FACEPLATE

The Official Magazine for the Divers and Salvors of the United States Navy

SALVAGE TRAINING

Winter 1984
Volume 15, No. 4

A diver enters the water during a propeller change on the USS HEPBURN at Naval Station San Diego.

MOBILE DIVING AND SALVAGE

UNIT ONE DETACHMENT

By HT2/DV Mark D. Faram, USN
NAVSEA OOC Photojournalist

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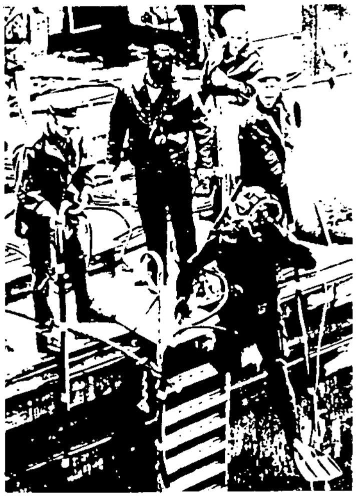

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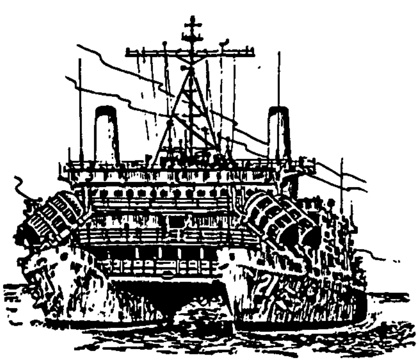

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SOUNDINGS

Seawater Hydraulic Motor Improved

Personnel at the Naval Civil Engineering Laboratory (NCEL), Port Hueneme, California, have made major modifications in NCEL's Seawater Hydraulic Motor, resulting in a running time of more than 200 hours under 70-100 percent rated load conditions. Engineers were able to overcome serious developmental difficulties caused by seawater's low viscosity, lack of lubricity and corrosive nature.

It has taken the Laboratory more than four years, since the prototype was developed and tested, to reach this planned breakthrough in motor endurance.

The accomplishment represents a major technological advancement, removing the motor from the experimental stage by proving a reliability more than adequate for diver use.

The first underwater hydraulic motor to use seawater instead of oil as the working fluid measures only 3"x 3"x2½" and weighs five pounds. The reversible motor is a double-entry, balanced vane motor with relatively simple shapes, and few parts, making it easy to maintain.

Orginally, this compact motor was limited to 50 hours running time (endurance). The limiting components in the design were 20 special vane springs, each 1/2-inch long and 1/8-inch in diameter. The motor was redesigned under contract by Westinghouse Electric Corporation, Research and Development Center, Pittsburgh, and incorporated such new features as a floating rotor and different vane configurations to reduce spring stress. The springs themselves were redesigned to reduce buckling and to extend fatigue life.

Based upon current successes, the Laboratory plans to develop a series of smaller and larger seawater hydraulic motors, some up to 15 horsepower. Presently, the Ocean Systems Division, Ocean Engineering Department, is designing and constructing a 5/12" horsepower motor.

The motor is the first component of a seawater hydraulic system under development at NCEL. The system will include newly designed pumps for supplying pressurized seawater, special flow control valves, hoses and fittings, filters to remove contaminates and the tools to perform a variety of underwater operations.

The hydraulic system offers many advantages over oil hydraulic, electrical and pneumatic systems. Obviously, oil is no longer necessary. Environmental pollution, contamination of the working fluid and fire hazards are therefore eliminated. There is no need for a return hose and less pump power is required. Divers will find that the reduced back pressure will provide increased tool working depth. They also will observe that the more flexible single-hose system is easier to handle. The drag force from current and surge is greatly reduced.

The potential for the seawater hydraulic system with its unique motor is not limited to divers and their tools. The technology can be adapted to such diverse military and commercial uses as propulsion systems on submersibles, conveyor systems, shipboard machinery, submarines and mining equipment and machinery.

Task Group 33.5 Decorated for BLUEGILL Salvops

Several units of Task Group 33.5 have been awarded the Meritorious Unit Commendation for their efforts in salvaging the World War II submarine BLUEGILL. Receiving the award were: COMSERVRON 5 (CTG 33.5), USS BEAUFORT (ATS 2), USS BRUNSWICK (ATS 3) and selected crew members from USS RECLAIMER (ARS 42) and MOBDIVSALVU 1, along with personnel from various other commands temporarily assigned to the operation.

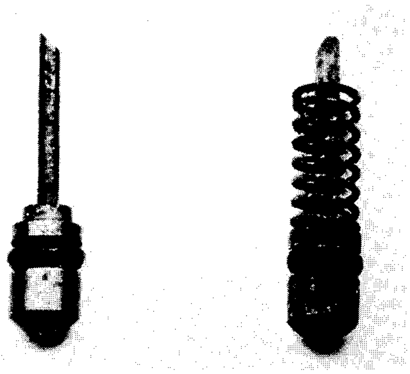
Five officers from Task Group 33.5 units received Navy Commendation Medals: LCDR John P. Speer, CO USS BRUNSWICK (ATS 3) and On Scene Commander; LCDR Alan M. Nibbs, Jr., CO USS BEAUFORT (ATS 2) and Rescue/Tow/Logistics Element Commander; LCDR James M. Evans, CO USS RECLAIMER (ARS 42) and Salvage Master; LCDR Robert A. Reisch, XO USS BRUNSWICK (ATS 3); and LCDR Gary E. Tettlebach, Salvage Engineer, NAVSEASYSCOM.

LCDR T. K. Pyles Named XO of NCEL

LCDR Troy K. Pyles, CEC, USN, has been named Executive Officer of the Naval Civil Engineering Laboratory (NCEL), Port Hueneme, California. He succeeds CDR John E. Heath, who has been reassigned to the Naval Construction Battalion Center, Port Hueneme, as Executive Officer.

A native of Bellflower, California, LCDR Pyles reported to the Laboratory from Underwater Construction Team TWO, Port Hueneme, where he served as Officer-in-Charge for more than two years.

LCDR Pyles was commissioned in 1971 upon graduation from the U.S. Naval Academy with a BS degree. He successfully completed a six-month course at the Civil Engineer Corps Officer School, Port Hueneme, before assignment to Naval Mobile Construction Battalion TEN for approximately 18 months. From 1973 through 1975 he attended the University of Hawaii and earned a BS degree in civil engineering and an MS degree in ocean engineering. He then qualified as a Navy diving officer after a four-month course in deep sea, scuba, and salvage diving.



MK4 Life Preserver Inflators

WARNING: NEW MK4 LIFE PRESERVER INFLATOR MECHANISMS MAY FAIL if the post-dive maintenance is not performed as prescribed. The new black, glass-filled polyester inflator mechanism (IM) being used on the MK4 Life Preserver is called non-corrosive. This is correct for the plastic body; however, the phosphor bronze parts will corrode if not maintained correctly. The pierce pins inside the inflator mechanism are made from phosphor bronze roll pins which allow the gas to be discharged much faster than solid pins. Without the recommended post-dive maintenance described on PMS card MRC-6GKCN (perform after each use), the pins are left soaking in a salt water bath, and corrosion builds up until it plugs the gas passage. The result is that when the pin pierces the CO_2 cylinder, the gas does not escape. Corroded pins may be soaked in a 3 to 5 percent nitric acid solution for 2 to 3 minutes to remove the corrosion. The pins may be reused if they are not badly pitted and successfully tested when reinstalled in the inflator mechanism.

Divesafe Workshop 1984

The 1984 Diving and Salvage Safety Workshop, sponsored by the Naval Safety Center, was held at the Naval Amphibious Base, Coronado, CA, from 5 to 7 December 1984. Representatives from both Fleet commands participated in work study groups to identify actual and potential diving and salvage safety problems and to recommend possible solutions. Workshop topics included:

- Diving Candidate Service Obligation
- Entrance Requirements for Diver Training
- The Individual Diving Log
- Master Diver Evaluation
- Master Diver Meeting
- Refresher Training
- Training Standardization
- Operational Training
- 190 FSW Scuba Training
- Ship Check-off Procedures
- Low-cost Diver Recall Device
- MK-12 Maintenance
- The Lightweight Diving System
- Diving Mishap Investigation

The recommendations presented by the work groups have been forwarded to cognizant commands for action.

Some of the commands represented included: NAVXDIVINGU, COMNAVSEASYSCOM (OOC), COMNAVMILPERSCOM, CNTECHTRA, COMNAVSURFPAC, COMSERVRON FIVE, COMSUBDEVGRU ONE, COMEODGRU ONE and TWO, and various afloat and ashore commands.

The 1985 Diving and Salvage Workshop will tentatively be held during the first quarter of fiscal year 1986 at the Naval Diving and Salvage Training Center, Panama City, FL.

NEDU TECHNICAL FOCUS

By CDR Frank Eissing, CO, NEDU

I recently attended the Diving Safety Symposium in San Diego. There were many excellent proposals made to help maintain the diving expertise we have developed over the years. However, some comments on the present state-of-the-art in diving equipment were grossly incorrect. One glaring item was the statement by a senior diving officer that "SCUBA hasn't been improved in the last 50 years." It is a matter of record that SCUBA was *developed* in the last 50 years. The following is a listing of some of the more important SCUBA developments in recent years:

- low-resistance, single-hose breathing regulators
- lightweight aluminum diving flasks
- submersible bottle gauges
- introduction of high strength plastics
- buoyancy compensation devices
- thermal protection suits/systems
- high reliability depth gauges
- repetitive air diving tables
- digital underwater watches
- introduction of silicone materials
- throughwater communications

You can probably add items of your own. However, if senior personnel in the diving community don't understand the technical advances being made in the most basic of diving systems, how can we even hope to keep the diver on the deckplates informed?

View from the SUPERVISOR OF DIVING

By CDR Raymond Swanson, USN

As Divers, we tend to be independent and strong in our convictions. Although these are good qualities, they at times can cause a disservice to our fellow divers. Specifically, I am referring to a conference I attended recently where senior Navy personnel, officer and enlisted, made a number of emotional rather than factual statements.

A particularly sensitive area for most divers is the inability to use commercial equipment as it becomes available. Why can't we use the equipment? After all, we feel it's as good as Navy equipment.

There are several reasons why we can't buy this equipment off the shelf for our local use; although some are economic, safety is the main reason. The Navy has stringent criteria which diving life support equipment must meet. These criteria include gas flow rates and breathing resistances, among other physiological and human factor requirements. It is essential that these parameters be met whenever possible since they relate to diver safety and the ability to perform, when necessary, at high work rates.

For example, the Jack Browne mask, still in use today, has had its working depth reduced over the years. Older divers ask, "Why? It's a good piece of equipment." Although this is true to a certain extent, improved technology made us aware of the physiological events that were taking place; the diver was not getting enough oxygen because the Jack Browne was inefficient at deeper depths. This cause and effect, however, was not readily recognized as the diver, a very adaptive animal, adjusted his work rate accordingly. What we thought was a heavy work load for the diver that could be compensated for by taking a "vent" was actually the body's way of saying it was not receiving sufficient oxygen. It was then realized that better air flow would permit fewer "vents" and would permit the diver to work harder when necessary. As the mask was already in the Fleet and performed well at ship husbandry depths, no move was made to withdraw it from service.

This is just one example of the type of technical problem that needs to be addressed before procuring new equipment. Now that we are aware of required air flows and oxygen consumption, all new equipment must meet this criteria. In many cases, the commercial equipment does not. Further, it is evident that industry still considers the Navy a leader in diving technology as it frequently requests us to either test their equipment or, in some instances, to establish design criteria.

Economic reasons also prohibit the procurement of new commercial equipment. In light of current Federal budget trimming, smaller programs such as diving are expected to assist major programs by absorbing cutbacks. This forces us to build reliable equipment designed to serve the majority of divers for a long time. It also permits us to establish spare parts support for the equipment. In today's peacetime environment, we tend to forget that our reason in life is to support a wartime Navy. The local dive shop may be thousands of miles away when you next need a replacement part.

My message is — do not sell our equipment short. Many hours of research, testing and evaluation go into our equipment to ensure that it is safe before it is sent to you, the user. It may not be a Cadillac but it more than enables us to get the job done. And that is why we are in the business.

Operational and Emergency Procedures

Several years ago the Navy had an accident in which five divers lost their lives. As a result, the review and approval process for technical matters has become more centralized. The Supervisor of Diving has been tasked to review and approve all operational procedures (OP) and emergency procedures (EP). This has placed an additional burden on all of us. I want to be able to respond to your needs quickly; however, this is difficult since each activity has a different format for its operational and emergency procedures. This lack of conformity increases our burden.

Recently, diving activities received guidance for the submission of their OPs and EPs. This guidance was based upon a review of various formats submitted to my office over the past months and discussions with various activities. We feel the format chosen fulfills both my requirements and yours and that it will standardize the system.

The requirements for activities to verify each procedure by a walk through hands-on line-up of the system, and to submit up-to-date drawings which have also been verified, will make for faster approval. Remember, we are approving the OPs and EPs based upon the drawing. Although the engineers will be able to point out certain discrepancies on your drawing, they cannot know if the actual component sequence is accurate. The drawings will be verified by the Office of the Supervisor of Diving during a design review conducted at your activity. At present, these reviews will only be conducted on new systems; existing systems will be addressed at a later

EPs has a direct bearing on your certification, the Commanding Officer is expected to be aware of your submission and to sign the forwarding letter. If the OPs and EPs have not already been approved by the Supervisor of Diving (NAVSEA OOC3), they should be forwarded to this office ninety days before your scheduled visit by the Systems Certification Authority-Naval Sea Systems Command (SCA-NAVSEA OOC4). Here is a sample of the format to be used. Each column is self-explanatory. ——→

Developments

An on-site certification survey of the *Standard Navy Diving Boat* was conducted in early February. At present, several cards remain outstanding and should be cleared within days. A dive to 166 feet of sea water using the MK 12 Surface Support Diving System was conducted as part of the survey. OPEVAL is still planned for mid-summer 1985.

The *MK 12 SSDS Mixed Gas Recirculator* completed first article testing. Approximately seventeen changes were recommended to improve the recirculator or enhance longevity and maintainability. Engineering Change Proposals have been approved and the contractor is modifying the prototype accordingly. As the schedule has slipped one to two months because of these changes, the start of delivery is now expected for June or July 1985.

The *R.O.P.E.R. Cart* continues on schedule.

Work by the Naval Medical Research Institute (NMRI) on the formulation of new Air Decompression Tables is nearing completion. The approach being used by NMRI doctors is a statistical mathematical model called maximum likelihood. Their work involves the mathematical modeling of thousands of dives coupled with research on tissue absorption of gases to determine appropriate decompression depths and times. After their work is completed, a lengthy verification process will begin.

DIVING SYSTEM:
OPERATING PROCEDURE: START-UP 4.2
SYSTEM: HIGH PRESSURE AIR
STEP: 4.2.4 (CONTINUED)

ITEM	COMPONENT/DESCRIPTION	PROCEDURE	LOCATION	CHECK	NOTE
1	ALP-15 REDUCER OUTLET	OPEN	SALVAGE HOLD		
2	ALP-GA-7 LOW PRESSURE AIR GAUGE	OBSERVE PRESSURE TO BE 200 PSIG	SALVAGE HOLD		
3	ALP-DR-3 SURGE TANK DRAIN	OPEN FULLY, OBSERVE ALP-GA-7 TO READ 200 PSIG FOR 15 SECONDS, SHUT	SALVAGE HOLD		

STEP: 4.2.5 VERIFY PROPER OPERATION OF A CHECK VALVE ALP-13

CAUTION

THE LOW PRESSURE AIR SYSTEM MUST BE IN THE SHUTDOWN CONDITION PRIOR TO PERFORMING THIS STEP OR COMPRESSOR DAMAGE MAY RESULT.

WARNING

A PRESSURE INCREASE OF GREATER THAN 10 PSIG IS CAUSED BY ALP-13 FAILING TO HOLD PRESSURE. PERSONNEL INJURY MAY RESULT FROM DEPLETION OF DIVER'S SECONDARY SOURCE OF AIR DURING AN EMERGENCY.

1	NR 1 LPAC AND/OR NR 2 LPAC SWITCH	OFF SECURE COMPRESSOR IN USE	COMPRESSOR ROOM		
2	ALP-3 VOLUME TANK#1 INLET	SHUT	COMPRESSOR ROOM		
3	ALP-4 VOLUME TANK #2	SHUT	COMPRESSOR ROOM		
4	ALP-DR-2 VOLUME TANK #2 DRAIN	OPEN UNTIL 170 PSIG IS READ ON ALP-GA-2, SHUT	COMPRESSOR ROOM		
5	ALP-GA-2 VOLUME TANK PRESSURE	RECORD PRESSURE _____ PSIG WAIT 10 MINUTES RECORD PRESSURE _____ PSIG CALCULATE PRESSURE _____ PSIG INCREASE			

NOTE: A PRESSURE INCREASE GREATER THAN 10 PSIG, INDICATES ALP-13 WILL NOT OPERATE PROPERLY AND MUST BE REPAIRED.

6	ALP-3 VOLUME TANK #1 INLET	OPEN	COMPRESSOR ROOM		
7	ALP-4 VOLUME TANK #2 INLET	OPEN	COMPRESSOR ROOM		
8	ALP-15 REDUCER OUTLET	SHUT AND HANG TAG "STANDBY AIR"	SALVAGE HOLD		
9	NR 1 LPAC AND/OR NR 2 LPAC SWITCH	AUTO LIGHT OFF COMPRESSOR IN USE	COMPRESSOR ROOM		

A diver enters the water during a propeller change on the USS HEPBURN at Naval Station San Diego.

MOBILE DIVING AND SALVAGE

UNIT ONE DETACHMENT

By HT2/DV Mark D. Faram, USN
NAVSEA OOC Photojournalist

In November 1979, a plan to consolidate divers in the San Diego area was initiated for a one-year trial period. This Consolidated Dive Unit (CDU) included divers from the Destroyer tenders and repair ships in the San Diego area: USS AJAX (AR 6), USS ACADIA (AD 42), USS CAPE COD (AD 43) and the USS SAMUEL GOMPERS (AD 37).

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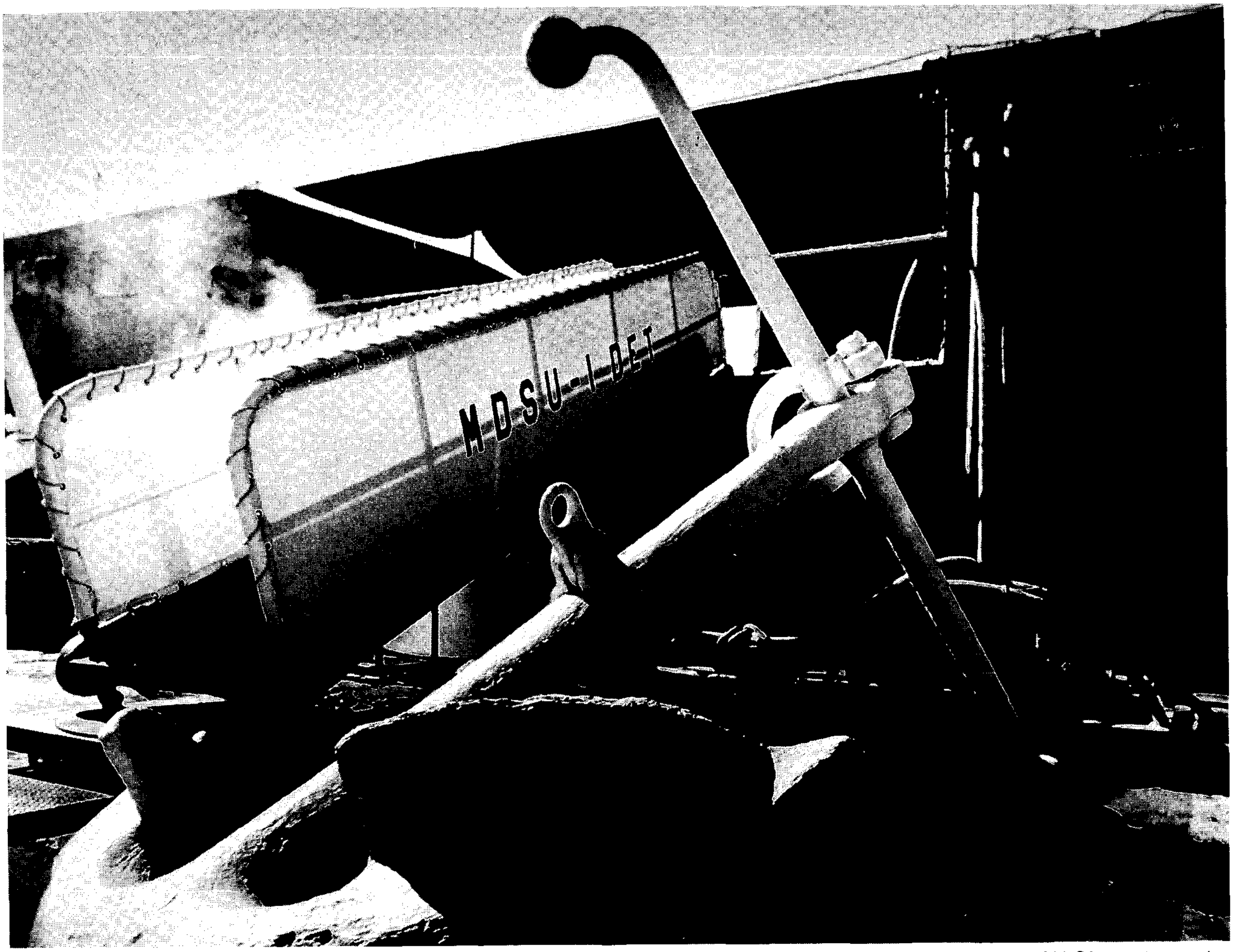


Headquarters for MDSU-ONE is located on the Barge YNFX 24 at Naval Station San Diego. The Barge contains administrative offices, equipment repair facilities and storage lockers for the tender crews.

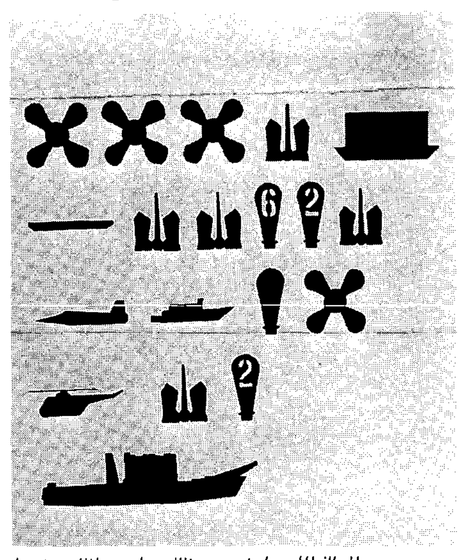
manageability as crews can be augmented with personnel from other units to make up for losses due to leave, schools, large jobs and detailing gaps. Equipment pooling has reduced major repair times and has increased the overall equipment inventory of such items as blade change equipment, cofferdams and patches.

The mission of Mobile Diving and Salvage Unit ONE Detachment (MDSU ONE) is to provide underwater ship's husbandry and fly-away salvage services to the entire west coast of the United States. To accomplish this, the consolidation of divers and equipment is essential.

Located between Piers 5 and 6 on Naval Station San Diego, MDSU ONE DET is headquartered on the barge YFNX-24. In addition to administration offices, the barge also houses a dive equipment repair locker, crew's lounge, duty berthing spaces and storage cages for each of the tender dive teams. A compound located nearby stores the Fly Away Diving (FADS II) System, various salvage patches, pumps, compressors and other tools normally associated with diving and salvage operations.

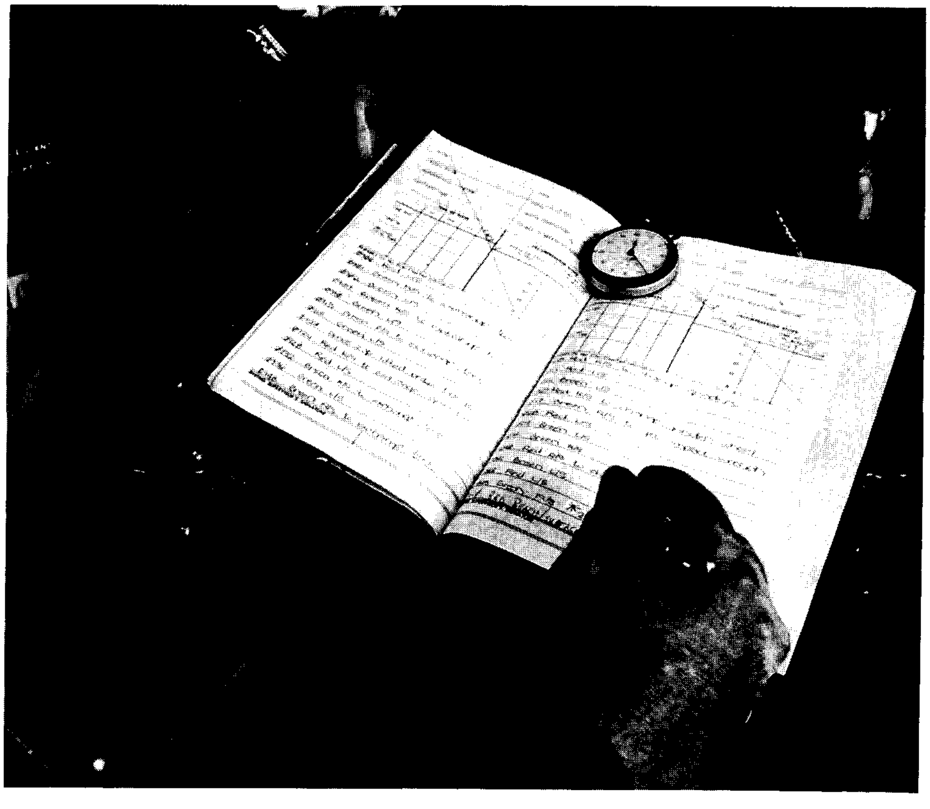
MDSU ONE DET has become a collecting point for expertise in waterborne repair techniques, and the result has been a considerable savings to the Navy in both time and money. Every effort is made to pass on knowledge to the rest of the Fleet. When a new technique is used, divers are brought in from other repair facilities to observe the operation so that deployed ships in the Western Pacific Fleet can benefit as well. This occurred on the USS ENTERPRISE (CVN 65) propeller change (FACEPLATE Fall 1983) and on the change of the controllable reversible pitch propeller of the USS CALLAGHAN (DDG 994). MDSU ONE DET has also benefited through the development of a diver PQS and training program and a technical library.

Ship's husbandry comprises the



In traditional military style, "kills" are marked on the side of the YNFX 24, noting significant jobs accomplished by MDSU-ONE-DET.

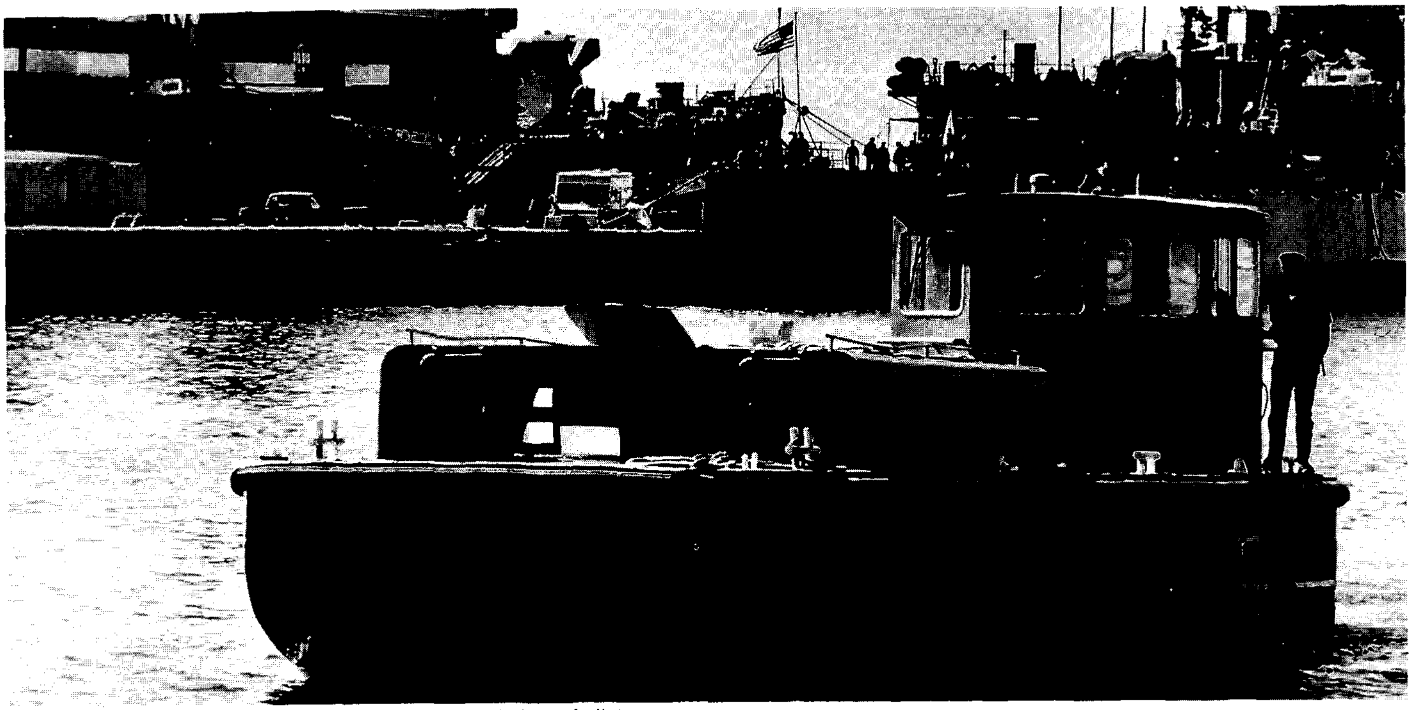
LCDR Pete Herlin comes back on deck after photographing the propeller of the USS HEPBURN.



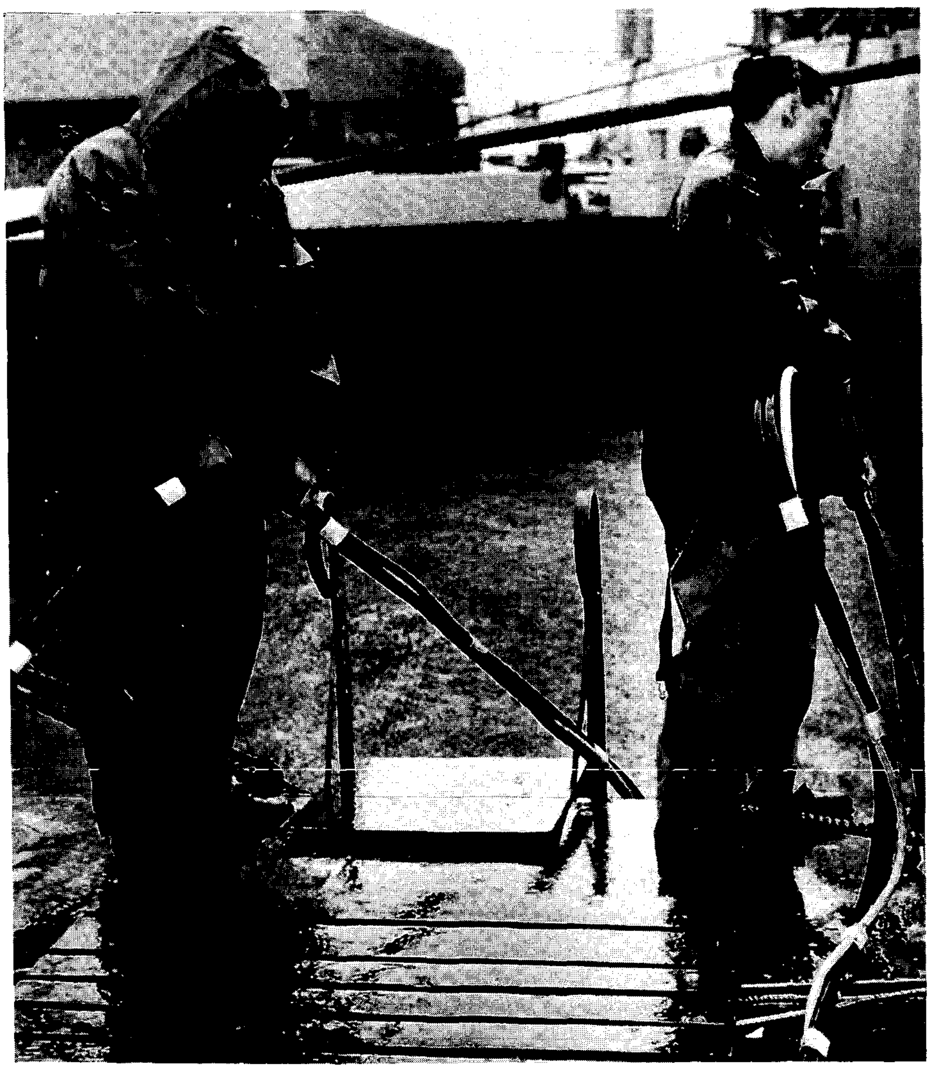
"Logs and Comms"—the job of documenting problems and new techniques—is a crucial part of noting divers' progress.

major portion of the MDSU ONE work; however, the Detachment is also tasked with fly-away salvage capability for the west coast and can load out the FADS II System onboard a TATF 166 Class ship or any vessel of opportunity at a moment's notice. Divers filling billets at the MDSU ONE DET (tender divers are assigned TAD) are used for the fly-away salvage assets, and are assisted by tender divers on an as-needed basis, providing the opportunity to gain salvage knowledge.

Examples of the fly-away capability include the salvage of military aircraft, five anchors and chains (valued at $500,000), the refloating of an LCU from the rocks off San Clemente, and flying divers by helicopter out to sea to clear propellers.



A dive boat returns to the YNFX 24 after a full day of diving.



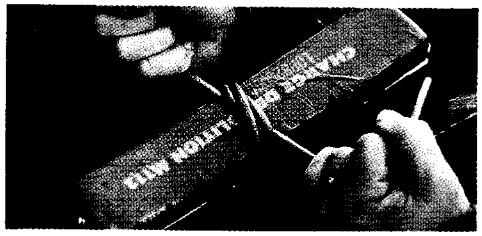
Tending comprises much of a MDSU diver's topside time, insuring the safety of the counterpart diver in the water.

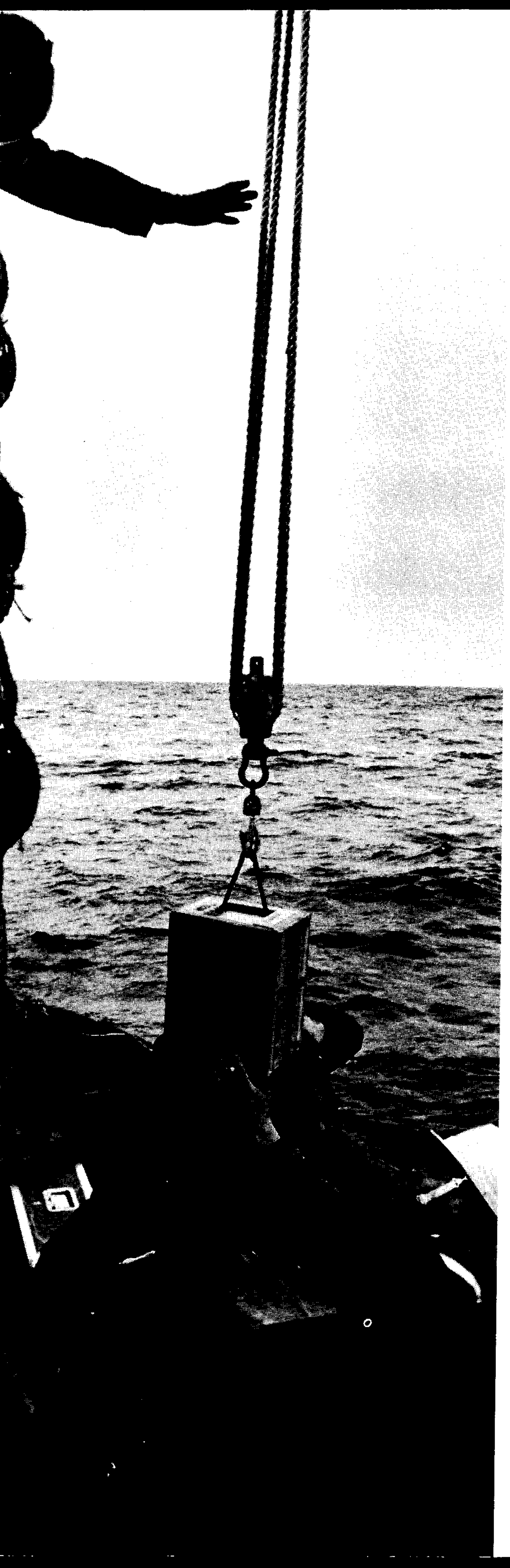
Consolidation has also increased the productivity of the divers in the San Diego area. During the period of 1 January 1982 to 30 June 1983, the detachment accomplished more than twice the average yearly number of dives than the total accomplished by the individual commands in the four years prior to consolidation.

The Navy's ability to save money through waterborne repairs has been helped considerably by the MDSU ONE DET.

By July 1985, the Detachment will move into a new facility near Pier 12, Naval Station, San Diego. A Butler building is being constructed to replace the old condemned buildings now used for locker rooms and storage. Upon completion of the new facility the YFNX-24 will move to Pier 12 and continue to serve as the administrative offices for the command.

MDSU ONE DET is a hardworking team of Navy professionals. The ability of the consolidated diving unit to respond to diving and salvage requirements is a tribute to all its members.





EOD GROUP ONE:

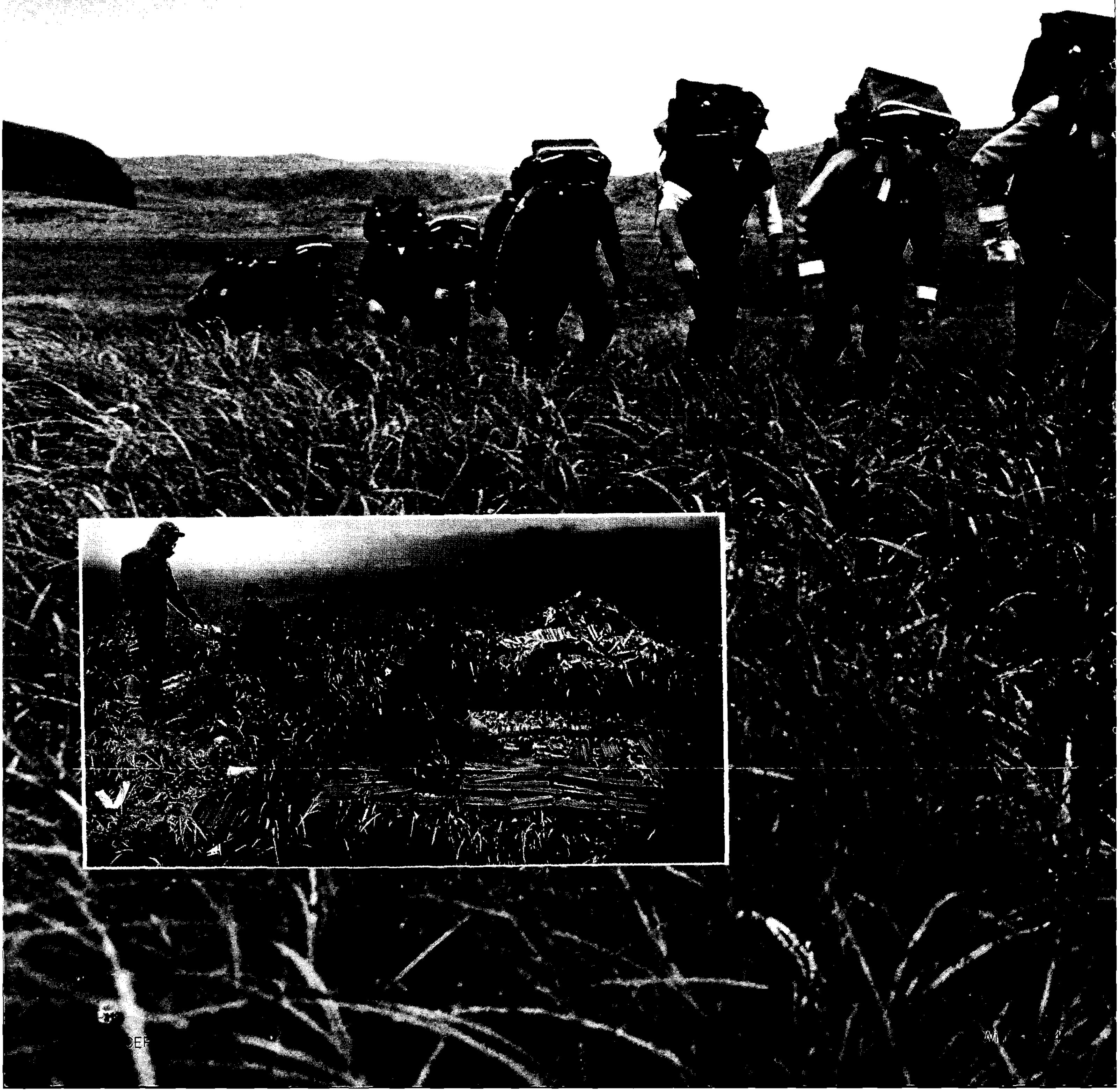
TANAGA ISLAND CLEANUP

By LT Kevin W. Kreidler, USN
Naval Air Station, Adak, Alaska

The U.S. Navy and Coast Guard recently teamed up to destroy 38,000 rounds of World War II ordnance left on the island of Tanaga, in Alaska's Aleutian Chain, at the end of the war.

As Tanaga is uninhabited, removing the ammunition was not a high priority. However, the ordnance posed a threat to the occasional visitor to Tanaga, and the Commanding Officer of nearby Adak Naval Air Station ordered it destroyed. Explosive Ordnance Disposal (EOD) Group ONE, Detachment Adak, tasked to carry out the mission, determined that 6,000 pounds of explosives would be needed.

U.S. Coast Guard Cutter STORIS crewmen offload a box of the 6,000 pounds of explosives onto the rubber raiding craft for transportation to Tanaga Island. Photos by PH1 Lon E. Lauber, USN.



LTJG Steve Dehart, Officer-in-Charge of Explosive Ordnance Disposal Group One, Detachment Adak, leads the caravan of U.S. Coast Guard volunteers and EOD team members on the one-mile hike inland to the ammunition disposal sites. Collectively over 80 such trips were made during this joint operation.

Inset:
AO1 Edward Robers, center, receives a C-4 charge from MMC David Green, left, as LTJG Steve Dehart, right, lays the C-4 charges on top of the World War II ordnance. Placement of the charges efficiently disposed of the 20 millimeter rounds while reducing the amount of shrapnel ejected into the air.

The first of two blasts which destroyed more than 38,000 rounds of World War II ordnance on the Island of Tanaga. This blast used 2,000 pounds of explosives leaving a crater eight feet deep by twenty feet across. Tanaga is an uninhabited island in the Aleutian Chain approximately 1,300 miles west southwest of Anchorage, Alaska.

The U.S. Coast Guard Cutter STORIS (WMEC-38) was assigned to transport the EOD team and explosives to Tanaga. During the ten-hour transit, the team provided ordnance-handling lectures to the ship's crew and on arrival at Tanaga solicited volunteers to assist in moving the explosives from the beach inland to two separate ordnance dump sites.

The sites, set back nearly a mile from the beach, were located such that the explosives used to detonate them had to be transported in backpacks, 50 pounds at a time. Struggling through the muddy tundra, often a foot deep, the 14 volunteers and four-man EOD team made many trips from the beach to the dump sites. At the close of the first day the STORIS crewmen returned to the ship, while the EOD team set up camp inside an abandoned quonset hut.

On the second day the volunteers finished moving the explosives as the EOD team started to lay out the ammunition for detonation. As the day wore on, a heavy fog settled in, causing the crewmen to spend a second night in the hut.

The following morning, however, a bright blue sky greeted the crewmen as they returned to the ship. The EOD team made final preparations for the destruction of the ammunition.

After all precautions had been taken and final clearance obtained, the crew stood by for the explosions. The first shot, after four decades of almost total stillness, sent out a shock wave that flattened the grass and showered the area with fragments. The second blast, larger than the first, resulted in huge plumes of black smoke, accompanied by white flares and red tracer bullets—still live after 40 years. Both shots were considered successful and all ammunition was destroyed, leaving only large craters and a scattering of rusted fragments.

Like Tanaga, remnants of World War II are interspersed through the Aleutian Chain. As more people begin to move out into these remote islands, more missions like this one may be required to remove antiquated but still lethal ammunition dumps.

NEDU REPORTS

Recompression Chamber Communications System Test and Evaluation

By Jerry D. Pelton, GS-11, Test Engineer
LCDR Michael D. Curley, MSC, USN, Human Factors Enginer
NEDU Report 8-84

ABSTRACT

Five commercially available Hardwire Communications Systems were tested at the Navy Experimental Diving Unit for use as two-wire communications systems on recompression chambers. These systems were designed to serve as the primary means of communications between outside personnel and personnel inside the chamber. The communications systems were evaluated and rated by how well they fulfilled specific critical parameters related to this application. The five systems evaluated were Helle Models 3220 and 3214, Amron Model AMCOM II 2820, EFCOM Model DAR-1000 and Atkinson Dynamics Model AD-27H-M2.

Overall, the AMCOM II 2820 and EFCOM DAR-1000 were rated the best communicators by the system operators on human factors variables. The poorest evaluation was received by the Helle 3214, with less than satisfactory ratings received in two sub-areas and in the overall rating. The overall ranking of the systems was in agreement with the operators' confidence in each communicator. In summary, the Amron Model AMCOM II 2820 and the EFCOM Model DAR-1000 communication systems were considered to be reliable and effective instruments of communication with occupants in U.S. Navy recompression chambers from 0 to 165 feet of sea water.

CNS Oxygen Toxicity in Closed-Circuit Scuba Divers

By LCDR F.K. Butler, Jr., MC, USN
CDR E.D. Thalmann, MC, USN
NEDU Report 11-84

ABSTRACT:

Sixty-eight man-dives were conducted at the Navy Experimental Diving Unit to evaluate the feasibility of extending the oxygen diving tables currently used by U.S. Navy closed-circuit oxygen SCUBA divers. Additionally, testing was done to determine the cumulative effect of previous shallower oxygen exposures on subsequent excursions to increased depths. Twenty-minute exposures at 40 feet of sea water (fsw) were found to be unsafe, with 2 convulsions resulting from a total of 17 dives. Fifteen-minute exposures resulted in no convulsions or definite symptoms occuring on a total of 24 dives. Excursions to 40 fsw for 15 minutes after a previous 1-hour exposure at 25 fsw, followed by another hour at 25 fsw, resulted in 1 definite toxicity episode in 13 dives. Excursions to 40 fsw, following a 2-hour exposure at 25 fsw, produced 2 definite toxicity episodes in 13 dives. One convulsion was seen after a 72-minute exposure at 25 fsw.

The following conclusions are made from this study: (a) Oxygen toxicity convulsions may be seen during what are usually considered safe exposures, as evidenced by the convulsion which occurred after only a 72-minute exposure at 25 fsw. (b) The current limit of 10 minutes at 40 fsw in the U.S. Navy Diving Manual will certainly not be extended beyond 15 minutes. Further dives at 40 fsw for 15 minutes are necessary to determine whether or not this profile is safe for operational use. (c) Brief excursions to 40 fsw were possible after a prolonged exposure to oxygen at 25 fsw. Pre-exposures of 60 minutes at 25 fsw do not seem to influence the safe 40 fsw exposure time but a 2-hour pre-exposure did seem to decrease the safe 40 fsw exposure time somewhat.

SERVICE SQUADRON 8 EIGHT

SALVAGE TRAINING

Responding to orders from the OOD during firefighting training, the helmsman brings the ship alongside the "hulk."

By HT2/DV Mark D. Faram, USN
NAVSEA OOC Photojournalist

Practice and training is an integral part of Navy salvage team responsibilities. Salvage ships in Service Squadron Eight (SERVRON EIGHT) are required to provide salvage, towing and diving services to the Fleet, and therefore must maintain a high state of readiness. To ensure that salvage capabilities are being maintained, each ARS/ATS must complete a three-week training evaluation every 18 months.

After an initial conference with the ship's Commanding Officer and SERVRON EIGHT representatives, observers from Mobile Diving and Salvage Unit TWO (MDSU-TWO) commence the administrative portion of the training evaluation. This includes verifying personnel records (all divers, officer and enlisted, must be qualified), and checking publications, logs, and PMS records to ensure they are current. Allowance lists are also compared to the ship's actual inventory to confirm that all required gear is on board.

Pumps and generators from the ship's inventory are also tested to ensure the top material condition of the gear, as well as the ability of personnel to maintain and operate it. Lifts are made with the ship's booms, verifying that the ship can execute the heavy lifts often associated with salvage operations.

The major portion of salvage training is the underway exercises involving the use of the "hulk" (exMSF 836). This training aid, maintained by MDSU-TWO, is turned over to the ship being inspected and towed to the training site.

During the first day of underway training tests, the ship's ability to fight a fire on another ship (the "hulk") at sea is tested. A small contingent of the ship's

All hands get into the action to take the beach gear aboard.

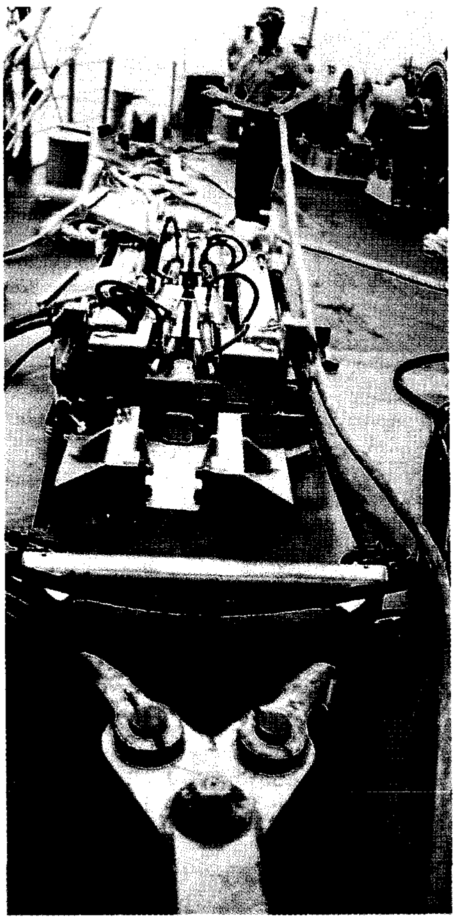
company is assigned to the "hulk" to cast it adrift, anchor it and ignite the contents of two dumpsters welded to the deck. When the fires are blazing the rescue ship pulls alongside with its monitors (firefighting nozzles are permanently mounted on the ARS to allow firefighting from a distance) to cool the fires, enabling the rescue and assistance detail to board the "hulk" and fight the fire.

With the fires out, the exercise ship again takes control of the "hulk," weighing anchor and taking it back in tow.

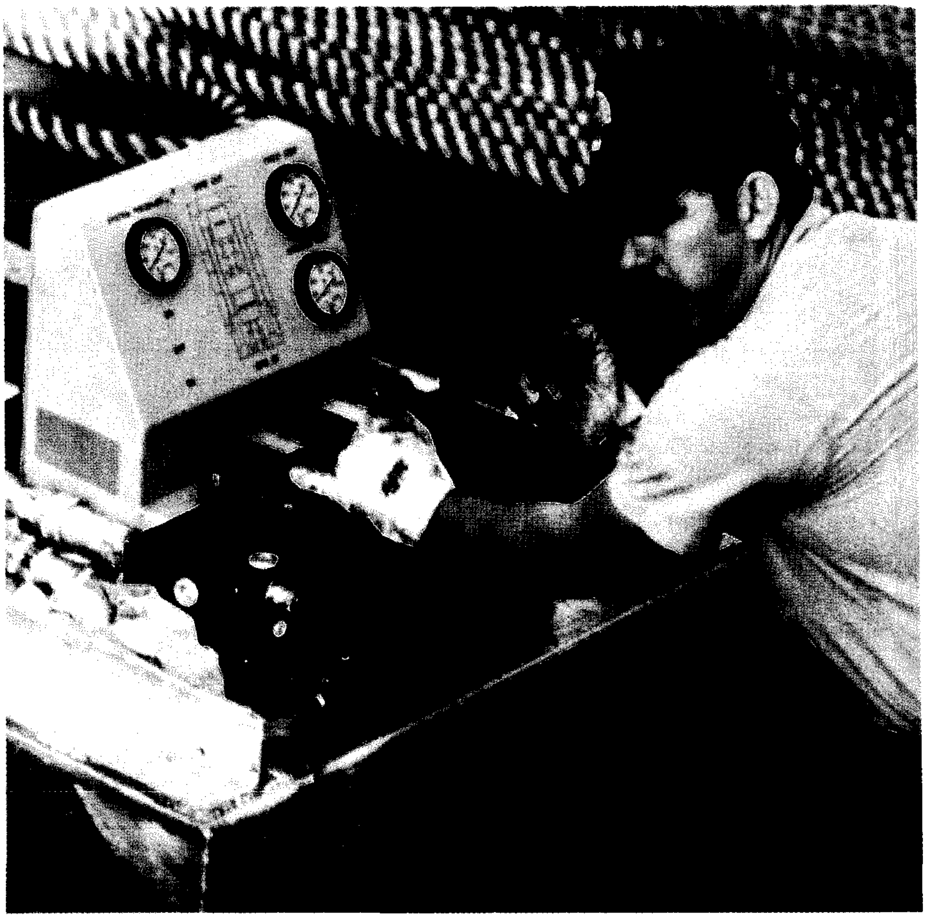
During the next high tide, the MK 8 chase boats from MDSU-TWO ground the "hulk" on the beach to prepare for the next stage of the exercise—the extraction of a grounded ship.

While the "hulk" is run aground and flooded by MDSU observers, exercise ship personnel rig beach gear on its fantail; two legs are required for this portion of the evaluation. At this time the ship's salvage officer will conduct a survey and submit a salvage plan to the

The Lookout scans the water to locate buoys marking a leg of beach gear to be brought on board.



Hydraulic cable pullers, developed by NAVSEA OOC to replace standard beach gear, improve the efficiency of salvage operation.



Manning the console, the operator carefully watches the cable pullers drawing the beach gear aboard.

Commanding Officer, with a copy to the senior observer.

After streaming the beach gear, evaluation officially begins. The beach gear legs are taken on board, rigged to standard beach gear on one side of the ship and to hydraulic cable pullers on the other. Simultaneously, a messenger is rigged to the "hulk" to transfer the tow wire between the fantail of the exercise ship and the beached "hulk."

When a strain of 30 tons is reached on both legs of beach gear, slack is given on all gear while the flooded spaces on the "hulk" are pumped dry. At any time during the dewatering and extraction process the ship's salvage officer may be required to give the senior observer the "hulk's" ground reaction and condition of stability.

When it is determined that the "hulk" is dry, the slack in the gear is taken out, extracting the "hulk" from the beach.

To closely simulate an actual salvage operation, Commanding Officers are directed to inject as much realism into the exercise as possible. Many times nature takes this into its own hands,

Crew members place cable from the leg of beach gear in the cable pullers.


A boatswain's mate on the forecastle releases the brake on the anchor chain as the ship anchors for the night.

using the wind and the sea to ground the "hulk" to the beach harder than planned, turning the exercise into an actual salvage operation.

After the "hulk" is extracted and returned to its berth and MDSU-TWO has once again taken custody, the observers meet with the Commanding Officer and SERVRON EIGHT representatives to critique the ship on performance.

Salvage training is a demanding process and requires 100 percent effort from the ship's team. Many days are spent in preparation for the exercise. "Getting into shape" therefore enables the ship to uncover potential problems that might ordinarily have gone unnoticed in the hustle of a salvage ship's life. When the exercise is complete, the crew is exhausted but confident of their ability to respond, at a moment's notice, to "any ocean, anytime."


LCDR Herb, Executive Officer, USS HOIST, returns from the "hulk" in the 35-foot workboat.

By CDR Frank Eissing, USN
Navy Experimental Diving Unit

NEDU Fly-Away Divers are: Free Swimmers at 300 FSW

In the modern Navy, deep diving has been almost exclusively the domain of the deep salvage and saturation diver. Surface or umbilical supplied gases, stages and winches, steady platforms and deck decompression chambers have allowed these men and women to achieve often difficult tasks. The self-contained Navy diver, whether using air or mixed gas, has been limited to the maximum depth that can normally be achieved within the bounds of no decompression diving and equipment capabilities.

The Navy's response to any need for deep diving has historically required a dedicated diving vessel with considerable support facilities, extensive breathing gas, mooring, life support and recompression chamber support. During the last five years, the U.S. Navy's purchase of MK 15 and 16 closed circuit Underwater Breathing Apparatus (UBA) has provided the Special Warfare and Explosive Ordnance Disposal diving communities with greatly improved diving capability. This self-contained, closed circuit, mixed-gas equipment has a depth potential as great as that of the surface supplied MK 12 or MK 1 used by the Navy salvage diver. In designing this equipment, a light, mobile deep dive system, independent of a dedicated dive platform that would offer advantages for certain sensitive diving operations and quick response diving was envisioned.

CDR Frank Eissing, CO, NEDU and Senior Chief Bill Ferrand, look over some of the mobile van support equipment prior to deployment.

To safely conduct self-contained diving from inflatable boats with minimum personnel, NEDU developed special mixed-gas decompression tables, open-ocean diving procedures and unique support equipment. In further support of a mobile dive system, NEDU designed, manufactured and tested many new systems, from emergency breathing equipment (used to prevent a stricken diver from compromizing decompression) to optical diver communications allowing operations in environments requiring low influence equipment. The fully independent mobile dive system consists of containerized workshops and stores, inflatable boats and breathing gases. It is capable of being transported by road and in single large aircraft to any suitable ocean platform for rapid response diving operations.

After 70 successful 200 feet of sea water (fsw) dives with the system during the spring of 1983 in the Gulf of Mexico, it was decided to push on to 300 fsw. Two months of training dives in both day and night scenarios formed a highly trained team ready for any emergency. Dive team members, including EOD, Special Warfare, Saturation and Salvage divers, were supported by medical and photography personnel. Using a USAF aircraft for transit from Panama City, Florida, to Norfolk, Virginia, and the USS PRESERVER (ARS-8) as a support craft, mixed-gas, self-contained diving and in-water decompression to a depth of 300 fsw in the open ocean was accomplished, the first such operation in the

Support equipment ready for transport to aircraft.

U.S. Navy diving history. The evaluation, which was conducted in September 1984, determined specific operating limits that included the proven practicality of 24-hour diving in up to 14-foot seas. The proximity of hurricane Diana to diving areas provided worst-case conditions.

Fleet use of this type of diving procedure will be primarily in support of mine countermeasures operations. Specially nominated and trained EOD teams will be instructed in the use of the newly acquired MK 16 UBA and will possess the mobility, flexible response and limited support capability so crucial to EOD operations; they will also be capable of attaining depths up to 300 fsw. NEDU also retains the mobile dive system and 300-foot dive capability to respond to any other special Fleet requirements.

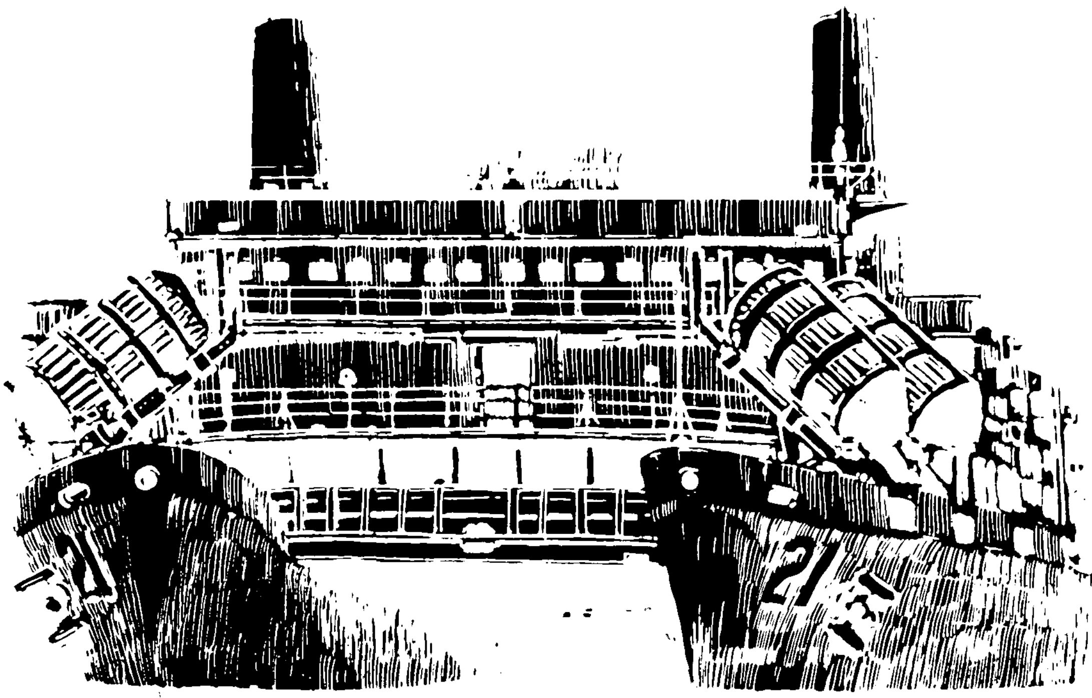
THE NEDU FLY-AWAY DIVING TEAM CONSISTED OF:

LT K. Wright, MCD, RN
CDR H.J. Schwartz
HMCM L.E. Burwell
CW04 R.C. Raseman
HTCM J.L. Scott
EMCS W.E. Ferrand
HTC T.R. Dingle
BMC G.T. Farmer
BMC T.L. Herron
QM1 J.A. Loman
HT1 T.D. Thompson
GMG1 D.A. Luther
MM1 C.W. Wentzel
BM1 W.T. VanDyke
PH1 N.T. Guest

Specially modified MK 15 UBA used for diving procedure evaluations.

Pre-dive brief of dive team.

USS PIGEON Recovers Projectile on Saturation Dive



By CDR Stephen R. Cleal, USN
Commanding Officer, USS PIGEON (ASR-21)

In mid-December 1984 USS PIGEON (ASR-21) was assigned to recover an air-dropped projectile deeply embedded in hard mud from the ocean bottom off Point Mugu, California; bottom depth was 400 feet. To facilitate locating the projectile, Pacific Missile Test Center (PMTC) personnel had attached a marker buoy to the target.

PIGEON departed San Diego 18 December, arriving early 19 December off Point Mugu to conduct a personnel transfer utilizing the PMTC torpedo retriever HM-8. During the transfer, it was discovered that the marker buoy had detached from the target and was floating adrift from the project.

In overcast weather with heavy squalls, the target was relocated with a hand-held sonar receiver, PIGEON's rubber boat, and geographic coordinates provided by PMTC personnel. The target's location was then marked with a Deep Ocean Transponder (DOT), attached by 500 feet of line to a crown buoy. Because the rubber boat was constantly being blown downwind from the target, placing the DOT near the target required extensive effort. The final DOT position, although not ideal, provided an excellent reference point for PIGEON's three dimensional sonar.

As heavy squalls continued to pass through the area, PIGEON began laying a four point moor. Each mooring leg consisted of a 5000-pound anchor, up to 32 shots (1 shot equals 90 feet) of one inch-and-a-half die-lock chain and a seven-ton steel mooring buoy. Two legs of the moor were laid on a relatively steep slope; due to the depth of the moor, the chain was walked out, rather than veered, on the deep legs. Ship control in the gusty winds provided a challenge as PIGEON laid each leg of chain toward the center of the moor.

All four legs of the moor were in place by the night of 19 December, and PIGEON night-steamed in the area awaiting daybreak. As 20 December dawned bright and clear, the target was verified within the moor. PIGEON completed the four point moor by attaching 10-inch double-braided nylon line from each quarter of the ship to one of the four mooring buoys; the average length of these 10-inch "fat-ropes" was about 650 feet. All legs of the moor were then pulled taut and adjusted to place PIGEON over the project. The location of the target was again marked using the hand-held sonar, and found to be 100 feet astern of PIGEON, just beyond reach. The process of hooking up the moor and drawing the legs taut had evidently straightened the chain on the port aft leg sufficiently to place the project out of reach of centerwell diving operations.

PIGEON tripped out of the moor about noon 20 December, and retrieved all four nylon mooring lines. The port aft mooring buoy and chain were recovered and the chain length reduced from 23 shots to 15. Although this provided only 1350 feet of chain in a water depth of 480 feet, the anchor was solidly set up slope and held securely. The mooring buoy was re-rigged for release during the afternoon, and by 1600 PIGEON was ready to begin connecting mooring lines to the recentered moor. By late evening 20 December, PIGEON was moored tightly, directly over the project.

Favorable weather continued on 21 December and four of the five saturation divers, who had been pressurized to a depth of 320 feet since 19 December, were transferred from the Deck Decompression Chamber (DDC) to the Personnel Transfer Capsule (PTC). The PTC was moved from the mated position (with the DDC) to the centerwell lift platform; the lift platform and PTC were then lowered to a depth of 30 feet where the PTC was given a final check by surface-supplied divers before being released and lowered to a depth of 370 feet.

Two of the four divers exited the PTC at 370 feet and began a search in the mud at 400 feet; the bottom was reported as one foot of silt over hard-packed clay. The target was located by the divers at 1100 on the 21st. The first team of divers cleared the work site of line, attached a surface retrieval line to the project and began excavating the eight-foot long projectile, one foot of which protruded above the mud. The second two-man team in the PTC relieved the first team early in the afternoon, and excavation continued. While digging was in progress on the bottom, a hand-tended strain was taken on the surface retrieval line and rigged through a block on PIGEON's port aft bridge crane outrigger.

At 1600, an offshore ("Santa Ana")

wind arose, increasing from zero to 25 knots in 45 minutes. With the wind almost directly off the starboard quarter, PIGEON was eased away from the project; the surface retrieval line tended under the bilge keel, and chafed through. With the wind speed continuing to increase, the divers were returned to the PTC which was returned to the surface and remated with the DDC after a 13-hour excursion. The entire port complex was maintained at a depth of 340 feet. By 1800, wind speed was 30 knots.

Recovery Team

SALVAGE OFFICERS	LT R.A. MIRICK, DEEP SUBMERGENCE OFFICER (D) LT D.K. LUECK, DEEP SUBMERGENCE OFFICER (R)
RECOVERY OFFICER	CW03 S.A. MILLER, WEIGHT HANDLING OFFICER
MEDICAL OFFICER	LCDR W.L. LITTLE, DIVING MEDICAL OFFICER (COMSUBDEVGRU ONE)
DEEP DIVE WATCH OFFICERS	CW02 C.O. WESTBROOK, DAMAGE CONTROL ASST. LT J.C. NELSON, MAIN PROPULSION ASST.
MASTER DIVER	BMCM(MDV)(SS) W.H. SHORT, DIVE DIVISION OFFICER
DIVE TEAM	ENCS(DV)(SS) R.E. CASE, TEAM LEADER EMCS(DV) J.A. CANTALE, SATURATION DIVER BMC(DV) J.P. CROW, SATURATION DIVER HT1(DV) D.S. NACE, SATURATION DIVER HT1(DV) J.L. KING, SATURATION DIVER
DEEP DIVE WATCH SUPERVISORS	MMCV(DV)(SW) R.K. CADWELL, SATURATION DIVER QMC(DV)(SS) T.R. GRIGGS, SATURATION DIVER ENC(DV)(SS) C.L. CHAPMAN, SATURATION DIVER

Dive Statistics

LEFT SURFACE	1858	19 DEC 84
REACHED BOTTOM	2209	19 DEC 84
LEFT BOTTOM	2300	22 DEC 84
REACHED SURFACE	1340	27 DEC 84

TOTAL BOTTOM TIME	3 DAYS	4 HOURS	02 MINS
TOTAL DECOMPRESSION TIME	4 DAYS	12 HOURS	40 MINS
TOTAL TIME OF DIVE	7 DAYS	18 HOURS	42 MINS

MINIMUM DEPTH	320 FSW
SATURATION DEPTH	340 FSW
MAXIMUM DEPTH	414 FSW

PIGEON rested securely in the moor throughout the night of 21 December and during the morning of 22 December as the wind held steady at 30 knots from the northeast. At 1000 on the 22nd, wind speed had decreased to 25 knots and preparations were made to warp back to the projectile by adjusting the length of the "fat rope" mooring lines, using the Deep Ocean Transponder as a reference to place PIGEON directly over the target. The warp was completed as the wind decreased 18-20 knots, where it remained throughout the remainder of the day. The PTC was launched shortly after noon and the divers re-located the projectile immediately. A second surface recovery line was attached, and again a manual strain was taken topside. Divers began excavation, removing mud which had filled in the previous excavation overnight. An air lance was lowered to the divers who used the tool to good effect in chipping out the adobe-like mud. Digging continued through the afternoon, with the divers alternately using the air lance, shovels and their hands.

Around 1800 on the 22nd the target became lively, and at 1830 it broke free of the bottom. The divers were returned to the PTC after clearing all hoses and lines; manual inhaul on the recovery line was commenced topside. The target was placed on deck in the centerwell at 1930 hours.

PIGEON then warped 100 feet in the moor to allow the PTC divers to reach the location of the DOT. The marker buoy line for the DOT had parted during efforts to relocate the DOT directly on the target, necessitating recovery of the DOT by the divers. Recovery was completed in short order and the PTC was returned to the surface and remated to the DDC, where the divers received a hot shower and meal locked down from PIGEON's galley. The duration of this second PTC excursion was 10 hours.

The target was secured for transfer to PMTC and passed to HM-8 at 2200 on 22 December. PIGEON recovered the four point moor on 23 December and arrived in San Diego early 24 December. The five saturation divers, who began decompression at 2300 on 22 December, continued decompression through Christmas Day, surfacing in mid-afternoon 27 December.

New Equipment Developments for the Fleet

By LT Susan J. Trukken, USN
Navy Experimental Diving Unit

Experience is a great teacher and the U.S. Navy Fleet diver has a lot of experience. Unfortunately, the Navy diving program is not getting the full benefit of this excellent source of information. In part, this is due to a lack of information at the Fleet level. If you have a sound idea to improve procedures, equipment, or if you know of a commercial company that has something the Navy should test, submit your idea in a letter, enclose any information, such as company brochures, have it endorsed through your chain of command and forward via CNO to Naval Sea Systems Command (OOC) Washington, D.C. 20362-5101. This will allow NAVSEA to put all of the proper experts on the suggestion. Direct liaison with NDSTC or NEDU is not the proper channel for these suggestions and slows down the process by adding an extra stop.

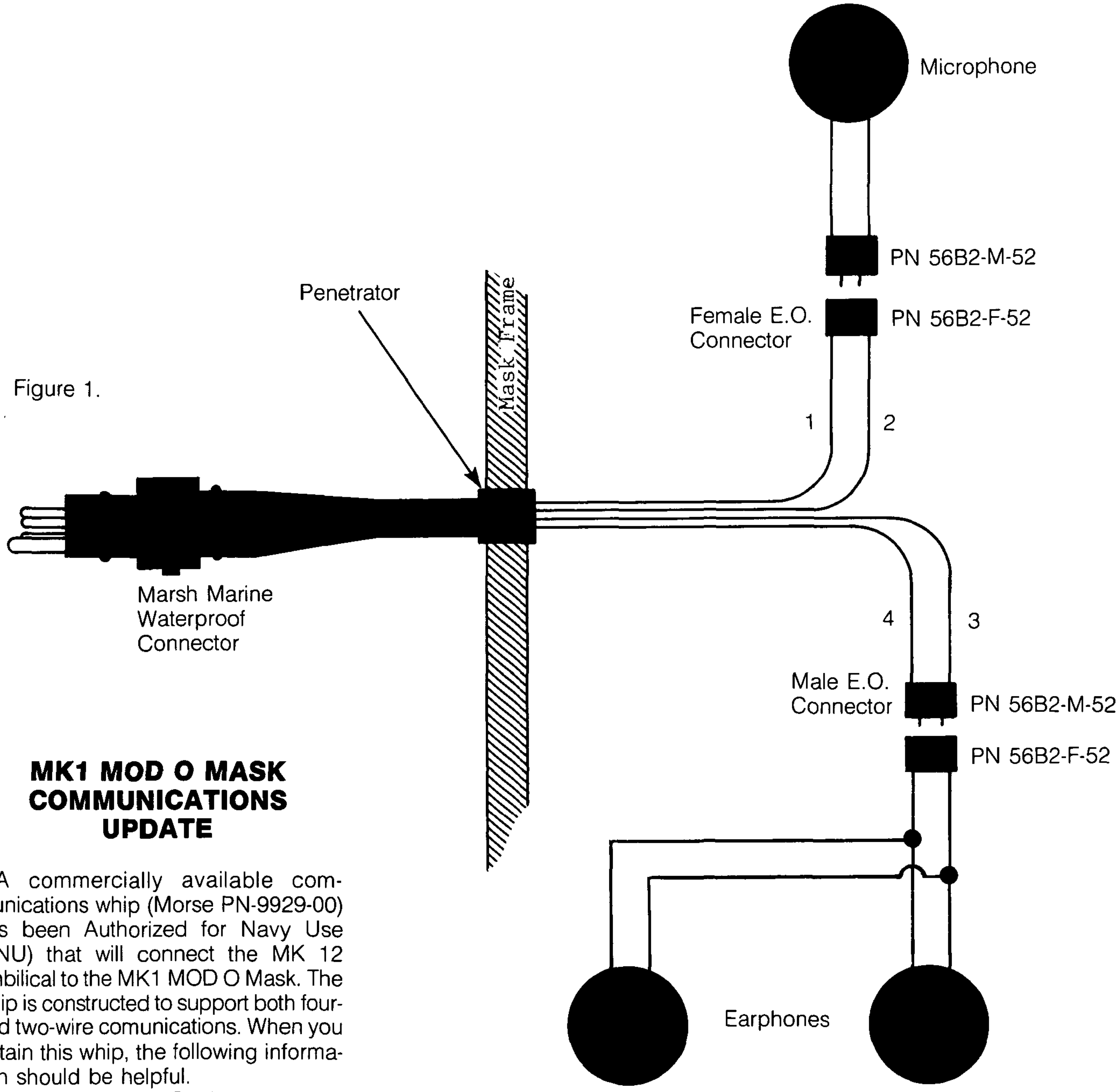


Figure 1.

MK1 MOD O MASK COMMUNICATIONS UPDATE

A commercially available communications whip (Morse PN-9929-00) has been Authorized for Navy Use (ANU) that will connect the MK 12 umbilical to the MK1 MOD O Mask. The whip is constructed to support both four- and two-wire comunications. When you obtain this whip, the following information should be helpful.

The MK 1 MOD O Mask currently uses a two-wire communications system. When the communication connections are hooked to the binding posts, an electrical short is created in the water that seriously degrades communications. These shorts are caused by a two-lug connection exposed on the outside of the mask frame that is not waterproof. Speech clarity and intelligibility can be greatly improved if a four-wire system is used. A mask wired for four-wire communications can still be used with a two-wire communicator (comm box). The following procedure describes how to wire for both two- and four-wire systems.

The mask should be rewired as follows: Connect pins 1 and 2 of the Marsh Marine connector to the microphone, and pins 3 and 4 to the earphones. Electro Oceanics (EO) connectors can be used with the MK 1 MOD O Mask microphone and earphone components (Figure 1). A male EO connector (EO part no. 56B2-M-52) should be installed on the microphone leads, and a female connector (EO part no. 56B2-F-52) on the earphone leads. The wires from the Marsh Marine connector that penetrate the mask frame through the packing gland should also be connected to EO connectors. The wires from pins 1 and 2 (microphone) should be connected to a female EO connector and the wires from pins 3 and 4 (earphones) to a male EO connector (same part numbers as above). The binding posts on the mask frame should not be electrically connected to any of the leads.

To use the above rewired mask with a four-wire comm box, match the microphone wires (pins 1 and 2) to the topside connections marked microphone on the comm box and the earphone wires (from pins 3 and 4) to the earphone connections on the comm box (Figure 2).

To use the rewired mask with a two-wire comm box, first short the topside wires from pins 1 and 4 together. Next, short the topside wires from pins 2 and 3 together. The shorting should be done at the topside end of the diver's cable (Figure 3).

These changes will greatly improve your communications with either four- or two-wire communications. You will be surprised at the improvement when using the MK 1 Mask.

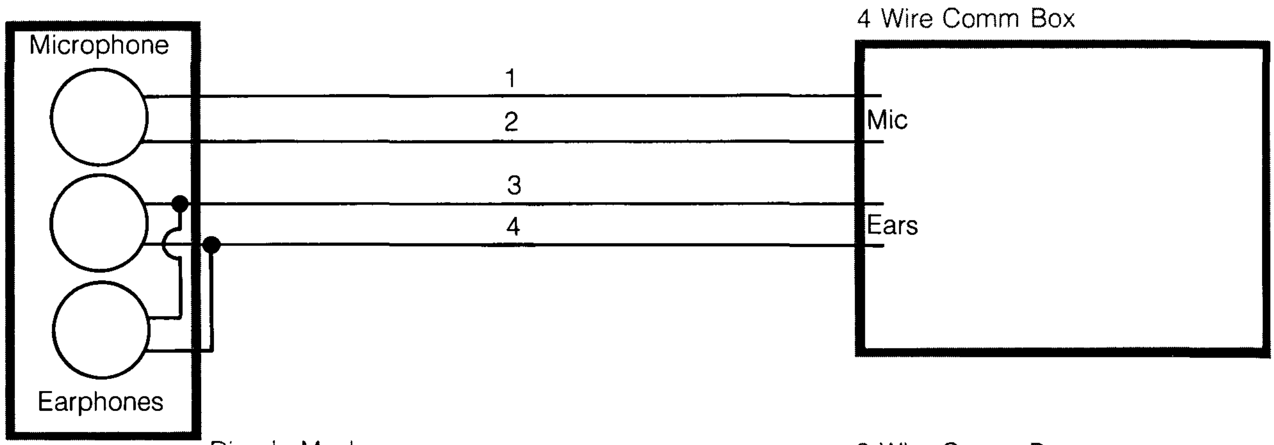


Figure 2.

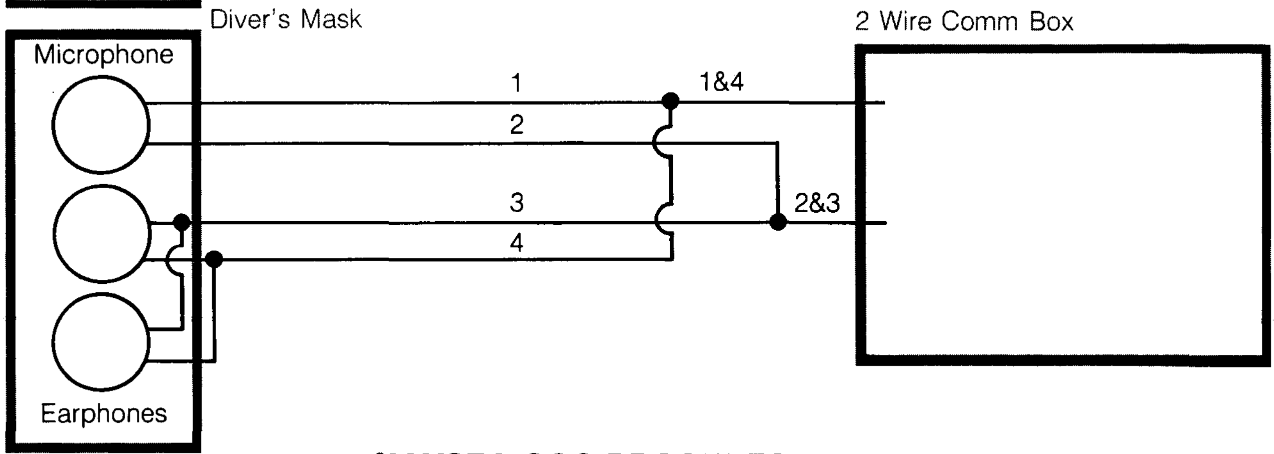


Figure 3.

NAVSEA OOC PROCURES NEW COMM BOX FOR THE FLEET

"Say again," is frequently heard on many diving stations while diving MK 1 or 12. NEDU, as directed by NAVSEA OOC, has completed testing three-diver communication boxes from four different manufacturers in an effort to eliminate the communication problem in the Fleet. Of the four units tested, only one met Navy standards of intelligibility. The HYDROCOM, manufactured by Hydro Products of San Diego, California, successfully passed all phases of test and evaluation. The comm box was tested for intelligibility, durability, and for resistance to water and temperature extremes. The HYDROCOM is compatible with both the MK 1 MOD O Mask and the MK 12 SSDS and should be available to the Fleet in about a year. The new comm box will provide a tremendous improvement for diver communications and increase flexibility in surface-supplied diving operations. The HYDROCOM features four-wire, party line communications, eliminating the need to "push to talk." Additionally, there is an optional helium speech unscrambler circuit board which can be plugged in easily.

MK 1 MOD O INTEGRATED DIVER'S VEST

A revised integrated Diver's Vest (IDV) was tested recently by NEDU. The improved model is constructed of a material that is resistant to fraying and the strips are sturdy and slip-resistant. The zipper has been replaced with straps and D-rings and the backpack is no longer sewn into the fabric, but is installed with strapping and quick release pins. This IDV will make PMS and repairs easier while lasting longer. A final prototype is now being completed and will be made available to the Fleet once evaluated.

HAND-OPERATED PRESSURE CALIBRATION UNITS

The Navy Experimental Diving Unit has tested and approved two Hand-Operated Pressure Calibration Units. The units, made by 3D Instruments Inc., are for testing the accuracy of both high and low pressure gauges in the field. Any calibrated gauge can be used to make the comparison. The accuracy of the units was found to be within 0.25 percent. The title of these units and the accompanying technical manual state that the units may be used for calibration. In fact, they may only be used to compare pressure measuring devices to verify accuracy. Calibration can only be accomplished by an official calibration activity.

Naval Medical Resear

By Don Chandler, Maureen Darmody and Tanya Ramey,
NMRI

CAPT Edward Flynn, MC, USN,
Scientific Advisor

Editors Note: The following are brief descriptions of research projects currently underway at the Hyperbaric Medicine Program Center (HMPC), Naval Medical Research Institute (NMRI). Personnel at NMRI want divers to know about their work to make the undersea environment less hazardous. If you would like more information on these studies, contact Don Chandler or Maureen Darmody at HMPC, NMRI, Bethesda, Maryland 20814, telephone (301) 295-5866.

Maximum Likelihood: Dependable Decompression Tables on the Horizon

Every experienced diver knows that decompression tables are not uniformly safe and reliable across the board. Some tables are commonly regarded as bad and Naval Safety Center statistics confirm this subjective impression. While the incidence of decompression sickness (DCS) is less than 1 percent for the tables overall, the risk of decompression sickness for certain tables may be as high as 5 percent. The bottom line is that the Navy currently needs more consistently accurate and safe decompression schedules to fulfill its mission, particularly in those critical operations that carry a greater risk of decompression sickness. In these latter cases, the Navy must have at its fingertips accurate decompression information to weigh the needs of the Fleet and the operation against the risk of DCS, and then devise the best operational strategy.

Thanks to milestone research at the Naval Medical Research Institute's (NMRI) Hyperbaric Medicine Program Center (HMPC), safe and reliable decompression tables need no longer be an unattainable goal for U.S. Navy divers. The long sought means to derive dependable decompression tables appear to rest with a powerful statistical tool called the maximum likelihood principle.

Let's look at the background of USN decompression tables to appreciate this research coup. Current USN decompression tables suffer from a lack of definable and uniform safety limits for all Navy divers. This is not surprising as the tables have been derived during the past 75 years primarily by means of lengthy trial and error tests. These rough cut-and-fit methods were born of necessity; the available subjects and time were limited, and modern biophysical, mathematical and statistical evaluation tools were not widely available.

This lack of a hard scientific approach is best reflected in two observations about the current tables. First, they do not take into account individual variability in response to decompression. Experience has shown us that as in many biological processes, people do not respond in the same way to the same circumstances. For example, a particular decompression schedule may induce DCS in one or two divers on a given day, but not necessarily in the other divers participating in the same operation. Stranger yet, the same schedule may not induce DCS in the originally afflicted divers on a different day! Here we are dealing not only with differences between individuals, but differences in the way the same person responds to decompression as well.

A second important observation about the current USN decompression tables is that because they were derived largely through trial and error, we now have several sets of tables for different diving operations whose surfacing rules, the limits used for the calculations, are not compatible. Thus, one cannot transfer the rules for one set of tables to another and obtain reliable predictions of DCS risk.

Previous assumptions about decompression risk have relied on the principle of a critical threshold, a point at which a diver definitely gets the bends if he violates the surfacing rules of the decompression schedule he is using. The threshold may be theorized to be a number of things from the quantity of

MEDICAL ADVANCES FOR DIVERS

gas bubbles in the diver to the level of gas saturation in the diver's tissues. Whatever the mechanism at work, the idea is that the bends are inevitable for all divers once the critical threshold is exceeded.

The principle of maximum likelihood, on the other hand, maintains that the vast differences in the ways individual divers respond to decompression is the most certain feature of DCS. Not all divers will suffer bends even if the tables are shortened considerably. So rather than specifying critical thresholds for decompression tables that classify diving conditions as either completely safe or completely unsafe for everyone, maximum likelihood analysis indicates the *probability* of getting DCS as the decompression time is varied. For example, a probability of .01 would indicate that there is one chance in 100 of getting bent, a probability of .20, one chance in 5.

Because maximum likelihood is based on solid statistical principles of probability, it can be used to quantify decompression risk and recommend safe diving procedures. Furthermore, this technique can guide human decompression trials, which are occasionally performed under dangerous conditions, so that a minimum number of subjects are used while obtaining reliable answers to specific questions on diving profiles.

Analysis of current USN decompression tables by maximum likelihood is a young and evolving research area, but HMPC scientists have been able to see certain patterns to date in their application of this method to data from both diving trials and actual operations. In an initial trial, the risk of the current USN tables for HeO_2 unlimited duration saturation-excursion dives was analyzed. In their most recent application of maximum likelihood, our researchers examined reported data from American, British and Canadian Naval decompression trials that included more than 1,700 individual exposures to decompression from standard air dives. The investigators found a wide range of hazard in the cases examined. It appears from the data that short standard air dives are quite safe, even to moderately deep depths, while long dives are risky, regardless of depth. A conclusion that will not surprise many Master Divers is that dives that are both deep and long are the greatest risk of all.

Even at this early stage, maximum likelihood analysis can be used to calculate new decompression tables for testing. Expansion of the underlying data base and refinement of the maximum likelihood technique should produce better predictions of DCS risk for particular dive profiles. In the near future NMRI will attempt to develop a new set of standard air decompression tables for USN diving operations that are uniform and have a very low level of decompression risk. The ultimate goal is a single method of calculating decompression requirements for the many forms of diving practiced by the Fleet. This method would standardize procedures and allow for free interchange of breathing gases while maintaining a low and predictable probability of DCS.

ACKNOWLEDGEMENTS

CDR P.K. Weathersby, MSC, USN of NMRI engineered the maximum likelihood analysis of USN decompression tables. He has been aided extensively by NMRI colleagues Dr. L.D. Homer, LT B.L. Hart, Mrs. S. Survanshi, Mr. J.R. Hays, CAPT E.T. Flynn, and CAPT M.E. Bradley.

The Case for Maximum Likelihood Further Strengthened

Over the years, scientists have speculated whether breathing a 40 percent helium/40 percent nitrogen/20 percent oxygen mixture during diving would lessen the decompression requirement when compared to breathing a mixture of 80 percent nitrogen/20 percent oxygen or 80 percent helium/20 percent oxygen. If the risk of decompression sickness is related to the partial pressure of the inert gas, and if inert gases act totally independently in the production of bends, then the multiple inert gas mixture should be vastly superior. At any depth the partial pressure of each inert gas in a multiple inert gas mixture would be only one half that of a single inert gas mixture. Despite the promise of this idea and some favorable Navy trials in the 1960s, past studies have failed to produce convincing evidence for or against the superiority of a multiple inert gas mixture. Past experimental designs and methods of data analysis have simply not been adequate to deal with the question. Recently, researchers at HMPC conducted studies to reexplore this question and analyzed the results with the powerful new analytical tool, maximum likelihood.

In the HMPC studies, experimental animals breathed gas mixtures containing various combinations of helium, nitrogen, argon and oxygen in simulated saturation dives, followed by rapid decompression. The most important finding was that the gases differed in their abilities to cause DCS. Argon had the most potential for causing DCS, followed by nitrogen; helium was least apt to cause DCS. Mixtures of nitrogen

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and helium or argon and helium were clearly superior to nitrogen and oxygen or argon and oxygen mixtures alone, but no mixture was superior to helium and oxygen. Researchers point out that they don't know yet to what extent these findings can be applied to human decompression data. Nonetheless, through maximum likelihood analysis our researchers were able to establish firm statistical predictions for the expectation of the possible advantage or disadvantage of one breathing gas mixture over another. Perhaps more importantly, they were able to validate the maximum likelihood technique as a completely satisfactory tool for the analysis of human decompression data and were able to predict the size of a human trial necessary to resolve a question that has lingered more than 20 years.

ACKNOWLEDGEMENTS

Dr. R.S. Lillo was the leading investigator for this decompression study. CAPT E.T. Flynn, MC, USN, collaborated in these efforts with Dr. Lillo.

Researchers Now Recognize Pulmonary Edema as Important Aspect of DCS

By virtue of its central location within the blood circulation, the lung is a major recipient of the gas bubbles formed during decompression. Surprisingly, though, the response of the lung to stressful decompression has not been described completely in past studies. A team of researchers at the Hyperbaric Medicine Program Center set out to study the response of the lungs and airways of animals to severe decompression and to obtain a more complete picture of this process in animals and its possible association to reports of lung and airway problems in man during DCS.

Caisson workers, divers and aviators, who all work in environments of variable atmospheric pressure, occasionally develop burning pain under the breastbone, coughing and difficulty in breathing as a part of the decompression sickness syndrome. In addition, these workers may experience a significant drop in blood pressure and blood oxygen level, leading to circulatory collapse. Collectively, these signs and symptoms are termed the chokes. Researchers at HMPC studied if and how the chokes syndrome affects animal lungs and airways under great decompression stress.

As expected, researchers found large amounts of gas in most of the blood vessels of dived animals. Other typical effects observed were increased blood pressure in the lungs, low blood pressure throughout the rest of the body, excessive thickening of the blood and a lack of sufficient oxygen in arterial blood. By far the most significant finding was the presence of pulmonary edema, an excess of fluid in the lungs and airways. This phenomenon was observed in nearly all dived animals. It was postulated that edema fluid in and around the air passages may be the mechanism behind chokes.

What puzzles scientists is how pulmonary edema develops after decompression. Some researchers have suggested that an increase in lung blood pressure is the mechanism at work. Investigators here pose an alternate explanation. They believe pulmonary edema is more likely attributed to a change in the microvascular permeability of the lungs due to air bubbles formed during decompression. In a nutshell, gas bubbles through a variety of mechanisms cause the lining of blood vessels in the lungs and airways to become leaky or more vulnerable to fluid penetration, resulting in a build-up of excess fluids.

Another possible cause of pulmonary edema after DCS, HMPC researchers note, is injury to the central nervous system. Injury to the central nervous system is well documented in decompression sickness and results from obstruction of blood vessels by gas bubbles. Researchers reported they commonly observed gas bubbles in the vasculature of the brain and spinal cord in this study.

Whatever the mechanism behind pulmonary edema in DCS, investigators at HMPC emphasize that pulmonary edema appears to be a common response of the lungs and airways among man and other species to decompression sickness. Through their efforts, we have an increased understanding of both general and specific effects of decompression. This understanding has shed some light on the chokes syndrome in man and has presented further directions for study.

ACKNOWLEDGEMENTS

CDR P.W. Catron, MC, USN, directed the efforts of the nine member research team for this study. Other team members are CAPT E.T. Flynn, CDR L. Yaffe, Mrs. L.B. Thomas, Mr. D. Hinman, Mrs. S. Survanshi, HM2 J.T. Johnson, ENS J. Harrington, and CAPT M.E. Bradley.

The OLD MASTER

At one time or another we all need to talk to someone responsible for a piece of equipment, but we just don't know who the best person is. With this in mind, you should be aware of the names of personnel in the Office of the Supervisor of Diving and their responsibilities.

CDR Raymond Swanson is the Supervisor of Diving and Mr. Walt Bergman is Branch Head and Assistant Supervisor of Diving.

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In the next issue I will let you know who's in the Salvage Division of The Ocean Engineering Directorate.

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