NAVAL RESEARCH

REVIEWS

JULY 1973

PROFILES IN SCIENCE

Dr. Jerome Namias

Dr. Jerome Namias is research meteorologist at Scripps Institution of Oceanography and was the former chief of the extended forecast division of the National Weather Service. He is known for developing methods for studying interactions between wind and weather systems over vast areas of the Earth and for long time intervals up to a season. These studies, which have been supported for many years by ONR, lead to a better understanding of short-period climatic fluctuations and to economically valuable methods of predicting the character of the weather for periods ranging from 5 days to a season. Dr. Namias discovered ways of improving weather analysis and invented ways of estimating pressure and wind patterns over areas where data was sparse. Dr. Namias was among the first to study the effects wind and weather patterns had on sea-surface temperatures. Abnormalities in these patterns in turn provided long-lasting heat reservoirs that could affect subsequent large-scale weather patterns. Thus the ocean and atmosphere must be treated as coupled media for proper long range forecasting. After 1959 Namias devoted much of his research to documenting these interactions and identifying casual factors. He believes that the solutions to the challenging problems of improving forecast accuracy will continue to be found in the combined physica-statistical-synoptic attack, but with increasing emphasis on physical methods.

Research at the Naval Undersea Center*

ORGANIZATION AND FACILITIES

The Naval Undersea Center (NUC), San Diego, California was organized as a major command in 1967 from selected elements of the Naval Ordnance Test Station, China Lake and Pasadena, California and the Navy Electronics Laboratory Center, San Diego. Part of the staff from the Marine Bioscience facility, Naval Missile Center, Point Mugu, California was added later. From these beginnings has evolved a research and development (R&D) center with a staff of more than two thousand, including a military contingent of approximately three hundred officers and men. The center is a major command within the Navy, and its Commander reports directly to the Chief of Naval Material.

NUC's scientific efforts are divided among six major, or line departments: fleet engineering, undersea systems, undersea surveillance and ocean sciences, sensor and information technology, ocean technology, and computer sciences and engineering.

The military complement is divided largely between San Diego and Long Beach. A few of the officers and most of the enlisted personnel are assigned to the Operations Department, which supports San Clemente Island's test operations, and mans the support craft based both in Long Beach and in San Diego.

An extremely high caliber of personnel is attracted by NUC. Some 423 of the staff are college graduates with BA or BS degrees, 228 others hold master's degrees, and ninety-four PhD's. Disciplines represented span the engineering/science spectrum.

The facilities of NUC consist of the headquarters in San Diego which is the largest activity followed by the Pasadena branch, with its nearby torpedo facility at Morris Dam. Another branch activity is located in Hawaii at Kaneohe Marine Corps Air Station. The Hawaii Laboratory concentrates on marine mammal research, and in development of undersea technology. The warm, clear water off the island of Oahu are ideal for programs requiring underwater work for extended periods. It is here that training and handling of marine mammals to perform naval tasks takes place, together with considerable physiological research.

NUC exercises administrative and operational control over San Clemente Island, some fifty-seven miles off the Southern California coast. Here the Center conducts a wide variety of developmental test

*This article was compiled by Carolyn J. Smith, Assistant Editor of Naval Research Reviews, from material supplied by Ivan L. Manning, Public Affairs Officer at the Naval Undersea Center.

programs in an environment relatively safe from interruption or compromise. It was at San Clemente Island that the Polaris missile was first tested, followed later by Poseidon. Long Beach, California is the site of the support facility for test operations on and near San Clemente Island. Several torpedo recovery craft are berthed at the U.S. Naval Station there, together with a diving locker and attendant personnel.

A relatively small facility at Lake Pend Oreille, Idaho, calibrates and tests sonar transducers too large for the Point Loma TRANSDEC pool. The deep, quiet waters of the lake are ideal for this work. Depths in excess of one thousand feet have been measured. NCU has a small unit at Cape Prince of Wales, Alaska, where year round studies of the Arctic environment are conducted. Approximately forty ships and crafts of various sizes and types are assigned to NUC in support of one or another on-going oceanographic research projects.

A submarine of Submarine Development Group (SubDevGrp) One, the deep diving USS *Dolphin,* used in communications and sonar research, is assigned nearly full time to the Center. Other craft range from small, specialized boats to the USNS *S. P. Lee,* a full-fledged oceanographic research ship capable of extended voyages. A ninety foot sailing yawl, the *Saluda,* is maintained as a research platform for sea tests where a non-metallic hull and no engine noise are important requirements.

The physical capabilities of the Point Loma headquarters complex are surprisingly extensive. They include the Transducer Evaluation Center, or TRANSDEC, a huge, million gallon freshwater pool. TRANSDEC provides a carefully configured water environment for testing sonar transducers. Essentially echo-free, the pool is isolated against structure-generated noise which might enter the water and distort sound measurement.

The Center operates an oceanographic research tower in shallow water approximately a mile off San Diego's Mission Beach (Figure 1). The tower permits field measurements in a laboratory environment for studies of water motion, temperature, underwater sound propagation, marine biology, chemistry and geology.

Facing the open sea on the Northwest side of Point Loma is the marine life sciences laboratory. Here the Center conducts a program of mammal research with sea lions, porpoises and whales. Of special interest are such aspects of mammal biology and physiology as nutrition, disease control, echo location, and development of new and better foods for mammals in captivity. The marine life sciences program of NUC is perhaps the broadest presently underway anywhere in the country.

The Artic Submarine Laboratory of the Center is the only one of its kind in the free world. The facility creates climactic conditions simulating those of the polar regions. Refrigeration equipment and generated low

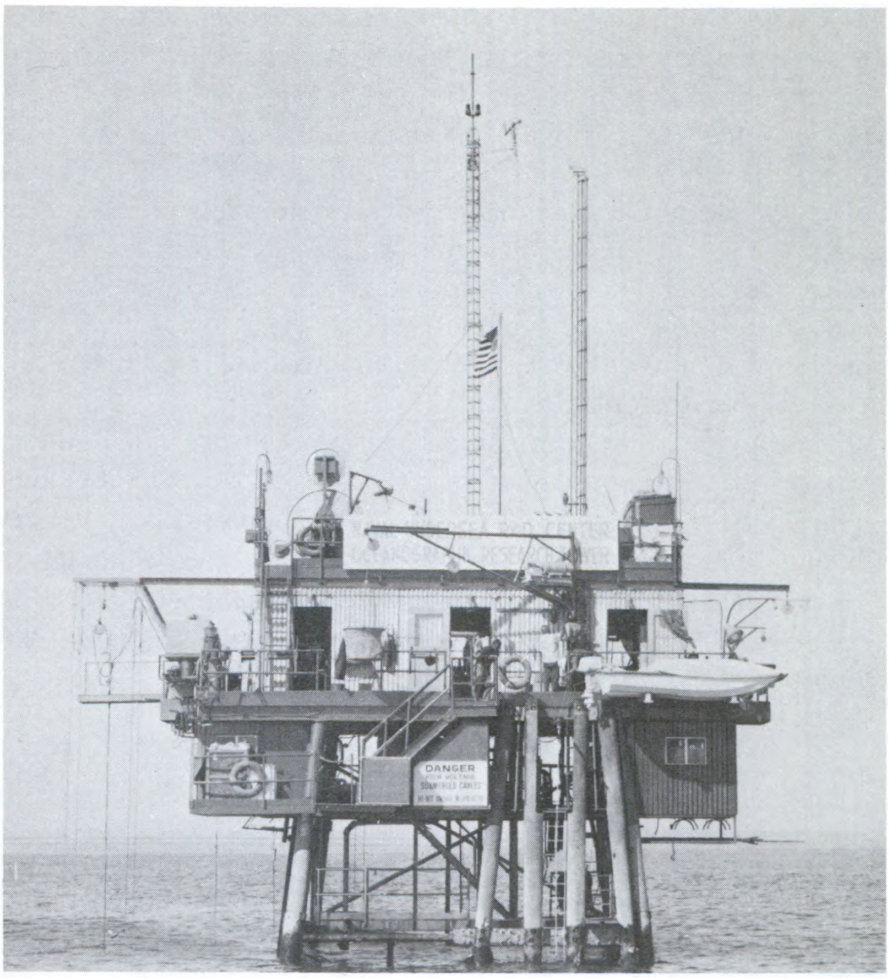

Figure 1 — The oceanographic research tower at NUC

velocity winds form thick ice floes in a seventy-five foot long, thirty foot wide seawater pool. A submarine sail is mounted on a hydraulically operated carriage in the bottom of the pool. The carriage can be moved upward, bringing the sail into contact with the underside of the ice much as a surfacing submarine might do. NUC scientists can make measurement of pressures created, and study crack patterns. The Arctic Laboratory also does investigations into icing of periscopes, snorkel masks and antennas. A cold room in the facility is of sufficient size to study the effect of extreme cold on a D-6 tractor, or a Marine Corps LVT (tracked landing vehicle) operations.

The Center's accomplishments ably reflect its recent redefined mission: "To be the principal Navy research, development, test and evaluation center for undersea surveillance, ocean technology and advanced undersea weapon systems." The military applications of NUC work are by no means the entire story. Spin-offs of value to civilian life have emerged from Center research, just as has been the case in the nation's space program.

NUC's work on the use of polymers in drag reduction has led to the possibility of employing the principle in the medical profession's treatment of blood pressure problems. It appears possible that polymers introduced into the blood stream *via* saline solution or plasma may be able to ease the flow of blood through constricted vessels. The same principle applied to fire hose may provide improved nozzle velocity, and permit the use of smaller diameter hose.

Another researcher studying venomous sea snakes has broadened his investigations into other types of venom. He is currently exploring the possibility of using bee venom in the treatment of arthritis and some types of heart problems.

NUC researchers, the Bureau of Marine Fisheries, and the tuna fishing industry are cooperating in an effort to develop methods of saving the lives of an estimated two hundred thousand porpoises accidentally and unintentionally killed each year by the tuna fishing industry. Porpoise schools are common indicators of the presence of schools of tuna beneath them. Seining for tuna has, in the past, meant entrapping large numbers of porpoises at the same time.

Two NUC bioacoustic scientists have developed a system to broadcast killer whale sounds below the surface of the water. The broadcast of the sounds of the killer whale, coupled with a redesigned net of smaller mesh less likely to entangle the porpoise, and with new "backing down" seining techniques by the fishing boat skipper may be one answer to the problem. One recent test resulted in safe escape of nearly ninety percent of the encircled porpoises.

The Naval Undersea Center performs extensive research in numerous areas. However, this discussion will be limited to its research in three major areas: Mammal Training, Oceanographic Vehicles, and the Simulation Facility.

MAMMAL TRAINING

Quick Find

The Center has provided significant results in locating and recovering objects from the seafloor. Through the use of sea lions, the NUC laboratory in Hawaii has been able to retrive objects at depths of five hundred feet.

NUC marine bioscientists knowing that sea lions can dive to at least seven hundred and fifty feet devised Project "Quick Find" and began to explore the possibility of using these animals to assist in the recovery of submerged objects (Figure 2). Until now the Navy was limited to the use of divers who are depth-limited, or submersible vehicles which are difficult and expensive to transport. Divers, whether scuba or

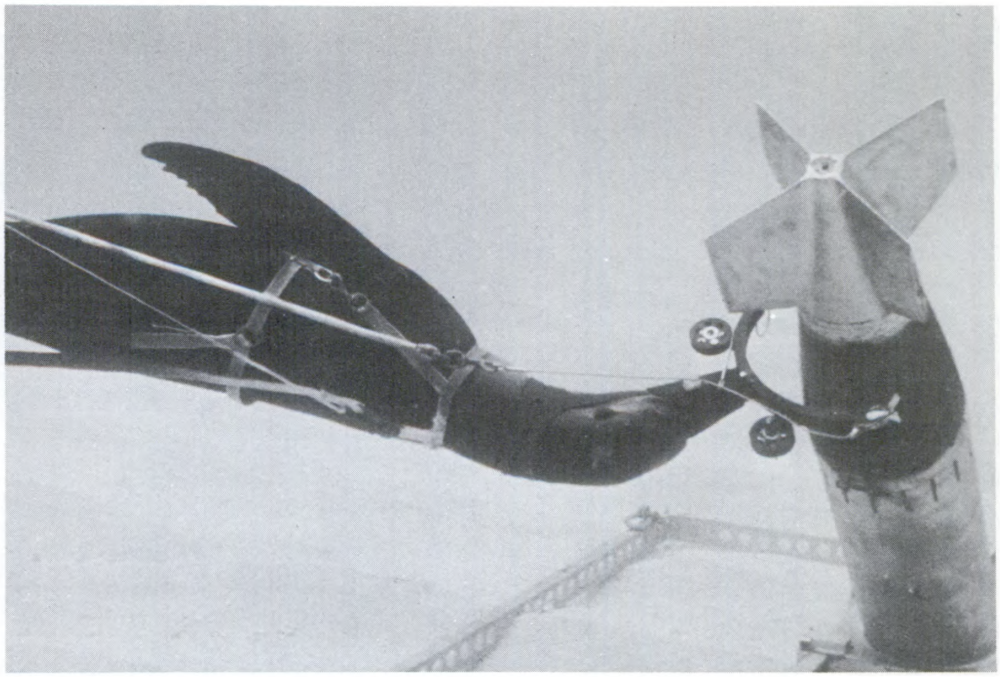

Figure 2 — A sea lion trained in the "Quick-Find" program attaches the grabber device to a simulated torpedo target. The line attached to the grabber is then hauled in, bringing the piece of hardware with it.

hard-hat, are also limited in the amount of time they can work underwater. Additionally, teams of divers must be used when men are required to work on the sea floor. In early, 1969, a number of sea lions were selected from island rookeries off the California coast by NUC's Marine Bioscience Facility at Point Mugu. The mammals were then flown to the NUC laboratory in Hawaii to be trained.

Sea lions adapt quickly to a training environment. They can be captured wild, and within two to three weeks will submit to a harness. The harness enables a trainer to lead a sea lion about on a leash just as a person would a dog. By attaching a very long leash, the trainer can maintain physical control of the mammal during early training in the open ocean.

The recovery system, designed around a small marine mammal that could stay out of the water for long periods of time and move about on land, is an easy system to transport and use. What has evolved is a remarkably uncomplicated recovery system with none of the disadvantages associated with divers and submersibles.

The "Quick Find" recovery system consists simply of two or three men, a rubber boat, a reel of nylon line, a pinger receiver, a grabber device and one sea lion. It makes possible the recovery of any object containing a pinger device that sends out a sound signal. One of the targets the sea lions have been trained to recover at depths to five hundred feet is a mock-up of an Anti Submarine Rocket (ASROC). In a matter of minutes the animals locate the target, first by homing in on an acoustic pinger

emanating from the target, and then by eyesight. Their eyesight is dark-adapted, comparable to that of a cat. During early training, the sea lions are worked in shallow water. A training session begins when the work boat is positioned about 100 yards from the submerged target. While one trainer operates the rubber boat, and another tends the sea lion, the third man uses a pinger receiver to position the boat approximately over the target. The animal is then allowed to dive into the water reporting back whether or not he hears the target's pinger. If he does, he presses a rubber disc, then returns to the water where the grabber device is placed over his nose. The grabber device is attached to a nylon line capable of lifting a two thousand pound object. As the sea lion dives to the target, it encircles and locks on. During practice sessions, the grabber does not lock and is raised to the surface repeatedly for more dives.

In November 1970 "Quick Find" participated in its first actual Fleet operation. The system was flown to San Nicholas Island in the Pacific Missile Range, sixty miles southeast of Point Mugu, California. "Quick Find" was challenged to attempt the recovery of an instrumented ASROC fired by the Oahu Naval Ammunition Depot for a quality assurance test in waters adjacent to the island. Since this was the first operational use of the sea lion recovery system, two back up animals had been brought along. It was not known how they would react to the long trip and strange surroundings. It became apparent very quickly that they were not adversely affected. In fact, they appeared unconcerned with the variety and excitement about them. "Quick Find" was taken to the recovery area aboard a Navy support craft. The buoy marking the location of the submerged target had drifted during the night, but the trainers re-established the recovery sight by using a pinger-receiver. The rubber boat carrying "Quick Find" was then launched from the support craft. A sea lion named Turk (Figure 3) was selected to attempt the recovery. Divers aboard the support craft were alerted to stand by, ready to make the recovery should "Quick Find" fail. Turk dove from the rubber boat into sea without a leash. The trainers had a tone signaller aboard to recall him. Turk returned immediately and pressed the rubber button to indicate that he heard the pinger. He again slid over the side, raised his head and received the grabber device from the trainer. He carried the grabber to the ASROC, pressed it home, and returned to his trainers. For the first time in U.S. Naval history, a mammal other than man had been used to locate and attach recovery hardware on an operational test device. Because this was a first, a team of four divers descended the line that Turk had attached in order to check the grabber locking mechanism.

In contast to the simplicity of "Quick Find," in order to get these men into the water, the support boat had to have a decompression chamber and medical van on board and a medical officer standing by.

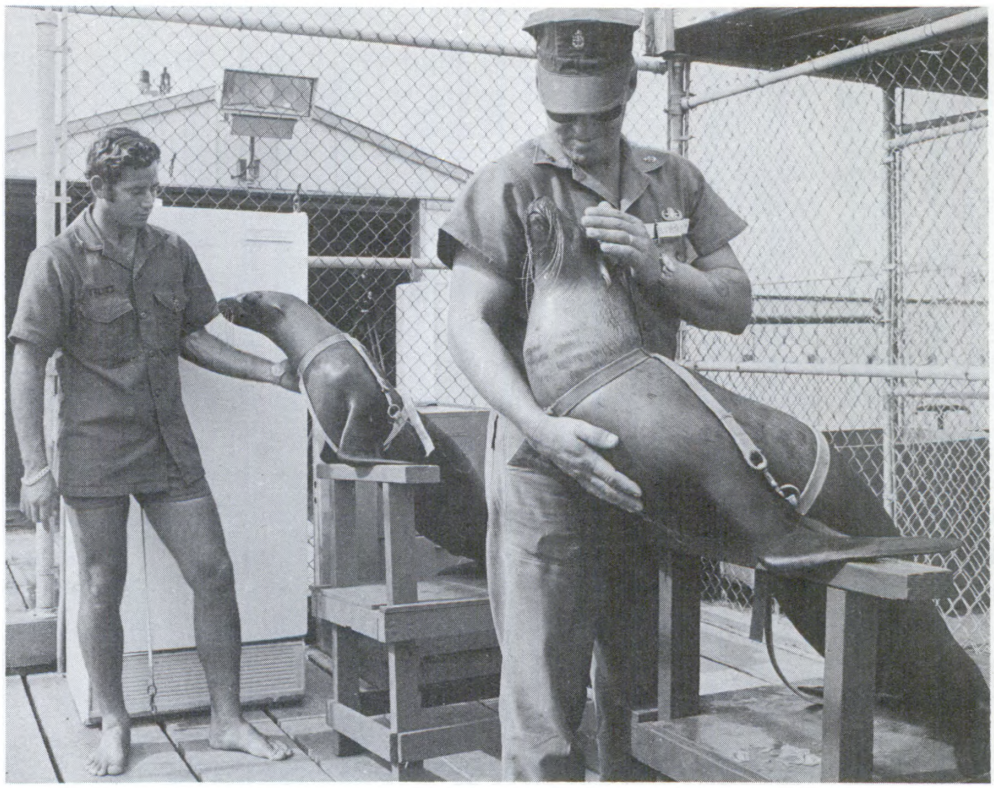

Figure 3 — The sea lion is trained to climb on the harnessing stand. In this position the trainer can conveniently harness the animal. Harnessing the animals prior to work in the open sea are: (l-r) Jim Corey with "Fatman" and Chief Gordon Sybrant with "Turk."

Two of the divers breathing a special mixture, descended to the target which was in about one hundred and eighty feet of water. The two other divers, breathing compressed air, descended part way on stand-by to give aid in case of emergency. The divers reported that the sea lion had effectively carried out its mission. The recovery operation demonstrated that the "Quick Find" system devised by NUC scientists does work. Unlike its diver and submersible counterparts, "Quick Find" can also exceed the working depth of human divers. It will, in the future, fill a real operational need. The Center believes that Turk, and sea lions like him, will play a very important role for the Navy in locating and recovering objects from the sea floor.

Deep Ops

Another ongoing project at NUC somewhat like "Quick Find" utilizes whales to recover submerged objects. Two whales at the Hawaii laboratory of the Naval Undersea Center have been trained to make deep ocean recoveries of such objects as experimental torpedoes and other inert test ordnance in NUC's "Deep Ops" program.

Morgan, a 1200 pound pilot whale, and Ahab, a 5500 pound killer whale, have made dives to 1000 feet routinely. This is twice the depth achieved by sea lions in similar recovery work under the "Quick Find" program.

Morgan descended on one recovery dive to the depth of 1654 feet. The "Deep Ops" system employs a hydrazine gas generator lift device attached to a mouthpiece. The whale grasps the mouthpiece and descends to the ocean floor. An acoustic pinger attached to the target guides the whale. A grabber claw, (Figure 4) when pressed against the target by the whale, locks the lift device onto the torpedo. The hydrazine system is activated when the mouthpiece apparatus separates from the lift device. The gas inflates a balloon, which floats the torpedo to the surface for loading aboard a Torpedo Recovery Boat. The present hydrazine system can lift objects with an in-water weight of 600 pounds from a depth of 1000 feet, 300 pounds from 2000 feet, and 150 pounds from 3000 feet. Morgan has demonstrated that pilot whales can be used with the system to at least 1600 feet; and the "Deep Ops" project has

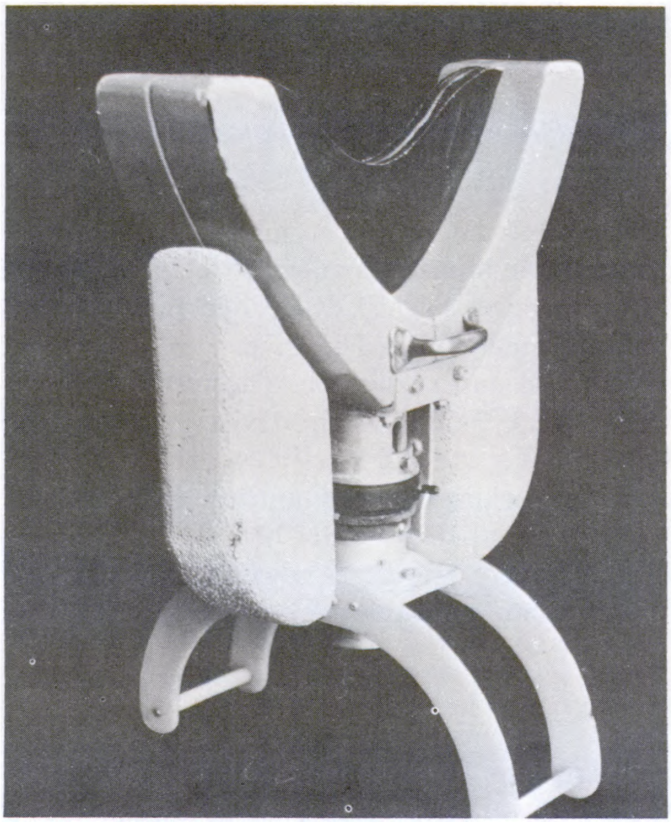

Figure 4 — This photo shows the mouthpiece (top) which the whale grasps with his teeth. The grabber (bottom) locks around the torpedo.

shown the potential of using other species of whales for recoveries to twice that depth. Morgan, who proved the more reliable and controllable of the two whales, was captured near Santa Catalina Island in 1968 and later transported to Hawaii. When he was released in the open ocean after his initial training he returned voluntarily to his pen, the first time this has been done by a pilot whale. With further training Morgan became a reliable open-ocean worker.

During actual recovery operations, the whale was obliged to follow a small boat for about six nautical miles to the work site. Morgan adapted to this task easily, swimming along side or behind the boat and coming up close a number of times to receive a fish snack.

In the future, all Navy sea test ranges may use the "Quick Find" method to retrieve test devices. Not only is the system easier to use then the conventional ones, it is also easier to maintain. The sea lion requires only a wire cage enclosure, access to water and shade, and ample fish to eat.

RESEARCH IN DEEP SUBMERSIBLES

Deep View

The charter of NUC includes the pursuit of Research and Development of equipment for the operational forces, scientific investigation of the ocean environment and the development of equipment for working in the sea. Thus developing and operating submersibles is an important part of the Center's mission.

It has been discovered by nearly everyone involved in deep submergence that submersibles are extremely expensive to build and to operate; the cost depends generally on size, design depth and operational capabilities. Cost per dive to the Navy on over twenty-five contracts for over 400 dives have ranged from a high average of $16,000 per dive to 12,000 feet, to a low average of $7,000 per dive to 2000 feet. Deep View, (Figure 5) one of the submersibles developed at NUC, is the first submersible with a glass encased bow.

Deep View recently completed certification dives to one hundred feet. The manned, untethered dives were performed at Santa Catalina Island during the last week of February, 1972. Certification of Deep View included evaluation of the submersible's controllability, attainable velocities, hovering and acceleration capabilities, propulsion, life support, and communications systems. Participating in the program were personnel from ten NUC codes, four other naval commands, two commercial companies and the University of Southern California. Sea-See, a NUC research vessel, with an underwater observation chamber, acted as mother-ship during the certification dives. Transporting the submersible

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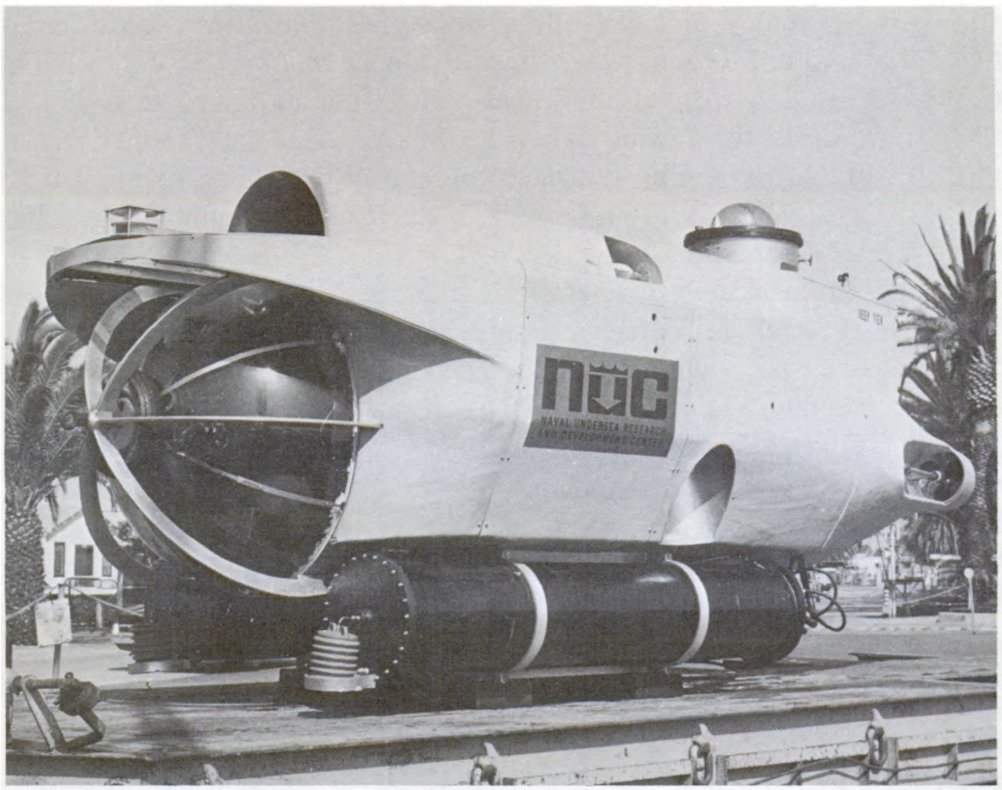

Figure 5 — The new submersible DEEP VIEW is undergoing test and evaluation procedures at the Naval Undersea Research and Development Center, San Diego. With its large glass hemisphere view port, DEEP VIEW is a forefunner of the all-glass submersible of the future. Sea tests on the unique craft are progressing satisfactorily.

to Catalina Island was a major project in itself. A small craft from the Amphibious Base was loaded at the 32nd Street Naval Station Mole Pier with a fourteen ton crane, a two-ton truck with trailer, and Deep View. The following day, the equipment was off-loaded at the Santa Catalina Marine Railway facility near Big Fisherman's Cove. The railway served as a contact support facility in launch and recovery of the submersible during the operation. Following a practice unmanned launch and recovery, the first manned, untethered dive was made by Deep View in December, 1971. Within a week of the February 23rd dive, eight manned, untethered certification dives and two unmanned tests were completed.

The most serious malfunction of the Deep View trials occurred when the port propulsion motor became inoperative after a dive. However, after removing the motor, it was found that the armature brushes had simply been installed too tightly. After the brushes and holders were replaced, the motor was reinstalled and tested satisfactorily. The operations were totally successful. The maneuverability, visibility and reliability of the submersible exceeded our expectations and met virtually all of the project design goals.

The Deep View project was initiated in 1966 for oceanographic research to depths of fifteen hundred feet. The glass hull is capable of withstanding the extreme pressure at that depth, in contrast with similar hulls of acrylic plastic, which are presently limited to operational depths of six hundred feet. The sphere permits wide visibility for two occupants, who normally ride in a prone position, although there is adequate space to sit upright. Deep View's streamlined hull permits speeds up to five knots fore and aft, two knots vertically or one knot laterally. The six ton submersible is neutrally buoyant in water. The battery pods of the sub can be released in an emergency for rapid ascent. An access trunk to the pressure hull can be blown at the surface to permit personnel transfers in calm water, eliminating the need to recover the vehicle or dock for crew rotation. Normal duration of dives is four to six hours. Greater depth certification dives are scheduled for the near future.

MAKAKAI

Another submersible which has brought deserved publicity to the Naval Undersea Center is the untethered transparent hull submersible MAKAKAI (Figures 6 and 7), which successfully completed its six hundred foot material certification dive on July 31, 1972 and operator

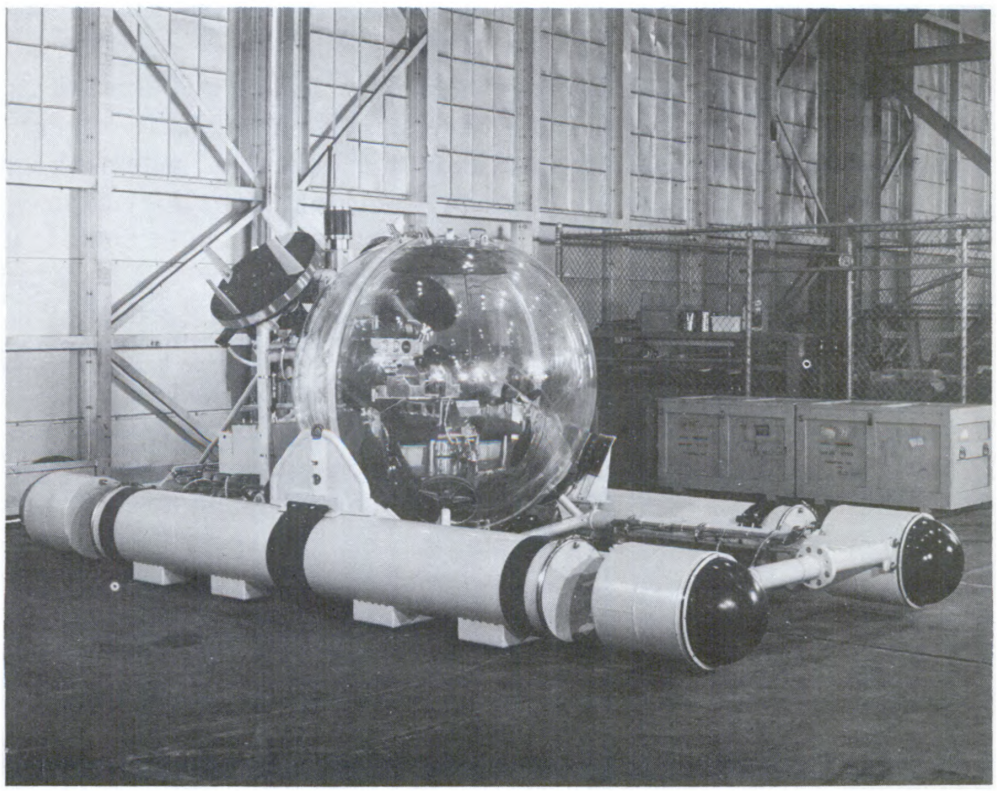

Figure 6 — Submersible MAKAKI

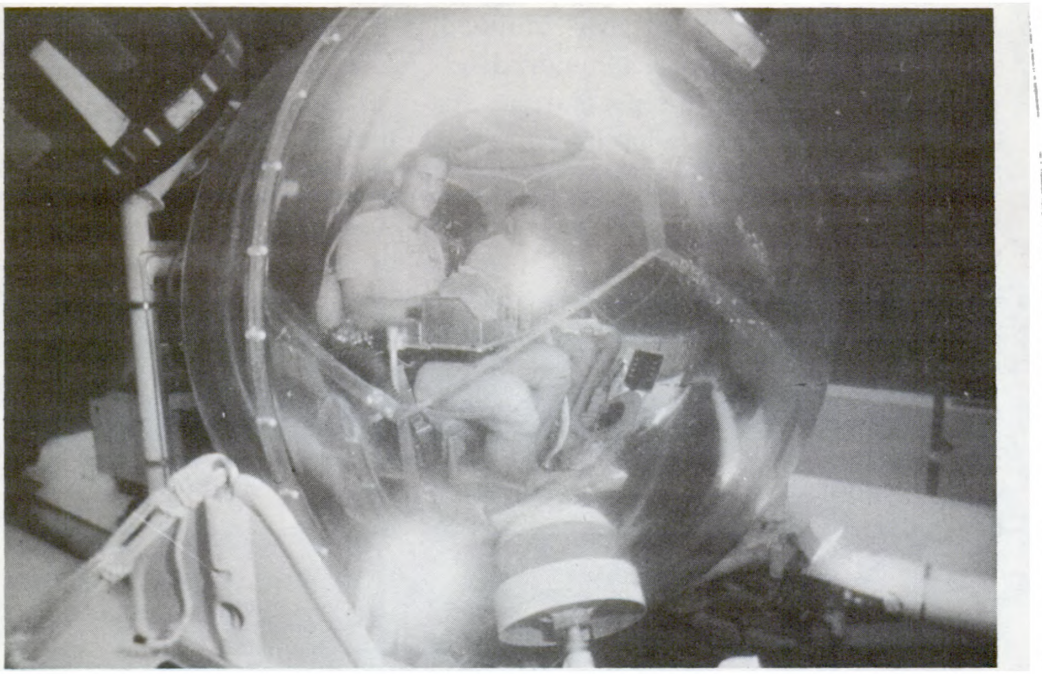

Figure 7 — The instrumentation of the Navy's newest submersible vehicle is checked out by Hawaii Laboratory personnel. The MAKAKAI is being tested in about 25 feet of water and soon will be certified to operate at depths of 600 feet.

certification dives on August 2, 1972. The manned, untethered dives were performed about two miles off-shore from NUC's Hawaii Laboratory.

Certification of MAKAKAI by Naval Ship Systems Command examiners included evaluation of the submersible's controllability, hovering capability, propulsion, life support and communications systems. Each operator was certified by an observer from Submarine Development Group One, San Diego, California after observing the pilot's abilities in handling and operation of MAKAKAI. The submersible was launched and recovered from the Hawaii Laboratory's Launch and Recovery Platform (LARP) at a water depth of fifty feet. LARP was designed and fabricated by NUC Hawaii to recover and launch submersibles below the surface where the water is calm and not affected by surface waves.

The initial dive on July 31 lasted for one hour and 13 minutes, with MAKAKAI remaining on the bottom for about 15 minutes. Descent and ascent rate was fifty feet per minute. The three operation certification dives lasted for a total time of two and one-half hours.

MAKAKAI, Hawaiian for "Eye in the Sea," has the appearance of a helicopter with its sixty-six inch diameter acrylic plastic "bubble" mounted on top of two large pontoons. It was developed and built by the Hawaii Laboratory of the Naval Undersea Center.

The innovative and potentially highly useful vehicle utilizes a 2.5 inch thick transparent acrylic sphere as the pressure hull. This affords

the submersible's tow operators with an unobstructed panoramic view of their aquatic surrounds. To insure safety for its occupants, the sphere was prooftested prior to its installation in the submersible to 1200 feet at the Deep Ocean Simulation Facility of the Naval Civil Engineering Laboratory, Port Hueneme, California.

The pressure hull or bubble is attached to a frame to which the two pontoons are secured. The pontoons house the lead-acid batteries used to power the vehicle. Propulsion is provided by two cycloidal thrusters which give propulsive control in four degrees of freedom. Ballast tanks are placed at the end of each pontoon for controlling buoyancy, trim and pitch during diving operations. In MAKAKAI, an operator and one observer passenger can descend into the ocean without leaving a comfortable shirt-sleeve environment. The normal life support capability is twelve hours with an emergency back-up supply of thirty-six hours. Another innovation of MAKAKAI is the location of its control electronics outside the pressure hull in ambient pressure housings. One reason for this approach was to reduce heat within the plastic sphere. Placement of controls outside the sphere also provided more usable room within. The controls signals are transmitted out of the sphere on a modulated light beam to a receiver outside (another advantage of the transparent hull). The system's chief advantage is that it reduces drastically the number of support system penetrations in the bottom of the sphere.

MAKAKAI is expected to have many uses, both military and civilian. Initially it will be used by NUC for marine observation and bottom photography. Later a manipulator may be developed for MAKAKAI so that the vessel can perform engineering tasks on the ocean floor. Although the submersible is stationed at NUC, it will be operated for the benefit of any qualified Navy, university, industry or private scientist involved in ocean oriented research. Since MAKAKAI can dive to 600 feet it is capable of exploring the limits of the continental shelf. NUC is presently developing an acrylic sphere, having a two thousand foot operational depth capability, which will be interchangeable on MAKAKAI with the present six hundred foot sphere.

RUWS

The Navy's dream of a system to do useful work in the deep ocean came one giant step closer to reality recently when the Remote Unmanned Work System (RUWS) vehicle (Figure 8) successfully completed its initial ocean demonstration at the Hawaii Laboratory. The completion of the vehicle tests is regarded as a major program milestone in development of the system. RUWS is designed to operate at depths of twenty thousand feet, which permits it to reach and explore more than ninty-eight percent of the ocean floor. The system, which employs an undersea

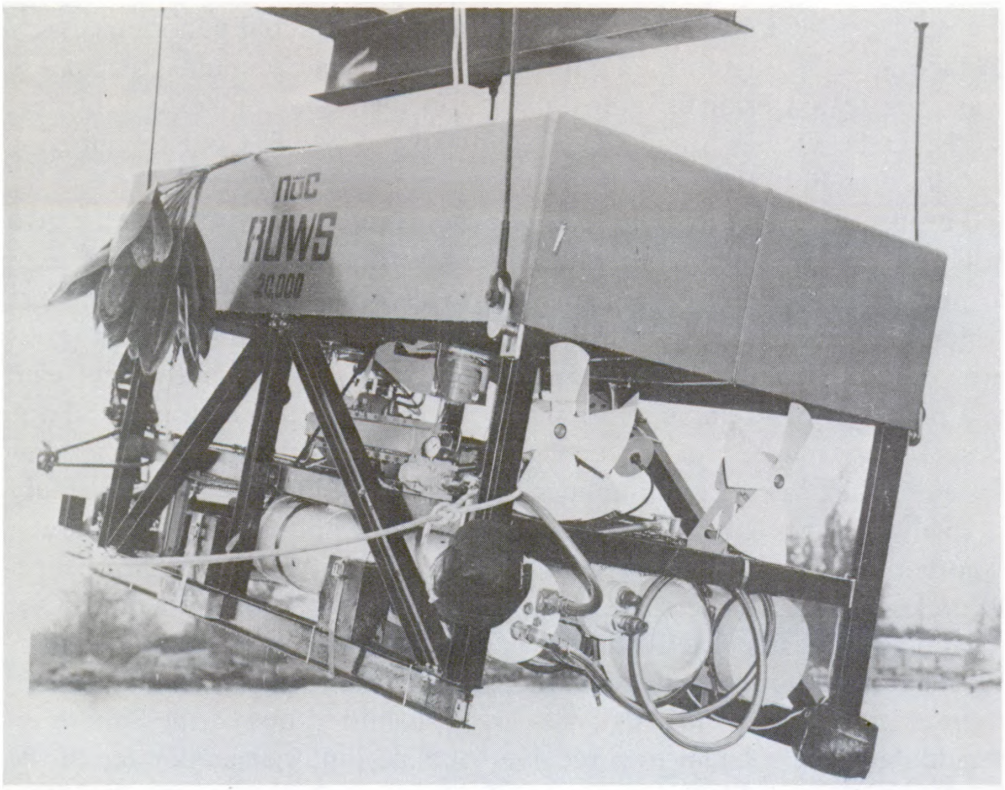

Figure 8 — The submersible vehicle for the Naval Undersea Center's Remote Unmanned Work System (RUWS) is lowered into Kaneohe Bay in Hawaii for its initial ocean tests. The vehicle is part of a system being developed by NUC that will provide the Navy with the capability to do useful work in the deep ocean. The work on RUWS is being done at NUC's Hawaii Laboratory.

vehicle controlled by a cable from a surface ship, will be used for recovery, surveying, documentation, and research. The system will be outfitted with a number of sophisticated innovations to aid in deep water work, including a high-accuracy deep ocean navigation system, advanced search sonar, head-coupled TV, and an advanced manipulator.

In the RUWS concept, a control center, navigation center and cable handling system will be installed on a surface ship. The system was designed for use on various classes of ships (principally salvage ships, salvage tugs, and nuclear submarines), so NUC scientists are not restricted to a particular support vessel operation. All signals and power necessary to control and operate the undersea vehicle are multi-plexed on the single coaxial core of the cable that connects the surface systems to the vehicle. The control cable itself is a major breakthrough. Special synthetic members, stronger per pound than steel, provide added strength to the cable, which must be 4-1/6 miles long to attain the twenty thousand foot depth. At that length the cable alone will weigh 16,400 pounds in air, and 6500 pounds in water. The submersible vehicle is eleven feet long, 4-1/2 feet wide, and 4-3/4 feet high. Its weight in air is approxi-

mately 5000 pounds. The vehicle is equipped with television camera, sonar, underwater lights to penetrate the blackness at deep depths, a 35 mm camera and strobe light, and a pair of manipulators to perform work. In designing RUWS, NUC scientists emphasized the extension of man's senses into the deep ocean. For close viewing, the RUWS operator employs head-coupled television, whereby he dons a special helmet which controls the direction in which the vehicle-mounted television camera is pointed. The camera pans with the motion of the operator's head, and a visual display in the helmet allows him to "see" as if he were underwater. In addition to providing the operator with the impression that he is actually riding on the vehicle, the head-coupled TV frees both his hands to operate the controls. A seven function manipulator will be the operator's "hands" on the bottom. The manipulator, armed with a claw-like grabbing device, employs force and position feedback so the operator can "feel" the forces exerted by and against RUWS in performing underwater tasks. The manipulator operates separately powered tools, including a drill, a cable cutter, and and Auxiliary Lift Device, capable of moving two hundred pounds. The RUWS navigation system employs real-time cathode ray tube displays to provide coordinated navigation and location. Advanced integrated displays allow the operator to control the vehicle with a minimum of learning or conscious thought.

RUWS is designed in modular packages for fast air transportation and can be operated from almost any available ship. This allows a quick response to urgent recovery needs such as occurred with the loss of the hydrogen bomb. In 1966 an Air Force plane accidentally dropped a hydrogen bomb into the ocean off Palomares, Spain. The Cable-controlled Underwate Recovery Vehicle (CURV), a NUC vehicle similar in purpose to RUWS, descended to 2500 feet to successfully recover the bomb.)

The initial RUWS testing was preceeded by a successful launch in the Hawaii test pool. An operator at the control panel maneuvered the craft near the dock to test the vehicle's responses to control inputs. Each of the subsystems was exercised to demonstrate the general capabilities of the system. After tests of the vehicle system's maneuverability in shallow water, RUWS will undergo extensive testing of all its components, culminating with twenty thousand foot demonstrations scheduled for 1975.

RUWS is one of the key projects of the Hawaii Laboratory and is a major element of the Navy's Deep Ocean Technology (DOT) Project. The launching of the RUWS vehicle is one more step in the long and successful history of unmanned vehicles developed by NUC for naval operational use.

NUC not only develops underwater equipment but it keeps them in shape by taking advantage of improved design and materials. The most

recently modified piece of equipment was "Snoopy," NUC's highly useful underwater television system (Figure 9). The "facelift" improved Snoopy's portability and capability.

Snoopy was given a new, sturdier, lightweight frame made of anodized aluminum. This made the vehicle about six inches shorter in length and height. It now measures four feet in length and fifteen inches in height. The small size and weight of the vehicle (51 pounds) allows it to be easily operated from small surface vessels or packed with its controls in a shipping container for airlift to any part of the world.

Snoopy is operated remotely using a small television camera and light mounted on the vehicle. The operator watches underwater landscapes above the surface on a TV monitor mounted in his control console. Depth is controlled by varying the buoyancy or displacement of the vehicle. Snoopy's capabilities were increased by fitting it with a grabber, a compass, and automatic depth control. The latter permits Snoopy to hover at any depth, which the operator selects using a dial on his hand-held control box. The new claw will permit Snoopy to accomplish other

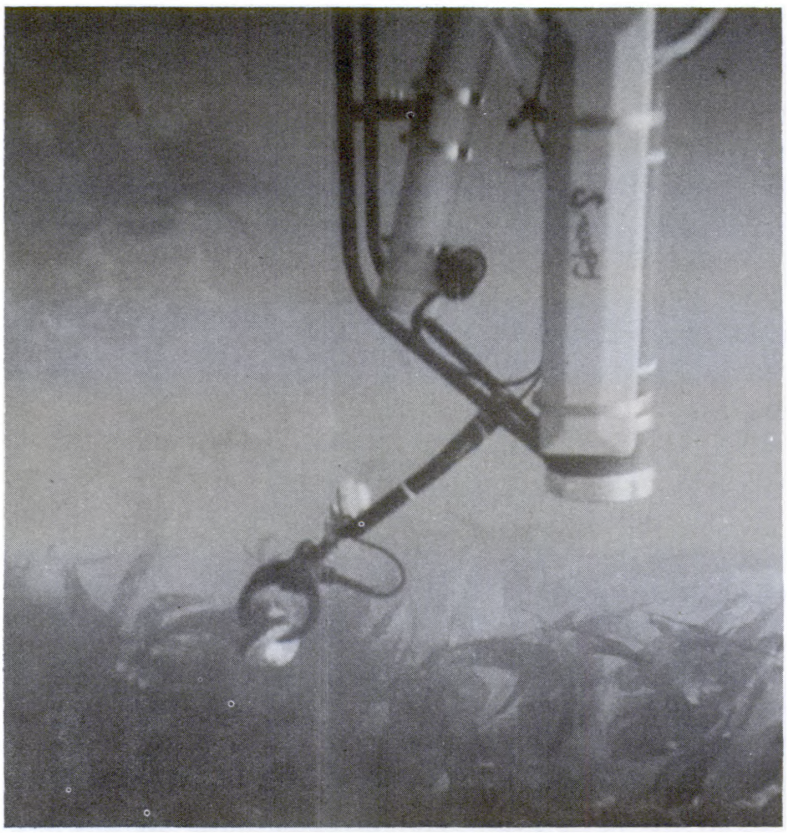

Figure 9 — Snoopy picks up a large seashell in about 50 feet of water off Catalina Island in a recent operational test of its new capabilities. In addition to the new grabber seen in this photograph, the vehicle now has a compass and automatic depth control.

tasks in addition to its underwater viewing capability. Its "arm" can pick up small objects or place instrumentation such as sound beacons on the ocean floor to depths of one hundred feet. Powered by two joystick controlled hydraulic motors which provide about twelve pounds thrust each, Snoopy is capable of traveling at approximately 1-1/2 knots. A small hydraulic piston which adjusts the total length of the buoyancy cylinder allows the vehicle to assume positive, negative or neutral buoyancy to ascend, descend or remain stationary as required. The buoyancy tube eliminates one of the problems facing undersea exploration by unmanned vehicles—visibility. When operating near the ocean floor, vehicles using vertical thrusters can stir up a considerable amount of silt. The operator then has to wait for the silt to clear before he can "see" well enough to continue operations.

A second generation Snoopy is now being planned by NUC's Advanced Systems Division of the Ocean Technology Department. The new design calls for a small streamlined fiberglass-hulled vehicle with a single coaxial tether. As presently planned, this new vehicle will be capable of dives to 1,500 feet. It would be used to observe, and to inspect underwater construction sites and implanted objects on the ocean floor.

Reinforced Concrete

Responding once more to the challenge of Fleet productiveness, NUC has come up with the idea that many ships of the future Navy could be built of relatively inexpensive reinforced concrete. They would be of various types, including underwater cargo vessels (Figure 10). Studies underway at NUC show that reinforced concrete may be used as the basic hull material for limited depth submersibles. Since many casts could be made from one master form, construction time and costs would be reduced.

By using moderate working stresses for the concrete, very large hulls could be constructed to withstand the pressure and buckling forces, generally without the use of ring stiffeners. The underwater helicopter carrier would have two large elevated hatch openings for use in handling of helicopters in and out of the hangar deck in flight deck. The elevated hatch openings would serve as a reduced water plane area to reduce wave response during launch and recovery of helicopters.

The underwater aircraft carrier would be similar in design to the helicopter carrier except the elevated deck would be continuous from forward to aft hatch openings. To reduce wave response of the landing platform, the ship's flight deck would be supported by a series of streamlined vertical struts. A reinforced concrete cargo vessel could be constructed with hatch openings large enough to accomodate containerized

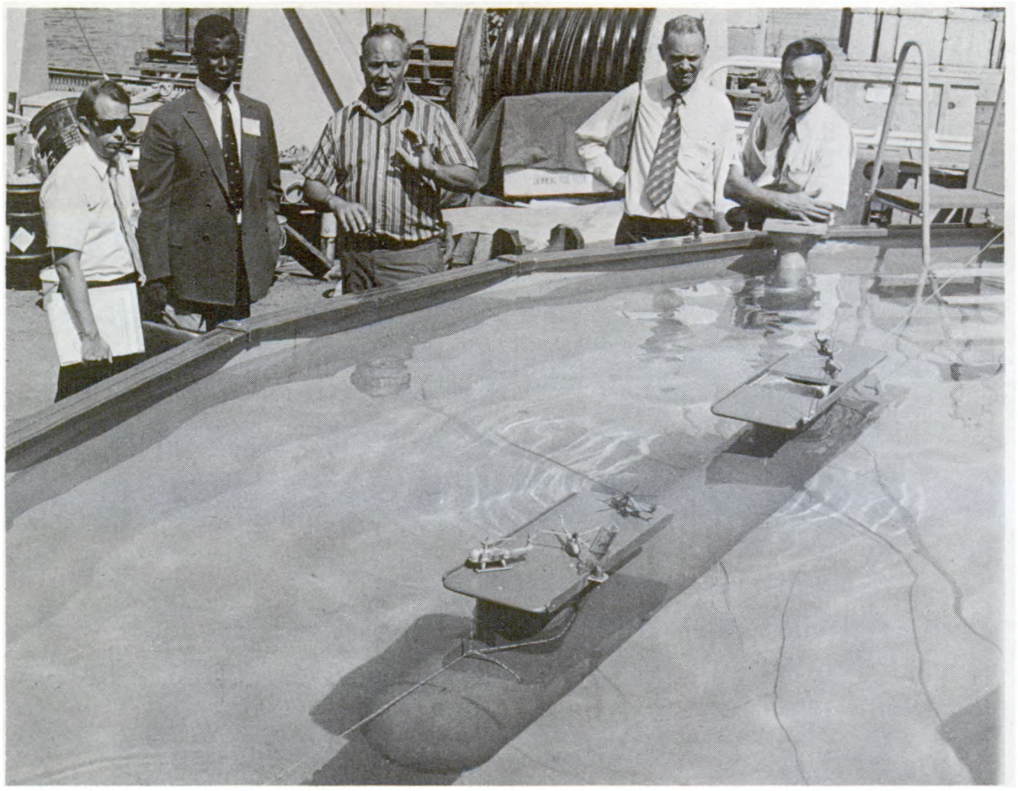

Figure 10 — Ed Rosenberg, center, explains to visitors to the Naval Undersea Research and Development Center the advantages of the concrete submersible concept. Only the helicopter pads break the surface with the hull submerged, making it a small target for enemy radars.

cargo. This submersible could be self-powered or towed under the surface by another submarine. If it were designed with an elevated trunk like the aircraft carrier, it would be less responsive to waves when ballasted low in the water. This would make it compatible for use with large stable ocean platforms which are also being studied by the Center.

Further studies of a scale model of an underwater helicopter carrier are planned at NUC. This will possibly include dynamic response in launch and retrieval mode and coupling or mating with a large stable platform array. Underwater tow studies may also be carried out on the model.

NUC'S SIMULATION TRAINING

A bank of complex and highly sophisticated computers at the NUC in the Computer Sciences Division is currently working day and night on development of the Navy's two newest torpedoes and a new ship fire control system. The bank, consisting of a series of analog computers and 1108 and 642B digital computers, is running twenty hours a day,

six days a week, on development of the torpedoes Mark 46 and 48, and the Mark 116 Fire Control System (Figures 11 and 12).

New improved circuits for the MK46 and everything in the way of logic that went into the MK46 and 48, were developed and tested at the facility, which has been used for evaluation of every torpedo developed by the United States since 1951. NUC engineers evaluated the MK48 MOD I, both of which have been largely developed in the Simulation Center, to determine which development was best.

The Simulation Facility started its intitial operations in 1951 with MK37 torpedoes. It grew steadily for the next ten years, during which time NUC personnel put together one of the first major hybrid complexes (analog and digital computers working together) in the country.

At one time the only way to evaluate a torpedo was to fire a dummy unit and gather data on its performance. It was costly and data was sometimes difficult to get. What has been established by means of real-time simulation is a laboratory environment where the Navy can make

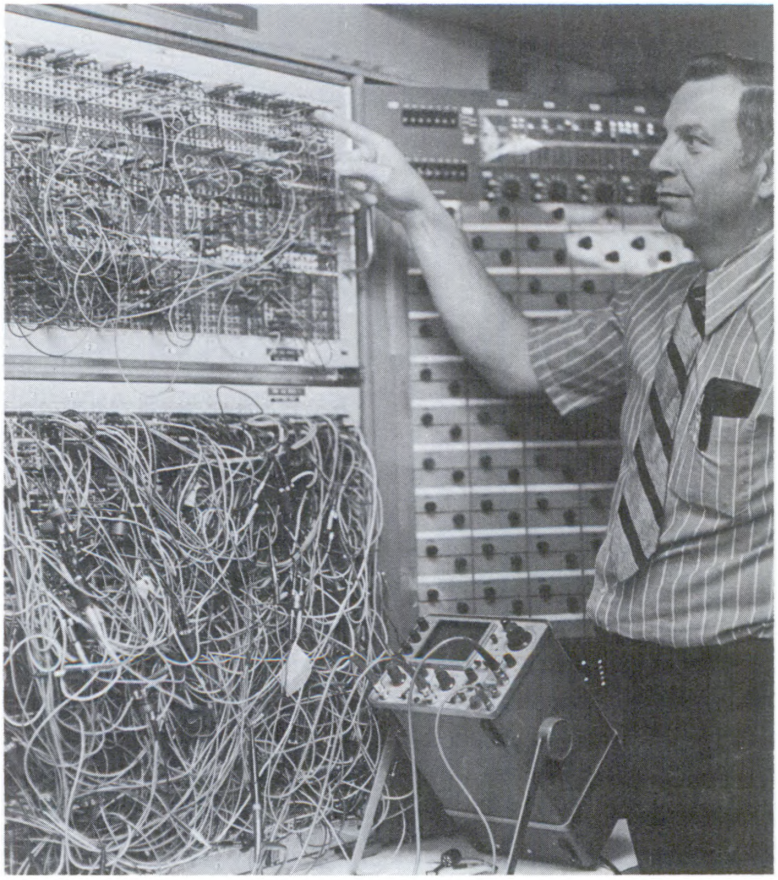

Figure 11 — L. Z. Maudlin, head of NUC's Computer Sciences and Simulation Division, points out one of the many complex circuit boards used for simulation work in developing the Navy's newest torpedos.

Figure 12 — Don Robinson, an electronics engineer at NUC, punches in a program for a run of the Mark 48 torpedo. Th television screen above him will give him a visual presentation of the torpedo run on a target.

dry runs to evaluate torpedo performance. The computers are programmed to simulate conditions under which a torpedo might be operating, *eg.*, pressure, water temperature, *etc*. The real-time simulation can provide data as good as that obtained from actual measurements.

The philosophy of the Simulation Facility has three basic points. First, simulate the physics of what happens in the water; second, use as much of the actual hardware as possible in order to discover any deficiences; third, use the engineer as an actual part of the analysis. He can then question as he runs the program rather than waiting until the data is gathered. A television type display allows the engineer to watch the progress of a torpedo run, programming evasive action for the target if he desires. This gives him a feel for the operation and performance of the torpedo, which enables him to make suggestions for possible improvements.

The Simulation Facility initially did only evaluation work, but as people began to see its worth they started using the system for development. The Operational Test and Evaluation Force, Norfolk, made ten water runs and their findings were duplicated without knowledge of the results. Since that time NUC simulation has become an official part of OPTEV testing. Runs on the MK46 and 48 have been made with the simulator,

followed by actual water runs to verify the results. Using this method, NUC engineers are able to accurately predict torpedo performance under any given set of circumstances.

About thirty NUC personnel and four people from Computer Sciences Corporation in Pasadena presently staff the Simulation Center. They work closely with members of the NUC's Undersea Systems Department in development of new improved torpedoes for the Fleet.

A second simulation is a computer-aided system to reconstruct large-scale fleet anti-submarine exercises. The system has been utilized to reconstruct ASW exercises involving up to fifteen surface ships and submarines operating in a circular area over two hundred miles in radius for one hundred and sixty-eight hours. In the past, these exercises were reconstructed by teams of personnel of the participating ships working long hours, employing tedious manual techniques occasionally involving arbitrary decisions based on uncertain memory. These manual track reconstruction techniques took up to two weeks to complete.

The present computerized system is far more accurate and can reconstruct the complete exercise in four days. After each exercise the position and navigation logs of each ship are keypunched and individually fed into the computer. This provides a listing of the time, latitude and longitude of each ship throughout the exercise. After known fixes and other operational information are given to the computer, a track of the ship's course and speed during the period is drawn onto graph paper by the computer. Tracks are developed for each ship consistent with their respective data. Contact data and other operational information are then used to develop a set of tracks relatively consistent with each ship.

Once the tracks have been established as being correct, reconstructed track listings for each ship, annotated color coded plots showing all or part of the ship tracks on a single sheet of graph paper, and relative range and bearing listings between all participants are prepared. This gives fleet commanders a picture of what happened during the exercise a very short time after it took place.

Commander, Antisubmarine Warfare Force, U.S. Pacific Fleet, stated in a recent letter that "the development of these track reconstruction programs represents a significant step forward in establishing a mutually beneficial interface between the operational forces and the analytic community."

The Naval Undersea Center is one of the Navy's primary research and development activities. NUC has an impressive record for development of systems which answer the challenge, "What have you done for the fleet today?", a question frequently asked by Admiral Isaac C. Kidd, Jr., Chief of Naval Material.

Leucogenenol and the Maturation of Blood Cells

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Introduction

A chemical substance discovered through an Office of Naval Research program has experimentally stimulated the production of white blood cells in animals without side effects and appears likely to increase the formation of germ-fighting antibodies that are produced by white cells. Leucogeneol is of particular interest to the Navy because it holds promise of correcting damage to white blood cells caused by exposure to nuclear radiation as well as by the drugs used to treat severe burns and injuries or to inhibit transplantation rejection.

In order to understand leucogenenol and its effects on man's blood count it is helpful to review some of the basic facts about blood cells.

There are several types of blood cells and each type serves an important specific function in the body. The red blood cell, present in the blood of humans in concentrations of approximately (5 million in a cubic millimeter), carries oxygen to the other cells in the body. The actual concentration of red blood cells is critically dependent on the body's requirement for oxygen and is increased under conditions of lowered oxygen tension such as found at elevations above sea level. Other blood cells, collectively known as white blood cells or leukocytes (Figure 1), are present in the blood of humans in concentrations of approximately (7 thousand per cubic millimeter). Two of the most important types of white blood cells are the neutrophils and lymphocytes, which respectively account for approximately 55 and 35 percent of the white cells in the circulation. The neutrophil has the ability to act as a scavenger and remove foreign particles from the body. For example, neutrophils can engulf inhaled dust particles and remove them from the lungs by carrying them up the bronchi to a point where the cell and the engulfed particle may be expectorated or swallowed. Neutrophils (Figure 2) also ingest living microorganisms such as bacteria and by destroying them prevent disease. In cases where the neutrophils readily available do not suffice to destroy the bacteria present, disease occurs. Additional neutrophils

*Dr. Rice, who discovered leucogenenol, is Professor of Chemistry at American University. He received the Hillebrand Award for 1972 from the Chemical Society of Washington for the isolation, chemical structure, and studies of the biological activity of leucogenenol.

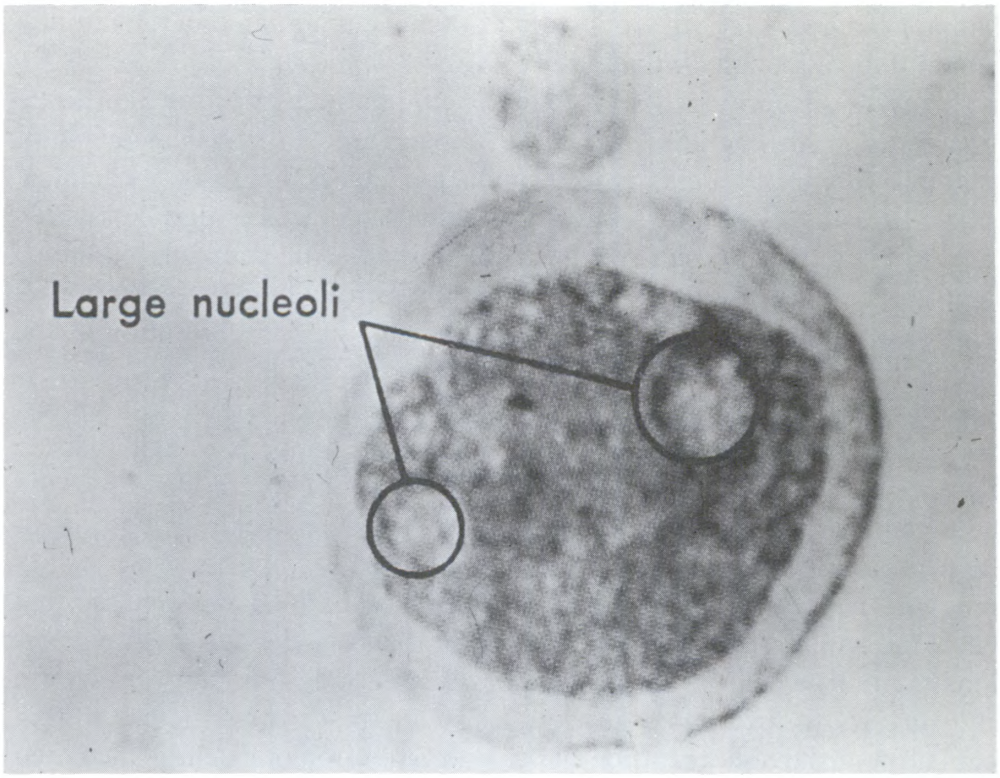

Figure 1 — A white blood cell or leukocyte

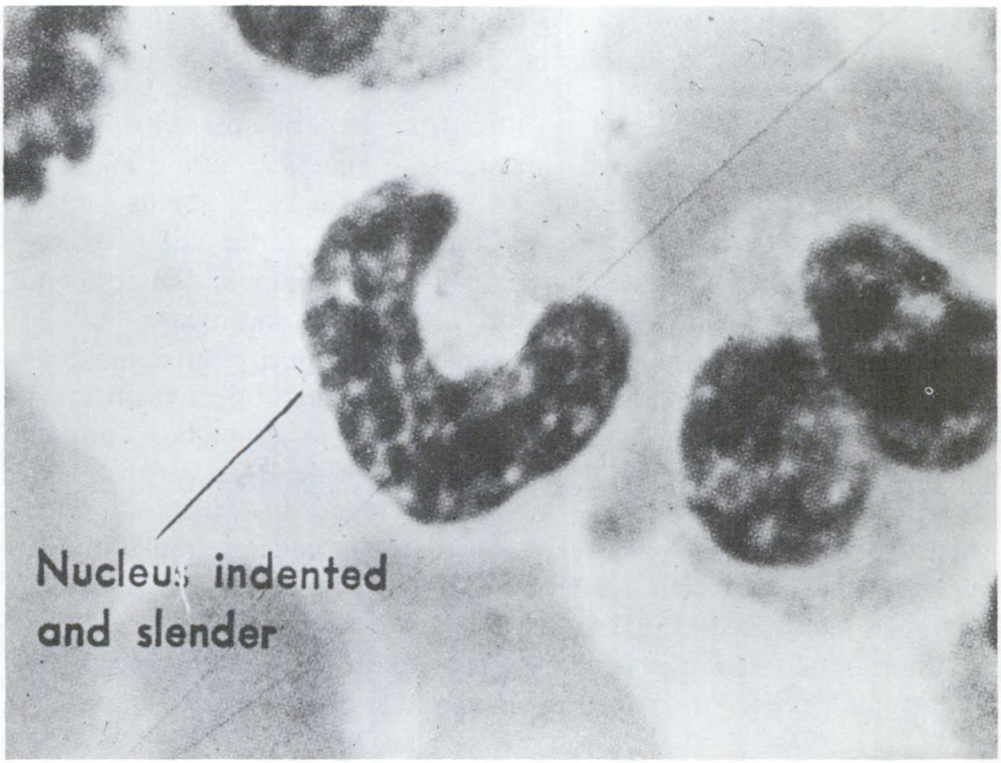

Figure 2 — Neutrophils

than appear and a higher proportion of them is maintained in the circulation until the infection is conquered.

The weapons provided by blood for combatting infection and toxic substances from bacteria do not all depend on the physical event of engulfing foreign particles as the neutrophil does. There is a chemical attack as well. Lymphocytes form proteins known as antibodies which can kill bacteria, can cause cells to disintegrate, or can cause them to clump together in handy bite-size lumps for the scavengers to dispose of. The need for antibodies is met in emergencies by a proliferation of the appropriate antibody-forming cells, lymphocytes.

Both red blood cells and neutrophils start life as primitive, undifferentiated cells in the bone marrow. Something happens which induces these cells to begin to change through a series of forms leading either to the adult, specialized red blood cell or to the neutrophil according to the need of the body. In normal life the process is going on at a constant rate, with new cells replacing those which have served and died, so that the blood sample taken at any one moment shows the expected proportions. Primitive cells in the spleen and lymph nodes similarly transform and mature to become lymphocytes. Our research anticipated that regulation of the concentration of various types of blood cells is mediated through chemical messengers and it was established that leucogenenol (white cell generating "enol") is undoubtedly one of these messengers.

Discovery of Leucogenenol

Discovery of leucogonenol resulted from experiments with quite a different goal. Physicians who must use saline and other injectible fluids are plagued by the occasional presence in such liquids of substances which are pyrogenic—fever causing. Though the fluid may have been properly sterilized, the fever is caused by compounds left behind by the organisms which were killed in the sterilization process.

The experimental scheme was to separate and purify the compounds elaborated by a mold *Penicillium gilmanii,* and then inject them to see what they might do to an animal. Initially it was as a metabolic product of the mold that leucogenenol was separated in nearly pure form. Surprisingly it had no capacity to act as a pyrogen, but it did affect the proportions of the white blood cells in the experimental animal in such a way as to indicate that the process of cell maturation was hastened. Continued study proved that quite large doses had no deleterious effect, and that administration of leucogenenol could elevate first the number of neutrophils present in a drop of blood and later the number of lymphocytes.

The potential value of a compound with such properties is vast. A serious early result of exposure to radiation is damage to bone marrow

and other blood-cell forming tissues. Damage to the sources of scavenger and antibody-forming cells reduces the body defense against infection. The same thing happens in transplant surgery. when the physician uses drugs to permit the body to accept someone else's skin, kidney or heart. Even though the new tissue may be essential for life, it is alien; and to allow the graft to succeed, the surgeon has to overcome the normal protective mechanisms. A counter medication which could aid in restoring the immune capability could be one stimulating rapid maturation of white blood cells when needed to combat infection.

Vaccination against disease is specific; a shot against diphtheria confers no resistance to lockjaw. During the period after a vaccination there can be an initial reduction of the defense mechanisms in the blood while the immunity process is getting under way. Leucogenenol is not keyed to a specific disease; it stimulates the proliferation of white blood cells generally and should shorten the period between innoculation and the attainment of immunity to any of the diseases for which protective shots are administered. It might also increase the immunity to disease previously experienced or vaccinated against.

The Composition of Leucogenenol

In order for leucogenenol to benefit man it had to be identified and produced in quantity. From the metabolic products of the mold, the metabolic products of the mold, the pure compound was separated and analyzed. Its chemical structure proved to be relatively simple as biological products go (see Figure 3). Once known and identifiable, the next step was to look for leucogenenol in the body itself. Investigation soon showed that it was present in small quantities in bovine and human liver, adrenals, thyroid, blood, urine and the gonads. Leucogenenol thus can be easily extracted from sources ranging from molds to meat from the slaughter-house.

The process of isolation and purification, and eventually that of accounting for the action of leucogenenol requires some simple and reliable method of measuring accurately very minute amounts of the material in the compounds typical of biological tissues and fluids. Fortunately it has been possible to establish a very sensitive and accurate biological assay procedure.

Effect of Leucogenenol on the Transformation and Maturation of Bone Marrow Blood Cells

The injection of leucogenenol into animals was found to increase the rate at which primitive, undifferentiated cells transform into the precursors of blood cells, and to increase the rate at which these precursors mature into the cells found in the circulation. Approximately

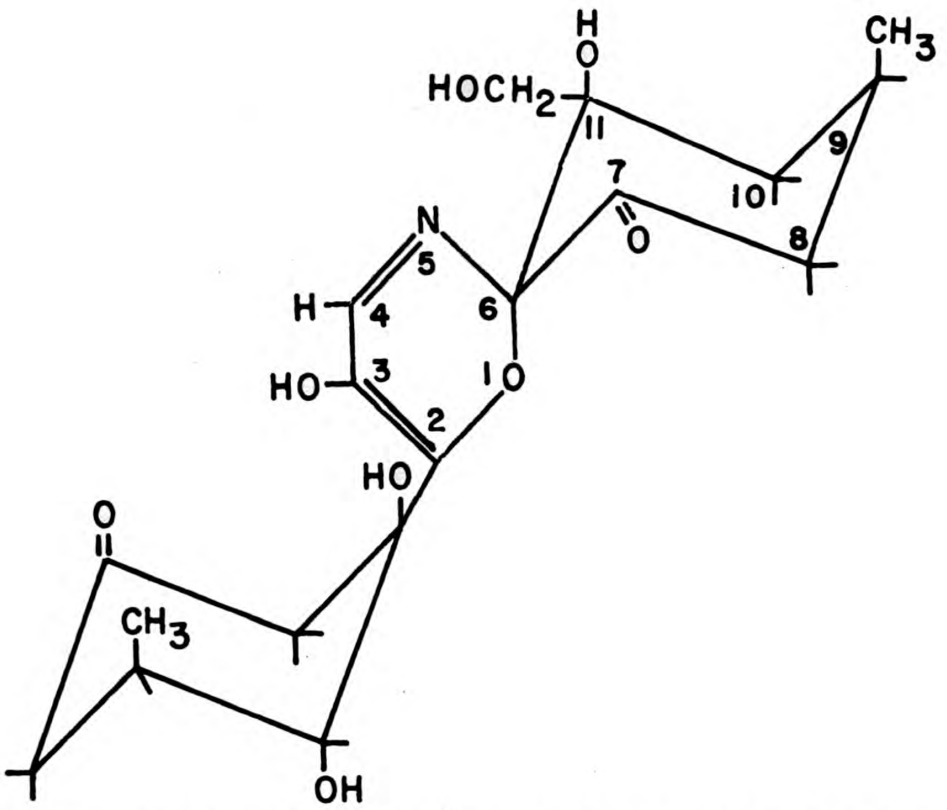

Figure 3 — The chemical structure of leucogenenol is relatively simple as biological products go. [2-(1,2-dihydroxy-3-methyl-5-oxocyclohexyl)-3,11-dihydroxy-11-(hydroxymethyl)-9-methyl-1-oxa-5-axaspiro (5.5) undeca-2,4-dien-7-one].

12 hours after animals are injected with leucogenenol there is a fivefold to tenfold increase in the relative concentration of the earliest form of precursors of blood cells in their bone marrow. The rate at which the earliest form of precursors mature to neutrophils is increased to such an extent that, although considerable number of neutrophils are liberated into the circulation, there is no decrease in their relative concentration in the bone marrow. The rate at which the earliest form of precursors to the red blood cells mature is also increased, as evidenced by an increased relative concentration of nucleated red blood cells in the bone marrow.

Studies with labelled cells furnished additional evidence that leucogenenol increases the maturation rate of bone marrow blood cells. Within 15 minutes after the injection of tritiated thymidine, animals have a large number of the earliest form of the precursors which mature to neutrophils and red blood cells, but few other bone marrow cells, labelled with sufficient radioactivity to affect a photographic emulsion. Since the radioactive label is not lost as the cell matures, we were able to follow the maturation of these precursors into neutrophils and red blood cells by autoradiography. In the rat it takes approximately 24 hours after the injection of tritiated thymidine for the neutrophils and nucleated red blood cells to be labelled. When leucogenenol, as well as

tritiated thymidine, is injected, only 12 hours are required for these cells to be labelled. We also found that if animals whose neutrophils are already labelled are injected with leucogenenol, labelled neutrophils appear in their circulation within 8 hours and are then sequestered and destroyed by such tissues as the spleen. Apparently a physiologically controlled maturation step is involved in the release of neutrophils from the bone marrow to the circulation is involved as well as maturation of the cell.

Fossati and coworkers at the Medical School in Bari, Italy, confirmed our findings by showing that blood cells from the bone marrow of animals injected with leucogenenol have an increased rate of maturation in tissue culture. The same investigators found that bone marrow from mice injected with leucogenenol transferred to lethally irradiated mice gave rise to a greater than normal number of colonies in the spleens of the irradiated mice. Presumably this is due to the presence of a greater than normal concentration of primitive cells in the bone marrow of mice injected with leucogenenol.

Effect of Leucogenenol on Formation of Lymphocytes

Mice subjected to radiation which is damaging but not lethal can be shown to have a reduced ability to form antibodies when injected with foreign antigens until healing was progressed sufficiently. A convenient antigen for test purposes is the red blood cell of another species. Rats show a similar loss of immune competence following the removal of their spleens. Leucogenenol administered to sub-lethally irradiated mice or to splenectomized rats quickly restores their ability to make antibodies against sheep red blood cells. Even when the rat is not subjected to surgical removal of the spleen, leucogenenol will shorten the time required to produce measurable amounts of anti-sheep cell antibodies.

Since the antibody formed in response of this antigen is of the type capable of destroying the red blood cells, and since the change from a powdery red to a clear wine color is a readily visible change as the red cells are destroyed, it is possible to spread a mixture of cells in a tissue out on the surface of an agar containing blood, and to recognize which are producing the antibody by the ring of hemolysis which appears around the cells from which antibody is given off. Using this method, it was found that leucogenenol stimulates the formation of antibody forming cells in the spleen and in other lymphatic tissues, both of intact rats and of those which have had their spleens removed.

Metabolic Effects of Leucogenenol

The respiratory quotient (the ratio of the amount of carbon dioxide given off to the amount of oxygen consumed) is an index to the vigor

of life processes in the cell. It is, in a sense, an indicator of what fuel the cell is using. Changes therefore indicate changes in the metabolic process involved.

When cells taken from the lymph nodes of normal hyman beings are tested in a tissue culture medium containg leucogenenol, the respiratory quotient is found to be higher than usual. If the cells are taken from tumors, the respiratory quotient is depressed. These effects are proportional to the amount of leucogenenol employed. While the observation is intriguing in providing a clue to differences between normal cells and cancerous ones, it has a more immediate value to this study. Since the change in respiratory quotient (RQ) is proportional to the amount of leucogenenol, and since the measure of the respiratory quotient is relatively easy in the laboratory, the RQ of standard cell preparation becomes a sensitive and accurate quantitative measure for extremely small amounts of leucogenenol in tissues and biological fluids. This opens the door to studying changes in the amount of leucogenenol in the healthy and diseased.

Leucogenenol in the Blood and its Association with Certain Types of Injury and Disease

Using this method of assay, it is possible to show that normal human blood contains approximately three micrograms of leucogenenol per liter. Patients suffering from various arthritic diseases show at least ten times this much leucogenenol in their serum. Those with various forms of leukemia have approximately one-hundreth of the normal amount.

Within a day after exposing dogs to lethal amounts of cobalt radiation, the amount of leucogenenol in their serum decreases. This is followed two days later by an increase above normal, but the level then falls off until it is no longer detectable, approximately four days before death.

Observations such as these can provide new insights into what is happening during certain types of injury and disease, and suggest things that might be worth trying in treating the condition. Leukemia is a disease in which there are abnormally large numbers of leucocytes in the blood, but now we know that there is also an abnormally low level of leucogenenol—the agent which stimulates development and maturation. Could it be that the disease is not due to the production of an abnormally large number of the cells, but rather to their failure to age and be removed? If so treatment with leucogenenol might solve the problem. These ideas are, of course, speculation, but they can serve as the guide to useful research.

Possible Practical Therapeutic Applications

The immediate interest of the Navy in leucogenenol is in the possibility that it might restore immune competence in persons who have

suffered from exposure to radiation. A possible treatment for radiation damage is the use of bone marrow transplants, but there is a serious limitation to this approach. It is the cells of the donor that retain the ability to recognize alien antigens, and such grafts may respond to their new host by attacking it as though the patient were the graft to be rejected. If there are a few surviving cells in the bone marrow of a victim of radiation exposure, and if these can be stimulated by leucogenenol to multiply, differentiate and mature, the effect should be the equivalent of an infusion of the patients own marrow, quite free from any damaging graft-versus-host disease effects.

It has already been pointed out that the potential exists in normal, healthy human beings for speeding up their response to immunization procedures and perhaps for restoring prior immunities without limiting the effects to one particular type of disease. It is also possible that the use of this agent would permit the establishment of immunity to a wider range of diseases than has hitherto been possible, if the antigens which have been tried for immunization failed because they only elicited a marginal response.

Since leucogenenol is associated with the growth of cells, and very probably with normal regulatory functions related to the immune response, the potential for practical applications would seem to be almost unlimited. It seems certain that many developments in the understanding and treatment of a wide variety of medical problems will follow from these beginnings in basic research.

Lunar Glass Particles Oxidized on the Moon

Scientists at the Naval Research Laboratory (NRL) have evidence that the mysterious green glass spherules brought back to earth by the Apollo 15 astronauts were oxidized on the moon.

This conclusion is based on an experimental technique called electron spin resonance (ESR). All fine soils returned from the moon invariably have displayed an extremely intense ESR signal, which in the usual interpretation has been attributed solely to the presence of metallic iron.

NRL moon scientists had previously challenged the "orthodox" view by demonstrating that a portion of this signal could in principle arise from an oxide of iron similar to terrestrial magnetite (lodestone).

New findings now indicate that such ferric oxides are indeed present in the lunar soils.

At the Fourth Annual Lunar Science Conference recently held in Houston, other lunar scientists presented evidence that the Apollo 15 green glass spheres are probably of volcanic origin and that they contain absolutely no iron metal.

Therefore, Laboratory scientists say, the ESR signal obtained at NRL for these glass spheres cannot arise from metallic iron and consequently must result from some other source as the "magnetite-like" material suggested by NRL.

CATO Expedition—Leg 6

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The Atlantic Ocean is unusual when compared to the two other major oceans in that it has a source for renewal of its deep water in the north as well as in the southern source for its bottom water also found in the Pacific and Indian oceans. In the South Atlantic the effect of the two source regions is most pronounced. Here the North Atlantic Deep Water, which has its origin in the Norwegian Sea, is characterized by temperatures near 3°C and salinities near 34.9 parts per thousand, while the Antarctic Bottom Water, which has its origin in the Weddell Sea, is characterized by temperatures near 0°C and salinities near 34.7 parts per thousand. As the North Atlantic Deep Water flows southward, it overrides the slightly denser Antarctic Bottom Water, which is flowing northward along the bottom. In order to investigate the flow of these two water masses, Joseph L. Reid with the support of the Office of Naval Research organized an oceanographic cruise to the South Atlantic aboard the Scripps Institution of Oceanography's research vessel *Melville* as Leg 6 of the CATO expedition. Other scientists who participated in the cruise were Theodore D. Foster and William C. Patzert of Scripps Institution of Oceanography, Hugh J. McLellan of the National Oceanic and Atmospheric Administration, and Worth D. Nowlin of Texas A&M University. The *Melville* departed from Rio de Janeiro on 7 November 1972 and returned to Rio de Janeiro on 16 December 1972 after cruising 6535 nautical miles.

The waters in the vicinity of the Rio Grande Rise, which stretches southeast from the Brazilian coast to the Mid-Atlantic Ridge, were the primary concern of the cruise. Because the Rise serves to constrain the flow of the bottom waters to two passages in the Rise, it was anticipated that the flow of Antarctic Bottom Water could be directly measured with current meters placed in these passages. Current meters were also set out along two lines of hydrographic stations north and south of the Rise and recovered later in the cruise. The scientists took a total of 51 hydrographic stations at which precision measurements of temperature and salinity were made, using Nansen bottles and reversing thermometers

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*Dr. Foster, an Associate Research Oceanographer at Scripps Institution of Oceanography, is a Lieutenant Commander in the Naval Reserve and a member of Naval Reserve Research Company 11-5 in San Diego. His recent scientific interests include geophysical fluid dynamics and physical oceanography of polar regions.

Dr. Patzert is an Assistant Research Oceanographer at Scripps Institution of Oceanography. His present principal research interest is in regional circulation problems.

at discrete depths as well as using an electronic salinity-temperature-depth recorder (STD) which produced continuous profiles. Eleven bottom-moored current meters were successfully emplaced from about 10 to 1000 meters off the bottom. These current meters recorded current speed and direction internally on strip chart recorders and were equipped with time release and flotation gear so that they would rise to the sea surface after a predetermined time interval. Satellite navigation equipment on the *Melville* and radio beacons and flashing lights on the current meter floats facilitated recovery of these meters.

In the region from about 2000 to 3600 meters depth we saw the southward-flowing relatively warm and highly saline North Atlantic Deep Water and below about 3700 meters the northward-flowing cold and less saline Antarctic Bottom Water. The transition region from about 3600 to 3700 is a region of mixing between the two water masses. Preliminary calculations show that the density gradients, and thus stability, increases at these depths, suggesting that this is a layer of shear between the oppositely flowing deep and bottom waters.

The temperature and salinity profiles determined from Nansen bottle and STD data can be combined into hydrographic sections in which the properties are mapped as a two-dimensional field. Five stations from *Atlantis* cruise 247 have been added to complete the section in the east. Potential temperature, which is ordinary temperature adjusted to sea level taking into account the cooling due to the expansion of sea water so that compressional effects are adjusted for and comparison of water masses at different depths is easier. We noted the tilt of the isotherms in the bottom water between 36°W and 29°W corresponded to the tilt of the lines of equal salinity in the bottom water. The temperature and salinity data allow the calculation of the density field, which in turn allows the calculation of pressure field. The tilt of the lines of equal temperature and salinity indicates that a pressure gradient is probably present in the bottom water region. In an equilibrium situation the gradient of the pressure balances the Coriolis force induced by the velocity of the water perpendicular to the gradient and the earth's rotation. The relative velocities perpendicular to the hydrographic section can thus be determined, and by use of the bottom-moored current meter measurements these relative velocities can be converted to absolute velocities. A preliminary evaluation of the data showed that the most significant flow of the Antarctic Bottom Water is northward through the western passage in the Rio Grande Rise with a velocity of over 20 centimeters per second and that the North Atlantic Deep Water flows in a large counterclockwise gyre in the vicinity of the Rise.

NRL Detector Observed Cosmic Rays from Skylab

S-009 is a detector, but not in the same realm as James Bond. Rather it is one of the several experiments prepared by Naval Research Laboratory (NRL) scientists here for NASA's Skylab.

Dr. Maurice M. Shapiro, Chief Scientist of NRL's Laboratory for Cosmic Ray Physics and the Principal Investigator for the S-009 said the experiment was used in Skylab to study the heavy atomic nuclei present among the cosmic ray particles constantly bombarding the Earth from outer space.

In speaking of cosmic ray studies, Dr. Shapiro stated that most available data on the energetic particles have resulted, thus far, from the exposure of sensitive detectors flown on high-altitude balloon flights. However, he added, interactions between incoming cosmic rays and the Earth's upper atmosphere break up some of the primary nuclei and distort the arriving composition of cosmic rays obtained during the balloon flights.

The S-009 apparatus, unaffected by the upper atmosphere, obtained more accurate measurement of the relative abundances of various nuclei in the primary cosmic ray influx.

Revealing comparisons have already been made between the source composition of cosmic rays and the element abundances in the solar system and in nearby stars. These suggest that certain nuclear processes occurring on a very short time scale during the explosion of a supernova could play an important role in the production of cosmic ray nuclei.

The S-009 detector, which contains many sheets of nuclear photographic emulsion stacked together, operated in two modes. One, the data-collection mode, operated while Skylab was in near-equatorial portions of its orbit. The second, the data-rejection mode, operated while the spacecraft was in the region of the South Atlantic anomaly and during high latitude portions of its orbit.

In the latter mode, the configuration of the detector was altered to discriminate against low-energy cosmic ray nuclei that reach the Earth at high latitudes and against Van Allen protons that dip down close to the Earth over the South Atlantic. The instrument was located in the multiple docking adapter on Skylab.

"Man-Made" Heavy Cosmic Rays

Recently, laboratory beams of heavy ions have for the first time been speeded up to cosmic ray energies at the Princeton Particle Accelerator and the Berkeley Bevatron. These new beams of man-made "cosmic rays" have made it possible to measure some important nuclear reactions, and have brightened the prospects of understanding the origins of the cosmic rays observed in our local region of the Milky Way. As a remarkable "spin-off" from the cosmic ray studies on nuclear fragmentation, the knowledge thereby gained is already applied to radiation biophysics and it may soon be helpful in experimental cancer therapy.

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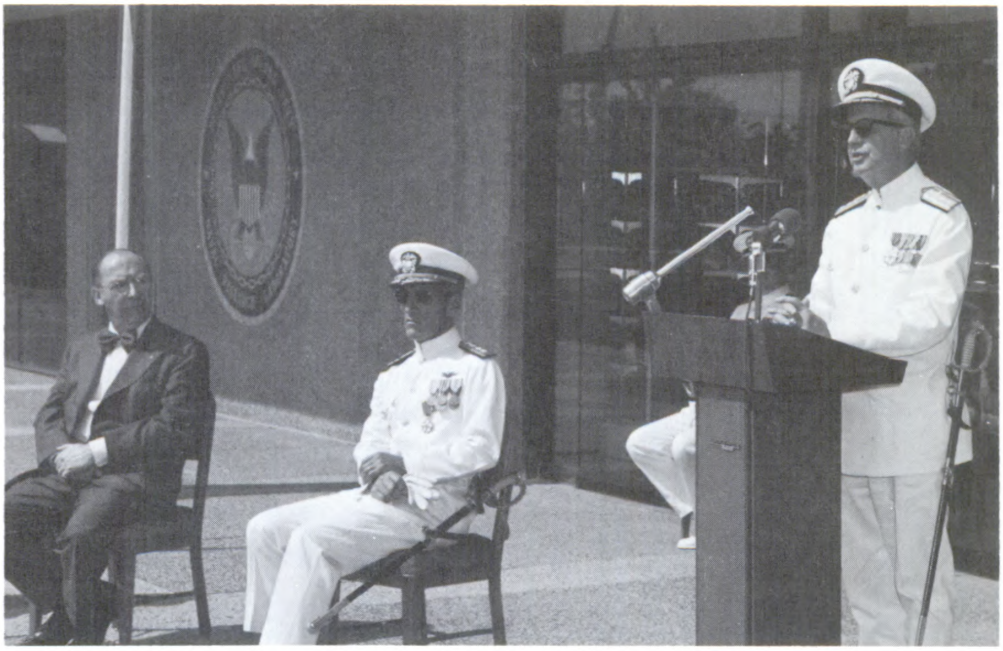
Rear Admiral M.D. Van Orden, USN, Assumes Post of Chief of Naval Research



From left to right: Dr. Peter Waterman, Assistant Secretary of the Navy (Research and Development), RADM Carl O. Holmquist, USN, and RADM Merton Dick Van Orden, USN. RADM Van Orden has assumed the post of Chief of Naval Research, relieving RADM Carl O. Holmquist, who retired on June 1. RADM Van Orden took command of the Office of Naval Research at a change-of-command ceremony held at the Naval Research Laboratory on May 31. He was previously Vice Commander of the Naval Electronic Systems Command.

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Cover Caption

Morgan, a pilot whale at NUC's Hawaii Laboratory prepares to fasten a grabber claw to a torpedo. Morgan is part of the Deep Ops recovery system, which provides routine recoveries from depths of 1000 feet.

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