cases, like paradoxical recompression. We had a lot of good clinical academic experience, all of which has been written up elsewhere. The Val Hempleman tables were meticulously controlled and recorded by people like Sarge and Cass Trotter. A whole lot of that information has gone into the University of Pennsylvania databank because it's accurate and was beautifully kept.

Those dives were being done with the ship in deep water off the Iles d'Hyeres, which are not far from Toulon. They were important because we learned a lot of lessons. The cases themselves have been written up elsewhere, but just for marking the milestones, I think two are worth mentioning because they do affect the policy of deep bounce diving, recompression, and those sorts of things.

I think the first thing to mention is that somebody had made one of those deep dives. Bear in mind that in the British navy, for academic purity, the dive was made with no single atmosphere of air in the chamber to start with. The chamber was cleared out and filled with oxy-helium, so there was no nitrogen loading of any significance in the chamber—that was in the RNPL. On board the ship, they used an oro-nasal mask as they did their compression. They then went down to depth in the bell to do their swims, which were quite brief. The maximum duration was an hour, and a lot of the dives were only thirty minutes. They came back into the bell, locked into it, brought it back to the surface, locked into the deck chamber, and underwent a decompression, which would last, as far as I can remember, for maybe a couple of days or so.

There was no great sort of structural engineering problem except that our deck chamber had a maximum depth of 300 feet. Any decompression deeper than 300 feet had to be done in the bell in the water. Our particular protocol was that the people breathed oxy-helium all the way to the surface. Upon reaching the surface, the door would be opened, and at atmospheric pressure, they'd switch to air.

That was important because there was a particular incident, and I won't mention the chap's name, but I know exactly who I'm talking about, when the diver came out. I think he had a little bit of a knee problem at depth. This is more of a parenthetical paragraph. We had already worked out that when a person got a bend deeper than 165 feet, the conventional treatment tables were absolutely useless because they didn't go that deep. What we used to do was take people down a bit, keep them there a while, and then bring them up more slowly, which sounds very pragmatic, but that was exactly what we did until we found a safe way to bring people to the surface who had been recompressed. That is essentially the curve you also find with diving in Royal Navy Table 71, which is not very different from US Navy Table 4. We came out with this pragmatic solution of just letting the pressure off a little bit. If you didn't say, "Ouch," we'd let it off a bit more in an hour's time or so.

I mention all that because the particular individual had knee pain, as I recollect, coming to the surface, and he responded to that treatment. In actuality, when he came out of the chamber, I gave him a post-dive medical. He was fine. I think he was just itching to go and get a decent bath and something to eat. Being hungry was a pretty good sign of somebody who was feeling good. I'm not giving a great big clinical decompression sickness lecture here. What we'd learned from laboratory dives was that if after coming out from such a dive in the laboratory, a person didn't want to demolish his plate of four sausages, two fried eggs, a pile of chips, a bit of fried bread, and lots of fried tomatoes all covered in tomato ketchup in two minutes, he was obviously going to develop decompression sickness. It was a very good indicator. Therefore, we thought this guy was probably okay. He went off to have his bath, but it wasn't a hot shower.

All the people who say that hot showers induce decompression sickness fail to realize that decompression sickness usually occurs after a dive, and most people have their showers not before, but after, the dive. There can be a statistical association, but people who say that there is a causal relationship need to prove that. He had his shower or bath and came back and said that the pain he previously had in his knee was getting worse. We put him in the chamber, but it was not the deck chamber. We had another chamber there. It was a 300-foot chamber. It was a triple-compartment chamber, and we compressed him back in accordance with our protocol. It was essentially the same as the US Navy table. Well, we tried the 100-foot table one, but that didn't work, so we went to 165 feet and treated him there.

By the time he got to that depth, he had pain in other joints he had none in previously. He had skin rash. He was looking a bit blue. He had developed heavy breathing. We wrote this all up in the *British Medical Journal*, where the details can be found. When you read the paper, you can see that we'd sort of thought about it. Peter Barnard joined me in that paper, because he came back from shore, and the pair of us were sorting the case up at the time. I decided at that moment he wasn't doing too well. We took him back to 300 feet on an oro-nasal mask, breathing oxy-helium. He'd been vomiting a bit, so I was a little bit concerned. There he was in an air atmosphere breathing from a BIBS mouthpiece, and had he wanted to vomit, he was obviously going to get fairly narcotic. I had no idea about counter-diffusion in those days, but the nice thing was that at 300 feet on oxy-helium in an air atmosphere, he actually got better. We then changed the atmosphere to pure oxy-helium. We already had an internal carbon dioxide scrubber. It was a high-pressure air-driven motor with a submarine carbon dioxide canister sitting on top of it. I can remember that on that particular occasion, the filters over the top hadn't worked very well, and the diver, the patient, and his attendant were inside the chamber and covered in a fine dust of soda lime. It couldn't have done them much good, but it was the least of their problems.

Cyril Williams, who was the engineer on board from the Admiralty Experimental Diving Unit (AEDU), devised a system of converting a chamber of air into a chamber of oxy-helium. We already did that routinely, but it was the first time we'd done it in an emergency. It was quite neat because all he did was give the divers a balloon inflated with oxy-helium. That immediately went to the uppermost part of the chamber. Then, the inlet gas was gently piped up toward the surface so that there wouldn't be too much mixing.

The oxy-helium came at the top of the chamber, and the vent came from the bottom. Gradually, the balloon slowly sank to the floor, and the sampling line went from 21% to 10%, I guess, which was the mixture of helium that we were fitting in. Therefore, we knew perfectly well that by the time we'd finished that the guys were on 10/90 oxy-helium and we could add oxygen and so forth during the subsequent decompression as needed.

That was very nice and written up in the *British Medical Journal*. Since then, everybody has agreed those were probably the initial symptoms of a manifestation of some form of internal counter-diffusion. That led to the Royal Navy rule that anybody who dives on helium all the way to the surface should be recompressed on oxy-helium, not on air.

Mickey Goodman's table was just coming in at that stage. We then put down as our guidance, though it never got published in the manual as such, that if you went and did a table six, the diver should have gone onto a BIBS mouthpiece and breathed oxy-helium while the chamber was compressed on air to sixty feet. Then, if we needed to go deeper, because he had not responded, and bear in mind that this was following 400, 500, 600, and 800-foot dives, we then compressed on pure helium. You already had 2.8 atmospheres of air in there, so you had enough oxygen. You had some nitrogen, but who cares? The rest was pure helium. Given the

starting point on BIBS at 2.8 atmospheres, anything you did in the way of compression with pure helium afterward merely took you back to the depth of relief. Once we got to the depth of relief, we scratched our heads and decided how we were going to get out. That was the way we did it.

We had very conveniently gotten these divers to the surface and established a new routine for treating people who surfaced with bends after helium exposure. I emphasize that because there was some confusion between the British and the American navies, who have a very close working relationship. It is similar in the United States. The dives are not quite as deep, but there is a switch from helium to air quite deep. Therefore, because the divers had already made the switch and decompressed an hour or two or longer on air, they had no problems at all when they recompressed any bent diver on air and did not see why we insisted on using helium. That sort of concluded that phase. It was a setback, but we carried on diving.

The next dive, which was a 600-foot dive for thirty minutes, was one on which the divers were fine. The two divers came back up to 300 feet in the bell with the bottom door open, at which time the bottom door was closed, and the bell was pulled out of the water and locked onto the deck chamber. It was designed by Hemp to do that and allow them to move to their next stop, which was 230 feet. At that point, one of the two divers got severe vertigo, and we recompressed him to 300 feet. He wasn't any better there, so we had a dilemma.

Once again, Peter Barnard had cunningly arranged to be ashore. It was probably in the evening and his time to go for a decent meal on shore. I was stuck with a casualty. In fact, it was the middle of Sunday Night Cinema, as well, which is the sort of thing that always happens when these cases always arise, you know.

I scratched my head about it. I already knew from experience in the chambers that anybody with vertigo, provided you compressed him to the depth of relief immediately, would make a full recovery. I could see no way of achieving it, since the maximum depth of the chamber was 300 feet, where we already were, other than to getting him to climb back up. Thank heavens it was vertigo and not paralysis. We had to get him to climb back up into the chamber, above the depth chamber, and get his dry suit on again.

Because we didn't have any thermal heating in those days for helium diving, they put hot water bottles inside their dry suits in secret because they didn't want anybody else to know. They'd be thought of as sissies. They had a couple of hot water bottles quietly locked in without me noticing, which, of course, I think was very good, indeed. We unlocked the diving bell, dropped it over the side into 300 feet of water, opened the bottom door and then started slowly to lower it.

We didn't even have a helium unscrambler. In the bell, you could hear topside, but if they spoke, it was in a helium voice. When an individual had a problem with staggers, as did happen, you'd be asking, "Are you better? Are you worse? Are you the same?" To those questions, the responses would be thumbs up, thumbs down, or the horizontal okay. That was the only way we could communicate with the people in the bell.

We actually lowered one diver, as far as I recollect, from 300 feet. It must have taken a half an hour or so to get to about 455 feet, where he suddenly looked up at the little television camera in the top of the bell, grinned from ear to ear and gave the thumb's up. There, we had a fit diver with an exposure beyond what we'd ever planned to do, but at least he was grinning and got rid of his bends.

We then sort of pulled him back to 300 feet without causing any great damage, as far as we could tell. It was a bit of a tense moment. We locked him onto the deck chamber and he got through. Then, we did the usual thing. We just gave him a very slow decompression. If a diver said "Ouch," we put him down again and held him awhile. We hoped the next time that we

pulled him up, he would be fine. That was what happened to him.

That was a very important dive because it demonstrated one particular thing. It was particularly interesting because the poor old HMS *Reclaim* had steam-reciprocating engines with a bit of an engine problem. It was the last ship in the Royal Navy to have those engines, and it was very lucky that we were still in 500 or 600 feet of water, because we should have been, at that stage, heading in, toward the Toulon Navy Base. We weren't, though. We were stuck at sea. We did it without any problems.

That made us conclude, because we did the little board of inquiry on board the ship afterward, that ethically, in order to dive as deep as, shall we say, 600 feet, the deck chamber had to go to 600 feet. You couldn't rely on a 300-foot chamber. That essentially meant that was the end of the diving trial. In fact, that proved to be the end of the Royal Navy's deep bounce diving.

We still did quite a lot of bounce diving, though, and there was some operational bounce diving, too. For instance, we concluded that if we got a helium bend, it was preferable to recompress in helium. We decided if you were going to do a deep dive, the chamber must go to the maximum depth of that dive so that you did not have to put people back in the water for recompression. Those, to me, were all the highlights. We had lots of ordinary bends and things like that, but those were things that really sort of struck one firmly between the eyes.

What really got us was the fact that we could not recompress deeper than 300 feet. Even at 300 feet, we had difficulty locking the bell onto the deck chamber. We had many other reservations about it. Peter and I advised the captain, "We cannot guarantee that if you have a problem at these depths, we are going to be able to solve it."

The other dive was on board the same ship, but it was an operational dive. We recovered some prototype torpedoes from Loch Fyne from about 450 feet. Our 450-foot table was a good one, and so the divers would go down and do that, but that is a much longer story. They would come back and do their stops and change their breathing mix to other gases and eventually would come back to the surface. Yes, it was 450 feet. I think it was because we knew the table was good.

We actually said that, operationally, we could exceed the 300-foot limit of the deck chamber. I think we made a risk assessment and decided that was all right and the other rule would apply only to the very deep experimental diving. Anyway, the important thing was that the divers would come back into the bell for lock-on, because the decompression stops were fairly short on that particular dive. There wasn't time to lock them on until they had reached 120 feet, which was where they switched from 10/90 to 20/80 HeO_2 mix. I happened to be watching the closed-circuit television. In fact, there was a new doctor on board, so he and I were in the diving flat, which was below decks. Whereas, everybody else was on the upper deck, winching in the bell, and locking onto the deck chamber; the hatch of which was available to them there.

There was suddenly a sort of noise from the television set that looked down inside the bell. I could see two divers collapsing to the floor, unconscious. They didn't have any BIBS over their mouths, but they should have. They were breathing chamber atmosphere. At that particular moment, we realized there could be a crisis. I went up the stairs and asked the diving officer if we could actually do something about it. You just made those decisions very quickly. They may not have necessarily been the best decisions, and there may have been other ways to do things. But what we did worked, which was immediately blowing the chamber back from 120 feet, where this happened, to 300 feet, using a new bank of gas. I have a feeling that what they had been breathing from their BIBS, because they should have been on BIBS, was air, actually. If that were the case, we would have put in 10/90 so as not to raise the oxygen too much, but at least it would be a breathable atmosphere.

The trouble with the bell was that it had an inwardly opening door, and we locked it on. Luckily, one of our divers, who later became a policeman, was a huge individual, and he was locked into the deck chamber. We blew him down to 300 feet. By sheer strength, he opened it. One of them came around a little bit because the bottom door was dogged, as well. The one diver recovered enough to knock off the dogs. Then, one particular petty officer managed to open the bottom door enough so that the gases mixed, and the other diver slowly recovered.

Again, I knew the names of these individuals and one of them was a great yapper. He was always talking. He was the one to recover first because he, like divers when they were breathing on BIBS, would take the BIBS mouthpiece out, say something, and then put the mouthpiece back in so he could take another breath, and then take it out again to finish his sentence.

Obviously, he wasn't very good at that technique because it meant that he was actually breathing more air in the chamber and less BIBS gas than the other guy was. The other guy was merely listening and breathing the BIBS gas. That was, of course, the problem the entire time. The other guy, who was actually the newly appointed diving officer on board doing his first-ever dive in that system, actually took much longer to recover. We then discovered that those individuals had accidentally been put onto pure oxygen at 120 feet. It took us a few hours to work that out. What they had done was go into oxygen anesthesia without fits or anything. We sort of scratched our heads about that.

But the consultant to the Navy was Bill Paton, professor of pharmacology at Oxford, and he said, "Ah, yes. Well, you haven't read my paper, have you?" He'd actually published a paper on the narcotic effects of oxygen, and we had demonstrated it.

Thereafter, the subsequent decompression was reasonable, but it did actually sound the death knell of the HMS *Reclaim* and the deep diving research. We realized that we didn't have a decent system. Although the Navy wanted to put a new chamber into the *Reclaim* during the following years, you can well understand the bureaucracy that went on. We were offered a free chamber by industry to fit into the HMS *Reclaim*. It was the right size. The only difference was that it had something like a 600- or 800-foot capability, as opposed to the 300-foot capability of our present one. The Navy rejected it on the grounds that it didn't have any STANAG number. A STANAG is the standardization within the North Atlantic Treaty Organization, and the numbers are assigned to each part so that there is an adequate supply of spares in time of war. You could think of nothing less relevant. There, we had the opportunity of a deep diving system on the HMS *Reclaim*, and we could have continued our program. It was killed because Peter and I said, "This is not safe," and the bureaucrats wouldn't replace the unsafe equipment. That was the end of the Navy's deep diving program. We had a few convulsive efforts trying to get it started again.

That would have been 1965 to 1966.

We continued expecting the HMS *Reclaim* to be ready. We continued the development program in the RNPL. We also did some diving research for a commercial firm under contract because the Navy needed the money. It was for a company called DiveCon, run by Murray Black. One of the reasons that the superintendent at RNPL accepted DiveCon for research with the Navy was because its medical advisor was Al Behnke.

At that time, DiveCon came in and dove with us, using our dry chamber. Behnke used the same routine that the US Navy had been using. He actually switched the divers from oxy-helium to air at quite a deep depth. His tables switched from helium to air at about a hundred feet. We had quite a few little problems with that. Every time that happened, the divers got symptoms just after the switch. We had a discussion with Al and made the switch to air at a more shallow depth and stretched the stops a bit, and I think that worked out okay. Peter and I used to phone him up and say, "Look, can't you change it?" He never actually came down to the RNPL. He stayed up in London all that time,

which was rather curious, because he didn't want to be involved, as the person generating the tables, with those who were evaluating. It was a very ethical position, but we had to tell him, "We can't do this." We had a very instructive and rewarding period then. It was a very interesting phase. That, again, lasted several months. You can well imagine that with all the horrendous bends and so forth we were getting at that time, we were gaining a lot of experience. I suppose that in the same year, 1965, I went out to do the submarine escape ascent trials.

The dives were being done at the RNPL and were dry chamber dives, testing Behnke's schedules for work in the oil industry. They could have been 600 feet for an hour of bottom time. Those were the sorts of tables, as I recollect. My memory could be very wrong. I think that was about all we were doing at that stage. It was around then, too, or a little bit later on, we started to do repetitive dives and other things in the deep trials unit.

At that time, the US Navy was actually not doing saturation work. It was looking at some fairly deep bounce for some particular reason. I don't know why. At that particular stage, the British Navy's approach to decompression was based on the bounce dive, and we had a lot of experience with that. I think in the US Navy there were two other developments to which we were not a party. One was saturation diving, up to SEALAB. The other one was, of course, the minimal recompression tables developed by Mickey Goodman and Bob Workman, of which we'd heard whispers.

I came over and stayed with Will Bell, one of the NEDU doctors. The NEDU was opening up for SEALAB III, and it was interested in doing some deep excursions. I think I was invited because people knew by then that I'd been in some crazy situations. I think that is fair to say. I tend not to flap. I have this tendency, if there is a panic on, to stay cool and say, "Mmm." What I do is stay cool and think, "If we don't do something about this in the next few seconds, we're going to be sunk." I think they wanted somebody with them who had the experience of some very deep and difficult bends.

Anyway, they very kindly paid for me to go out. On that occasion, I stayed with Will. Then, as soon as the SEALAB crew came in, I shared a flat with Walt Mazzone, Paul Linaweaver, Mark Bradley, and Jim Vorosmarti. The SEALAB team took the chamber deeper than 1,000 feet for the first time in the history of the US Navy, and that was really quite a remarkable experience.

At about that time, Johnny Rawlins, whom I've mentioned already, was the British navy exchange officer with the Bethesda team. I was then appointed to replace him, which I did around about early 1970, and I had three years out at NMRI. It was a superb occasion. I witnessed, as everybody did, for the first time in our experience, the needle of a navy chamber going to the thousand-foot mark. That was an incredible experience.

What I really liked was that for the first time, I was exposed to the culture of a different navy. I think that although the diving branch of the British navy was moderately relaxed, it was still extremely hierarchical. It was great to see the ways that Walt Mazzone maintained the morale of his group and did it in subtle ways, like being the chef for everybody and cooking the meal. It may have been instinctive, but it was wonderful leadership. That was really remarkable. It was a wonderful occasion for me, as a visitor there, perhaps because of my experience in treating bends deep.

I think that the end of our deep diving research probably occurred in 1966 or 1967, a year or so after the other incidents. But at that particular time, after the tragic fire in the NEDU dive chambers in Washington DC, the US Navy came to use our research unit. NEDU came and worked with us in Alverstoke at one stage, and that was a great experience.

There is no doubt that there was a lot of collaboration between the two navies. We had the IEP B-12, the information exchange program, which was very useful, because it meant we met every six months and compared notes. There's

no doubt about it. The US Navy was very helpful to us, as well. It was very much a healthy, two-way exchange.

When it comes to specific items, let's take the closed-circuit breathing apparatus first. That makes me think of the breathing apparatus that was being developed for use with the Mark I diving system, rather than the Mark II diving system. I think that was almost post-SEALAB, actually. Divex in New Orleans was developing it under a US Navy contract, but we were very much involved in that.

I can remember driving to the Divex place a few times during our various visits. That went on for a long time, because we were developing the bell-mounted scrubbing system of recirculation, so the closed circuit refers to a bell-mounted unit with a supply and return-line hose to the diver.

Unlike the commercial stuff that Krasberg and others developed later, the gas was not returned all the way to the surface, as far as I recollect. But that was very much an engineering project, so I didn't get too involved with that, except that I'd go along for the drinks.

During the period that I was at the Royal Naval Physiological Laboratory (RNPL), from 1964 to 1970, when I came over to be an exchange officer at NMRI in Bethesda, a lot of things were going on. I think that in those days, and remember that I was really quite a junior person then, my perception was that it really came from two stimuli. One was that the British Navy, which had been doing a lot of deep diving research, suddenly said, "Well, hang on, we can't do anymore deep diving research because our ship, the HMS *Reclaim*, has not got the physical resources to do the job safely."

The US Navy was very keen, therefore, to make sure that we were able to continue to do such work when possible. That led to programs that lasted into the 1970s, in which we would do joint dives with the US Navy. By that time, the US Navy had moved, in fact, to Panama City. That was all part of this same continuing IEP, or Information Exchange Program, and the MOU, or Memorandum Of Understanding, which existed between the two countries, through which we freely exchanged information on all sorts of things.

I was not concerned with breathing apparatus equipment development, which could well have been part of the entirety, but very much more concerned with the human aspects of the development of safe diving protocol. Because of the tragic fire at the NEDU, divers from the Navy Experimental Diving Unit actually came to Alverstoke. I can't remember for how long it was, but certainly for months. They worked at the RNPL deep trials unit and did some deep dives. We got some very good experiences out of that.

I think our experience in deep diving was also of great help to the US Navy. At that stage, Bob Workman and Mickey Goodman had developed the protocol for shallow oxygen recompression of compressed air decompression sickness, and the mind-set of the NEDU doctors was very much in favor of that. We in the British navy were not that convinced, because our experience was with deeper diving, which required deeper recompression.

In one particular instance, and again, one tends to remember these incidents as little landmarks, I know that the NEDU was diving in our chamber. Being a NATO organization, of course, a doctor of either navy could cover things, and I think I was sharing the watches with Mickey Goodman. It was daytime and the divers had done a deep dive. I can't remember to what depth they went, but it could have been in the 400- or 500-foot range, and we were just beginning their decompression. Mickey Goodman, although he was actually the medical officer of the dive, had stepped away for a minute or two, and I was the one standing around with the dive control unit. One of the divers reported sudden whirling vertigo. I said to Bill Filer, who was the officer on charge of the unit, "Take him back." I didn't have to ask anybody. It was our unit; they were NATO divers, and it was an emergency, so we went straight back to maximum depth, and the guy was fine.

A few minutes later, Mickey Goodman reappeared and somebody, but I don't know who, mentioned to him, "Look, one of the divers had just had vertigo." I can't remember his exact words, but to paraphrase him, he said, "Oh, well, we should think about going back a few feet." Somebody said, "Well, David's already taken him back all the way and cured him." He just couldn't believe it. I think that illustrated the difference between the US Navy's approach and the RN's approach. It was an example of how we interacted so well, because Mickey Goodman realized that while his treatment was okay for shallow air bends, our treatment was good for deep helium bends, and those were different animals.

Of course, while associating with him, I had to persuade the people at the submarine escape tank, for instance, that with the 165-foot recompressions, we ought to think about trialing the Table 6A with the 165-foot spike and the Table 6—and so on. In fact, I still believe in those.

It was very much with the IEP-B12 and the MOU. We were meeting in alternate countries every six months or so and exchanging a lot of information. I was confined to the medical and physiological staff, really, so I'm not really the person to speak on equipment development. Of course, I can say that all the teams were composed of not just members of the naval diving teams, but also scientists from RNPL and the other groups, and scientists from the experimental diving unit, who were the engineers responsible for the breathing apparatus and that sort of thing. It was very much a teamwork arrangement.

During those years, from the end of HMS *Reclaim*'s deep diving trials, we continued to dive operationally and get quite a lot of experience in the 450-foot range. Through the tragic fire in the NEDU, all those things combined to give us a tremendous we-are-really-one-diving-navy sort of ethos.

My time at the Naval Medical Research Institute in Bethesda, Maryland was fabulous. That was the best appointment I ever had in the Navy. Bearing in mind that while I was supposed to be doing physiological and animal research at RNPL, it was very difficult to get it properly funded. The nice thing was that I went to NMRI, and the Commanding Officer Tor Richter, whom I'd already met at various meetings, was there. He and his wife were very supportive of us. I took over from Johnny Rawlins, who was the previous officer. He had been working on thermal balance and so forth at the unit. I was determined to work on decompression sickness because of all the experience I've already recounted, in addition to a lot of cases I haven't even mentioned.

I was actually due to work with a brilliant young MSC Lieutenant Dick Buckles. Dick had already generated a paper on the laser imaging of ultrasound of bubbles induced in the hamster cheek pouch and published it in the *Journal of Aerospace Medicine*. I understood it at the time, but I've completely forgotten the details now. But the idea was that he and I were to work together because of my experience and knowledge of how bends, unfortunately, occur.

Dick sort of spoiled that party by resigning from the Navy at about the same time that I arrived. But I think it's worth saying that what he did was probably wise. I don't know how far we would have gotten with that work or whether anybody would have benefited. He then moved on to a company called Drug Delivery Systems, and they developed what proved much more important: a scopolamine patch for seasickness. It was his physics and physiology knowledge that did that.

I met him later, while I was the project manager for Professor Buhlmann's diving experiment, which involved going down to 500 meters with a fifty-minute compression. Dick Buckles was then working in Zurich, which was where our chamber was located, on a totally different project for the same company. I knew Dick. He then died, unfortunately, of cancer. The little program I came to NMRI for fell to the ground. I was left down in Building T-2 with two or three chief petty officers and a blank form with which to complete an application for funding.

As it happened, Tor Richter called me to his office almost immediately and said, "We've got this young lieutenant commander coming in on reserve training. He's a board-certified neurologist and has heard about this business of recompression. He cannot believe that a paraplegic can be recompressed and walk again, and he wants to find out about it." His name is John Hallenbeck. He and I brainstormed and put together a program to do animal experimentation. Then, Tor Richter got hold of us again and said, "There's another young guy around who's also doing reserve training. Would you like him to join your team? He's a pulmonary physician who has done radiological studies of blood flow in the lungs, and his name is Fred Bove."

The three of us settled down in Building T-2 and had a three-year program. The first year was for brainstorming and involved mostly black coffee and experiments that didn't work, as is the case in all research, and getting the money together. But the nice thing about that unit was that the money was not the problem. The problem was the brainpower. Even with the three of us combined, it was hard-pushed. I think serendipity played a big role in it, but what we actually did was all the work of those three years in one experimental rush that only lasted about two weeks.

We actually went down, having done a lot of work at NMRI, and set up this dog model, which is probably still being used by people who followed us. John Hallenbeck actually stayed on for much longer. We repeated our experiments, and instead of doing them in the little animal chamber we had there, we actually used the Duke University chamber.

The thing about the Duke University chamber was that it had the possible fluorescein angiography at depth, and of course, it was available because of US Navy connections. We could actually inject the animals and see the circulation and bubbles. That just absolutely made the research and solved the hypothesis that we had of venous congestion due to bubble surface activity as being the cause of spinal cord decompression sickness. That took just two weeks worth of work. Then, we went back and spent the next year writing it all up. That's the way of research. To me, it was an absolutely superb time. I suppose when that was all over, I just went back to England and started to work at RNPL again.

DR. JAMES VOROSMARTI

After SEALAB III was over, I was sent off to the University of Buffalo for two years of post-doctoral training in environmental diving research. From there, I was told I was going to go to England to do an exchange with the Royal Navy for three years.

I didn't really know exactly what I would be involved in. But it was diving research. Bob Bornmann was the person I was relieving, and he took me around and introduced me to all kinds of people. I met with the Superintendent of Diving, who told me that he wanted me to work on saturation diving, and he wanted decompression tables from 250 meters to the surface. He told me that I had three years to do it and to not call him. When I achieved that goal, I could call him.

Peter Barnard had been doing a lot of the basic stuff in that program. He was in England before I got there. I kind of took over from him. He got transferred. We spent three years doing decompression trials for 250-meter dives and doing a lot of research on the side too, medical research. That was at Alverstoke.

The lab was the Royal Naval Physiological Laboratory and the chambers were at the Deep Trials Unit. They were actually on the same ground. I had an office at RNPL.

The US Navy and the Royal Navy medical departments had been very close for years, ever since the Second World War. After World War II, there was a lot of close collaboration. I think that the first exchange officer went over sometime in the 1960s. For the medical officer, it was in aviation.

The Deep Trials Unit was very much like the set up that the NEDU had. It had the large chamber on one deck. A large center section was the living compartment. There was another lock at one end that could be used for locking things in and out. At the other end was a large dome that was over a wet pot, which was the floor below, filled with water so that you could actually do in-water diving at depth.

Peter Barnard had started his research by looking at how far you could decompress somebody without giving them decompression sickness with the depth differential. He started at the surface and went down different depths. It was basically a stepped procedure from there down. The only problem was that as you got shallower, you had to slow the decompression procedure. Using the Royal Navy's tables, if you started from 250 meters, you could drop five meters immediately. Before you got to 240 meters, you had to stay at 245 meters for a certain period of time. Well, as you got close to the surface, that time period had to be extended before you could go to the next shallower depth. Nobody really knows why.

The other thing we found out during those dives was that if you used a normal oxygen tension, .21 bars of oxygen, in the breathing mix, you couldn't get the guys out without giving them decompression sickness. Now, saturation diving uses .35 to .4 bars of oxygen, because it's very difficult to get anybody out without causing decompression sickness. Nobody knows why that happens, either.

The other problem was that when you're at deep depths, people don't seem to be as efficient as they are at the surface unless you raise the O_2 pressure. I've been convinced for years that there is probably something happening at the cellular level with the oxygen exchange, but we've never had the chance to really investigate it.

The other thing that we ran across, because we were going that deep, was that we started seeing a lot of high pressure nervous syndrome. That is what we think is a purely pressure-related event. It has nothing to do with inert gas narcosis or anything. People get very sleepy. They fall asleep very easily unless they're stimulated all the time. Their EEG changes. Mentally, they're not as sharp as they should be. It's thought that this is due to the high pressure itself, that it causes changes in the cell membranes in the central nervous system.

If you compress slowly enough, pain really doesn't bother you much. Most people don't get joint pain at all if they are going slowly enough. It only happens on the really rapid compressions. Those two things can pose real problems if the Navy has an operation and they have to get somebody to 800 or 1,000 feet in a hurry. They can get them there, but they may not be worth much for a while afterward. They may not be able to do very much.

We did a survey of divers once on joint-popping that occurs when the compressions are fast ones. Then we did some theorizing about what causes it. As far as I know, it's never been followed up.

My tour with the Royal Navy was a great tour because of the system they used there. I mean, I didn't have to turn in budgets every year. I didn't have to write reports every six months to somebody. I didn't have to worry about hiring and firing people. It was all there. The researchers basically did research. Somebody else worried about all the other stuff.

I also had additional duty with ONR London, and that duty entailed traveling to other labs in Europe to meet people, see what was going on and then report back to ONR about the new stuff. I got a lot of traveling in and visited lots of labs while I was there.

It was a great assignment. We got double holidays. If the Royal Navy had a holiday on a day the US Navy didn't, we took the day off. If you were with the Royal Navy and it was a US holiday, you also took the day off. It was a lot of fun and a nice place to live.

There were two commanding officers (CO) there while I was there, and I can't recall who they were. I hardly ever met the CO because I used to just go there. I had a little cubby hole

somewhere and did my thing, so I didn't spend a lot of time there, maybe only three or four hours a month. To go on travel, I never went up there. They would send me the orders, and I would just leave. I was ordered back to the US Navy in August of 1975.

DR. WILLIAM SPAUR

Our interaction with the British was very beneficial. In fact, when I started the limited duration excursion tables, Peter Barnard was doing 33-foot jump-ups, which certainly pointed the way to that kind of operational work. I thought it was absolutely essential that we be well acquainted with everybody else and have an exchange with the Royal Navy. I thought this not only on the medical level, also on the diving officer level, such as what Julian Malleck, Pat Dowland or Bryan Barrett exchanged back and forth.

I always went to the meetings in England, and they came to us. I thought it was useful, as well as the work that the Swedish and French were doing at the time. The scientific community, if it is open, is very much better. One of the things that I fear now is the attitude that you have to close the publication to all these things rather than watching what other people are learning about and sharing your own research.

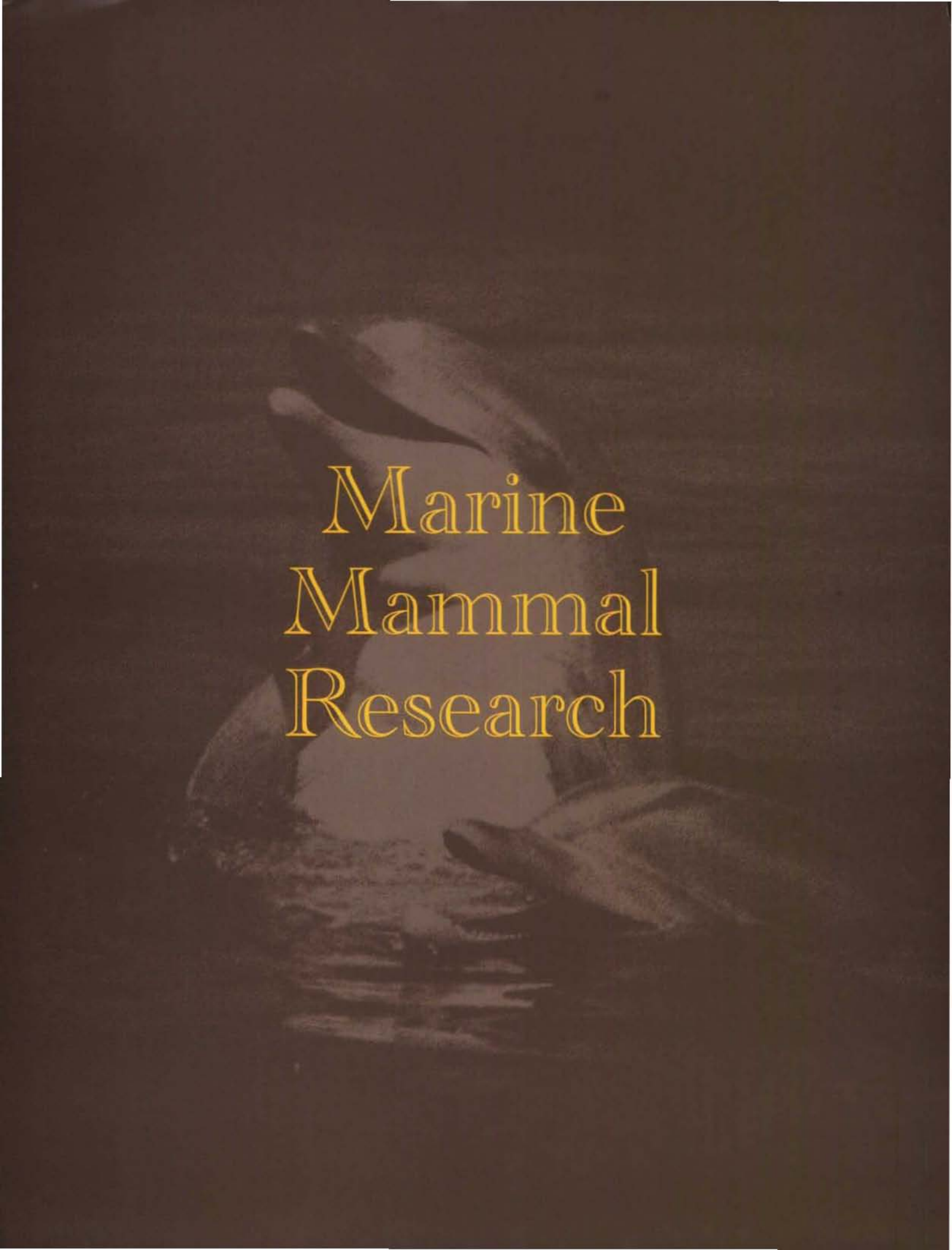
DR. EDWARD THALMANN

In 1985, I left NEDU to go over on exchange to England. When I went to England, I tried to garner some interest in getting a joint program going with the British and the Americans to come up with a single set of helium tables, but that didn't work out. Before I left NEDU, we tested some helium-oxygen tables for the Mark 16, which were all bounce dives, and we eventually went down to 300 feet for 30 minutes.

The helium tables were actually finished before the air algorithm was done. Those got published and were based on the 75-meter heliox tables for the Royal Navy EOD when I was stationed in England for two years.

When I left England, I left behind three things. We finished up the saturation excursion dives and developed the 75-meter tables, and these were actually just proposed tables. The deal was they had a big meeting over there with the Supervisor of Diving, and we decided that we didn't have to formally test them. We could field-test them, we figured.

The tables were issued for use during practice diving, and the only change in their operational scenarios was that they had to have a medical officer at the dive site when they used the tables until they accumulated a hundred man-dives. After they accumulated a hundred man-dives, they would then look at the data and decide whether these profiles were okay to use in the fleet. As I understand it, they eventually accumulated a hundred man-dives and decided the tables were okay.


Marine
Mammal
Research

The Marine Mammal Program has been around for many years. Much of what these marine mammals are trained to do is highly classified. In these interviews, we have captured some of the important work of the trainers, the operators, and the marine mammals and how they contributed to the advancement of undersea technology for the US Navy. It is a story of how marine mammals became part of the US Navy's underwater team during the 20th century.

History of Marine Mammal Program

DR. SAM RIDGWAY

I started with the Navy Marine Mammal Program in 1961, when I was an Air Force Veterinary Officer at a place called Point Mugu, California. Some scientists from the Naval Ordnance Test Station, in China Lake, California, and the Naval Missile Center at Point Mugu, had designed a collaboration to work with dolphins. It was headed by Dr. William McLean, who was the technical director of the Naval Ordnance Test Station. He was notable for being, among other things, the inventor of the Sidewinder missile.

Dr. McLean was a physicist who was very interested in science in general, and he got Commander Jim Berien from Point Mugu, who was a Navy physiologist and particularly interested in high altitude physiology. He also got Dr. Thomas Lang and some others at the Naval Ordnance Test Station. Dr. Lang is a hydrodynamics expert.

The first goal of the project was to try to learn how dolphins could swim so quickly, and to see if they violated any of the principles of drag when they were swimming at full speed. That was the impetus for the project, the hydrodynamic design of dolphins. Dr. McLean was also interested in communications, and interested in the idea of communicating with another species. Some work was also started along those lines. The hydrodynamics work lasted for about three or four years, culminating in some speed trials in some test tanks, as well as in the open ocean. It was concluded that dolphins did not have any unique hydrodynamic secrets that could be easily translated to Navy equipment. The conclusion was that they were well designed, hydrodynamically speaking.

That program then transitioned to Hawaii, where we had warm water, and where the swimmers could stay in the water longer than at Point Mugu. That program was successful, and we deployed five dolphins to Vietnam in 1970 to guard the ammunition depot at Cam Ranh Bay. It worked there for about a year, and during that time there were no attacks in that area. We don't really know about actual successful interdictions. We just know that there were no more attacks. Either they were scared off or something.

There had been attacks before the dolphins came, but there were no attacks after they arrived there. We started the system that we still have today, called the Mark 6. There were other important things to detect. They have other means of interdicting them all and taking care of them, but the swimmer detection was the main thing. That system is still in the EOD today and is still being deployed on a regular basis.

SEAL team personnel deployed at Cam Ranh Bay. The system worked. The SEAL team was SpecWar. They were under the command of Lieutenant, later Lieutenant Commander, Usrey, and he had two lieutenants (junior grade) with him, Les Bivens and Hal Goforth. They were the key guys with the system. Later, both of them worked with our program for quite a few years. That was our first operational dolphin system.

After SEALAB, there was a lot of interest, in addition to scientific research, in actually employing the animals to do things. One of the things that we developed was a sea lion system for retrieving the ASROC (Anti-Submarine ROCket) depth charge. The ASROC was a nuclear depth charge, and it had to be tested. Of course, when it was tested it was a dummy. There was no nuclear warhead on it. But it contained many highly classified components,

and therefore, it was fired from a ship. It had to go down to about 180 feet for a good test, because it was supposed to blow up submarines. When those things were fired off of San Nicholas Island, CA, they had a whole crew of divers there, a deck decompression chamber, diving medical officers, and they had to stay at the site until the simulated weapon was retrieved.

The ASROC could be outfitted with a pinger that would make a beeping sound that would make it fairly easy to locate for a sea lion. We trained the sea lions to go down and attach what we called a "grabber device" to the charge. That saved a lot of time and the recoveries had to be adept. As you know, deep diving is more risky, and the sea lion could dive down very quickly, attach to this thing and then retrieve it. Even though they always had the dive teams available, it would save a lot of their time and a lot of their risk, because sometimes it would take them a long time to actually locate and retrieve the device. The sea lion could retrieve it fairly quickly and everybody could go home.

They were the primary recovery for the ASROC for about eighteen to twenty years, until the ASROC program no longer existed. At some point in there they were transitioned to an operational system called "Mark V." Today, it's used to retrieve grill mines and other such exercise targets.

Along the way, of course, we did a lot of scientific study on both dolphins and sea lions. We discovered through work with Tuffy and some other dolphins that dolphins would always dive on a full breath of air. They would usually hyperventilate a little bit before diving, especially if they knew it would be a deep dive.

We trained them to what we called a "diving test switch." We would turn the sound on at the surface. We knew how deep it was. The dolphin would take a few breaths, depending on the switch's depth, and dive down. When the animal pressed a plunger on the switch, indicating that he had successfully been there, he would come back up, and trainer Bill Scronce would turn on a buzzer. That would signal the animal to come back and blow his air into an inverted funnel for us to analyze.

We found that their lungs would collapse, as one would expect from Boyle's law, and there was no exchange of gas between the lung and the circulation below about seventy and a hundred meters depth, even when the animal went to 300 meters depth.

That, we thought, explained well why they didn't get bent. They just take in one lung full of air, and go down. They would absorb most of the oxygen from that air, but because they could come back and give us several liters of air in the inverted funnel, they weren't absorbing all of it. They might have absorbed half of the lung air and half of the nitrogen in the lung full of air, but not all of it. That kind of explained why they didn't have any problems with bubble formation and decompression sickness.

It did not explain anything about some other problems, like high-pressure nervous syndrome, although the dives were so short that one wouldn't expect for them to have that problem. We also took pictures of the dolphins at depth, and showed the physical nature of the lung collapsed. The whole thorax collapses. That's because they have cartilaginous extensions on their ribs, and thus the whole thorax easily collapses.

The underwater photography unit at Point Mugu rigged up a camera so that we could photograph the animals at depth. We had photographic evidence down at a thousand feet, so we knew that was what was going on.

Dolphins dive to where their food is, basically. If the fish are at fifty feet, they dive to fifty feet. If the food is deeper, they go deeper. We learned from some later studies done by a colleague, Bill Evans, in our program. He was one of the first people to put radio transmitters on dolphins at sea. He found out that common dolphins would feed on the deep scattering layer, which could be 200 to 300 meters at depth, in the early evening. He put a dive recorder on the transmitter and found that the

animals were making a series of dives, not just one dive to depth, but several in a row. We thought, "Well, if they're doing that and they're doing it rapidly, what about the buildup of nitrogen in the system?" Between dives, they might not really have to blow it all off.

That's like the way they say some deep pearl divers would get the bends after doing enough breath-hold dives.

We devised another experiment in which a mass spectrograph with a Teflon catheter could be inserted in the muscle. That way, we could track the nitrogen washout from the animal after a series of dives. We took two dolphins, Blue and Brown, that had been trained to dive. We had them dive rapidly to a hundred meters, because we knew by that time their thorax was collapsed, and there wasn't any exchange going on with the circulation. We had Blue dive 25 times to a hundred meters within about an hour.

Then she slid out on a mat and we put the catheter in her muscle. We did the same thing with Brown. Brown made 23 dives. Anyway, we were able to measure the nitrogen washout from their muscle. We showed that at the end of the dive, they had a super-saturation of nitrogen in the tissues, probably sufficient to bend a person, at least according to Dr. Workman's formula.

The dolphins didn't have any apparent ill effects. We theorized that if they did have bubbles of decompression sickness, maybe the bubbles were trapped within the reedy morobala, a vast network in the dorsal portion of their thorax. All the circulation from the core, from the heart to the brain, comes through this reedy morobala and we thought that maybe it was a really good bubble catcher. That was one theory, and we published that in *Science*.

Various other people had other theories, and so in 1982 we had a little debate in *Science* magazine about it. We debated with Stuart McKay, who thought that bubble nuclei were crushed by the repetitive diving, and there was a group at MIT, who thought that maybe the dive dolphins' circulation was especially quiet, because the sound of heart valves can cause bubbles to form and grow. Then we measured the dolphins' heart sounds, and we really couldn't see that they were any quieter than our heart sounds.

There was another theory propounded by my friend Jim McCormick, at Bowman Gray Medical School. McCormick thought it had something to do with heparin. He thought that the dolphin and whale heparin reduced the propensity of the blood to form bubbles. He did some experiments on guinea pigs, diving guinea pigs, and suggested that with the heparin they didn't form bubbles that would cause deafness. He was able to dive heparinized animals and they did not lose hearing. The non-heparinized animals did.

It was always a goal of ours to come up with something that would help with human diving, like help divers to dive longer, help the treatment of diving diseases, and similar things. The effect of heparin was one thing that was theorized, at least. The acoustic issue has become important, and people are questioning whether it will trigger bubble formation if a dolphin has been diving rapidly, feeding on a deep food supply, and we hit him with sonar or with seismic sound. We don't know that yet, but that's one area of investigation.

There's a great deal in the press right now about the Navy's sonar causing harm to marine mammals. That's a theoretical mechanism of injury, but it's not been proven. We would like to go back with our trained diving animals and find out if we think it could be safely tested. We would use ultrasound to try to see if they formed bubbles in both dolphins and the sea lions. We've never been able to determine whether they actually bubble after a series of deep dives.

They've done autopsies, but first of all, the autopsies have usually been done after the carcass has been frozen or buried, or has usually been in an advanced stage of deterioration. Also, Captain Bond told me years ago, if you want to really detect if an animal was killed by decompression sickness, or had bubbles, you should do the autopsy, or necropsy, as we call it

for the animal, underwater. But none of them have been done under such conditions.

There are other things that can cause bubbles, such as gas gangrene organisms, clostridia, and different other bacteria that build up on a carcass. You have to get a carcass that's very fresh, and you have to do the necropsy underwater, as I understand it, to really detect the bubbles. Nobody has ever been able to do that, so it's kind of theoretical as to whether that could really happen.

In the 1970s we started teaching the animals to find objects on the bottom. Among those, of course, were mines that the animals could detect with their sonar. We learned that it's fairly easy to teach the dolphin to find different mine-like objects. But we were concerned that if the animal dropped a mark right on the mine that it could explode the mine and kill the dolphin. We had to train the animals to mark it in a way by which they didn't touch it. That was difficult, but it was accomplished.

Hop Porter was in charge of developing the system that was eventually called Mark 7. The lead trainer, Jim Cory, and I were able to get the animals trained. We first deployed at a navy exercise in 1980 in Charleston. During this mine exercise, as I recall, they put out twenty mines that the dolphins could work with. We had one dolphin, a female named Little Bit. Her name was Little Bit because she was small.

We had six dolphins there, and we were going to work with all of them, but Little Bit went out and found all the mines the first morning.

Then they had to figure out for the next animal whether they should move the mines around because the trainers then had some idea of where the mines were. Anyway, eventually, all the dolphins got to work, but the one dolphin did it all in a fairly short period of time.

The mine commander was quite impressed with that performance. That system then was on all the major exercises in mine hunting from 1980 forward to virtually the present time. The system was improved so that they could locate bottom mines, or buried mines. Then, another cadre, a small group of dolphins, was trained to go after deep moored mines. That system is the Mark 9.

We use sea lions for ASROC or deep object location because the sea lions don't have sonar. Dolphins have really sophisticated sonar, and they can find things even buried in the bottom. ASROC and the drill mines all have pingers on them. The sea lion would just follow the sound.

Sea lions can hear the pinger. We have found that the sea lions have fairly sensitive whiskers. They have good low-light level vision. If we can get them near mines or things to recover on the bottom, they will go down and find them, even at a thousand feet. They can hunt. They can search an area on the bottom, so we have used them. But the dolphin's skill is the sonar, and that's why we used them mainly on the mines.

In recent years, sea lions have been recovering passive targets, or those on which pingers don't work. They just have to search a bit longer, but they will actually cannonball down to the bottom. After they leave the surface, as Boyle's law suggests, the chest collapses, the lungs compress, and the animals gets heavier as it dives. We found out that what they do is simply pull their flippers in and rocket down to the bottom. They hit the bottom on all fours. We were amazed.

We put a video camera on the cable that they were pulling down, because they pull down a cable to attach to the object. We were amazed, because after they leave the surface, within a hundred feet or so, they just fold their flippers and, zoom, they just go down. They're not swimming at all.

We train dolphins by what we called "approximation." It is a thoroughly difficult thing to do. It takes a fair amount of time. You have to give them an area around the mine in which they're permitted to mark. They're not permitted to go any closer than that. You have to know the area that's marked. If it's too far away, the thing may become lost. You have to get it within a fairly narrow proximity to the object. That's just done by repetition.

They're rewarded if they do it correctly. If they mark on it or too near to it, then you don't reward them. If they're marked too far away, you don't reward them. They just learn that they have to mark it in that narrow range. It's just done by repetition, repetition, repetition.

Once, on an airplane going to Hawaii, I managed to get an upgrade. I happened to be sitting by an NFL quarterback who was going out there for the Pro Bowl. I asked, "How in the world do you learn to run backward so quickly?" He said, "Repetition. That's what it's all about. You just repeat it until you can do it better and better and better."

It's the same thing with the dolphin. You just repeat it over and over and over again, and they will get it. In the case of the human, of course, as you're repeating it you're building up muscles that allow you to do that.

Dolphins are somewhat like people; some are more capable of learning than others. There is a lot of difference in individuals, a huge range of difference. Once, I took a psychology course, and my professor said if someone asked you what the normal range of intelligence is, or any other capabilities within a group of people, most people would say the best individual would be ten times better than worst. But that really isn't true, he said. On many different skills the best individual is 2,000 or 3,000 or 10,000 times better than the poorest individual on the scales. I won't say that quite such a range applies to dolphins, but some animals are much better than the ones that don't make it. In fact, some just flunk out for various reasons. We employ them in research, or we find that they'll do something else exceptionally well.

Tuffy was a very exceptional dolphin. We have others now that are just as capable, or more capable, because they've been around longer. Thinking back, if our first dolphin had been an idiot, we probably wouldn't have lasted past 1966 or so. It would have killed the program. We were just lucky we got a good one with which to start.

We also have worked with white whales. They are very good divers. We found out that they could dive to over 2,000 feet on command. We had them retrieving test torpedoes off of Canada and the Pacific Northwest. We also had them dive down to 1,000 feet and rest on a hearing test station and test their hearing at depth.

We were interested in seeing if depth decreased hearing sensitivity, because there was a theory that stated that if you put a lot of pressure on the middle ear, the air becomes more dense, and that could theoretically decrease hearing capability and increase the threshold. We did a study to see if that happened in whales; it does not.

White whales hear just as well at 1,000 feet as they do at the surface. It's probably because the sound comes through the body tissues to the ear on a fairly direct path and doesn't require the tympanic membrane or the ear canal for hearing. Although the ossicular chain is still there and may be important as an inertial mass between the cochlea and the middle ear, the eardrum and ear canal are probably not functional, as far as hearing goes. The whale demonstrated that at depth.

We had evidence about it from previous neurological studies, but this was a demonstration that the animal in the open ocean can hear. The way we did that was by playing a tone to the animal, a 500-millisecond tone, and we had the animal whistle when it heard the tone. We presented a tone and the animal whistled. We presented another tone and the animal whistled, and we kept bringing the tone down in what is called a "stair step fashion."

It was just like an audiogram. After a series of those, we watched the animal on television from above, and the whale would come up and get a fish reward. A few minutes later, we all went down and did it again. We were able to do that near the surface and at increments of a hundred meters. We showed that they hear just as well at depth as they do on the surface. I have a paper on that, too.

Our first dolphins were captured in the Gulf of Mexico or from the East Coast of the United States. The initial group of dolphins was from Marineland in St. Augustine, FL, and that group was composed of three dolphins. Previous to

that, we had a group of five dolphins, that included Tuffy, and they were from Gulfport, Mississippi, in the Mississippi Sound.

The largest percentage of our dolphins came from that area of the Mississippi Sound. The Mississippi River is a great engine that flows into the Gulf of Mexico, and it makes for a very rich area, a very productive area. That's where all the Louisiana shrimpers and Gulf Coast fishing people go. Thus, there are a lot of dolphins there.

Of course, dolphins live in fairly shallow water, and that makes them fairly easy to collect. For the Navy's purposes, because that water is very murky, almost opaque, the dolphins that live in that area have excellent sonar, because they need it. You can't see your hand in front of your face underwater there. That's why the majority of our dolphins were collected there.

In the late 1980s, we decided that we wouldn't take any more dolphins from the wild because of the public pressure against it. Also, we wanted to see if breeding our own would not improve our capability to train them faster, perhaps. We caught the last dolphins from the Mississippi Sound in 1989. Since then, we've been breeding our own.

Now, the normal dolphin in the Navy program should be with us for twenty years. We have some that have been with us almost twice that long. We have one dolphin that served in Vietnam and was initially captured in Florida in 1966. She's still here. She's kind of retired now.

She has a very bad name. She's a wonderful female, but her name is Toad. That's just what one of our redneck trainers named her when he first got her, and so that's what she's still called. She's a wonderful, beautiful animal.

Anyway, we've got a number of animals that have been with us since the early 1970s. Two of our best animals that helped with the mine clearance in Operation Iraqi Freedom, in Umm Qasr, have been with us since the early 1970s. They were either caught in 1970 or 1971, or in one or two cases, 1974, and have been with the program ever since.

We are getting better at their healthcare and keeping them fit and conditioned and working with us for longer and longer periods. We've been able to extend the useful life for many of the animals from twenty years to thirty years in some cases. We don't really know how long these animals live. We know that some females live into their early fifties, at least. Males usually don't live past their mid-thirties, but we've got some that are in their late thirties now and still seem pretty active. We are still learning more about how long they live, and how to take care of their major things.

As I said, we are hoping that breeding the animals here will improve their performance, but so far, I couldn't say that it has worked. The first dolphin we have that was born here was born in 1979, and she's quite a good animal. At the time, she was needed more for research purposes than for the Navy systems. As a result, she never got into the Navy systems.

We had some others that were born in the 1980s that actually haven't done extremely well for one reason or another. We have another one that was born in early 1980s that's been just a real champion. We think genetics probably has a lot to do with it. We probably need to introduce our best performing males to our best performing females.

We noticed that one animal that was born in 1983 has bad teeth, and both of its parents have bad teeth. I guess you have to expect that. But he's been very good at some things, and not very good at other things.

To see if dolphins can learn from each other, we start exercising and doing some tasks with the mother and her calf at a fairly early age. We think that a young animal will pay more attention to its mother and learn more from its mother than any other animal. It's probably a complex learning situation, and the animal that would be a so-called "teacher" has to be an animal that the animal you're trying to train is going to pay attention to. We don't know the key to that yet, but we were trying to use that type of relationship to see if we can improve the training. I

think we've got a long time before we'll know how much good it does. We've still got a lot to learn about the training, and about animal perception, intelligence, motivation, and those types of things. We just don't know nearly enough about that yet.

My perception is that it is easier to train the white whales, because they are a much more mildly tempered animal and pretty consistent from one day to the next. It might be just the ones that we have had. Maybe we've just been lucky. They are also large and very mellow, for lack of a better term. Sea lions and dolphins can both be fairly aggressive. The white whale is a little slower, but they tend to be more consistent from day to day.

Again, we have worked with only a small number of animals, and any animal that eats can be trained. Depending on what you're training, it can be better for the animal to be a little bit dumb. Motivation is a difficult thing to understand, but the animal gets some reward—and it's not always fish. For example, on our hearing test, we give the animal one tone and the animal will respond. We don't give him the fish immediately. The animal may get another tone at a lower level. The animal will respond to that. But responding to the following tones will be for the reward. They can do a long series of behaviors without getting food for it.

That's lucky for us, because we train them to do things that will be employed in the open ocean and away from us. We can't be giving them a reward when we're not even there. It's difficult to give them a fish reward if they are at depth, for example.

Each step in the process seems to have its motivational features. You can be consistent if the animal dives down and the apparatus is there. That is motivation. That is consistency. The apparatus gives them a tone, or does whatever it's supposed to do. That's another motivational feature. That gives the animal confidence that he's in the situation in which he's supposed to be.

They enjoy these procedures so much that when the trainers come to the enclosure with their boat, and the animal is trained to slide out on the rubber mat to go and work at sea, the animals are very excited, much like your dog at home. Some dogs love to go in the car. If you rattle the car keys, the dog gets excited and goes jumping around. That's the way our dolphins are when they're coming to work. When we're working them in enclosures, like doing some hearing tests or something else, often they line up and kind of compete to get to go first. They're motivated to do their work because it's rewarding. It's not just about getting fish, I think. The work itself is rewarding because it's interaction.

The animals are fairly flexible in getting used to a new trainer, such as when a Navy trainer is transferred. As long as the equipment, the sounds, the boats, and all the different parts that make up the marine mammal system are there, you can change trainers. Sometimes you have a little bit of difficulty changing from one trainer to the other, but usually more than one trainer works with the animal anyway. There is not too much difficulty with that.

When we first started out in 1961, there really wasn't much known about dolphin or marine mammal physiology. That was good, in a way, because it enabled us to learn a lot on our own and rely on what was known about other species. It has had its difficulties, because we couldn't, at the time, use some of the modern methods that we have now. Now, we use ultrasound extensively, for example. At that time, we didn't have ultrasound that we could use with the animals.

Early on, we didn't know nearly as much about their anatomy and physiology, but we got to learn for ourselves. That, in a way, was an advantage because we had to learn it, and we had to learn it on our own. There was anatomy work done by the Germans back in the 1800s, and work done by the British, especially with big whales that were killed on whaling expeditions. There was some work done with some smaller animals, as well. There was a lot known about skeletal material, because skeletons have been collected in museums. There were good old drawings that one could find in the library, the

big University of California-Los Angeles Biomedical Library, the Los Angeles County Museum of Natural History, or places such as the San Diego Museum of Natural History.

Some of them, of course, are very good drawings, because people had more time to sit and draw things like whale bones than they do now. Doing that now would cost a tremendous amount of money. Back then, people had more time to do that sort of thing, or at least it seems that they did because they did a lot more of it. You had to work harder to find it and put it together. A lot of it was there already. There were some old studies.

My friend, John Kanwisher, from Woods Hole, published a number of papers. He was very interested in physiology. He worked with us early on at Point Muguo with the Tuffy diving work. He was a colleague of Pete Sholander, who was a Norwegian physiologist and diving physiologist who came to Scripps and finished his career in La Jolla. He did a series of studies that were very helpful, so we had a lot of useful information.

There was also an MD, John Lilly, a neurophysiologist. He had a lot of ideas about dolphin communication, and a lot of them were very outlandish. He wrote several fairly mystical books about dolphins, but if you could filter out his mysticism, he had a lot of useful information. Those were all coming out about the time I started. Those were helpful, too.

We still really don't know how complex dolphin communication is. They use whistles and burst false sound. They use echolocation quirks. They click at different rates. Some people think that their communication is done at a fairly high level. They think dolphins do things that are only done by higher animals, like chimpanzees, for example. But that's been disputed to a certain extent.

In our Navy program, we've never carried that line of investigation very far because it wasn't really necessary. The people who started out working on that weren't able to carry it very far. They kind of ended up in blind alleys, so to speak. Instead, we focused on what we could do with them, and we always think about it and are interested in it, but because of the mysticism that has been attached to it in the past, it's very difficult to get a research project to really work on that. It would take some years to make progress. Nobody has come up with a really brilliant idea about how to do it.

Our best approach is to interact with the animal through a computer so that we get the human somewhat out of the loop, because the human can mess up results by telegraphing information. We give the animal a call and the animal whistles. Then, we can work with that basic element and make everything more complex. In order to get funding, we've done it from the standpoint of learning about their hearing and their basic responses, rather than just learning about communication per se.

Of all my experiences over four decades, I think my early experiences with this dolphin, Tuffy, and the ability to work with the animal in the open ocean was the most satisfying. I've also been satisfied by getting to work with a lot of people who were very capable that were interested, such as divers. I've gotten to work with regular Navy salvage divers on occasion, when we would take the animals on grill mine recoveries. For a number of years a SEAL team handled the animals, and I got to know a lot of them. For about twenty years we always had SEAL team corpsmen work with us to help with the medical care of the animals, and they were very good guys, and I really enjoyed working with them. There are also the EODs, with whom we work now. That's been really enjoyable. It's been enjoyable to be able to deploy with human/animal teams.

In the early days it was all secret, so we would come out here at midnight and load up our dolphins and go across to the old pier across the base and over to a big black airplane that was sitting out there on the tarmac. We would load up our dolphins and take off. Oftentimes I wondered, "You know, we're taking off over San Diego at two o'clock in the morning in this big

barn of an aircraft. What would people think if they knew what we were doing?"

We would have these dolphins that would be whistling, you know, as we take off. A lot of them kind of became excited and whistled. We'd go halfway across the country or halfway around the world and land somewhere, and they'd take us off to a remote location and unload us. Then, we would go and do our work. Of course, now, it's all unclassified, so they don't have to do that. But I always found it was kind of exciting that we were doing stuff that nobody knew about.

One setback for me was when Tuffy died. We had a number of setbacks like that, when really good animals died. We, of course, know a lot more now about how to take care of them. Some setbacks occurred when the animal didn't perform up to expectations for unknown reasons.

I know one mine exercise on which we didn't perform very well at all. Mines were sitting all up on a clump, on top of a rocky bottom. The animals, for some reason, just didn't recognize them. The mines weren't like what they'd been finding. They'd been finding mines in much harder environments. It was too easy. They figured it wasn't what they were supposed to do, you know. That's the way it seemed. That happened really only once that I know about.

I think we've been very fortunate, other than losing some really good animals. We had one major setback with SEALAB III. We had animals trained to work with SEALAB III, which was at something like 600 feet down at San Clemente Island. We were getting ready to take the dolphins out there, and we had assured ourselves that they could perform very well at that depth. But by putting the habitat down, one diving officer lost his life.

Berry Cannon was the diver. The whole thing was cancelled. At the time that seemed a big setback. But, as it worked out for us, it wasn't such a big setback, because it kind of demonstrated that diving to 600 or 700 feet is a dangerous thing for people to do. It's kind of ordinary activity for dolphins. As a result, doing some of those things with dolphins became more credible and more important.

Still, our work has always been in conjunction with divers and it has always been a human/animal team. We know dolphins and sea lions can do these things. It's no risk for them. If they can do it, it's probably a good idea to utilize them when you can. In some cases you cannot use dolphins and you need that human down there to do complicated work. But if it can be made simple and repetitive, the animals can do it very well. Dolphins have a really good sonar system that allows them to even see through the bottom of the ocean, to a certain extent. That is a capability that we certainly can exploit.

I think that, eventually, we will be able to duplicate some, if not all, of the marine mammal abilities. I think they're getting closer and closer every year. We've always been working on a five-year program, or we work as if we expect to go out of business at the end of five years. We've done that since the early 1980s, at least. Now, I think it's kind of a ten-year program. I think at the end of these ten years, it may be that at least some of these things will be done by robots and different kinds of simple undersea vehicles. Mine hunting, for example, will probably be done this way. Hopefully, what some people in the program have learned about the dolphin's sonar ability will be useful in helping that come to pass.

My hope is that if we learn to replace the animals with different robots and so forth, that we will take the opportunity to use the highly trained animals we have to learn more about them in the open ocean. We could research things like hearing at depth, which we have learned about. There are a lot of other things that we'd like to learn about, like pollution effects on animals in the wild and bubble formation. There are a lot of things that we can employ.

Because this group of Navy dolphins is highly trained, we could employ them in research from which we can just learn an awful lot. They could work with us in the open ocean. That's what I would hope will happen in a few years.

We use Atlantic and Pacific bottle-nosed dolphins, but we have experimented with other types, such as Pacific white-sided dolphins, common dolphins, Dahl's porpoises. But the bottle-nosed have excellent sonar. Of course, I mentioned the white whales—they worked for us. They're bigger. We were doing things in the Arctic. They're Arctic animals and can adapt to the environment there because they swim under northern rivers in the summer to breed. The temperature in those rivers is about the same as it is in San Diego Bay. But they can also winter inside the Arctic pack ice. We thought there might be a need for recovering torpedoes in very cold waters. That was why we worked with them. We worked also with pilot and killer whales for a few years. Those animals, for our purposes, really have no advantage over the bottle-nosed dolphins. A pilot whale can dive a little bit deeper, but they're much bigger animals and harder to handle.

The Orca whale is harder to work with. They require such heavy equipment and they're so large. As far as we could tell, they couldn't dive any deeper than the dolphins. The Orcas we had were not aggressive. Of course, you wouldn't want to make them mad, you know. They have big teeth.

A sea lion is bad enough. That would be bad. We didn't work with the Orcas for very long. That was at the end of our time at Point Mugu.

CAPTAIN WALTER MAZZONE

I got to help train dolphins to go into the dry deck shelter on a submarine with saturation diving and we decompressed them. I thought that was clever. It was never written up, nor can it be. Using dolphins was a good thing except that again, a lot of politics got involved. They did not want us to train dolphins, not necessarily for killing people, but for tagging submarines or something else, like putting a transponder on there so that you could query, "What's your position?" They wouldn't let us do that.

We used a dolphin named "Tuffy" on SEALAB II. That was the start of my interest with dolphins. Then, in looking at the use for detection underwater, we took the *Deep View*, which was a one-man, glass bowed submersible, to Hawaii with some dolphins and did tagging studies. That was interesting. They would come out and put a tag on a submersible. If they could put it on a submersible, couldn't they put in on a submarine? Could you fly them, drop them off and let them go do that? Those dolphins were brilliant.

MR. WALLY JENKINS

In learning cave diving I also learned to have a line, and I didn't leave that habitat on SEALAB without a line. I mean, that would mean "Tuffy" the porpoise was going to come and get you. That's just show biz. You know, that dolphin, he's not going to come and get you. He did his own thing. We had him down one day, and he—the story that he's going to deliver SEALAB mail, and all that, which is fine. But, we didn't depend on him for anything.

Marine Mammal Classification

MARK 4: Mammals trained to locate moored objects (mines) in water columns of various depths

MARK 5: Mammals trained to retrieve mines (grill) and other such exercise targets

MARK 6: Mammals trained to detect swimmers in harbors and protect moored ships from enemy swimmers

MARK 7: Mammals trained for hunting bottom or buried mines in a methodical means using circle searches in shallow water (to clear harbors)

MARK 8 (previously EX-8): Mammals trained for quick recon searches; mostly clandestine operations. Trained to clear assault lanes for Marines and for amphibious assault

MARK 9: Mammals trained to locate deep moored mines

Operational Use of Marine Mammals—Operation Iraqi Freedom

CHIEF ENGINEMAN FRED LIEDER

During Operation Iraqi Freedom, I was the leading chief petty officer for both Mark IV and Mark 7 marine mammal systems. Mark 7 is a mine hunting capability that detects mines, usually bottom mines or buried mines. Mark IV is a mine finding marine mammal system that locates moored objects in water columns at various depths. They both use Atlantic bottlenose dolphins.

They are accustomed to doing harbor searches; Mark 7 can do harbor. It was kind of in their plan when they first started. But they hadn't practiced it in a while. Basically, you can look at a carpet on the floor, and if you put a chair on the middle of it, you are going to be able to see that chair. It's the same thing for the animals. If it's a sandy bottom, and you put a mine out in the middle of that sandy bottom, it's very easy for them to see it. Take that same thing, put it into mud and sink it to where it is halfway buried, with a lot of trash floating around, which we all know is in harbors, trash cans and metal chunks that have fallen over the side or wheat bags or whatever. The animal has to go through and decide what is a mine and what is not, and then report that back to us.

The animals mark mine-like objects. An object has to have certain criteria for the animal to mark it, and we maintain those behaviors. Now, there are false positives, but very few. Of 2,000 search stations that we did in Iraq, for example, we laid 16. Of those, 12 were verified as non-mines. The four were buried items that they couldn't find. In less than one percent of the area that they searched they reported things that were not mine-like objects. That was not too bad.

We did a lot of work on that. We actually had two exercises between the time I got here and the time we left. During those, the first time didn't go very well. We were using a different set of equipment for marking mines than on normal excercises. We came to the issues there. We swapped back to our original equipment, thinking it would work with just some modifications. In the second exercise, we did tremendously well, with a 93% allocation. We missed one mine that we were looking for, out of all of them. That was pretty good.

Then we deployed in March and flew over there. Normally, what we do is, when we land, we take the systems with the animals and we put them into a Miller pen. The pen is a twenty by twenty-foot square pen, and twenty feet deep. We can put it together and inflate the outside, and the net hangs down twenty feet. The animals kind of get used to being in that environment. It's usually seven to ten days they remain there.

For this war, we were not able to do that. Basically, what happened was that they flew thirty hours out of the water. They fly in these big bathtubs, for people who don't know, and they land in a stretcher. The bathtub is about half full of water. We keep them wet the whole time, but they are not swimming in water. For them, it is a little more stressful than being in open water.

We got there and we were supposed to put them in the Miller pen, but that was all kyboshed before we left. They wanted to keep it on the down low, and we needed to get to the North Arabian Gulf as soon as possible so that we could get into the war, because our flights were delayed three weeks. We weren't able to do that.

We went straight from the plane to the pools on board the USS *Gunston Hall*. It's called a "ship forward deploy pool." It's three inflatable rings stacked on top of each other; they are smaller as they go up. They wedge inside of each other. There's a whole bunch of straps that hold them together. Then, a liner is put in there and we fill that up with water, and it's a pool. It has a cover over it so that people can't drop stuff on them and things like that, and it gives them shade from the lights.

We put them in there, which was the first time we have ever had to do that. By the time they actually got back to a pen, it had been 37 days. That was the first operational use, but even for an exercise, it was the longest we had ever had them in a pool, and it worked very well, actually. We went on board those pools and then went to the North Arabian Gulf, where we were 32 miles off Kuwait. It was our first time putting them in the water, so we didn't know if they were going to run away, come back, work well, or what they were going to do.

We have this IDP, which is an intermediate deployable pool, I think. Basically, it's a ring, one of the rings from off the pool, but it has a net that hangs off of it, so it floats on the surface of the water. You can re-beach in and out of there, which just means we can put the animal in the water and they come back in the boat. Then, we knew we had control. Yes, they were with us and they weren't going to run away.

Then we took them out into the open water that day, if they showed us that commitment. We took them out in the open water and we worked them on a simulator mine and stuff like that, just to see how their control was. It turned out that of the five systems that Mark 7 brought, four were up and running within about a four or five day period. They were one hundred percent, luckily, because it was on day nine, I want to say, that we got the call telling us that we were going into the port of Umm Qasr.

We put in food and equipment first, pools, our rubber boats that we had to build up, life support equipment for the marine mammals, food for the marine mammals, and personnel. We built up three pools. They were different; they looked like an above ground pool that you have at home. We built up three of those inside of a warehouse right off of Pier 2 there, which is all the way down the bottom of the set of piers.

We were on Pier 2, which was secure, supposedly. We flew in while it was still kind of hot in the new port. Umm Qasr is divided into two ports. There's the old port and the new port. The old port was secure; the new port still had gunfire going on. But we flew into the old port with the MH-53s and set up three pools.

Then we got our boats on the next day, after we filled the pools and had everything. We had to borrow some fire hose from the Iraqi people to make it happen, because the distance was greater than we ever thought it was going to be from the water to the warehouse. We filled up the pools and got them treated and shocked, just like we do at home.

Then, we got the animals. Two of the systems came in and started working the next morning. So, it was actually about day two and a half when we started working. We had a bad storm. We were supposed to work the night they came in, but we had a terrible storm with forty knot winds and we couldn't get the boats out.

We also borrowed a box loader, which is like a humungous forklift that holds Conex boxes. One of the Iraqis was nice enough to leave the keys in for us. Because of the 18-foot tide and lack of boat ramps, we were able to use our lifting slings to lower the boats right over the side, and also the systems, the animals, into the boats.

We were required to clear Pier 5 as quickly as possible. That was what we used the marine mammals for. Mark 7 was declared what they call the "mine burial zone." Because it was a silty, soft mud that varied in length off of the sea wall, depending on where you were in the port, we had various lengths that we had to clear away. Then, mine hunters and UUV took care of the actual proud-type contacts.

If there was something that was out of the normal, they would use us to go and just re-verify for the second check, to see if it was a popular native in the system, but we weren't really used for the proud area. That was the old port that was a mine burial zone.

The new port was 2.37 miles long and about an average of 500 yards wide. We had to do the entire port, because it was just a silty area. We were there, in the old port and the new, for 19 days. We did something like 1560 waypoints, and we did them with basically three systems,

because Takoma, the second male that we brought in, decided to run away. He didn't actually run. He kind of drifted away from us when we had a gas attack, so we all went running in to get our gas masks on. Well, we had our gas masks, but we had to put on all our chemical gear. By the time we got back out, after we found out it was a hoax, he was nowhere to be found.

Takoma went UA. We spent time the next day, if we weren't working a system to clear a field, hunting for Takoma. A day and a half later he came back to us. We were out working one night and he swam right up to us. It was a bright, glowing body through the water. His whole outline was just glowing from the bioluminescence. It was quite pretty. I wish I'd had my camera to take a picture of it. But he came back to us. They go UA and come back after a couple of days.

We try to maintain them in the area. We use recalls and different things like that to try to keep them in the area. Like I said, there was an 18-foot tidal difference in the harbor. We were also dealing with a four-knot current when it was fully kicking, and the systems were able to work through that.

We were wondering if he would swim with the current out to sea or swim with the current upriver farther. So, it was quite an extensive zone that we had to search. He ended up being a hundred yards away from where we left him. He tried to hide.

Macay is our oldest animal. He's currently 34 years old and has been with the program roughly thirty years. They found him when he was around four or five, they say. They don't know his exact age. He was a captured animal. I worked with him in Key West, back in the late 1980s, early 1990s.

Of those 1500 sonar waypoints, Macay himself did roughly, I would say, eighty percent of that area. Every day, you took him out and he did his two or three hours a day out there, hunting his lanes. He got a little slower. All the systems got slower as we went through. Like I said, that was the longest pool time we had ever had. So, it was good to see how hard you could push him and the different things you could do to keep his energy.

When you think about it, you're taking an animal that's used to echo-locating off of everything, and you put him inside of a pool. He can't echo-locate off of anything other than the other animal that's in there with him, you know, to get any entertainment. So, we spent a lot of time with the guys in the water with them, keeping them motivated and things like that. We made sure that they got out every day. That seemed to be the key to keeping them okay. We were basically in that port for 19 days. Well, there were two ports in 19 days.

Then, we flew them all back to Kuwait. When they flew in and out we used their beaching mat, which is a gray, gym-like pad that falls over them so that they couldn't fall out. We flew two of them, side by side, and just lifted them out when we got to the other end.

They went to Kuwait and got six days off in the pen. Then we tried something new. We put them onto a LCU, put a smaller version of the shipboard pool on the back of an LCU, and loaded our two Mark V's on there, our little inflatable boats. All our people slept on deck. It kind of looked like the *African Queen* going up and down the river. But it had all these covers on it to keep us out of the sun, because it was really hot.

We went back up the river; it was the Kaa River for another 12 miles to the port of Azubayr, which is another deep port that they use. The conditions were terrible. We had a tremendous amount of mud and a tremendous amount of oil.

They had drifting nets that were coming down on us all the time, like fishermen, and big piles of bamboo. I didn't know where in the desert they got bamboo, but it just came flying down the river at four knots. You were driving this lane on your little boat, driving off of a computer screen, trying to keep on line. You just got the warning, "Hey, bamboo." You had to go around and get back on track again and things like that.

We were worried about the safety of the animals then, with the contamination in the water and the obstacles. We had light oil contamination in Umm Qasr. But basically, the vets, and we travel with a veterinarian, told us that as long as we cleaned them off, they'd be perfectly fine. We had soap to clean them off after every comeback. They would have a little bit on their control surfaces. When I say "control surfaces," I mean their pecs, dorsals, and gluts, which are the tails. They had a little bit and we just cleaned that off. It wasn't a major deal.

When we got to Azubayr, on the other hand, it was all over them. It was on the control surfaces, the rostrums, which are their noses, all the way up their foreheads, and on their backs. It was nothing that was hurting them, and we would clean them off as soon as they came back. It didn't seem to affect them at all in their performance. They worked tremendously well.

They were quite resilient to just about everything in the water. It was amazing to see. We were very concerned, personally. We didn't want to hurt the animals for any reason other than, you know, if we had to save human life. But we were concerned about their safety. We got there and started working. It cleaned right off. We had an eye cleanser, just in case there was some in their eyes. Everything seemed to work fine.

We brought Macay and Spetsnaz, which is our other male, not Takoma. They did that port. Only two animals did that port because it was smaller. It was about 500 waypoints every day. Again, going out to the mine burial zone was what we were tasked with. We didn't find a single thing in that port. It was good. The animals were tremendously better the second time around. Once they got those six days off, they were super fast.

The animals have personalities. Some marine mammal systems will have beaching issues, or coming in and out of the boat. But when you get them into the field, they work like champs. So, there are just little things, and they change. There are set patterns that you can see. There are also times we have to ask, "Why won't he beach today? That doesn't make sense," or "Why is he not finding the calibration target when we're only thirty yards away and he should be finding at fifty? What's up?"

There are decisions we have to make out there, while we are doing it, like whether an animal is safe to bring into the field. We don't want to go through a field with an animal and say, "Yeah, it's clear," when there's a mine sitting in the middle of it, and a ship blows up when it pulls in with humanitarian aid. That's just something we don't need.

There are patterns for each of the systems. There are set patterns but they will have off days in there. There is always correction. I don't have any children, but I would say it's like working with children, except that all your answers are "yes" and "no" You can't say, "Okay, go and pick that tree out or pick that stick out and put it over there next to that rock." You can't tell them that. They have to figure out that they are going to go do it and then you either say, "Yeah, that was good," and feed them, or "No, that's not what we want." It's a little harder.

Try to train your dog with a clicker. Maybe "yes" is one click and "no" is two clicks. Tell him to do stuff. We are talking about a chain of behaviors that is 12 or 15 steps per signal. It is not something easily learned, so there can always be a breakdown here and there.

Training may take a long time. Right now, they are up to Mark 7, which is the most complicated of the marine mammals. It is roughly eight years now.

Training used to be a lot shorter. Now, we have added a lot more behaviors to them and the Navy was really short on animals, so they trained them as fast as they could to get them to us. We found issues with that. We would have control problems or not the best detection. Now, they keep them longer at SPAWAR before they get them to us, so we get a better product in the end.

What it comes down to is the needs of the Navy. I think that in Mark 8, right now, we have

one animal that used to be a Mark 6 animal, which is an anti-swimmer dolphin. Most of the other three Mark 8 animals were prior Mark 7 animals. We used to have two depths of Mark 7 animals, which means we had four each. Now, we only have one. We gave four back to SPAWAR to maintain. They took some of those and made them into Mark 8 animals, because it's easier to train Mark 7 to Mark 8 than it is Mark 8 to Mark 7, which was a new program. I dive with the mammals to verify what they are performing.

I didn't go to the personnel side of this whole thing. Basically, for the war, we took nineteen personnel. Of that, three of us were EOD techs and the other 16 were either scuba divers or second class divers. All the divers, but not the EOD part, were the marine mammal handlers. They were the guys that were out there, handling the animals every day.

In the end, we didn't actually find any mines. We were able to verify that the port was clear. We had four contacts from Mark 7 that were nothing found on the surface by a diver, which meant that of those four marks, we had a buried mine, or something mine-like, just buried. The commander decided to place charges and blow there, just in case. That way, we considered it taken care of. That was how the system worked out. We used the mammals to mark, and we used the divers, since the animals were more time consuming than we were, to verify and take care of those.

Now, if we had found a mine, I think the plan might have changed. Instead of hazarding a diver, the marine mammal was definitely low MEU. The shape that he places is definitely low MEU, so why not send him in instead of taking the chance a whole dive team might go up by mistake? Reducing human casualties is definitely a plus. But the animals did very well. We went over with nine animals altogether, five Mark 7s and four Mark 8s. I haven't talked about Mark 8. I wasn't working with them, but they were placed in Kuwait, just in case they were needed for some sort of amphibious assault on a beach. Their job is the VSW field, the very shallow water area. They weren't needed, so they got a vacation in Kuwait, unfortunately. They were probably not too happy about it.

It has been just great to be part of the first operational deployment of the marine mammal systems. It was successful for mine hunting. Of course, we had the anti-swimmers for the Vietnam War. But for mine hunting, yes, it was great. It was a great tool. There is no other system in the Navy for buried mines, yet.

The admirals have seen that and they were very happy to bring this over and do it. It turned out really well. I know everybody thinks there are a lot of logistical headaches going along with marine mammals, but it turned out well. I don't think the admirals ever really heard anything that I know of that would make them not call us again.

It's good to see something the US people have paid so much money for be used in a real operation, and it worked so well.

EM3 EDWARD KOTH

I came here to the Naval Special Clearance (NSC) Team One as repair, just turning wrenches. Then, I went to dive school and transferred to mammal. I went to dive school right here. The people from Hawaii brought some instructors out here and they taught a class of us. There was about seven of us from this command who went.

At the time, we had a dive crew. We were called "whiskey divers." When an animal takes a mark away, it has to put it a certain distance away from the mine. Then, as a dive crew, we dive down and come back up and tell the handler who has the primary handle on the system and how far away the animal was from the mark.

We get what's called a "pinger." When you are going through the minefields and the animal sees what it thinks is a mine or an obstacle underwater, it will pop up and the handler will know, through certain communications with the animal. It will give what we call a pinger or a marker. It sends off a signal. Our dive platoon

can pick it up on some of their instruments. He will have the bite plate on it and the animal will bite it, take it down and place it next to what it thinks is a mine or a shape that we deem as dangerous. Then, it will come back to the boat and you continue on to the minefield.

After the animal marks the mine, we go down and check almost instantly. Right when the animal takes the mark to the mine, a buoy will pop up that's attached to the pinger itself. I would say that within a couple of minutes after the dolphin marks it, we check. Once the dolphin starts coming back from dropping the mark, we go down on the mark.

This is all for training purposes. If we were to do this in a real time scenario, we wouldn't be there because they would be going tactically into a minefield. So, obviously, we wouldn't be there. For training, we shadow the work boat that has the animal and every time they drop a mark, we come back up and tell the handler the distance and stuff like that.

If the animal has done well, he gets a reward. The faster you are, the better it is, because as smart as dolphins are, they are still animals and they will forget why they are waiting there. They are trained to wait next to the boat, but they'll get bored or preoccupied and want to take off and they'll forget why.

My job has a lot of bounce diving. It's a lot of up and down. Some days, we can do 25 to 30 dives. We work all four animals, and each animal will take eight or ten marks, which isn't unlikely in a minefield. We try to train them every day. There is a lot of up and down. We don't really go that deep. It's very shallow water. We rarely go down to the depths of forty feet.

When I was in Iraq for Operation Iraqi Freedom over there, we were pretty much attached to the USS *Gunston Hall*. We would help out in well deck operations and also do watches and stuff to help the animals and anything else that the handlers and the rest of the team needed. You need guys to help. We would pull the animals for medical reasons, for sonograms, for instance, and make sure they are doing well, and take blood. You need someone to hold the animal down. We just helped with basic needs for our platoon.

On the *Gunston Hall*, we had what is called a "beaching cart" to get the animals off the ship. It has a net on it that the animal beaches in and out of. I guess it's about 4 feet tall. It's on wheels, like a big cart. The animal will beach up onto that cart and we close the mat up, which is called a "beaching mat." We close the mat up and we roll the cart next to the boat that's on the well deck. Then, the animal will beach into the boat from the cart. The boat then gets marched off the well deck and gets transported into the minefield.

The problem with being on a ship with those twenty-foot pools is that you can't keep an animal in there for too long because of its attitude. They start to get depressed and their attitudes start to go down and they start to slip. Medically, it starts to become a problem. It's probably stress related.

There are two dolphins in a twenty-foot pool. Since they have been moved halfway across the world, they are really tense. Some of them don't sleep very well in the pools. Since they are so confined, they hate going in and being in there. We're still trying to figure out a way to make it positive for the animals. But right now it would be like putting you in a closet for a month and then letting you go out on the town but telling you that you have to come back.

We saw it when we were on the *Gunston Hall*. The animals' attitudes just started to slip away. They didn't want to work. They were really lackadaisical. They were really lazy. They didn't have the energy they would normally have. We moved them off of the ship and got them into Kuwait in Miller pens, which was a lot better because those pens are much bigger. It seemed to definitely help the animals a lot.

We had two animals run. One of our animals ran and then another one ran when they were in Umm Qasr. That's a perfect example of the animal not wanting to come back, you know. It stayed in the general area. It's not like it went anywhere far. It stayed within our box and

every couple of days we'd see him. He'd come back to us and let us know he was around. He just didn't want to go back to the boat. He wasn't the first one that went unauthorized absence (UA).

It was interesting to go into Kuwait. The only thing I would say is that right from the get-go, you've got to get these animals out of those pools and into somewhere, like Kuwait. That should have been done right away. They sat on a boat for over a month, some for like a month and a half, you know. It's just not healthy for the animals.

I didn't know what was going on. I was just there to do my job. But there are a lot of lessons learned. It also has to do with effectiveness, you know. The animals aren't going to be as effective as they could be if they are cramped in the pools.

We had a lot of VIPs while we were in Kuwait. It seemed like every day we would have some Kuwaiti family, some ambassador, or somebody come down and check them out. It's pretty cool to have civilians come down and actually see, first hand, what we do with the marine mammals.

There are a lot of rumors out there about how we abuse them or something. These dolphins live a lot longer than dolphins in the wild, because they are kept so well and stuff like that. It's good to see civilians come down and get rid of some of those myths. That was my experience of a month on the boat and a month in Kuwait.

BM1 PAUL ROBINSON

Initially, I specifically came to Naval Special Clearance Team One with the idea that I wanted to handle marine mammals. I got here and that was what I ended up doing. I ended being Heffy's handler, who is a 450 pound Atlantic bottlenose dolphin.

When I got here, Heffy was part of a group called EX8. EX8 was an experimental program then. It hadn't yet become a marked system. Now, it's called Mark 8. What they are trained to do is clandestine work, basically search, or what we call "recon," as well as clearance.

You basically have a primary handler and a secondary handler. The secondary handler meets the basic needs of the animal, for example, while I am away at some type of school or something of that nature. That's what his role is. But primarily, I handle the animal. I would be the guy out on the water if he were employed.

I didn't start out with Heffy. I started out with Conar. She was our "new-guy animal," I guess you'd call her. She had all kinds of things that she would do. If you could learn to handle her, then you could migrate to another system easily. She had all the little quirks that you could get in an animal. I started on her and once I was proficient at handling her, I just moved over to Heffy. I had him for a little over a year.

When I went over to Operation Iraqi Freedom, I took Heffy, but my animal was not employed. Mark 7 seemed to be the animal of choice. The Mark 7 was designed a little bit more for administrative mine clearance. We do what is called a "scan search" and they do what is called a "circle search." The animal is cued to go and do a sweep of an area and then come back and report whether there's something there.

Our animal is designed to be on the move and constantly sweeping. Then, when they locate something, they report. Our designation, or our design, was so that you can get a larger area done in a shorter period of time, but with a little less accuracy. The Mark 7 takes a little bit more time, because you're slowly moving step by step.

The animal is pretty good at shifting over and taking already-learned behaviors and modifying them for a particular task. The hardest thing, I guess, was just to have that behavior solidified on such a consistent level that you can say, "Yes, this animal is rock solid and ready to perform this task in combat." You can only get to a certain point. I guess that was probably not quite at the point at which we wanted to be.

Transporting the animals was probably the biggest hurdle that we had to overcome. The standard operating procedures (SOP) in the movement of the animals had already been done

and proven in the experimental stage. But we had never done it with that quantity of animals, because we took nine systems with us over there; each animal is considered a system.

There were nine animals total. It was pretty complicated and it involved a C-130 flight that had two in-flight refueling stops. Following that, we had to transport the animals to flatbeds on their ATCs. ATCs are animal transport carriers. We had to move those onto flatbeds and then crane them into the well deck of a ship. It was a pretty complicated evolution because you had to maintain water quality, keep them fed and at the right temperature, because they are sensitive. It was quite the evolution within itself, just getting there.

We fly them over in ATCs. I don't know the exact material that they are made out of, but they are boxes that hold about nine inches of water and have two poles that run the length of the boxes. The animals are actually slung and sitting in a barrier of water so that when the aircraft takes off and lands suddenly, the animals aren't thrown or injured in any way. It's kind of a cradle-type thing mixed with water.

The animals are used to being in confined spaces. We keep them in pens and stuff, and we do transports with them pretty routinely. They are accustomed to it, but I can't say that they are just totally happy about doing it. There are certain indicators that can tell you how an animal is doing. They have certain aggressive-type behaviors, like chirping, and their heart and respiration rate go up if they are angry or in distress. Those things are constantly monitored when we are doing it. What I would say is that they fared very well in going over there. Their attitudes were halfway decent. The obstacle, really, in the training portion, came after we had arrived there.

Our original plan was to work out of pens. Instead, what we found when we got there was that we would be working off the back of a well deck. We are not designed to work off the back of a well deck. We never really knew what the limitation was because we never pushed it quite that far.

Shipboard pools are very small, and when we keep them in pens they can use their sonar to look way out and it keeps them more entertained. I guess the philosophy is that in training, build a trust relationship with the animals.

We do everything off of operant conditioning, which means they get positive reinforcement for doing what we request. When you ask them to beach up and get in the boat, then suddenly throw them in a container, and then take them for thirty hours in that container and throw them in a tiny pool halfway around the world with a radical temperature change, there is an impact on the animal.

It breaks down the trust barrier a little bit. You end up with an animal that is now looking at you, second-guessing, wondering, "What's coming next? What's next in your plan for me, because everything you've done to me so far has been pretty good, but now what are you going to do?" We went out to sea and experienced some control issues with the animals.

When you put the animal in open water, you want it to be right with you and attentive and alert, and you want the animal to beach up when you request it to beach up. We had a few of our systems, including mine, have some problems. I had my animal run for four days while we were out there. We tracked him for 24 hours. Then, we lost contact with him. We sat on watch for 24 hours, around the clock, with what's called a "recall pinger" in the water. On day four, he finally showed up and we had to kind of work with him to get him in the boat. He was more coerced than volunteering, you know.

That was unfortunate and I kind of blame it on the fact that we didn't put him in pens. We knew that after the long transport, if we had put them in pens and let them acclimate for about a week or so, it would've been easier. It was kind of like if I body-snatched you, but I put you in a luxury hotel, you might think, "Well, I guess that wasn't so bad," but when I stick you in a closet, it changes your perspective on things. I think that was where we were at with them.

Several of the systems had problems. Heffy probably reacted the worst to it. All of them exhibited a few control issues, but after a period of time they adapted. Once we had them in a cycle moving back to the shipboard pools and then back out into open water and back and forth, they realized they were going to get in open water again, and they weren't so hesitant to go back to their pools. They overcame a threshold that was a big concern as a group, but it took some time. It wasn't immediate. We just can't throw them out there and run with them when we do stuff like that. We kind of have to do it stage by stage it. It's kind of a tedious process.

The school to become a marine mammal handler is only about a month long. But that teaches you basic husbandry skills and basic operant conditioning. Where you really start to learn how to handle an animal is here. Every session that we do here and abroad has a technical representative who is a bonafide trainer. They watch your moves and they coach you along the way. So, you get that one-on-one, which is really where you learn the most.

The training is basically just to give you the dos and don'ts so that you assure the safety and health of the animal. After that, as you progress, you get better and better from that one-on-one coaching.

Katrina was one of our animals that we took to an exercise that we did up at Camp Pendleton. She did five hours of work on one small bucket of food and cleared 98 percent, which is incredible for five hours. I can't even conceive of how long it would take MCM (Mine Counter-Measures) divers to do that. It would take days, if not weeks, to get every single mine in five hours time.

When the animals are on, they are on. Unfortunately, there's a lot of maintenance and upkeep associated with them. They are not as flexible as you would like them to be. They're not like a machine gun, which you load up, charge the handle, and pull the trigger, and it works. They've got to be coddled along and they've got to be made to feel comfortable. You've got to keep that trust factor going. As long as you keep all those things lined up, they're pretty good. The problem is that the military operates on a timeline and animals have a thing called the "free-will factor."

We did a lot of adaptation with the animals in Umm Qasr. The area around Umm Qasr was incredibly bad. To work the area, they had to improvise things never done before so that they could keep the animals in pools right there in warehouses in Umm Qasr.

You couldn't put the pens there because of the current and the poor quality of the water. There were things that guys just improvised on the spot to make it happen. It was pretty impressive work. Everybody got their chances to do different jobs. I ended up fulfilling kind of a SEAL team role. We were doing force protection for our own people. We were under the impression when we went in there that other forces were going to provide force protection and we would just focus on the clearance.

The reason that we have special operators and other guys is because we are not really designed for force protection. We were supposed to be giving tactical input into the design and the workings of the MCM mission, clandestine-type operations. However, as it turned out, we ended up picking up errant arms and holding the fort, as it was, so that we could get the job done.

We were pretty flexible. We had to do a lot to compensate for the animals, because they were doing something that wasn't their normal mission. They were also being housed in a way that made them uncomfortable and in water that was less than optimal.

I think the animals were happy when we got them back to Coronado. That was primarily because when they got home and hit their pens, they were in familiar waters. They were definitely happy but they didn't show it too much.

There was a period during which we moved the animals off station when we went off task to Kuwait. We actually put pens in the water in Kuwait. They had some time in pens in Kuwait after coming off task. That time in the pens instantaneously improved the control issues with the animals. The ideal way to do it would be to get

to the area of operation, set up your pens, acclimate, work your animals on some local training fields that you set up, and then go do your mission when you are called. You live and you learn.

Marine Mammals and UUV

COMMANDER ANTHONY RODGERS

The notions behind commissioning Naval Special Clearance Team One (NSCT-1) were free amphibious landing and mine and obstacle clearance. The command was a consolidation of what was before the VSW MCM detachment, that is, the Very Shallow Water Mine Counter-Measures detachment, and the two other marine mammal systems, Mark IV and Mark 7. The Very Shallow Water Mine Counter-Measures detachment started in 1996.

I think the transition of the mammals went really well. It's funny, because when we were written into the planning order, right after we were commissioned, I made a visit to 5th Fleet. Its desire was for us to go over and be part of the plan, but they didn't want to bring the dolphins. They knew that the dolphins were going to be a pain in the neck, in terms of logistics. They are logistically very intensive.

However, the handlers at this command, the support from SPAWAR, the veterinarians, the tech reps, and all the folks who thought about the logistical requirements nailed it. They covered everything. There was never a time when we were in a condition in which we thought an animal was in danger, except for of a couple of times when they ran, and that does happen. But the 5th Fleet didn't want to have to deal with the dolphins. It knew we had dolphins. The 5th Fleet people knew we had unmanned underwater vehicles (UUVs) and they were thinking, "Well, it's a much smaller package. It's a much easier package." They said, "We want you guys, but don't bring the dolphins."

During my visit, the point that I made was that we had been feeding these dolphins restaurant-grade mackerel for thirty years and we had never taken them to a mine hunting campaign. We had never had them hunt mines in a real scenario and the environment was tailored for it. We thought we might be working in the river. Ultimately we didn't, as a command. The plans showed the river. We thought, "This is tailored for dolphins. If we don't bring them to this one, why do we have them? We should just let them go, sell them to Sea World or do something, because this is really what they are there for." If they are too much of a logistical pain to bring to a theater of war, it's just not worth all the effort that goes into them.

Whether it was that argument or the fact that dolphins are the only ones that can find buried mines, and the likelihood of buried mines during the planning stages was pretty high, or the combination of the two, the powers that be were convinced. They said, "Okay, bring your dolphins."

The one issue with the dolphins that we advertised was that when they were to fly over there, at a distance like that, we wanted to have an acclimatization period. Seven to ten days was what we advertised. They get off the plane and go into what we call a "Miller pen," which is a pen that is set up in open water. The dolphin is worked every day out of that pen for a week or so, so he gets used to the water temperature, the salinity, and the environment in general. It's a new place for him. He can get all the vibrations of the plane out of him and all that other stuff. After that period, we can embark the ship and be ready to go to war.

Well, we were running about a week and a half behind. The theater commander wanted to say that he was ready to go, but the dolphins were not there yet. Our flight kept getting pushed back because the delay was affecting us, as it was everybody else. When it came to the point at which it was about two weeks behind, he said, "Okay, look, when these dolphins come you're just going to get on the ship and you're going to wait until you get called in." Against our objections, the thought was that we would

go there and still have some time to acclimate them up there. We were to set our pools up in the well deck and then work them out of the stern gate. The thought was that they could be up close to where they were going to be working anyway.

Well, that posed to be sort of a problem, because one stern gate and nine dolphins is not a reasonable way with which to work them. But we did that. The dolphins flew over and they embarked directly on the USS *Gunston Hall* and we got underway. It was basically a one- or two-day operation. We were underway, trying to get them in shape. When they're in pools, which are these twenty-foot wide pools that are about five or six feet deep, they just aren't as content. It's harder to get them motivated. They're just kind of swimming in circles. You try to get them out every day to work. But with our schedules, a couple of bad weather days, and just trying to work boats from a stern ramp and get nine dolphins out every day, it didn't happen.

When it was time to start, we had four dolphins that we thought were ready. In that period of work-ups, which was actually for about two weeks while we were up in the northern Gulf waiting to get the call, one of them ran for about five or six days. It was Heffy. At the time, it was considered a mine threat area. It wasn't a minefield. It wasn't a mine danger area because no mines had been found. But it was considered to be an area that might be mined and just a dangerous area. The possibility of suicide boats was in some of the intelligence reports. It wasn't an area in which you wanted to have to leave a boat in the water overnight with the pinger in the water, hoping for the dolphin to come back. It caused us a little bit of stress.

After five or six days, the dolphin did come back. We got him. He had lost a bunch of weight. But after that, there were a couple of dolphins that we didn't even want to put in the water, because we were afraid they were going to run. It took up man-hours to sit in the boat, when in fact we had to get these dolphins ready. The same thing applies to acclimatization. We had four dolphins that were ready to go. When it was time to go into the port, we sent in, by helo, all the pools and stuff to set up before we could send the dolphins in.

Again, it was logistically covered without a hitch. The tech reps had taught our guys how to set a pool up, but they knew how to do that already. It is kind of like your swimming pool at home. You fill it up, shock it with a bunch of chlorine and then retreat it after the chlorine has worn off. You retreat it to the salinity, the temperature and basically everything that is ideal for the dolphin. Then, you call the dolphins in and they come in on the helo and you put them in the pools.

It worked fine, but it is a lot of baggage to use these systems. But we did use them successfully. I say successfully. We got them over there and they calibrated fine. We didn't find any mines in the water. It was stressful for the dolphins, but it worked out fine.

We didn't find mines because there weren't any there. The dolphins were able to verify that the port was safe, and that allowed the humanitarian material to flow through the port. They were not, certainly, the first sensors in the water. When we got the call to go in, the first sensor in the water was a UUV. The system we used was the Remos. Had we not suspected that mines might have been buried, we wouldn't have used the dolphins, because the resolution from the side-scan on Remos gave us a good picture.

STAFF SERGEANT TOM DURAND

I came here after being a reconnaissance Marine. My duty was with a very shallow water Mine Countermeasures detachment. A lot of people I knew found out about the Marine Mammal Program from a *Leatherneck* magazine story on it. It was basically centered on the dolphins. A lot of my buddies thought I was just coming out here to play with Flipper or something.

The UUV just collects the data. Then, you go back to the old human eyeball and say, "Huh,

what do you think that thing is?" At first, we were taught, "Let's err to the side of safety." At night, out of a 2,000 by 800-meter search area box, we had 150 contacts with UUVs. Mammals would come up with sixty. So, there's a lot of argument about what's better, mammals or UUVs. They are finding out that the best way to go about it is to not use each system separately, but to overlap. Anything that mammals and the UUV hit are things we are definitely going to check out.

The problem with us right now is that everything is geared to go after one mine at a time and our tactics dictate that we get them all at once so that we don't tip our hats to the coming invasion. It's kind of a problem with the vendors. They're working on it. We're getting there. It's definitely progressing forward like it needs to be. Eventually, the mammals will be gone. I know that creates a lot of heartache with EOD guys, and I'm sure a lot of civilian people, because it's been their little breadbasket, their sandbox with the big walls.

SENIOR CHIEF JOHN CARR

In August of 1998 I got here to the Special Clearance Team, and I'd had prior mammal experience with Mark IV. I already had orders to come here, and I was going to go into the dive platoon. But I made chief before I got here, and they asked me to relieve Chris Winn, who was the senior chief who had EX-8 at the time. I relieved him and we had an officer, Rob Seinert. Chris Winn got out. Rob Seinert came in. He knew that he was only going to be here for a year or so. We had all our developmental tests and everything as EX-8. Then he left and I gapped the billet for about six months. I was the officer in charge (OIC) of the platoon.

I was with the platoon for something like three and a half years. I then made senior chief and I got into operations. We were not co-located, at the time. We are not co-located now, either. But we always had some buildings here and we had some buildings over there. We kind of had buildings everywhere.

I want to say that the push came from commander, Mine Warfare Command (COMINEWARCOM). They wanted to have everybody co-located. So, with the facilities that you see out here, the pier and everything, they just now took the pens away from us. They took them back because we never really utilized them. We had all this unspecified money, or whatever, for projects. The Navy has something like ten of them a year at $1.5 million apiece. We ended up getting in on one of them. We got the fish house, the compound, the pens and the pier and all that stuff built.

It really didn't work out for us. We were kind of told, "You need to be together so that we can keep the command unified." But what happened was it was just a long haul for us every day and our boats were breaking down. I mean, we were using experimental boats. We were using boats that had come from D.R. Merrell, and it never transpired for us.

We made an agreement and left the mammals over there. The guys still showed up here and they'd transit back and forth every day. Man, that was miserable. It didn't work out for the animals. The productivity of the animals went down, I think, because they didn't get as much time in the water working. By the time the guys got here, did their physical training, mustered, and did all their stuff and drove over there, they were already an hour or two behind the power curve.

Then you tried to get them out there and work them and then came back and cleaned everything up and then drove back here. We just increased the shift. We made their eight-hour day a twelve-hour day, every day. Well, you know what suffers from that. The guys kind of get to the point at which they say, "This is stupid." Then, they start cutting back training sessions.

Those dives are three or four hour dives. That is a long mission with an animal. An unmanned underwater vehicle (UUV) mission is pretty much the same. They set it up, drop their sensors, spin the prop, and off it goes. But for the man and the mammal it's pretty intense,

because you are driving over the horizon in the middle of the night. You only have one cover of darkness. You've got to get there, stay undetected, get in the water, do your mission, get the information back, pack up, and leave with enough darkness to get out of there safely.

I think that's more labor intensive than what we just did. But who knows? I mean, the port was hostile when we got there, for the most part. The guys who had secured it were leaving as we were showing up. During the first couple of nights stuff was being blown up around us and across the way until everything was secured. I'd say that the first two days were a little bit sketchy.

If we run into that situation again, in which we are actually having guys fighting on the wall and guys trying to do their diving at the same time, then that, I think, would be difficult.

But if it ends up like it was, you know, those missions are pretty easy. You just suit up. You rack up. You go out and you do your dive. The UUV is already gone. A mammal has marked it. You've already had two good looks at it. You go out with your high speed INSS and it's either something or it's not.

You take the data from the UUV and that gets downloaded into your INSS. From there, you can go to specific contacts that are of interest. We usually take a mammal across, at first.

The mammal will go, and you run tracks and you know where he should be going positive. If he doesn't go positive over that track, you can turn around and you can actually interrogate him. It's good to give him a blank look at it, a blind run, so if he hits it right off the bat, that's a really good indicator. I mean, the UUV has given us some type of imagery of something. We don't know what it is, but it's meeting some of the criteria for a mine. None of us are really sure. We've seen it enough that we can tell what we are looking at.

The next thing to do is if you run a mammal over that and the mammal goes positive on a blind run, and you are not interrogating to that spot, then you get a really good feeling there's something down there. There's something that's sticking out. It's very prominent.

If you go over it and you pass it one way and you pass on the way back and you don't get anything from the animal, then, you know, with two good looks at it you can turn around and interrogate the animal. You can bring the animal into that area and start keying him. The animal may be messing around, not really hunting, and not seeing anything for a long ways. But you bring him in and you really work him on that area and then he goes positive, you know, then you've had two solid looks at something. That's pretty good. That's better than nothing at all, like we used to do.

It's a lot of work for a diver to do it like that, but that's what we grew up on. I've been doing that since 1986. You know, now you look at it and wow, it's pretty. A lot of technology has been put into it.

UUV's are great, especially with both of them put together. You get guys who are pro-mammals. You get guys who are against the mammal program. I'm pro-mammal, obviously. I've worked with them. I'm pro-UUV, too. I think we can use both of them if we have the time.

Index of General Topics

180/40 284
1st class 25
2nd class 25
6th Fleet 86
7th Fleet 86
9th Naval District 56
A. J. Morse & Sons 4
A. Schrader 4,5
acoustic mine 58
Administrative Command Amphibious Forces, Pacific 54
Admiralty Experimental Diving Unit . 291,352
Advanced Naval Intelligence School 53,54
Advanced Swimmer Delivery System 62
Aerojet Corporation 62
amphibious forces 49,50,52,54
amplifier 7
anti-amphibious mines 55
Aqualung 39,50,51,81
aquanauts 97,108,109,112,113,116, 123,124,149,151-154,199
Aqueon 62
Argos Island 106
Army 41,44,47,49,50-52,72
ASROC (Anti-Submarine ROCket) 365
Atomic Energy Commission 228,241,245
bathyscaphs 286
Bethesda, MD 68,69
BIBS 352-355
Blind Man's Bluff 283,285
Block Island 13
Blow All Ballast 336
Blue Jacket 306
Boston Navy Yard 214
bottom-mounted habitats 60
Bowman Gray Medical School 367
British Admiralty 42
British Medical Journal 352
British Submarine Escape Immersion Suit 343
Brooklyn Navy Yard 6,9,13,97,259
Buffalo 64,65,67
Bureau of Construction and Repair 5,10,22,24,27
Bureau of Medicine and Surgery 98,100,134,135,137,149
Bureau of Mines 11
Burma 47
carbon dioxide scrubber 34
Caribbean 42
charioteers 50,81
Chariots 39
China 47,54,91
Clandestine Operations 283
clearance diver 290,291
CO_2 42,58-60,63,69,81
CO_2 absorbent 174
Coast Guard 44,49,50,80,169,183,185, 186,192,281,329,338,339
Coastal Systems Laboratory 292
Code 3802 90
Cold War 86,88
Columbia Midshipmen School 53
Columbia Research Corporation 63
cryogenic breathing system 59,60
CURV 197,202-206,221,222,227,229,235
Danger Is My Business 40
Data Exchange Agreements 349
DCIEM tables 293
deck decompression system 277
decompression computer 294
Deep Sea Diving School 329,330
Deep Submergence Rescue Vehicle 165,216,217,231,277,278
Deep Submergence Operations 134,136,140,159,164,195-236
Deep Submergence Systems Project 124,126,130,137,143, 147,149,158,332,344
Deep Submergence Systems Review Group ... 134,136,199,216,223,240
Deep Submersibles 283
Deep Trial Units 349
Deep Trials Unit 356,357,359,360
Deepsea Diving School 5
Defense and Civil Institute for Environmental Medicine 64

Delaware Capes 12
Department of Defense 278
derrick barges 13,14
Disabled American Veterans 302
DiveCon 355
diver training 3,4,24
Divex 357
Diving and Salvage Program 59
diving dress 4,5,19
diving lamps 17
Diving Manual 9,21,28,36
Doppler navigation 62
Doppler sonar 87
Draeger 50,77,81,82
Draeger LAR-5 51,52
Draeger LAR-6 51
DSRV 216,217,224,225,231, 277,278,279,280,283
Duke University 270,273,359
Dwyer apparatus 98
Egypt 188,190
electric torpedo 298
Emerson Company 51
Emerson—Lambertson 51
EX 19 sensor 59
Experimental Diving Unit (EDU) 24,26,27,34,100,103,126,138,143, 149,153,165,193,268,272,273,275, 283,286,290,291,330,332,343
Explosive Ordnance Disposal (EOD) 37-92,131,185,190,191, 193,245,330,365,379,386
F-class submarines 11
Fleet Ballistic Missile 63
Formosa 324
Formosa Straits 305,307,323
Fort Pierce, FL 43,53,54
frogmen 39,53,86,88
Genesis 97-104
Geneva Convention 317,325
Goodyear habitat 272
Guadalcanal 44
Guam 319
Guantanamo Bay 46,169
Harbor Clearance Unit 72,247-256
Harvard University 100
Hawaii 125,129,132,138,140-142,149
Hayes Aircraft 56
heliox 28,29
helium-oxygen 99,105,121,126
helium-oxygen mixtures 11
heparin 367
High Pressure Nervous Syndrome 127,269,272
Historical Diving Society 349
Ho Chi Minh Trail 73
Hunter's Point 116,119,120,124,125,130, 143,152,161,198,200-202
HY80 107,110,113
hydrogen 60,61
hydrogen bomb 197,201,219,221,226,227,229,234
hydrogen gas 11
hydrogen-oxygen cutting torch 19,21
Hydrospace Lab 58
hypothermia 88
hypoxia 48
Interagency Committee on Oceanography . 134
Ivy Bells 164-166
Jack Brown rig 249
Japan 49,297,298,314,316, 318, 325,328,330,331
Jason program 224
Jetting Nozzle 20
JIM suit 270
Journal of Aerospace Medicine 358
Key West 26,27,31
Kiirun 324
Kobe 325
Korea 54,56,85,86,89,91
Korean War 182
Kuwait 376,377,379-381,383
LAM 87
LAR-5 51,52
LARU 39,41
LCRs 45
LE model 294
Limon Bay 12
Limpet Assembly Modular 87
lithium hydroxide 59,60
Long Beach Naval Hospital 328
Long Beach Naval Shipyard 120,121
Long Island Sound 6,12,13,19,170-173
Los Alamos 241,243
Lund Draeger 81,82
M values 66,67,70,293
Mae West 311,312
Magdalena Bay 11

Man in the Sea 97,107,134-136,139,140,147, 151,156,199,223,229,291
Man-of-War Rock 21
Manila Bay 340
Mare Island Navy Yard 9
Marine Mammal Classification 374
Conar 381
Heffy 381,383,385
Katrina 383
Macay 377,378
Spetsnaz 378
Takoma 377,378
Tuffy 366,369,370,372-374
Marine Mammal Program 124
Marine Mammal Systems 278
Marines 44,70,75
Mark 14 diving system 290
Mark 15 63,64,66,68,69,85,87
Mark 16 69,85
Mark 6 77,79,81,82,83,84,85
Mark 6 semi-closed circuit scuba 109
Mark 9 85
Mark I 4,5,6
Mark I Saturation system 255
Mark II 5,58,61
Mark II deep diving systems 290
Mark III 5
Mark IV 5
Mark V 5,6,25
master diver 8,17,22,29,35
Mayport, FL 49
McCann Rescue Chamber 27,28,31,231,259,297
McDill Air Force Base 39
Medal of Honor 8,9,22,23,29,34,35,302
Medical Research Institute 100,102,137,151,269,275,289
Memoranda of Understanding 349
Mike Boat 72,74,75,122
Military Sealift Command 192
Miller pen 375,384
Mindanao 54
Mine Counter-Measures 383,384
Mine Countermeasures 56,57,62,79,85
Mine Countermeasures Station 56,108
Mine Defense Laboratory 94,114,132,164,287
Mine Safety Appliance Corporation 28
Mine Warfare Command 386
mixed gas 58,59,84,87
Mixed-Gas Diving Suit 29,34
MK 16 77,85
MK I 61
MK II 61
MK II PTC 291
MK III 63
MK V 29,30,34,58,59
Mk V diving helmet 259
MK VI 58,59,62,63
MK VIII 61,62
MK-6 diving rig 115
Mk-7 91
Mk-8 91
Mobile Diving Salvage Unit One 282
Momsen lung 10,26,310,311
National Aeronautics and Space Administration (NASA) 106,118,119,129,134, 137,138,156,158
National Geographic 109,115,134,136
Naval Academy 197,202,239,245,246,302,315
Naval Beach Jumpers 54
Naval Coastal Systems Center 56,64
Naval Combat Demolition Units 54
Naval Electronics Lab 132
Naval Hospital, Oakland 328
Naval Medical Research Institute 68,69,349,358
Naval Missile Center 365
Naval Ocean Systems Center 63,69
Naval Ordnance Test Station 365
Naval Research Lab 239,240
Naval Sea Systems Command 69,81
Naval Special Clearance 379,381,384
Naval Torpedo Station 3,36
NAVSEA 58,63,68,82,85,90
Navy Air Medal 302
Navy Bureau of Construction and Repair ... 5
Navy Dive Manual 66
Navy Diving School 9,27
Navy Electronics Laboratory 207,208
Navy Experimental Diving Unit (NEDU) 24,27-29,31,34,63,64,67,69, 103,106,107,126,138,150,151, 153,257-264,332,343-345
Navy School of Diving and Salvage 24
Navy Special Warfare 53,54,56
Navy Yard Museum 318

New London Submarine Base 16
New York Harbor 174,177
New York Navy Yard 11,13,16,21
Newport 3,4,9,13,17,19,24,36
nitrogen 11,28
Nitrogen narcosis 28
NMCS 56,57
NMRI 93 model 294
North Atlantic Treaty Organization (NATO) 349,355,357
North Korea 85,86
North Vietnam 83,88
Ocean Simulation Facility 260-262,274,288-291
Ocean System Center 125,130
Ocean Systems 345,346
Oceanographic Museum 286
Office of Naval Intelligence 286,349
Office of Naval Research (ONR) 65,100,114,119,124,125, 129,135-137,140,143,155, 156,159,164,199,209,227, 229,237-246,349,360
Office of Strategic Services (OSS) ... 39,40-49
Official Court of Inquiry 35
Ofuna 314,316,325,326,328
Ohio Chemical and Manufacturing Company 39-42
Okinawa Marine Detachment 75
Omaha Beach 54
Omori 327,328
Open bottom PTC 183
Operation Iraqi Freedom 370,375,380,381
operational swimmer activity training 42
Ordinance Test Station 120
oxygen intoxication 11
oxygen poisoning 9,28
oxygen toxicity 99
Panama 182
Panama Canal 12,26
Panama City, FL 56,58,63,64,66,75, 276,281,282,291,292
PDP-12 63,64,65,67
Pearl Harbor 40,41,45,54,89,174-179,249,282, 297,301,308,315,319,321,323, 329,330,331,333,334,340,341
Penfield Reef 12
Pensacola Naval Air Station 110
Pentagon 56,85,89,141,239,240,243,244
Personnel Exchange Program 77
Personnel Transfer Capsule (PTC) 112,114,152,161,183,184
Philadelphia Naval Shipyard 231
Philippines 54,55,307,340,341
Pier 88 177,178,179,180,181
pinger 366,368,379,380,382,385
Pirellis 81
Point Mugu 365,366,374
pontoons 3,9,18,21,26, 33-35,170-174,182
Portsmouth Naval Shipyard 35,182
PPO_2 66,68,69
PQS sonar 131
Pribilof Islands 76
prisoner of war (POW) 302,314-316, 318,325,327,340
Project MANFISH 57
re-breathing system 40
reconnaissance 50,54,55,83,84,85,86
Red Cross 316,318,325,326,327
Red Sea 77,78,79
remotely operated vehicle (ROV) 57
Research Oceanographic Support Center .. 114
Royal Marines 70
Royal Naval Physiological Laboratory 357,359
Royal Navy 269,272,290,291,293
Royal Navy EOD 361
Royal Navy Physiology Laboratory 350
Russians 55,83,84,86
Salvage Training Center 177
San Diego 56,90,91
San Francisco Naval Shipyard 198
SAT school 276
saturation diving 60,66,94,97,102,103,105,113,119, 127,140,147,151,156,158,161,164, 197,206,217,226,259,260-263,265, 267,268,269-271,273-277,279, 281-283,285-287,289-291,293,344
saturation excursion dives 292,293
School of Diving and Salvage 231
School of Nuclear Medicine 97
Science magazine 365,367
Scout Intelligence Officer 54,55
Scouts & Raiders 53,54,55
Scripps Institute of Oceanography 94,116,117,118,119,122, 124,129,130,132,135,239

Scripps Pier 116,129
scuba 39,53,55,56,57,59,77, 81,83,84,90,260,261
Sea Horse 62,90
SEAL 40,52,56,70,80,81,86,118,123, 260,261,263,330,365,372,383
SEALAB I 148,199,226
SEALAB II 94,101,104,106,107,116-120,122, 124,125,129-133,137,139,142,143, 146-151,157-159,162,164
SEALAB III 94,97,101,106,119,122,124, 126,130,134,137-140,142-154, 157-162,164,283,286,356,359,373
SEALs 43,44,52,54,66,72,76,77,80,86,87,90,245
Seventh Fleet 54,55
Shanghai Shore Patrol 54
Sharpey V-notch 346
Silver Star 302
Sleeping Beauty 39,47,48,49,52,53
SOSUS 284
South Vietnam 84,88
Southeast Asia Command 47,48
Soviet submarines 284
Soviets 283,284
SPAWAR 378,379,384
Special Operations Forces 39
Special Warfare and Mixed Gas School 58
Special Warfare Group I 62
Special Warfare Program 59,63
SPU 61
SQS-26 sonar 243
SRS 48
STANAG 355
standard decompression table 7
steam torpedo 298
Steinke Hood 128,232
sub-mersible lights 17
sub-surface demolition 39
Subic Bay 73,91,249,250
Submarine Base New London 52
Submarine Medical Center 98,102
Submarine Medical Research Laboratory 102,103
submarine rescue chamber 277,331,338
Submarine Rescue Program 282
Suez Canal 77,79,174,188,189-191
swimmer delivery vehicle (SDV) 61-63,69,81,82,85-91
swimmer propulsion unit 61
Taipei 314
Terni Sphere 211
the atomic bomb 49,50
thermal protection 60
Thinsulate 70
time pencils 45
Tonkin Gulf 83,89
Tooker Patch 178,180
Trass boats 90
Treasure Island 43
Umm Qasr 370,376,378,380,383
Undersea and Hyperbaric Medical Society 349
underwater closed-circuit-breathing apparatus 42
underwater communication 43
underwater demolition team (UDT) 43,45,50,52-56,75,81,86,89,91
Underwater Swimmers School 260
unmanned underwater vehicle (UUV) 376,384-387
US Navy Dress 10
US Special Operations Command 39
V value 68,293,294
vacuum tube telephone 34
Viet Cong 70-73,89
Vietnam 62,63,70,71,73,76,82-84, 88-90,124,125,131,249-256
Vietnam War 73,76,90,282,379
Vietnamese 63,70-73,76,82,83,88,89
Warsaw Pact 85,86
Washington 41,45,47,49,81,90,98,100, 103,107,117,131,138,143, 147,150,154,157,158,166
Washington Navy Yard 24,26
wet NASA 206,208
White Horse Rock 173
Wonsan Harbor 55
Woods Hole 239,245
Works Progress Administration 39
World War I 13,16,169
World War II 10,23,29,35,39,53,54,83,86, 180-182,85,259,260,280,349,359
X-Craft 39

Index of People

Adams, Ensign Vin 54
Alexander, John 272
Alvis, Dr. Harry 97
Anderson, Chief Gunner's Mate Jacob 4
Anderson, Lester Andy 106,112,131
Andrews, Captain Frank.....
202,203,213,215,218,220
Aquadro, Dr. Charlie 102
Armstrong, Bill 138
Baber, Dennis 75
Bachrach, Dr. Arthur J. 137,269,341,349
Badders, Chief Machinist's Mate William .....
22,29,35,36
Badick 336
Ballard, Robert 223.224
Ballinger, Bill 302,310,311,312,313
Barham, Dr. Eric 209
Barnard, Peter .. 349,350,352,353,359,360,361
Barraca, Peter 188,189
Barrett, Royal Navy Captain Bryan .. 290,361
Barrow, Nat 336
Barth, Bob .....
99,101,104,115,116,119,131,132,138,
139,145,152,154,157,158,161-163,333
Bartholomew, Captain Chuck "Black Bart"....
222,294
Bazet, Dr. 39
Behnke, Dr. Albert R. 28,99,127,268,355
Bell, Ensign J.J. 53
Bell, Will 356
Bennett, Peter 350
Bent, Wally 275
Bentz, Ray 144
Bergman, Walter 345
Berien, Commander Jim 365
Berkitch, Joe 130
Bivens, Les 365
Black, Murray 355
Blackburn, Blackie 145,152,157
Bladh, Commander Jim .....
111,112,190,192,285,349
Bland 338
Bob Barbee 322
Bob Workman 356,357
Bogey, Lieutenant 340
Bond, Dr. George "Papa Topside" .....
94,97,98,100-108,111-116,119,124-131,
135,136,138,139,146,148,149,151,152,
154-156,158-160,164,197,199,202,226,
260,261,267,270,289,291,292,350
Bornmann, Dr. Robert .....
159,270,273,275,342,343,344,
345,349,359
Bove, Fred 359
Boycott, Arthur E. 6
Boyd Jr., Captain John Huntley .....
188,190,191,192,197
Boyington, Major Gregory "Pappy" .....
315,316,317,318,326,327,328
Bradley, Mark 272,275
Brashear, Carl 197,205,233
Brathwaite, Bill 292
Breeze, Denny 346
Brewer, Captain Glenn "Tex" 285
Brokaw, Tom 305
Brown, Dr. Harold 226
Bryan, Captain Russ 220
Bryce 335,341
Bryson, Allen 338
Bryson, Carl 174
Buckingham, Ian 64
Buckles, Lieutenant Dick 358
Bucklew, Phil 47,53,54,55
Bunton, Bill 119,132,133,164
Buono, Giuseppe 208,209,210
Burns, Governor 141,142
Cannon, Berry .....
60,94,97,117,131,132,144-146,
152-154,157,158,161-164,291,333,373
Canty, John 290
Carpenter, Ed 120,144
Carpenter, Commander Scott .....
94,106,113,116,118, 123,124,
125,129,131,135,163,201,271
Carr, John 386
Carter, Lieutenant Rob C. 263,274
Caverly, Floyd 315,323,324,325,326
Chandler, Captain C.F. 180

Chandler, Don 291
Charbonnet, Vice Admiral Pierre 56
Chase, Capt. 333
Ciphers 339
Clark, Lieutenant Commander Lyn 332
Clements, Bill 189
Cochran 294
Collins, Lieutenant Mack 70
Combs, George 130
Conda, Ken 118,138
Coppedge, Commander "Bo" 332
Cory, Jim 368
Couper, B. King 218
Cousteau, Jacques .....
102,109,119,134-136,151,197,224,286
Craig, John 40
Crandall, Chief Boatswain's Mate Orson L. 35
Craven, Dr. John .....
137,140,141,142,146,155,156,159,
160,162,218,234,283,346
Cravens, Gunner's Mate Gene 338,340
Crilley, Chief Gunner's Mate Frank W. ... 8,9
Culpepper, Bill 59,108,119,130,131,143
Curl, Dr. 212
Curley, Norm 89
Damant, Guybon C. 6
DaSilva 324
Dave Hall 272
Davidson 331
Davis, Sir Robert 267
Decker, Clayton .....
297,301,302,312,315,317,318,324
Delanoy, Lieutenant Commander Billy ... 332
Delauze, Henri 197
Dill, Bob 130
DiNola, Edna 224
Donch, Mike 277
Donovan, General Bill 39,42,49
Dowland, Pat 361
Dowling, George 117,132,133
Doyle, Lieutenant Walter 337,138
Duke, Biddle 222
Durand, Tom 385
Dyer, Bruce 86
Dzikowski, Captain "Ski" 218
Eadie, Chief Gunner's Mate Thomas 23
Earle, Sylvia 197
Eastman, Lieutenant 187
Eaton, Wilber 59,132
Ede, Lieutenant Alfred Louis 8
Edison, Thomas 349
Edwards, Dick 55
Egstrom, Dr. Glen 342
Eisenhower, President 241
Elliott, Dr. David 197,291,349,350
Ellsberg, Captain Edward .....
16,18-21,36,169-174
End, Dr. Edgar 268
Ennis, Ensign 310
Evans, Bill 366
Evans, Del 275
Fane, Doug "Red Dog" 39,56
Farrell, Gene 218
Fife, Admiral Jim 53,124
Filer, Bill 357
Fisher, Ed 269
Fiskin, Grace 322
Fitzgerald, Lieutenant Commander John.....
325,326
Fitzgerald, Sue 79
Flanagan, Hank 310,315,324
Fleshing, Art 118,132
Fletcher 88
Flothy, Dr. 170
Flynn, Admiral Cathal "Irish" 81
Flynn, Dr. Edward T. 197,271,292,342
Fond, Dr. Eugene La 209
Frazee, Murray 302,303,306,323
Frosch, Dr. Bob 240,241,242,243,284
Frost, Bill 121,123
Gallagher, Master Chief 75
Garrin, Norm 71
Gaynor, Chief 335
Gilmour, Art 202
Gionatti 89
Goforth, Hal 365
Good, Dale 130
Gooding, Vice Admiral Bob 189
Goodman, Mickey 345,352,356,357,358
Gordon 94,129
Gore, Tom 190
Gorlic, Frank 91
Green, Chris 275
Greenstone, Leonard 175,176,178,181
Greenwood, Mike 128,145
Gregg, Ricky 132
Gruenau, Steve 270
Guest, Admiral 222,235
Hagner, Chief Torpedoman Charles 26
Haig, General Alexander 165

Haldane, Dr. John S. 6,259,267,268,270
Hallenbeck, John 359
Halsey, Bull 318
Hamilton, Dr. Ed 209
Hannigan, Master Chief 73
Harter, John 346
Hartley, Lieutenant Henry .....
5,7,11,13,24,25,28,36,169
Harvey Ardman 177
Haswell, Dave 46
Hawse, Dick 169
Hayward, Admiral Chick 141
Hedgepeth, Charlie 330,332
Hempleman, Dr. Val 350,351
Hendricks, Dan 90
Heron, Jerry 272
Hodges, Bill 109
Homer, Lou 68,293
Howchen, Johnny 215
Howland, John 216,220
Hurley, Chips 289
James, Admiral Bob 225,331
Jasper, Dr. 132
Jenkins, Wally 117,131,145,157,163,374
Johnson, Fenamar 53
Johnson, Lieutenant Roger 131
Johnson, President Lyndon 185,240,285
Kaine, Frank 39
Kalinoski, Chief Torpedoman Ed 26
Kanwisher, John 372
Kauffman, Draper 39,43,54,56
Keach, Don 207,208,212-216,218,226,286
Kelley, Chief Torpedoman John 21
Kelly, Captain Joseph 284
Kelly, Commodore Larry 78
Kelly, Ray 108
Ken 90,91
Kennedy, President 330
Kidd, Admiral Ike 201,239
King, Captain Ernest J. .. 16,169,172,173,259
Kinkaid, Admiral 181
Kissinger, Henry 165
Knutson 325
Korth, Fred 215
Koth, Edward 379
Krasberg 357
Kubokawa, Chuck 138
Kuney, Charley 338
Kuntz, Herman 199,202,205
Kutzleb, Bob 286,346
Kwiklinski, Stan 291
LaBrache, Lance 109
Lambertsen, Dr. Christian 39,49,271
Landron, Slim 318
Lang, Dr. Thomas 365
Lang, Gary 285
Langworthy, Chet 275
Lanphier, Commander Roy 108,109
Lanphier, Ed 65
Larson 313,314,324
Lawrence, Earl 187
Lazlo 269
Lehman, John 223
Leibold, William R. 315,319,322
Lemoyne, Chuck 83
Leydon, Admiral 242
Lieder, Fred 375
Liew, Hugh Van 66
Lilly, John 372
Linaweaver, Dr. Paul 255,356
Link, Ed 134,151,197,270,272,346
Lockwood, Admiral 304
Lofkin, George 301,302
Loughman, William F. 8,9
Lugo, Fernando 126,127
Lundgren, Dr. Claes 65
Lyon, Rear Admiral Richard 53,54,56
Mabry, Bob 86
Mac Kinnon III, Captain "Mal" .....
121,122,126,130
Mac Kinnon III, Rear Admiral Malcom ... 197
Mac Nicholson, Captain William .....
145,155,225,332
MacDonald, Dr. Gordon J. F. 240
MacInnis, Joe 197,272,346
Maderas, Torpedoman 340
Magnuson, Senator Warren 134
Malleck, Julian 361
Manalaysay, Al 275
Maness 335
Manning, Saunders "Tiger" . 104,115,131,149
Mark Bradley 356
Marsh, Captain Burt 281
Martin, Captain George W. .. 202,204,206,226
Mason, Captain 212
Mauer, Commodore "Bullet Head" 280
Maynard 89
Mazzone, Captain Walter .....
97,114,122-125,130,147,149,151,
154,155,267,332,333,356,374

McCann, Lieutenant Commander Allen ... 27
McCarthy, Jim ... 152,163,286
McCormick, Jim ... 367
McDonald, James Harper ... 29,35
McKay, Eric ... 350
McKay, Stuart ... 367
McKenzie, Ken ... 212,219
McLean, Dr. William ... 365
McLees, Gerald ... 333
McMeryl ... 310
McNulty, Captain Dave ... 73,190
Megow, Larry ... 289
Melson, Captain Lew ... 112,119,130,136,200
Michels, Fred ... 23
Mihalowski, John ... 34,35,337
Mihwa, Ken ... 292
Miles, Milton "Mary" ... 39
Miller, Steve ... 279,280
Mirick, Rusty ... 182,192,276
Mitchell, Captain Gene ... 83,126,291,332
Momsen, Charles B. "Swede" ... 9-11,13,22,26-29,31,33-36, 218,259,310,311,319,329,337
Moody, Commander Dewitt "Red" ... 184,190,202,221,232
Mooney, Brad ... 202,204,216,218,219
Mooney, Rear Admiral Bradley ... 285,339
Moorer, Admiral ... 239
Moran, John ... 49
Morse, Dr. ... 227,228,240,242
Murphy, Kevin ... 81
Murray, Earl ... 132
Naquin, Captain Oliver ... 336,338
Naquin, Lieutenant Oliver ... 31,32
Nelson, Lonnie Joe ... 321
Nelson, Lou ... 114
Nguyen, Tom ... 76
Nicholson, Captain ... 145,155,332
Niedermair, John C. ... 16,19,169,170
Nietzsche, Secretary of the Navy Paul ... 98
Nitze, Secretary of the Navy ... 127,137,227,229,242,244
Nohl, Max ... 268
Noriega ... 89
Norwanski, Pete ... 313,315,316,324
O'Brian, John ... 287
O'Kane, Richard ... 302-304,307,315,316, 319,323,326,328,329
O'Neal, Al ... 119
O'Neil, Hal ... 114
Odum, Tom ... 56,108,113,119,130,131,132
Ogura, Top Sergeant ... 328
Orts, Simo ... 202,221
Palermo, Pete ... 211,218
Parker, Eric ... 294
Parks, Gator ... 91
Parpinski ... 75
Paton, Bill ... 355
Patterson, Don ... 61,131,132
Persico, Donny ... 338
Peterson, Captain ... 212
Piantadosi, Claude ... 345
Piccard, Auguste ... 209
Piccard, Jacques ... 208,209,215
Pierce, Carol ... 338
Pigg, Lieutenant Commander Bill ... 278
Plunkett, Admiral ... 16
Porter, Bob ... 59,108,111,112,124,130,144,146
Porter, Hop ... 368
Powell, Charles ... 338
Prebel, Harold ... 338
Prepazich, Frank ... 176
Quigley, Bill ... 59,131,132
Raborn, Admiral William "Red" ... 137,241
Rahn, Herman ... 65,127
Raimer, Ed ... 176
Rawlins, John ... 290,344,349,356,358
Reaves, John ... 157
Rechnitzer, Dr. Andreas ... 207,218
Resick, Dave ... 78
Richardson, Tony ... 203
Richter, Commanding Officer Tor ... 358,359
Rickover, Admiral ... 136,156,198,205
Ridgway, Dr. Sam ... 124,365
Riefler, George ... 331
Rivers, Mendel ... 242
Roberts ... 45
Roberts, Danny ... 146
Robinson, Paul ... 381
Roceck, George ... 340
Rodgers, Anthony ... 384
Rokitka, Mary Ann ... 65
Ronan, Commander ... 76
Roosevelt, President Franklin Delano ... 179
Ruttman, Jim ... 74
Sareker, Captain Dave ... 198
Savitsky, Martin C.J. ... 32,174
Savadkin, Larry ... 315,323,324
Saxon, Dr. Ross ... 229

Searle, Captain Bill. 142,190,201,224,234,235,330,346
Seinert, Rob 386
Sharp, Lieutenant 339
Shaw, Dr. Louis 100
Sheats, Robert 17,129,130,132,133
Shoemaker, Lieutenant Larry 219
Sholander, Pete 372
Shotts, Commander Bill 279
Shriner, Heinz 273,344
Shumaker, Larry 206,207,216
Shurvansi, Shalani 294
Siebe, Augustus 4
Smallwood 331
Smith, Admiral 148
Smith, Dr. 203,215
Snyder, Rear Admiral J. Edward . 134,239,241
Sonnenberg, Dr. Robert. 125,129,132
Spaur, Dr. William 67,68,69,290,292,361
Spiese, Fred 223
Spritz, Charles 299
Stassen 328
States, Captain 55
Steinke, Harold 128
Stephan, Admiral 240,242
Stewart, Jimmy 132
Stillson, George D. 6,9,259,261,263
Sullivan 44
Sullivan, Commodore W. 179,180
Summit, Jim 272
Summitt, Jim 345
Swanson, Admiral 235
Tauber, John 344
Taylor, Dr. 350
Teller, Dr. 241,245
Thalmann, Dr. Edward 63,197,274,361
Thompson, Dr. Bob 106,115,336
Tibbals, Clarence 11,24,26,259
Tipper, Ron 246
Todd, Al 89,91
Tokker, Captain John T. 180
Tolbert, Bill 117,132,133
Tomsky, Commander Jackson "Blackjack" 140,142,143,145,154, 155,158,162,182,333
Tranchemontagne, Marc G. 263
Tresansky, George 269
Trotter, Cass 351
Trukke, Hayes 313,315,324
Truman 49
Tuckfield, Cyril 102,127,128,132
Turner, Admiral Richmond J. 55
Usrey 365
Ussery, Commander Dave 73
Valentine, Bob 83,84
van der Aue, Dr. Otto 268
Van Orden, Dr. Luke 127,128
Vann, Dick 87
Vine, Al 218
Vorosmarti, Captain Jim 94,149,154,155
Vorosmarti, Dr. James . . 267,275,291,356,359
Wagner, Dan 203
Wakelin, Dr. James 134-136,215,239,240,242,243
Waldren, Machinist's Mate 19
Wallin, Captain Homer N. 175
Walsh, Don 197,206,207,226,230,286
Wardwell, Ed 345,346
Waters, Rear Admiral Odale "Muddy" 235,242
Weathersby, Paul 68,293
Wells, Morgan 132,162
Wells, Paul 145
West, Chris 275
Wheeler, Lieutenant General 49,550
Wheland, Karl 329
Williams, Cyril 352
Williams, Rear Admiral J.W. 331
Wilson, President Woodrow 179
Winn, Chris 386
Woodward, William C. 70
Workman, Dr. Bob 98,100,116,127,149,151, 267,271,273,343,344,367
Wrench, Sam 128
Wright, Lieutenant Commander Wayne . 76,78
Yarbrough, Lieutenant Oscar D. 28
York, Herb 240
Yourkevitch, Vladimir 179
Zofkin, George 306,309,310
Zumwalt, Admiral 240,241

Index of Ships

Aluminaut 203,204,221,235,236
Alvin 197,202-208,218,221-223, 227,229,235,236
AM-36 22
ARS-9 34
ARSD-1 34
Avalon 278
Beaver 218
Boston 201
Bugara 229
Calypso 136
Card 72
Chanticleer 158
City of Rome 13,14,22,169
Cubmarine 204,221,234
Deep Drone 281
Deep View 374
Gatt (Liberian) 78
Genesis 97-104
Glomar Explorer 226
HMS Reclaim 350,354,355,357,358
HMS Stratagem 326
HMS Vernon 291,349
Independence 281
Inkhad (Tunision) 280
Jamaica Bay 254
Jason 223,224
Kaku Maru (Japanese) 22
Lafayette 177
LSD Ozark 328
LST 799 55
Mystic 278,279
Nautilus 205
Normandie 174-181
Oyashio (Japanese) 330
Paulding (US Coast Guard) 23
Pegasus 61
Penacook 31
Petrel 205
PY-1 8
Scorpio 281
Sea Owl 77
SeaCliff 224
SEALAB ... 97,103,267,271,276,283,286,291
SEALAB I 94,104-116,199,226
SEALAB II 94,116-134,199,200,201
SEALAB III 94,134-164,356,359,373
Sleeping Beauty 39,47-49,52,53
SS Abangarez 12
SS Alanthus 12
SS General Goethals 12
Tinosa 330
Titanic 223,224
Trasch 63
Trieste 197,206-211,213-215,217,218, 221,223,224,226,230,231,283,286
Turtle 224
USNS Gear 274
USNS Mizar 203,204,221,226,229
USS Ajax 331
USS Apache 223,230
USS Archerfish 102
USS Arizona 175
USS Argonaut (SS-166) 322
USS Baton Rouge 254
USS Benevolence 318,328
USS Benham (DD-796) 197
USS Besugo 230
USS Bittern 22
USS Bolster 278
USS Bone Fish 280
USS California 175,182,188
USS Capitaine (SS-336) 229,230
USS Cassin 175,321
USS Catfish (SS-339) 206,207
USS Chewink 26
USS Claxton 334
USS Cleveland 281
USS Cook 84
USS Coucal (ASR-8) 329-331
USS Crtiss 175
USS Crandall 35
USS Crevalle 340,341
USS Crilley 8
USS Dyshenko 84
USS Dixon 277
USS Dolphin 319
USS Downes 175,321
USS E-2 (SS-25) 11
USS Elk River (IX-501) 150,152-155,163,275,277
USS F-1 (SS-20) 11
USS F-3 (SS-22) 11
USS F-4 (SS-23) 8-12,16,36,259

USS Falcon (ASR-2) 13,16,21,23,24,26,29,31-35, 169,171,172,174,336-339
USS Florikan (ASR-9)..... 183,184,329
USS Fort Snelling 235,236
USS Franklin Delano Roosevelt 141
USS Grapple 252
USS Grayback (SS-208)..... 323
USS Greenlet (ASR-10)..... 330,331,332
USS Grenadier (SS-210)..... 318,325,326,332
USS Greyback 89
USS Grouper (AGSS-214) 52,198
USS Gunston Hall 375,380,385
USS Gypsy 34
USS H-1 (SS-28) 11
USS Haddock 333
USS Halibut 165,166,226,275,283,285
USS Helena 175
USS Helm 175
USS Hineman 185
USS Hoist 205,223,280
USS Holland (SS-1) 3,299,306
USS Honolulu 175
USS Indianapolis 330
USS Iuka 16
USS Gerald P. Lipscomb 205
USS Luzon 72
USS Mackerel 230
USS Mallard 26
USS Maryland 175
USS Mayflower 8
USS McKee 277
USS Menhaden (SS-377) 229
USS Monitor 205,262
USS Nereus (AS-17)..... 329,331
USS Nevada 175
USS New Jersey 227
USS O5 (SS-66) 12,13
USS O9 (SS-70) 182
USS Oglala 175,176
USS Oklahoma 175,176,179
USS Omaha 334
USS Ortolan (ASR-22) ... 26,231,275,276,286
USS Parche 166
USS Pelias (AS-14) 328
USS Pennsylvania (BB-38) .. 171,175,321,343
USS Penobscot 16
USS Pigeon (ASR-21) 26,182,184,231,275-278,280,286
USS Pirate 55
USS Plege..... 55
USS Point Defiance 212
USS Preserver 213
USS Pruitt (DM-22)..... 320-323
USS Quillback 52,53
USS R-12 (SS-89) 182
USS Raleigh 175,334
USS Relief 320
USS S-1 13
USS S-4 (SS-109) 8,22,23,259,260
USS S-5 (SS-110) 12
USS S-37 (SS-142) 12
USS S-38 (SS-143) 12
USS S-48 (SS-159) 12
USS S-50 13,14,16,172
USS S-51 (SS-162) 8,13-17,19,21-24,28, 33,34,36,259,260
USS Safeguard 183,184
USS Sagamore 16
USS Sailfish 259,340
USS Salvor 8
USS Scorpion (SSN-589) 230,231,236,283,284,345,346
USS Sculpin 31,336,337,340
USS Sea Leopard 340,341
USS Sea Lion (SS-195) 340
USS Seawolf 126,136,142,166
USS Shackle 34
USS Shaw 175
USS South Dakota 10
USS Sperry (AS-12)..... 329
USS Squalus (SS-192) 8,10,22,27,29,3135,39,40, 174,231,259,297,299,334-342
USS Tang (SS-563) 300-309,312,313,315,318, 321-324,326-328,332
USS Tennessee 175
USS Thresher (SS-593)..... 130,199,202,203, 212-226,260,278,286
USS Tilefish 323
USS Tunney 84,301,302
USS Utah 175
USS V5..... 9
USS Vestal 16,169,175
USS Volador (SS-490) 329
USS Wahoo 304
USS West Virginia 175
USS White Sands 230
USS Widgeon 26
Wotan 262
YHLC-1 8
YHLC-2 35
YR42 176