November 1965

SEALAB II

A Summary Report

SEALAB II, the longest and most ambitious deep-diving experiment ever conducted, came to an end on October 12, 1965. On that day, the final 10-man team of a three-team relay system of divers - 28 men in all - emerged from a decompression chamber off the coast of southern California.

The divers, representing both Navy and civilian scientific interests, had lived for a total of 45 days inside and outside of a 57-foot-long chamber that had been placed on the ocean bottom at a depth of 205 feet. The experiment was conducted and directed by the Office of Naval Research in collaboration with the Special Projects Office, as part of the Navy's Man-in-the-Sea program.

This undertaking and its predecessor - SEALAB I, which was conducted last summer in the Atlantic Ocean near Bermuda - were made possible by the conception, about 10 years ago, of the so-called 'saturation dive'. According to this technique, a diver is supplied with breathing gas at a pressure equal to that of the surrounding ocean water, which causes his body tissue to become completely saturated with the gas after approximately 24 hours. As long as the diver remains at a pressure level no lower than the saturation pressure level, he does not experience ill effects. Before returning to surface pressure, however, he must undergo gradual decompression - over a period of 31 hours in the case of the SEALAB I divers - in order to accomodate the naturally slow escape of the high-pressure gas from his tissues.

Conceivably, by means of the saturation dive and the new equipment that is being developed to facilitate it, man will be able to remain deep beneath the ocean surface indefinitely and accomplish a variety of tasks that would be difficult or impossible to accomplish by repeated dives from the surface. SEALAB II was undertaken to determine the feasibility of this concept. During the project, scientists representing many fields monitored the performance of the divers and their supporting equipment, accumulating much information that is needed to plan undersea-living projects of the future.

Following is a chronology of the major activities of the SEALAB II Aquanauts:

On August 28. 1965, the first team of SEALAB II entered the habitat. Commander M. Scott Carpenter, USN; Wilbur Eaton, GMI; Cyril Tuckfield, ENC; Lt Robert Sonnenburg, MC, USN; Billie Coffman, TMI; J.D. Skidmore, PHC and Fred Johler, ENCS, made up the Navy members of the team. Civilians were engineer Berry Cannon of the Navy Mine Defense Laboratory and Eary Murray and Tom Clark from the Scripps Institution of Oceanography, La Jolla, California.
The first team's main task was to get the habitat operating properly, establish an area of exploration, map the area they were located in, and to perform human factors and physiological experiments as well as marine biology studies. An underwater weather station was set up to measure current velocities, water temperature and other parameters at varying depths.
More tasks were scheduled for each team than they could possibly accomplish. This was to take care of any slack time which would rewult if an experiment were aborted. Aquanauts soon learned that it took a tremendous amount of work just to live at 205 feet.
In spite of a busy housekeeping schedule, checking equipment that was used for the first time in mant cases, the forst team on one day reached a total of 732 minutes in the water. All in all, they logged 6,067 minutes of time in the ocean and countless hours doing experiments inside the undersea habitat.
On Sunday, September 12, the first team (with the exception of CDR Carpenter) returned to the surface, undergoing 31 hours of decompression.
The second team was composed of CDR Carpenter; Robert Barth, QMC; Howard Buckner, SWC; Kenneth Conda, TMI; Glen Iley, HMC (who would serve as medical representative) and

John Reaves, PHI, for the Navy. Civilian scientist/divers were George B. Dowling, research physicist and William Tolbert, Jr., oceanographer and Wally Jenkins, equipment specialist, all from the Navy Mine Defense Laboratory, Panama City, Florida, and Arthur Flechsig, oceanographer from the Scripps Institution of Oceanography.

The second team was dubbed the 'scientific team' by the SEALAB officials. This was due to the high number of physiological and marine biological studies that were carried on inside and outside of the habitat.

A major achievement of the second team was completition of excursion dives to a depth of 266 feet at the sheer brink of Scripps Canyon. CDR Carpenter and Wally Jenkins made the first dive, with the entire second team later completing the excursion.

The second team had great success with Tuffy the porpoise, who worked for three days with the Aquanauts. The mammal proved to be an expert mailman and also carried a line to an Aquanaut who called him as if the diver were lost. This demonstrated that the porpoise can be a valuable assistant to men working in an undersea environment. Tuffy finished with his chores, and was returned by helicopter to his home, the Naval Missile Center at Point Mugu, California.

The second team logged 5,850 minutes in the water, but a major portion of their time was scheduled inside the undersea habitat performing special physiological and marine boilogical experiments. They entered the personnel transfer capsule on Sunday morning, September 27, and underwent 35 hours of decompression.

The third team entered SEALAB II in two shifts. Team leader Robert Sheats, Master Chief Torpedoman and Master Navy Diver, with Bill Meekes, BMl and Navy Electronics Laboratory scientist/diver Bill Bunton entered SEALAB on September 26. This was to enable the third team to become familiar with the routine and Chief Sheats with his leadership duties. The remaining seven men entered the habitat on Sunday morning. Navy members were Lt. Robert Sonnenburg, Medical Corps, USN; Charles Coggeshall, GMC; John Lyons, ENl; Lavern Meisky, SFC and Paul Wells, MNC. The civilians were scientist/divers Rick Grigg and John Morgan Wells, both of Scripps.

Primary objective for the third team was to test new salvage procedures at a greater depth. They used a special foam to salvage an aircraft hulk and to raise barrels from the bottom. They used explosive tools in an important experiment designed to attach plates and lifting surfaces to a portion of a submarine hull. They also worked with specially designed tools, with torque-free characteristics, to test the tools' effectiveness. Two different kinds of sample mining, air-lift and bottom coring, were also tested by the Aquanauts.

The third team had two immediate problems, both of which were solved by Aquanauts and topside personnel working together. The first problem was headaches suffered by most of the third team, and which coincided with the discovery of significant traces of carbon monixide in the SEALAB atmosphere. A chemical, hopcalite, was added to the air scrubbing system, and seemed to help. At least the headaches became fewew.

The second problem was one which all three teams faced. They had to send their air bottles topside for recharging with helium and oxygen, and this consumed valuable bottom time. A special high pressure line was sent to SEALAB II and the third team was able to charge their own bottles inside the habitat.

chief Bob Sheats and NEL diver-photographer Bill Bunton received permission from Captain George F. Bond, senior-medical officer, and Dr. John Craven of the Navy Special Projects Office, to make a 300-foot dive into Scripps Canyon. They completed the dive satisfactorily, and the remainder of the team three also made dives to the 300-foot level. The last team had the major job of preparing for ending the project. They prepared the habitat for raising from the ocean floor. This involved undoing many of the things the first team had done. All of the scientific gear had to be disassembled and returned to the surface, the Benthic communication laboratory had to be unhooked, and a general tidying up of the area made so that cables and wires would not foul during the raising operation. In all, the total ocean bottom working time accomplished by team three was 8,678 minutes.

Members of the third team came to the surface in the personnel transfer capsule on Sunday morning, October 10. They underwent 31 hours of decompression and emerged from the decompression chamber late Monday afternoon, October 11.
For the first time, numerical data on human performance in accomplishing work in cold, dark water were obtained. Foe example, tests were given to measure the force that divers can exert on a wrench and to assess such factors as two-hand co-ordination, manipulative skill, tactile sensivity, speech, intelligibility, arithmetical ability, and visual and auditory acuity. Knowledge of these capacities is essential to the design of tools and equipment required for undersea operations of the future and in establishing the performance limits of diver activities.
An intensive study of diver physiology was carried out, by means of which a large amount of data was gathered on all of man's vital functions. At intervals, while the divers worked inside of their habitat and before, after, or during the periods they worked outside, electrocardiograms were taken and measurements were made of such conditions as blood pressure, body temperature, pulse, and respiration. This information will be related to the performance and behaviour of the divers as determined by other tests in order to delineate an appropriate framework of activity for divers of the future.
By means of written questionnaires and TV monitoring, close attention was paid to diver behaviour. Contrary to some opinions held previously, the observations revealed that small groups of highly motivated men can live together in the ocean depths under hazardous conditions for long periods of time withoug friction occuring between them.
One of the primary interests of the navy in adapting man, techniques, and equipment to the performance of tasks underwater is the salvage of ships, aircraft, and other objects from the ocean floor. During SEALAB II, a special foam was used to salvage an aircraft hulk and explosive tools were used to attach plates and lifting surfaces to a portion of a submarine hull. The success of these and other experiments indicates that man is capable of performing difficult salvage tasks while living in the underwater environment.

All of the members of two of the SEALAB teams made short period excursions to depths as great as 300-feet. These dives demonstrate that man working out of a habitat can make brief deep dives to significantly greater depths than that of their habitat without undergoing decompression as they return.
Scientific and commercial explorations of the continental shelves of the world will be important objectives of many of the saturation dives to be made in the years ahead. During SEALAB II, investigations were carried out which demonstrated the feasibility of such projects. Experiments conducted by scientist-divers included physiological monitoring of marine organisms in their natural environment, observations of sediment transport and currents, and scale model undersea mining. Porpoises are noted for their ability to locate targets in dark waters by means os a natural sonar system. In order to determine the qualifications of this animal for membership in a team of Aquanauts, a trained porpoise was sent below to join the SEALAB II divers. The porpoise responded instantly and unerringly to acoustic signals given by divers stationed at locations beyond his range of sight. On some occasions, he was given messages to deliver, and on others, life lines to carry to divers 'in distress'. The animal passed the tests with high marks and thus may have earned a place beside man in the exploration and exploitation of the undersea world. In a congratulationary message sent to SEALAB II Aquanauts at the end of the experiment, secretary of the Navy, Paul H. Nitze, stated the following:

'thanks to the teamwork and dedicated efforts of the scientific community, Aquanauts, and support personnel, SEALAB II has accomplished its mission. You have proved that man can live and do useful work under the sea. Your accomplishments during the past 45 days have set one of the cornerstones for our future exploitation of the continental shelf.'

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SOME QUESTIONS ON ECOLOGY

C.J. Lawler

Ecology, being a study of life in relation to its environment, is a very important factor in marine research. The very nature of marine study, especially of sub-tidal life, makes it most difficult to form a balanced picture of the ecology of an area. Restricted sight, vagaries of weather and short time available to spend on site often make the ecological patterns ill-defined and hazy.

As little as we in the Group have done in this field, several questions have arisen over the years that may be interesting and may form a basis for some future study.

From 1959 to 1964 I dived regularly at Congwong Bay and since 1964 I have dived there occasionally. From 1959 to late 1961 the rock shelves on top of the reef were covered by a carpet of small sea urchinh (H. erythrogramma) so dense that a diver could not come in contact with the bottom for fear of injury. Scattered everywhere were big turban shells and swimming over the lot was a big population of 'cockies' (rock cale). Under ledges and in crevices were many species of brightly coloured sponges and ascidians. during the 6 weeks between Niovember '61 and December '62 came a deluge of rain and rough seas, the waters of Botany Bay and Congwong Bays turning brown with suspended mud.

I dived at Congwong on 30th Dec. '62 and in very poor visibility found the whole area a barren waste. The urchins were gone, completely gone: of the menaces I had cursed for years not one remained, gone also were the turban shells, the sponges, the ascidians, most of the fish and even a great deal of the sea weeds <u>but</u> there was no great amount of dead urchin tests or turban shells. Hat they been killed or had they cleared off? If so where? The rock ledges of Congwong end in cliff like drops to barren sand, DID millions of urchins and turban shells stream across sands in search of new pastures.

At the present time you may be able to find one or two urchins under rocks, and an occasional turban shell, the fish population has dwindled

to almost nil, the water is never as clear as it once was; is this a factor in the decline?

Will congwong ever recover its lost fauna? The big question is where the catastrophic conditions of the summer '61 - '62 a quick step in a long irreversable decline due to population, changing weather conditions, etc., or part of a cycle of decline and recovery operating over a period of many years or an unfortunate accident of nature that has changed the whole nature of the bay unrelated to any overall pattern.

A second question concerns the distribution and behaviour of the soft, alcyonarian coral 'Telesto smithi' why is this coral so prolific at Shiprock while at Glaisher Point 1 1/2 miles awaywith very similar conditions there is not one single growth? In fact we have only found Telesto in two other places, one small growth in a cave at Fairlight and at fort denison growing extensively on the sloping silty bottom.

As regards the behaviour of the polyps of Telesto, in early April when we first dived at Shiprock, all the polyps were 'out' in the feeding position giving the impression of huge banks of white flowers. In subsequesnt dives less and less of the polyps have been seen and now most of the Telesto is seen in its resting stage with the polyps withdrawn. We have at all conditions of tide but have found no relation in this factor. It is, perhaps, a yearly cycle and will the Telesto 'bloom' again in late summer? Only time will tell.

A third question again concerns the conditions found at Shiprock. Why are so many different species of fish found in this small area. fish unalike in habits such as deep water Knight fish and John Dorys, fast swimming pelagic fish like Kingfish and Pike, estuary fish such as Luderick and Whiting, rock fish such as Blue Groper and Morwong and at least one unidentified fish that we have not seen elsewhere.

The deep water and pelagic fish have to travel up to two miles overbarren, sandy shallows before reaching the deeper waters of Shiprock, Burraneer Bay. The fish there are also unusually tame considering that the habitat for some species is not their natural one. The great diversity of fish and inverterbrate life at Shiprock points to some, as yet unknown, factor operating there. It should be a prime target for future research to answer 'WHY?'

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REPORT ON TEST EXPOSURES, FILM ROLLS 4 & 5 WITH THE GROUP NIKONOS CAMERA

C. Lawler, F. Davis

ROLL 4: Using Kodak high speed Ektachrome film with and A.S.A. speed of 160 we exposed the film at 1/60th of a second and f. stop of 22 with wotan XM-5 or Philips PF-5 blue flash bulbs at distances between 2-1/2 and 3 feet. This resulting in all slides being reasonably correctly exposed.

ROLL 5: Again using Ektachrome film and the same setting 1/60th at f22 we used the smaller blue bulbs XM-1 or PF-1 with shots of light coloured subjects at minimal distances, i.e. 2-1/2 feet. These results were also very good. One shot was also taken at 10 fathoms without flash (1/30th at 5.6) the result showed a complete lack of any colour other than green but nevertheless produces a pleasing photograph with more 'feeling' of atmosphere than similar flash shots.

We recommend the following exposures with high speed Ektachrome film ASA 160 or any other film of similar ASA rating:--

FLASH: Coloured subjects at a range of 3' to 3'6" - 1/60th, f22 PF-5 blue (or equivalent).

White or very reflective subjects at a range of 2'6" to 3' 1/60th, f22, PF-1 blue (or equivalent).

All subjects at a range of 4' - 5' - 1/60th, f16, PF-5 clear (or equivalent): it is not recommended that flash shots be taken in excess of 5' except in very clear water. best results are obtained in the range of 2'6" to 3'6".

NO FLASH: (in reasonably clear water)

At a depth-surface to 2 fathoms	-	1/60th, f11, - f8
At a depth 2 to 5 fathoms	-	1/60th, f5.6 - f4.
At a depth 5 to 10 fathoms	-	1/30th, f6.3 - f4.

No flash shots progressively lose all colours but green at depths in excess of 1 fathom.

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from 'Materials in Design Engineering; April 65

A process recently has been develpoed for producing pressure vellels that ultimately may have burst strengths as high as 20,000 p.s.i.

These metal lined, high strength, glass fibre/epoxy resin wound structures are said to offer weight savings of from 25 to 60%, as compared to thick walled steel vessels now used for pressure vessel applications. For SCUBA diver tanks, a possible weight saving of 50% is said to be possible.

IT'S COLD DOWN THERE:

Dr. John Betts

Have you been diving lone enough to remember the days of dry suits with the attendant indignities of pinching and the cold discomfort of leake? Then you will recall the enthusiasm with which the new expanded neoprene suits were adopted. The dry suit died almost overnight. The new suits were more comfortable easier to put on, easier to make and repair. Nevertheless, one major disadvantage of neoprene has always been the way it compresses under pressure. This causes thinning of the material at depth, resulting in variable buoyancy and loss of effectiveness as a protection against cold.

While these effects have always been known in principle, the actual loss of efficiency has, as far as I know, never been measured. With the construction of a small pressure pot provided with an observation window, I decided to fill in the gap by covering a small copper rod, drilled to take an electrical heater and a thermometer, in a neoprene 'suit'; the amount of heating required to keep the rod at a constant comfortable temperature at different pressure under water in the pot was then measured. The neoprene shrinkage in both thickness and length was observed.

Under test, neoprene halved its thickness at a depth of 20m and was down to almost a third at 50m. Its heat insulation deteriorates even more than this: half at 20m and a quarter at 50m. In other words, a quarter inch suit is only 2.3mm thick at 50m and loses four times as much heat as it does at the surface.

As well as varying in thickness, the neoprene also shrank in length, being 2.3mm shorther by 50m. Although this is not very much, it explains why, on a deep dive, the suit tends to creep up the wrists or ankles, leaving them unprotected unless boots and gloves have been given generous overlap. There seems to be no significant difference between the performance of a single and double skin material or of nylon backed neoprene, the only important factor being the thickness of the neoprene itself.

Expanded material as an insulating material is not particularly good. Its thermal conductivity works out at about .0006 watts/sq.cm./C- only about half as good as kapok or cotton wool.

You may ask why, if neoprene suits have such poor performance at depth, people still continue to use them. Part of the answer is that the aqua-lung has a somewhat parrallel loss of endurance at depth and the diver runs out of air before he is seriously chilled. Nevertheless, wet suit diving below 30m is always a rather cold affair. Now that attempts are being made to stay for long periods at depth, these deficiences in the performance of the wet suit are becoming more important. From the experimental results, one can calculate that a diver wearing a quarter inch suit in cold water will become chilled below about 10m even when when exerting himself by swimming about.

It is difficult to forsee how these defects can be overcome but a revival of interest in the dry suit, used with some device to maintain a constant volume of air within the suit, has been noticed among people who go on very cold or very deep dives.

at this point there is a graph which I am unable to replicate

I suggest a photocopy will be necessary

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