

AQUA-HABITAT

by

Jack E. Clark

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of

BACHELOR OF ARCHITECTURE

Approved:

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STATEMENT

Historically architecture is a main element in mans created environment, and as such it is a decisive factor in his ability to adapt to the natural environment. Our present indulgence with esthetics and comfort is grossly disproportional if we consider a global situation. These are important considerations, but it is architecture as a means for further adaptation which holds promise for the future.

Northeast.

The island itself is barren and has no practical economical value at the present. It does provide a base for sea-birds and any design would have to consider the welfare of these creatures.

"In the end man must and shall colonize the deeper ocean floor."

Captain Jacques-Yves Cousteau

SITE

The South Coronado Island is 11 miles off the Baja Coast and 25 miles from San Diego the nearest port.

The waters around the island are remarkably shallow and ideal for aquaculture. They are clear and unpolluted with a year around temperature in the seventies.

The climate is the same as Southern California. Summer winds are from the South and Southwest. Winter winds are from the Northeast.

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SEA FLOOR INDUSTRY

Agriculture

The average yearly intake of fish is 55,000,000 tons. If we could institute a fish management program with a good method of harvesting we could increase this yield by 80 times. Such programs can not be managed from the surface.

Conventional methods of fishing today do not harvest many potential species. Conventional methods are also getting more expensive without a marked increase in production.

Proper fish management would eliminate dangerous over fishing of certain stocks, while providing ideal environments for rapid growth. For instance a four inch baby sail fish will grow to over six feet in six months.

Shell fish are another source of protein that could be optimised.

An acre of shell fish ground can produce 15,000 pounds of protein yearly and if the shell fish are supported above the floor on ropes or nets the floor remains free for fish and plants..

Giant kelp is the fastest growing plant known but it is easily harvested from the surface.

Mining

Half the total reserves of petroleum today are under the continental shelf. The oil companies hope to have 50 percent of the worlds needs met by this oil by the year 2000 and in order to achieve this goal they are spending over two million dollars a day in off shore drilling. The place for this industry is on the

AQUACULTURE

sea floor. The initial cost would be higher, but long range cost would be lower. On the sea floor this industry would be safe from surface storms. In 1964 the oil industry lost 20 million dollars to hurricane Hilda alone.

The ocean floors are rich in precious and base metals. It is estimated that there is 1.5 trillion tons of manganese on the floor of the Pacific Ocean. Manganese is so abundant and at such high demand that dredging for it is economically feasible. Other minerals that are in abundance are sulphur, phosphorite, copper, sluminum, and gold.

Biomedicine

Medical science is using more and more drugs that come from the sea. Some of them are a diabete-combating chemical extracted from tiger fish, blood coagulant from sea snake venom, local anesthetic 100,000 times more powerful than procaine comes from mussel, oysters and clams produce a antivirius sebstance called Prolin II. There are many more drugs and we have not even scratched the surface mainly because of longistics, the place for such research is at the source not hundreds of miles away.

AQUACULTURE

Aquaculture is the production and harvesting of fish protein. Presently it is practiced on a limited scale in parts of Europe and the Far East for the production of gourmet foods. Through the management of present harvesting methods the yield could be increased by as much as 80%. Through the improvement of fish habitat the population density could be increased several times.

Most of the methods that may be used to accomplish this are in the experimental stage.

Air fences could be used to pen certain species and to herd them into given areas where they could be harvested by a sub equipped with an air lift leading to a surface vessel. The Russians are using air lifts to harvest fish in the Bering Sea with disastrous results. They suck up unprofitable fish that are not yet mature enough as well as the larger fish. Thus the schools are being rapidly depleted at no value to the fisherman. This device needs underwater control to be used properly.

Dolphins may also be used as a means to control fish.

The improving of fish habitat has been done in many simple ways such as wreched cars being dumped into the water, almost anything that will provide the smaller fish protection from predators will work.

PRESSURE

Since the first time man started going to any depth he has faced two barriers, breath and pressure.

Both these problems pose a loss of mobility in their solutions. The problem of breathing can be overcome through the use of cumbersome gear and pressure through decompression.

Not being able to breathe is an obvious problem, but pressure is a more subtle and potentially as dangerous. Most of us live in a pressure that is relatively constant and around 14.7 psi. The Incas being one notable exception where they have adapted to much less than this by an increase in their lung capacity. They are indeed a remarkable example of the adaptiveness of the human species.

When one enters water, the water exerts additional pressure as you go deeper. In order for this pressure to be equalized, the air pressure entering a divers lungs must be the same as the external pressure. This air pressure serves to equalize the pressure in all the body cavities. Nitrogen and oxygen enter the blood and are distributed throughout the body.

This absorption of the gasses is called saturation. The deeper the diver goes the greater the rate of saturation. Saturation continues until the body reaches a point where it is saturated and will not accept any more gasses in solution. The deeper the diver the higher the concentration of gasses for saturation. In diving the initial pressure of the first ten feet are the most crucial. This is where the pressure change is the most drastic.

It is also where the body must adjust from one medium to the other. For this reason it would be desirable to undergo initial compression in a controlled environment.

The last few feet to the surface are also the most critical of the decompression cycle. The reason for this is simply that the pressure differential in depth is more accelerated toward the surface. For instance in the first 33 feet the pressure doubles from 14.7 psi to 29.4 psi and for it to double again you would have to go to 99 feet for 58.8 psi. At 66 feet you would have 44.1 psi to double that you would have to go to 165 feet for 88.2 psi. This differential is also the reason why a diver who started saturated at 50 feet could dive to 190 feet and remain an hour and return to 50 feet without stopping to decompress, but a diver from the surface diving to that depth for that period of time would have to stop at -50 feet for 10 minutes, at -40 feet for 17 minutes, at -30 feet for 19 minutes, at -20 feet for 50 minutes, and at -10 feet for 84 minutes; or a total of 183:10 minutes decompression time for 60 minutes of work. This fact and it alone is what makes saturated diving a feasible solution to the problem of pressure. Once a diver is saturated, 12 hours at -50 feet, then his decompression time is the same no matter how long he remains saturated. Captain Bond of USN recommends a decompression rate for saturated diving equal to an ascent of 6 feet per hour or 8:20 minutes for saturation at -50 feet.

ENVIRONMENT vs TECHNOLOGY

The nature of this project makes it highly dependent on technology. In the past however mans technology solutions have created about as many problems as they have solved. This has not been the fault of technology, but rather the men who have employed it. Technology has been at its worst when employed for monetary reasons with a disregard for the society it presumes to serve. Such technology is short term in nature employed by a small group, primarily for the groups benefit and valued only for the life time of the group. Such technology truly serves no society, and will have no place in an underwater community where one of the main psychological factors must be a sence of permanence.

Limited Environment

As on land, in the seas the sun is the source of life. Through photosynthesis, plankton transforms the suns energy and thus establishes the base of the food chain on which all marine life is dependent.

The maximum depth that light penetrates in tropic waters is about 100 meters, while in the northern and southern latitudes it onlypenetrates 20 meters even on a bright summer day. This effectively restricts marine life to the surface or about 4 percent of the oceans total body of water. The remaining 96 percent is comparatively about as poor in animal life as the deserts are poor in animal life on land.

Of the total surface area of our planet 71 percent is covered by water, but of this area only 8 percent represents that covering the continental shelves and 90 percent of all marine life is concentrated on the continental shelves above 300 feet.

X This means that 90 percent of all the life in the seas is in less than half of one percent of the total body of water.

Pollution

Pollution may in the end be the major problem of an underwater society. Not their pollution, but that from the land masses. Everything that is placed on the land or pumped into the air will eventually end up in the sea. The devastating thing is that these pollutants float and are distributed by rivers and currents to that small percent of the sea where the most life is, and where it can do the most damage.

{ One must also take into account the chemical and radioactive wastes that have been dumped in the seas for safe disposal.

One such is 7,000 tons of arsenic that was dumped in the Baltic Sea 40 years ago. The cement containers have now started to leak their contents, which in all is three times that required to kill the entire population of earth. Except for a thin surface layer the Baltic Sea is dead.

{ For all these reasons this project must not employ any technology that either pollutes or is short term in nature.

PSYCHOLOGY

There have not been that many opportunities for psychologists to observe men under the stress of saturated diving. The men who have performed under such conditions have been under severe stress. The stress stems from the possibility of human or mechanical failure resulting in fatality or injury, severe thermal stress, and the stress of living in close confinement while being highly dependent on each other and surface personnel. The tests that have afforded opportunities for psychological observation have been Sealab II, and Tektite projects I and II. Sealab II took place in 1965 off the California coast near La Jolla. At a depth of 205 feet, 28 individuals took turns staying down for periods up to 15 days in groups of 10 people. They lived in a tank 57 feet long and 12 feet on diameter. Tektite I employed one group of men for a period of 60 days. Tektite II employed nine groups of men and one group of women for periods of 14 to 30 days. In all cases, observations were made with the use of closed circuit T.V. The criterion components used were task performance, social interaction, and emotional adjustment. These were identified by Drs. Eric Gunderson and Paul Nelson as being factors of special importance in groups isolated from the normal environment. In saturation diving the principal task criterion has been diving time, and has applied well to the Sealab and Tektite projects.

For the groups in these projects the role of work assumed added

importance as a consumer of time, as a basis for the individuals status, and as a means for successful adjustment.

Social interaction was of crucial importance to such groups.

There was a noted increase in group solidarity among the individuals facing the stresses of saturated diving. In an analysis of isolated groups using social psychology Dr. L. Janis states, "such men depend on each other for support, self-evaluation, self-validation, and the satisfaction of a variety of needs that are either of lesser importance or are satisfied by a number of groups or persons in normal society."

The environment is one of the most important psychological factors in saturated diving. To quote Dr. R. Eadloff, "exotic environments have the potential of producing exotic emotional reactions.

These emotional reactions will be important, not only in their own right, but also in the feed back loop by which they are linked to social interaction and performance." He goes on to name a few emotions of special significance in a confined environment; they are fear, anxiety, depression, exhilaration, pride, and excitement.

There is no data however to give an indication to the emotional reactions that would be prevalent in a large group (1000+) taking up permanent residence on the sea floor. Such a group, or community, would however have a psychological dependence on the technology that sustained it. Members would have to have confidence in its reliability and its ability to coop with any emergency.

Though sensory deprivation does not seem to be a great problem in the undersea environment, the architecture should be designed in a manner to simulate the senses as much as possible.

Through organic technology, large volumes of gases will be available and through regular technology the gases will be mixed to proper partial pressures for any given depth.

Breathing liquids that are biologically inert, respiratory gas diluents such as physiologic saline solutions, will have the advantage of being non-compressible. This would enable divers to reach any depth, inert gases have a constant solubility and thus do not have this capability. The greatest advantage to such liquids is that no matter what the depth partial pressures would remain constant so the body tissues do not absorb excessive amounts of inert gases. This would enable a diver to dive to any depth and return without decompression.

Medical technology has produced artificial kidneys and other organs, there is a possibility that they may one day produce an artificial gill. General Electric Company has developed a machine that will extract oxygen from water so that any man with such a gill would take man as at home in the sea as he is on land.

Physiological Dangers

Bends or decompression sickness is caused by nitrogen retention in pressure after being under for some time. Under pressure the body absorbs more gases these gases are trapped in the body.

PHYSIOLOGY

The research in the field of self-contained underwater breathing apparatus is too extensive to cover in this report, I will mention only some of the more promising possibilities.

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Physiological Dangers

Bends or decompression sickness is caused by sudden reduction in pressure after being under for some time. Under pressure the body absorbs more gases these gases are trapped in the body

tissues and held there by pressure. A release in pressure results in a release in gas. With regular air it is the nitrogen which gives the problem. If nitrogen is released too fast for the body to get rid of it it bubbles into the blood stream causing damage to the circulatory system.

Decompression

The body can rid itself of absorbed gases only so fast. This is true for the exotic inert gases as well as air. Captain George Bond, pioneer and founder of the Sealab projects, states that the safe rate of decompression for saturated diving is an ascent of 6 feet every hour.

Oxygen Toxicity

Pure oxygen is toxic, what this means is that oxygen at 14.7 psf (pressure at sea level). Oxygen normally is only 20 percent of the volume of air we breathe, this means that it only exerts 2.94 psf partial pressure at sea level. As a diver descends the partial pressure of oxygen increases in proportion to the pressure exerted on it by the water until at 132 feet it reaches 1 atm or 14.7 psf. From one to two atmospheres partial pressure oxygen is deadly; depending on the individual's tolerance, pressure, and exposure time.

Nitrogen Narcosis

Captain Cousteau has described it as being drunk and not having to worry about a hang over. Using compressed air a diver will

start to be affected at 120 feet and will be severely affected at 190 feet. At given partial pressures nitrogen will affect the central nervous system in much the same way some narcotics do. The diver has hallucinations (slight), he experiences a feeling of utopia, and time distortion. The danger lies in that a diver might forget what he is doing 200 feet under-water and offer his mouth piece to a passing fish.

Pressure

This would not be a problem to some one under saturated conditions but a surface diver must be able to adjust his internal pressures such as ear and sinus cavity.

Body Convulsions and Unconsciousness

Under water a sneeze can kill you especially if you are saturated and can not surface. The only sure remedy would be the development of artificial gills.

DESIGN

AQUA-HABITAT

Design considerations for the habitat occur on several levels.

The major ones being psychological and physical adaptiveness of the crew personnel. Also the structural shell to accommodate pressure stress.

Circulation from and to as well as internal, constant monitoring and surveillance of habitat life support and other functions including the logistics of the diver support are also important considerations.

The accommodations for brief visits from friends and family, a stay of 4 hours would mean 50 minutes of decompression time for a visitor.

DESIGN

COMPLEX

The design considerations for the Support Complex included the requirements for physical and psychological readjustment for divers to normal pressure and also to higher pressures. The complex circulation patterns through areas of two different pressures. The control of privacy from public to semi-public to private to sacred or nearly so because of radical change in environment. To provide all the facilities for the support of the habitat in normal and emergency operation and the constant monitoring of those systems. To provide all the necessary spacial requirements of a large business and research facilities. To combine these elements in such a way as to fulfill the functional needs of the space while they create an interesting and expressive character that would minimize the adaptive necessities of its users. These would all be important considerations.

The central court would be a main element in doing this while at the same time cooling the building in the same manner that the central courts of the latin american home does.

DESIGN

HOUSING

The housing also should reflect the harsh climate and to me the architecture of the Island of Santorini (Thera) on the island of Cyclades off Greece offers one of the most satisfactory means of fighting the heat and at the same time being esthetically pleasing.

The barrel vault of brick or adobe traps a layer of air which acts as an insulator while the curved white washed roof offers the sun a minimum of surface area and a maximum reflectance.

Buoyancy is essentially a force equal to the weight of the volume of liquid displaced.

$$W_h = \rho_h V_h g$$

$$B = \rho_w V_h g$$

W_h - the weight of habitat, ρ_h - the density of habitat,

V_h - the volume displaced by habitat, g - gravity.

B - is the weight of the water displaced by the habitat.

Buoyancy is the resultant force acting on the habitat.

$$B - W_h = \text{Force}$$

Pressure

The pressure at a given depth is:

$$P = p_0 + \rho_f h$$

Where P - is the actual pressure, p_0 is the air pressure acting on the surface, ρ_f is the weight density of the fluid given in lb/ft^3 , h is the depth.

$$p_0 = 1 \text{ atm (14.7 psi)}$$

$$\rho_f = 64 \text{ lb}/\text{ft}^3 \text{ (sea water)}$$

$$h = 50 \text{ ft}$$

$$P = 36.3 \text{ psi at 50 ft}$$

ENGINEERING CONSIDERATIONS

Anchorage

Off shore drillin platforms have developed probably the best technology for anchorage. They are mounted on steel pipe encased in concrete. The steel pipe is tied into bed rock, in some instances they have had to drill several hundred feet befor finding sufficiently hard rock.

A nother possibility would be a built up concrete platform.

Buoyancy

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$$W_h = d_h V_h g$$

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W_h = the weight of habitat, d_h = the decity of habitat, V_h = the volume displaced by habitat, g = gravity.

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Pressure

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$$P = p_o + dg h$$

Where P = is the actual pressure, p_o is the air presure acting on the surface, dg is the weight dencity of the fluid given in lb/ft^3 , h is the depth.

$$p_o = 1 \text{ atm (14.7 psi)}$$

$$dg = 64. \text{ lb}/\text{ft}^3 \text{ (sea water)}$$

$$h = 50 \text{ ft}$$

$$P = 36.9 \text{ psi at 50 ft}$$

The pressure the hull will have to withstand while maintaining 1 atm (14.7 psi) is 22.2 psi. This would only be during emergency decompression as normally the internal pressure would be the same as the external pressure (36.9 psi).

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