Marine Sciences Program

Biological Studies

Phytoplankton, the microscopic plants that drift along in ocean currents and provide food for larger animals in the oceans' food web, will be studied. Water samples containing plankton will be pumped to the TEKTITE habitat from several different depths so that the productivity or biological richness of the area can be measured. The zooplankton (microscopic animals), which feed on the phytoplankton and in turn are fed on by fishes, will also be studied, particularly in respect to their relationships between other marine life and the physical environment of the reef area. Plankton studies of this type are usually done from shipboard with suspended sampling devices. Observations made directly from the ocean floor habitat, however, are expected to yield far better sampling control and continuity than can be gained from a rolling ship.

Various methods used for measuring the production of marine life in ocean and reef areas will be compared to determine the relative advantages of one method over another. Most productivity estimates of this type are based on measurements of oxygen produced and consumed in a given period. During the TEKTITE Project special equipment will be used to enclose some organisms while measurements are made of their oxygen production and absorption of radioactive carbon (C^{14}). These studies may help make it possible to standardize methods and reduce variations in estimates of organic production in ocean waters.

Most marine organisms exhibit definite patterns of activity or behavior in foraging, mating, escaping from predators, etc. Knowledge of these activities is necessary to understand better the life history of a particular species, and if it is a commercial variety, to design fishing gear for its capture. In the early phases of the project, spiny lobsters (they are the source of what are commonly known as "lobster tails"), reef and predator fishes and certain mollusks will be tagged with tiny sonic transmitters. Thereafter, movements and habits of these animals will be monitored on a small portable sonar device capable of receiving signals from the transmitters even if the animal is secluded in a deep coral burrow up to 4 miles away. The receiver will enable the scientists to track the tagged animals and record their location and activity in daylight or darkness. When a lobster is located, its identity can be

determined by a brand, visible at night under ultraviolet light. By monitoring several representative organisms, the biologists will obtain information on growth and survival, feeding habits, daily migrations, reproduction, responses to environmental changes, and other pertinent information occuring over the 2 month period. Observations such as these are extremely difficult to make working from the ocean surface.

Geological Studies

During the TEKTITE experiment, the types of sediment in Lameshur Bay will be identified and mapped. A few small portions of the sea floor have previously been mapped by diving geologists, but TEKTITE offers the first opportunity to develop a close familiarity with a sub-sea area comparable to what a geologist has with his onshore terrain. These data, combined with acoustically derived profile records of the strata or sediment layers beneath the ocean floor will provide a three-dimensional picture of the recent sedimentologic history of the bay. Analysis of the relations between sediments will provide a basis for interpreting certain types of carbonate rocks and may prove useful to the petroleum industry.

Study will also be made of the production of biogenous sand (sand formed from the remains of once-living organisms). TEKTITE provides an opportunity to relate the sand to the contributing organisms (mostly corals and mollusks) and to study the balance between reef growth and destruction. Study of the variation of sand composition with grain size and location should provide information on the mechanical breakdown and processes of distribution of biogenous sand.

The dominant feature of many portions of the sea floor is biologic reworking of the sediment. Moreover, the effects of organic reworking in the geologic past are shown by tracks, trails, and burrows in many sedimentary rocks. Certain apparently structureless rocks are suspected to have been homogenized by bottom dwelling organisms. Contemporary research indicates that the nature of organism reworking is related to the depositional environment. At present no data are available on this relationship in carbonate sediments in a reef dominated environment. TEKTITE will provide an opportunity to collect some of this information as well as a chance to study briefly the role of biologic ingestion in sediment modification. The duration of the experiment will permit observation on the rate of organic mixing in different environmental settings. These observations may be of value to geologists in providing clues as to where to seek petroleum or other mineral deposits, and what happens to sediments when they are disturbed by marine organisms.

Additionally, TEKTITE will aid in the development and evaluation of underwater geologic techniques such as sampling and mineralogic separa-

tions. The lack of laboratory facilities in undersea habitats poses a major problem for undersea geologic research and creates a potentially limiting dependence on surface support. During the TEKTITE operation experiments will be conducted attempting to establish procedures whereby routine sediment analyses could be made on the ocean floor without having to return samples to the surface.

Finally, by living in the submarine environment, the geologist has an opportunity to conduct other aspects of underwater research. He can monitor changes in the sediment and the sedimentation processes as frequently as he wishes. He can observe continuously the interaction between sediment and bottom dwelling organisms. Along with other studies he can measure the chemical and physical properties of the sea floor in a natural state.

General Environmental Studies

Continuous monitoring of the environment during the project will be carried out in support of the planned ocean floor program. Continuous records of water temperature, salinity, current speed and direction, pressure, ambient light, water chemistry, and bioluminescence will be made, and the effect of these elements on the behavior patterns of marine organisms or changes in the sediment characteristics will be determined.

Acoustical Studies

The widespread use of sonar for fishery applications and the increasing technical developments within the field point to a specific need for detailed studies on the effectiveness of sonar for differentiating between fish species either by a characteristic signal return from a single fish or by signal recognition of the swimming or schooling behavior of groups of fish. The TEKTITE Project will provide a unique opportunity for these studies, where sonar target species can be identified and correlated with their acoustical "signatures."

Additional uses for sonar are in various project support functions. The routine task of compiling charts of pertinent topographic and geologic features underwater is beset with several problems of little or no consequence to the land surveyor. The use of sonar for providing reliable range and bearing data appears to offer much promise for underwater survey and geologic delineation work. Furthermore, the location and range of free swimming divers during any underwater operation is of prime importance for safety reasons. Indications are that narrow band sonar can be an important aid in diver tracking and navigation.

TEKTITE Site: Physical Characteristics

Location - The underwater site of Project TEKTITE I is Beehive Cove in Lameshur Bay, a south shore indentation of St. John Island in the Virgin Islands, some 900 miles southeast of Miami, Florida. The cove is in Virgin Islands National Park, which is administered by the National Park Service of the Department of the Interior.

St. John Island - St. John is 9 miles long and 5 miles wide. It is the smallest of the three principal American Virgin Islands. Its land surface covers about 12,000 acres (19.2 square miles), a little more than half the size of Manhattan Island in New York City. The elevation ranges from sea level to 1,277 feet. The mountainous terrain, covered with dense tropical vegetation, drops steeply to an irregular shoreline containing rugged cliffs and sandy beaches. The island's shore is bathed by the Atlantic Ocean on the north and by the Caribbean Sea on the south.

Virgin Islands National Park - Nearly two-thirds of St. John Island and most of the colorful offshore waters are in Virgin Islands National Park. The Park was authorized by Congress and established in 1956 after philanthropist Laurance Rockefeller acquired more than 5,000 acres and donated the land to the Federal Government for a national park.

In 1962 the park boundaries were extended to include submerged lands and waters within approximately one-half mile of the coast. The park's land and water area now covers 15,150 acres including extensive coral reefs. Beehive Cove was selected for TEKTITE I largely because it contains an extraordinary reef.

The Cove and Bay - Beehive Cove is near Cabritte Horn Point, the tip of a stubby peninsula three-quarters of a mile long which forms the eastern side of Lameshur Bay. The Bay consists of Great Lameshur Bay on the east and Little Lameshur Bay on the west.

Rocky and roadless, the peninsula is not conducive to land travel between Beehive Cove and the TEKTITE base camp. Boats will ply the 1300 yards between the base camp docks and the cove where the TEKTITE support barge will be moored to the peninsula shore. The barge will contain the TEKTITE control van and the umbilical lines to the underwater habitat.

Research Station - The Virgin Islands Ecological Research Station, within walking distance of the base camp, is expected to occupy some of the base camp buildings upon completion of TEKTITE I. All other structures are to be removed by the Office of Naval Research.

BEHAVIORAL PROGRAM

The behavioral program is one of the principal reasons for conducting an extended ocean floor mission such as TEKTITE. The program, one of the most exhaustive ever designed for aquanauts, is intended to obtain data on a multitude of behavioral aspects from the amount of food consumed by the aquanaut-scientists to subtle changes in their moods at different times.

Notwithstanding the exhaustive nature of the program, all data collection methods have been devised to minimize interference with the marine science program on the ocean floor.

The objective of the behavioral program is to evaluate individual and group behavior in a situation where the mission is real rather than experimental, the duration quite long, and the environments are relatively hazardous.

The data gathered will provide information useful in planning future missions involving stress such as manned undersea stations or extended manned spaceflights. It will provide valid criteria in the selection, training and group composition of the crews for future undersea and space missions.

By studying the individual and group response to factors such as living space, volume, layout of work and rest area, lighting, recreational facilities, and waste management, it may be possible to develop more effective standards for designing similar systems in the future.

During the 60 days on the ocean floor, the aquanaut-scientists will be subjected to measurements designed to record (1) task performance, (2) social interaction and (3) personal adjustment.

Methods of data collection.

One of the principal methods of collecting behavioral information will be by closed circuit television, which will allow objective recording of observed behavior by personnel on the surface.

One camera is located in each of the four habitat rooms. Two portable waterproof TV cameras with remotely controlled pan, tilt, zoom, and lens adjustment will be placed in the water on tripods in the vicinity of the habitat. On the surface, six TV monitors with switching facilities to select any or all cameras or open microphones will be set up in the control van. In addition, a video taperecorder and playback will be installed.

Other methods of data collection include automatic recording of specified events such as entrance and egress from the water, use of entertainment facilities and use of communication systems; systematic recording of brain waves, (EEG) during sleep; photography; diaries and report forms; interviews; as well as an analysis of the amount and quality of the work performed by the awuanauts.

Prior to the mission, the aquanauts will undergo a series of measurements designed to gather data on demographic, personality, social and adjustment factors, sleep habits, habitat evaluation and food preferences.

Monitoring of task performence will permit the assessment of the ability of crewmen, singly or as teams, to perform manual, sensory and intellectual tasks required in the mission plan. The tasks in question will include routine activities such as monitoring the habitat systems, preventive maintenance, repairs of malfunctions, and housefeeping tasks; or more demanding mental tasks such as the mission-oriented scientific activities, or the handling of emergency and unplanned situations.

The purpose of the social interaction measurements is to monitor interactions between individual crew members and between the crew and topside personnel which affect the objective of the mission, and the morale and survival of the crew.

The objective of the personal adjustment measurements is to ascertain any variations in emotion, motivation, and fatigue of the crew which may occur.

Other important parts of the behavioral program of TEKTITE will be the Habitability and Human Engineering Evaluation of the habitat, Phychophysiological measurements (including sleep EEG) and the use of a psychomator test which includes manual dexterity and decision making. These evaluations will be conducted jointly with engineering medical safety and other personnel in the program.

BIOMEDICAL EXPERIMENTS PROGRAM

The objectives of this program are threefold: to aid in the monitoring of the medical aspects of a safe crew operation; to collect certain biomedical data; and to correlate this data with all the scientific aspects of the program.

For 60 days, the TEKTITE aquanaut-scientists will be breathing two gas mixtures. In the habitat, the mixture will be composed of approximately 92 percent nitrogen and 8 percent oxygen in which the partial pressure of the oxygen is maintained at the same level as in the air atmosphere at sea level. When in the water, the aquanauts will breathe air under pressure equal to the pressure of the water.

The data collected will help determine whether the two breathing mixtures and pressure affect blood composition, respiration, vision, and hearing of the aquanauts. Also of interest, will be the collection of bacteriological data to ascertain the actions and interactions of micro-organisms found in the immediate environments of the aquanauts whether in or out of the water.

Hematology

Prolonged breathing of the two mixtures may affect the formation and destruction of blood cells or produce other changes in the functional capabil ties of the blood. In order to permit a valid assessment of any change in the blood, measurements will be taken periodically. The aquanauts themselves will take the blood samples from each other. The sample will be then sent to the surface in a pressure pot and sent to a laboratory for analysis.

Pulmonary and Respiratory Studies

Before and after the 60-day exposure to the denser atmosphere, the rate, depth and minute volume of respiration will be measured by having the aquanauts inhale progressively, zero, two, four and six percent carbon dioxide in 21 percent oxygen. This will allow a determination of how increased atmospheric pressure alters the respiratory response to carbon dioxide. Related measurements will monitor the changes in the rate of diffusion of the carbon dioxide across the alveolar and capillary membranes.

Other respiration measurements before, during and after exposure, are designed to determine how the denser breathing mixture affects the ventilatory function -- the lungs' bellow-like muscular activity of breathing in and out. It is possible that this particular atmosphere may increase the workload of the lungs. However, the changed workload may condition the respiratory muscles permitting the lungs to have the same efficiency as in a normal atmosphere. At the same time, breathing work and efficiency will be monitored by measuring esophageal pressure. Additionally, before and after exposure,

efforts will be made to find out if the dense atmosphere results in any increase in pulmonary complianc e -- the ease of expansion of the lungs -- and airway resistance -- the opposition offered by the airways to the flow of air into and from the lungs.

Microbiology

These measurements are intended to provide information on how the body bacteria of the aquanauts is affected by the water immersion and the factors of temperature and microbiological content. Efforts will also be made: to determine whether new microorganisms are introduced in the habitat as a result of such exposure; to monitor the interchange of microorganisms among the aquanauts; and to predict the results of interaction of the microorganisms present on the bodies of the aquanauts with their immediate environment. The data will be collected by examining bacteriological samples taken from the bodies of the aquanauts. Bacteriological content of the habitat will be measured by taking concurrent atmospheric samples as well as swabs of the habitat itself. Periodic water samples will be obtained at various distances from the habitat and analyzed for bacteriological content.

Vision

Since vision disturbances are not anticipated, only "before and after" tests will be conducted to demonstrate that visual acuity has remained unaffected.

Hearing

Before and after their undersea stay, aquanauts will be tested by standard audiometric techniques. Analysis of the audiograms may indicate whether exposure had any effect on the hearing acuity of the aquanauts.

AQUANAUT STATUS ASSESSMENT

At least once daily a general physical assessment of the health of the aquanauts will be required. The aquanauts will give themselves a physical check-up and send the results to the surface. Among their daily measurements will be radial pulse and blood pressure. They will also take color photographs of any skin lesions they may incur and send them to the surface for analysis. This will enable the on-site medical officer to determine their general health or possible onset of disease.

TEKTITE I -- DESCRIPTION

HABITAT DESCRIBED

The basic habitat system consists of two interconnected vertical cylinders 18.1 feet high and 12.5 feet in diameter mounted on a base structure. Each of the cylinders contains two compartments, the left side houses the crew quarters on the lower deck and the bridge or control room above. The right cylinder connects with the left by means of a four and a half foot diameter transfer tunnel running from the bridge to the upper half of the right cylinder, the engine room. The lower half of the right hand side houses the wet room which is continually left open to the sea for easy access in entering and leaving the habitat.

The right side of the habitat also supports a five foot high, two foot diameter cupola mounted on top of the cylinder for additional observation purposes.

INTERNAL LAY-OUT

The crew quarters contain a small galley, bunks, storage for personal gear, and entertainment equipment consisting of radio and television facilities. An emergency exit hatch and scuba equipment are located in the crew quarters.

The bridge serves a dual purpose: (1) as the control center for the habitat system and (2) as a laboratory for the scientists.

The engine room contains the larger items of the environmental control system, the primary transformers, switch gear, and the large freezer for food storage since the four aquanaut-scientists will take a 60 day supply of food with them, this supply will not be replenished during the mission.

Since the wet room is always open to the base, and therefore directly to the sea, it is the only compartment which does not have controlled humidity; it houses the SCUBA gear, for use by the crew while conducting experiments outside the habitat, and an outlet for recharging the SCUBA bottles. In addition, it contains a laboratory including a wet sink where the scientists can perform specimen preparation. It also contains a hot shower.

COMMUNICATION

The bridge, which is the communications center, is connected to the Surface Support Facility by phone, intercomm and voice sonar. Each compartment is equipped with an intercomm station connecting it with the other compartments as well as the support barge, an open mike and closed circuit TV monitor for the behavioral program, and audible and visual alarms. The bridge also has sound-powered phone and voice sonar links to the Surface Support Facility. In addition, the Bridge is able to monitor the open mikes and any two of the closed circuit TV cameras. The voice sonar also permits direct communication with crew members when they are out of the habitat.

In the wet room there is a timer for recording the times when the individual crew members leave and enter the habitat. Externally there are audible and visual alarms and two closed circuit TV monitors. One of these monitors will be fixed so as to observe the habitat entrance while the other will be used for remote observation of selected areas by the crew. There will also be both fixed and portable lights outside the habitat.

COMMUNICATIONS SYSTEMS

PURPOSE	HABITAT EQUIPMENT
BEHAVIOURAL DATA ACQUISITION	4 TV CAMERAS IN HABITAT 2 TV CAMERAS ON OCEAN FLOOR 2 TV MONITORS IN HABITAT 4 OPEN MICROPHONES IN HABITAT 1 DIVER IN/OUT PANEL IN WET ROOM 1 CREW ACTIVITY MONITORING SWITCH SET IN CREW QUARTERS
NORMAL OR EMERGENCY COMMUNICATION TO SHORE	1 SOUND POWERED PHONE LINK IN BRIDGE 1 INTERCOMM SYSTEM IN HABITAT 1 EMERGENCY ALARM PANEL IN BRIDGE 2 WARNING BELLS AND HORN IN BRIDGE
DIVER TO DIVER COMMUNICATIONS	1 HARDWARE COMMUNICATION TO WAY STATIONS
ENTERTAINMENT	1 COMMERCIAL TV MONITOR 1 COMMERCIAL RADIO
BIOMEDICAL DATA ACQUISITION	4 EEG ELECTRODES & AMPLIFIERS IN CREW QUARTERS 1 EKG RECORDER/AMPLIFIER IN BRIDGE

The data for the behavioral mission will be obtained primarily by direct, around-the-clock observation of the crew by teams of psychologists manning a special station located on the Surface Support Facility. The primary data links will be closed circuit television monitors and open mikes. Each of the four habitat compartments is equipped with a TV camera and open mike, with two additional closed-circuit TV cameras positioned on the ocean floor immediately outside the habitat.

Additional behavioral data will be obtained by timing monitors on the entertainment TV and radio, on the usage of the galley equipment, and by the diver in-water timer. Another source of data will be the electroencephalogram equipment to be used by the crew during certain sleep periods.

ENVIRONMENTAL CONTROL SYSTEM

The Environmental Control System will provide a comfortable, clean atmosphere for the crew. The oxygen partial pressure will be maintained at the normal sea-level value with nitrogen used as a diluent.

A direct benefit of the maintenance of this value of oxygen partial pressure is that the fire hazard is considerably reduced since this percentage of oxygen will not sustain combustion. This is considered a distinct advantage by all except those in the crew who will have to give up smoking for 60 days because their cigarettes will not stay lit in this atmosphere.

There are actually four supply systems for the environmental gas supply. The normal supply is provided by an air compressor. Prior to emplacement, the habitat is sealed and charged with nitrogen to raise the pressure to the 36.9 psia needed on the bottom. Once the habitat is occupied, normal compressed air is introduced at the rate needed to maintain the oxygen partial pressure at the desired level. Should the cabin atmosphere become contaminated for any reason, the entire volume can be charged and recharged with the proper mixture in four hours by a purge system which operates off a bank of stand-by bottles on the Surface Support Facility. In addition, there are two independent sets of stand-by bottles, each containing a 72-hour supply. One of these is mounted on the Surface Support Facility and the other in the habitat base. There is also a high pressure (2800 psi) compressor for the SCUBA charging system. Additional safety measures include an emergency BIBB system plus walk-around bottles in each compartment.

The air treatment system is located in the engine room. The CO_2 is removed by a Baralyme-charged scrubber. The six Baralyme cannisters, being replaceable, will be changed as required. Humidity and temperature control is achieved by condensing out the excess moisture and then reheating the air. In addition, the air is passed through charcoal filters to remove noxious odors.

THE BASE STRUCTURE

The primary function of the base is to provide a mounting for the two cylinders with the adjustable legs making it possible for the base to compensate for small slopes and irregularities in the bottom. Another function of the base is to provide for the 175,000 pounds of ballast required to bring the total emplaced systems weight to net negative buoyancy of 20,000 pounds. In addition, the base serves as a shark cage for the diver's protection. Both the normal and emergency hatches open into the base with simple cage doors opening out to the sea. Finally, the base serves as a mounting structure for both a 72 hour supply of breathing gas and for the large high pressure bottles used to recharge the regular SCUBA tanks.

SURFACE SUPPORT FACILITY

The Surface Support Facility will provide the direct surface support required by the habitat. The equipment will be mounted on an Ammi barge either moored or

jacked-up near the habitat site. On the barge will be a van containing the duty stations for the test director, medical duty officer and behavioral observers. The electrical generating equipment, air compressors, purge bottles and stand-by breathing gas are also located on the barge, as well as the habitat water supply. All these utilities are connected to the habitat by umbilicals. The Surface Support Facility also provides safety services for the habitat. A deck decompression chamber (DDC) and a personnel transfer capsule (PTC) will be available for the transfer of the crew at the end of the mission or in case of an emergency. In addition, a safety patrol with qualified divers, in a small boat, will be standing by at all times.

OTHER EQUIPMENT

There will be five way stations located in the general area of the habitat. These stations will provide several benefits to the crew. They will make excellent observation posts from which the aquanaut-scientists will be able to observe the immediate area and, if desirable, record their observations in a dry environment. These way stations will also enable the scientists to make minor adjustments to their equipment or to carry on a conversation with their comrades in the habitat. Also, if the occasion should arise, the way stations will provide a place of refuge from sharks.

A simple dumbwaiter system will be installed adjacent to the habitat for the dry transfer of small items between the surface and the habitat. Typical items to be transferred are blood and urine samples from the crew, marine biological and geological samples for surface laboratory analysis, and special tools or equipment for the scientists.

TEKTITE - I LAYOUT