

THE NATIONAL AQUARIUM

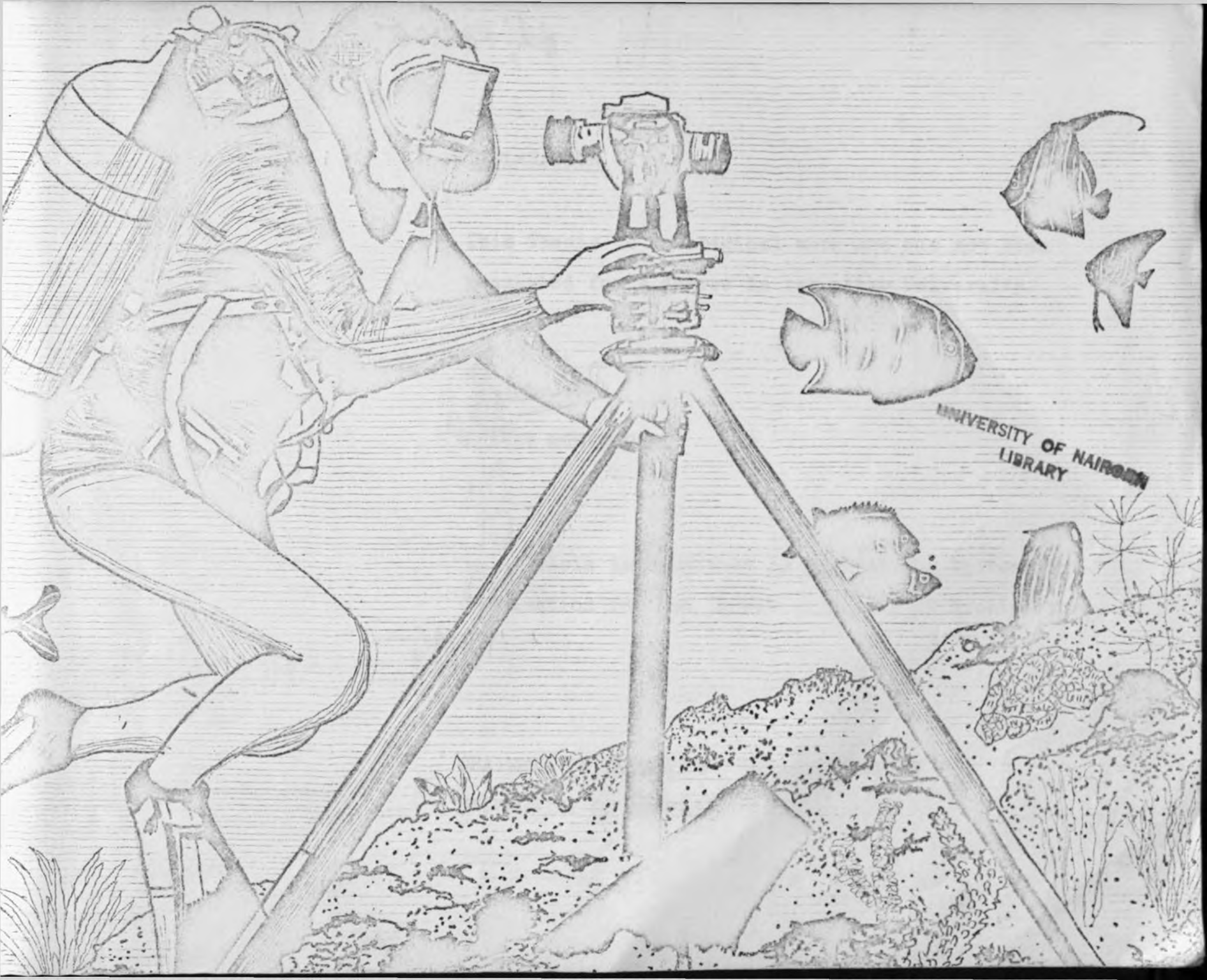
A THESIS ON AQUARIA IN TERMS OF
SUBJECT APPRECIATION, ANALYSIS
AND COMPARATIVE STUDIES LEADING
TO DESIGN CRITERIA AND AN OUTLINE
BRIEF FOR THE DESIGN OF A NATIONAL
AQUARIUM FOR KENYA.

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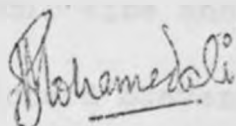
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DECLARATION

This Thesis is my original work and has not been presented for a degree in any other University.

A handwritten signature in cursive script, reading "Shiraz Mohamedali". The signature is written in dark ink and is positioned above the printed name.

SHIRAZ MOHAMEDALI

This Thesis is submitted as part of the University Examination for the Degree of Master of Architecture.

CHAIRMAN OF DEPARTMENT OF ARCHITECTURE
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The staff of the Kenya Marine Land.

P.G. Kimani - for typing.

Samuel Pepys (1665)

...ence home and to see my lady Pen
...re my wife and I were shown a fine
...iety of fishes kept in a glass of
...er, that will live so for ever;
... finely marked they are being
...eign".

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INTRODUCTION

"For man there is no rest and no ending
- he must go on - conquest beyond
conquest. This little planet Earth, its
winds and ways and all the laws of mind
and matter that restrain him. Then the
planets about him. And at last across
immensity to the stars. And when he
has conquered all the depth of space and
all the mysteries of time - still he
will be beginning"

from 'Things to come' by H.G. Wells.

Early man noticed an object or an event and made a
mental note - thus became an observer. He speculated
why, and searched and researched; and began to
assemble his ideas, thus becoming a theorist, an
investigator and a natural philosopher. He developed
the dialectic - the art of reasoning about matters of
opinion and discrimination in relation to truth. This
learning process gave man a culture. Culture has



Man in space!

given him science, a science which is an adventure - an adventure of the inquiring mind.

For centuries, man has been intrigued by the science of exploration - the exploration of the unknown lands, the vast oceans and the infinite outer space. In his ventures, man experienced new environments and new ideas. On land he found a unique type of climate and terrain. The oceans presented a new medium, where he learnt to experience water, to sail and to swim. Eventually he tried the experience of flying and ventured out into the outer space - the most challenging undertaking by man. A new experience, the experience of no gravity or walking on the moon's surface came into his sphere. Everytime he met a new challenge he set out to face it. In this process he made amazing discoveries and added to man's knowledge.

Sea, from time immemorial, has remained a challenge

to man. Though he has attempted to chart the sea and explore its world, he has not wholly succeeded.

There is more and more to fascinate him and to entice him to go further. Even superstitions and mythology, with Neptune and Posiedon the centre of such romantic and superstitious beliefs, mermaids and under-sea dark world have gripped the lovers of the oceans with awe and fear.

There is more life to be found in the sea, with greater variety of species, than on the land. The creatures of the land are in fact an evolutionary product of the sea. The mineral deposits in the sea are ten-fold compared to the dwindling supplied of the terrestrial surface. Already more and more countries are turning towards the sea to seek and extract oil.

The sea has a fantastic potential of feeding the future generations of mankind. As far as the exploitation of the food resources from the sea is concerned

mankind is still at the primitive stage. We 'hunt' our fish, we do not husband them, nor do we cultivate the sea-pastures. The protein needed for the world's increasing population could be supplied by doubling the present catch.

In many urban situations, the continuous demand on land and its current shortage - especially the urban areas near the sea, man is planning to move into the sea, where he would erect marine cities. Such 'Ocean city' projects are proposed in many urban schemes. The knowledge of the sea is increasing and with modern means, new techniques and development, more and more is coming to be known. As the knowledge of the sea increases, so does the knowledge of its creatures. Therefore, it is but natural that mankind all over the world shows a particular interest in the creatures that live in a different medium - different environment. The creatures from which eventually all

sorts of land creatures were supposed to have evolved.

MAN AND ANIMALS

All men are aware of their kinship to animals.

Irrespective of their religious or philosophical allegiance, and whatever the sophistication of their scientific knowledge, they perceive in their minds and feel in their hearts the deep philosophical significance of love for the fellow beings, the beasts, and of reverence for life.

Man learnt the significance of his fellow creatures on earth thousands of years ago - that the animals were not only for hunting, and sporting activities, but also for companionship and other uses. They became a sort of mutual aid, the most classical examples being the dog, the camel and the horse. The religious purposes, husbandry and milk were some reasons for the animal captivity.


During the Mesopotamian civilisation, huge zoos were

built and animals of different kinds kept. Also the Egyptians and Greeks have kept huge zoos and Alexander the Great is responsible for first public display of animals. The tutor of Alexander, Aristotle made first scientific studies of these animals.

Throughout recorded history we find man interested in animals and their habits. Animals were domesticated. Some of them, he tamed and used to his advantage. He made exhibitions of uncommon rare creatures and eventually introduced the first public zoos and circuses.


Hediger, in his "Man and Animal Zoo" speaks of the three main ages of animal keeping in the history of mankind.

1. Age of Cults - includes animal divinities
2. Profane Age - menageries and bear pits.
3. Scientific Age - commercialization and zoos.

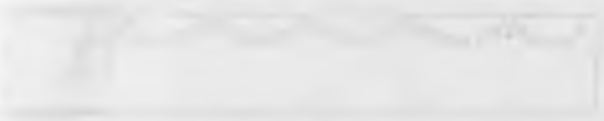


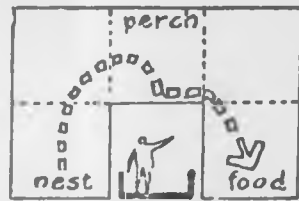
Man has been the only animal to keep other animals in captivity. Since earliest history he has used animals and simultaneously been fascinated by the more fearsome and curious species.

ZOOS

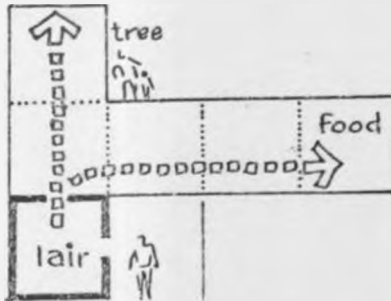


To-day there are now hundreds of zoos throughout the world besides the big nature reserves, where the human race comes to watch with a keen sense of love and interest, to emotionally and scientifically experience this vast heritage of centuries. To realize the complex and beautiful world he lives in, a world which, as he gets "civilized", he tends to ignore - to his detriment. As an urban refuge, animal displays are a useful recreational facility that can give welcome variety within the city. Open spaces and city parks are an accepted part of any urban situation and animal displays re-establish contact with nature, that include animals. To-day man has a





Leaping: cats



Territories: bears



Enrichment: gibbons



new humane attitude towards animals - and he reflects them in his man-made environment created for animals. To an animal quantity and quality of space play an important role. Boredom has always been the worst enemy of the animal in captivity. It does not matter if the animal is provided with large space. The fact that the space is interesting and well designed forms an important criteria.

The architecture of Zoos and Aquarias, have tremendous design potential. Design not only for an urban situation, and man, but also the most important of all, for the animal. An efficient design of keeping animals in captivity - dens, pools, aquariums etc. depends on the study of ethology, to give increased knowledge of behaviour patterns and social groupings. It is better understood how the concept of the animal territory and environment is effectively linked to social order and dominance. For example, the design

of a tank to contain chichlid fish will be effected by the discoveries of Lorenz, who studied examples of territorial behaviour and aggression in this species. He proved that two of these aggressive fish can be kept alive in one tank, as long as there were sufficient physical demarcation points in the tanks to divide their territories, and there was provision for the weaker to hide in its territory escaping the notice of the stronger. Restraints on animal and man alike are becoming more apparent. Research into animal behaviour in captivity has given information of reference to human in similar voluntary and involuntary restricted urban spaces. We know now that the urban dweller is almost captive of his own world - the "human zoo"! Work with small mammals, concerning the structure of the environment and its effect on possibilities of choice and time apportionment, has indicated problems of boredom, adjustment, and anti-social, networking applicable to humans-suffering

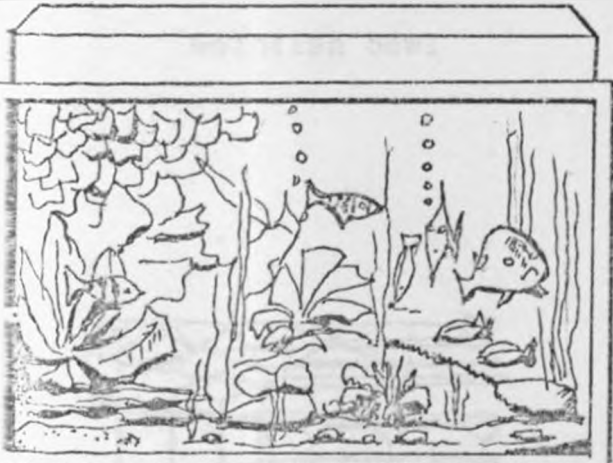
similar situations.

The responsibility of the animal heritage rests upon man. Man the top-most destroyer of this heritage must realize his folly. He must undo the damage already done. He must protect his fellow creatures. With the present stage of humanity, and the maturity of civilization, the very realization of this immense responsibility is half the battle won. Not only the animal world stands to benefit this, but also the humans. After all man's importance is in how he changes the environment for the next generation.

HISTORICAL EVOLUTION

DEFINITION

An aquarium is defined as a receptacle or institution in which living aquatic animals or plants are exhibited or studied - the word aquarium has latin base - Aqua - meaning water; though 'aquarium' was artificially constructed. The inventor and constructor of the word was P.H. Gosse (1810-1888), who used it to describe the vessels in which he kept aquatic organisms alive for observation. Later the meaning was extended to cover a building or a place of public entertainment, where several such vessels were contained for public displays; with the object of instructing or entertaining the public.



Simple aquarium for the home

Although the word aquarium itself was not used in the established sense until 1852, fish have been kept in captivity since at least 2500 BC., when the Samaritans maintained them in ponds for food. Romans of the first century of the Christian era, had pet marine fish

while the Chinese domesticated the goldfish in their Sung Dynasty (970-1270 AD).



Goldfish bowl

The first containers specifically designed for aquatic specimens, and positively identified as such, were the strictly functional open-air tanks used by the Romans from at least the second century to preserve and fatten fish for the market. It was not until the 18th Century that the importation of goldfish in France from the Orient for domestic and aesthetic enjoyment created a demand for small aquaria. Ceramic bowls, occasionally fitted with transparent sections, were produced to serve as showcases.



Interior Regent's Park

The first public aquarium in Europe was opened at Regent's park, London, in 1853. Other large public aquaria in many European cities followed suit, built for the most part during the epoch of scientific romanticism, between 1850 and 1880 - Berlin (1869), Naples (1873), Paris (1878) etc... Competition between

cities to outdo one another also began, with interesting results.

This was the time when Jules Verne's very popular novel, '20,000 Leagues Under the Sea' was published (1869), and there is no doubt that the architects of aquaria during that period were influenced by the romantic concepts of the time and made conscious efforts to create the illusion that the spectator was entering into the underwater world. Thus, the surface of the water was concealed and labyrinthine plan forms, rocky wall facings, dark colouring effects and low lighting were all used to produce a mysterious, and at times a terrifying effect.

To-day, as in "Marineland" in Florida and the New York Aquarium (1956), the trend has been to emphasize the natural beauty of the specimens, and to make a sharp distinction between the water and the viewing space. Most frequently, though not always, the aquaria

are special display buildings within zoological gardens. They therefore share a common image with the zoo and also share its associations with recreation and release.

However, the most recent aquaria buildings which have appeared, are unique individual institutions, combining other marine fields both historical and scientific. Emphasis is more directed to educational ends, and the result is an "aquaseum" or an aquarium--cum-museum.

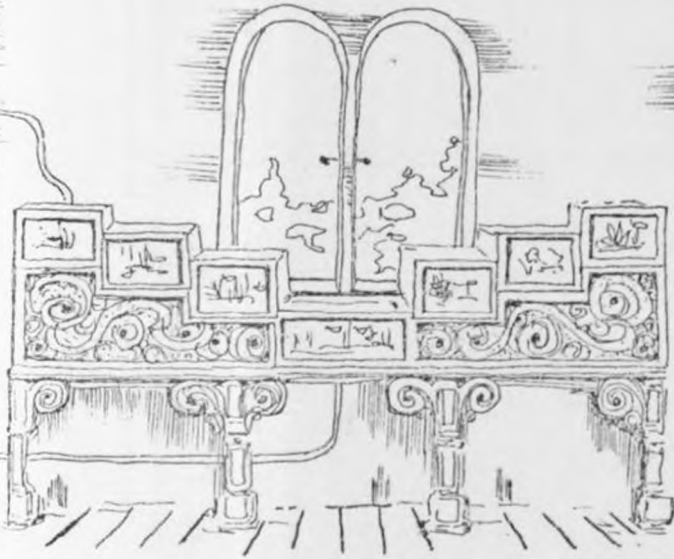
HISTORICAL DEVELOPMENT

There are historical records including scripts and paintings which strongly indicate that the Chinese kept Goldfish, bred them, and took pleasure in such a rewarding hobby - as long back as in the 10th Century. The Europeans were influenced by the oriental cult towards the keeping of fish as pets in the 18th

Century. The Chinese knowledge of the art of fish-keeping was introduced to Europe by Europeans who had visited the Far East.

During Victoria times, another incentive, a mechanical system to maintain the specimens in 'aquarium' was invented, and with the aid of scientific discoveries and technical developments, the interest in fish-keeping in England evolved.

Most animals can exist in captivity in extreme conditions, or conditions that are just tolerable, but fish are absolutely dependent upon their natural environment cold-blooded creatures, they cannot regulate their own body temperature easily, or maintain a balance between their body fluids and that of the surrounding containing water. Thus the physical environment has to be very carefully controlled to conform to the exact requirements of the thermal conditions, the visibility and light level, and the



of the first water circulating

systems. 1858

chemical contents and salinity.

Therefore, during these times, a lot of dependence upon scientific research and technology was undoubtedly necessary for the skills needed to keep other fresh and sea-water specimens. The accumulation of scientific knowledge necessary to design an efficient aquarium, first began with W. Priestley (1733-1804) and his experiments with oxygen gas. He discovered that aquatic animals and plants could live together in a symbiosis - a balanced state - within a restricted volume of water.

It was discovered that aquatic animals used oxygen from the water, replacing it with carbon-dioxide, whereas aquatic plants during the day maintained as reversed exchange removing carbon-dioxide and replacing it with oxygen. This was the basis from which the balanced aquarium developed, although at first the full significance was not appreciated.

The first public aquaria in Europe was opened in 1853, a 'Fish House' at Regents Park based on the balanced system. This being possible because of the work and dedication of Robert Warrington, a chemist, and Phillip Henry Gosse an aquarist. By this time, the 'Zoo' was a definite well established entertainment, and considerable knowledge of the habits and the life histories of land animals and plants had already been largely accumulated, and little was known if anything of marine life. Naturally the public and its scientific interest in a preliminary display led to the "Fish House" becoming an instant success. The "Fish House", the first public aquarium or aquavivarium, in the world, was later recognised as one of the most significant events in the development of the natural history of fish, in the 19th Century. The "glass house" as the aquavivarium was then described, was unfortunately not an exciting building in the Regents Park. In fact the 1885 guided tour quickly dismisses it as

"Next.... we come to the fish-house, the three-island pond, and the large central lawn, the latter a pretty sight on a fine Sunday afternoon.."

However, the contents by themselves were more interesting. Table tanks were made of slate, cast-iron and glass, and the water slowly circulated through them by gravity. Every morning some water was siphoned off, pumped to a high level cistern and allowed to overflow back through the tanks to a cistern below.

Learning from the problems of Regent's Park Fish House, the later examples of aquaria had the amount of exterior glazing to the aquaria reduced and thus amount of natural lighting also reduced, the tanks being exhibited in a very small amount of light. Also efforts were made to improve water circulation and aeration, to help stop stagnation and putrefication. At Dublin, built in 1854, the visitors were encouraged to oxygenate the water by activating it with bellows.

This is a sort of participation by the public in the maintenance of the aquaria, in an action highly recommended at the time.

By the mid 19th Century, a form of aquarium mania swept the middle classes throughout Europe, and an increased interest in the aquaria grew beyond anyone's expectations. Those who could afford, travelled by the railway to the coast for sea-holidays, and to collect specimens. Aquatic shops were opened, and Specialists appeared to design individual circulating systems for aquaria, Catalogues of fish tanks and types of fish, information on fish-keeping etc... began to appear in full tempo.

In 1860, the Jardin d'Acclimatation, Paris was opened. Based on the balanced system; the aquarium dominated other aquaria for thirteen years in the techniques involved.

In 1864, Hamburg and 1871, the Crystal Palace Marine

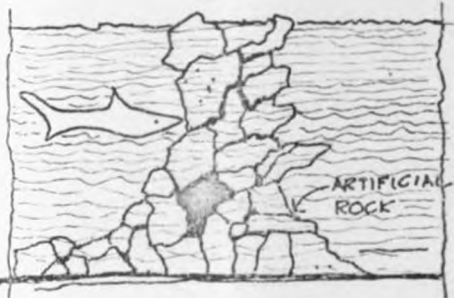
Aquarium opened. Different systems for mechanical plants were being developed by this time and an air compressor developed by Mr. Hurwood of Ipswich 1859, which worked with water pressure, steam engines for energy and other weird complex systems were introduced.

The success of these public aquaria encouraged the appearance of others, Hanover 1866, Paris 1867, Brussels 1868 and Cologne 1869. Marine natural history had arrived as a popular entertainment, and made its debut. At this time a differing attitude to the display of fish, caused a divergence from the British original school of thought.

The Europeans introduced new "atmospheric" displays and grottoes ... eg. the aquarium at Hanover and the International Exhibition in Paris, as well as numerous others.

In the Hanover Aquarium, opened in 1866, the whole

display was built to resemble a stone grotto, with rock work



A stone grotto display.
tank

"projecting from wall, suspended from ceiling and rising from floors, in which places it was improper and most objectionable"

- W.A. Lloyd.

In the English school, most English educationalists, in particularly W.A.Lloyd strongly disfavoured and objected to the 'artificial' intrusion in the natural setting. To them the aquarium was primarily of scientific and educational value, e.g. Brighton, Crystal Palace, etc.... The educational aspect of the establishment was clearly stressed at Brighton. It was the aim of the proprietors to

"instruct as well as to delight, and at one to excite and gratify a thirst for information respecting submarine curiosities."

The Brighton Aquarium was built in a restrained

classical style, the groined brick roof was supported on columns of Bath stone, Serpentine and polished granite, carved with designs of fish, shells, and technological motifs to emphasise the scientific and serious aspect of the aquarium. A conservatory was included that contained a rock fall, dropping well and ferns. Some of the tanks were wall mounted, with service corridors behind, some were free-standing, but all carefully lit from above by natural lighting. The difficulties of maintaining the delicate balance between plants and animals necessary to prevent collapse, and increasingly complex displays, heralded the end of the aquarium era of the century.

By the end of 19th Century and the beginning of 20th Century, Marine Biology expanded rapidly as a science. Marine Research Stations began to spring up and the potential value of the study of fish to the fishing industry was recognised. Eminent Zoologists became

involved in research and the public aquaria were rediscovered and the use of artificially controlled water was made possible. Lots of experimental projects were undertaken and different methods of maintenance of aquaria were discovered and introduced. More research was done and marine biology became one of the major biological fields.

The advent of new materials and technology simplified the construction of tanks and reservoirs. Materials like mass concrete and reinforced concrete were used in the construction of tanks and reservoirs. The plasticity and strength of the new materials proved advantageous to the design.

The introduction of more efficient pumps and air compressors ensured the success of the 'closed water system' - where huge supplies are stored in huge reservoir tanks and supplied when required. The new pumps and compressors assured standard rates of

supply flows.

The closed system, in most installations, only a small amount of water would circulate at one time. Most of the water is supposed to be in the reservoirs, till it is pumped to a high level gravity feed tank.

Descending with considerable pressure, it passes through the tanks and the overflow is filtered before returning back to the reservoir. Compressed air is also provided to all tanks, to reduce the amount of carbon-dioxide in the water.

In 1924, the London Zoological Society opened the first controlled water system aquarium to the public at Regents Park. The design of the aquarium complex had been completed by 1912. The aquarium was to occupy a part of the volume enclosed by the famous 'Mapping Terraces', the first enclosures in Britain constructed after the 'Hagenbeck' prototype in Germany. Carl Hagenbeck of Stellingen, Germany had proved the

ability of most 'animals' to survive outdoors, so that in 1907 he reduced the number of buildings in his new zoo, and presented his animals in wide panoramas. He thus introduced a revolutionary idea to the original concept of small dark enclosures - cages etc.... The 'specimens' appeared unrestricted, for they were restrained, not by the bars, but by artificial rock outcrops, hidden trenches, and wide water moats.

In the aquarium at Regents Park, the higher artificial rock peaks concealed the aquarium gravity feed tanks, and the public halls followed the curve of the terraces at ground level. Beneath them, adjacent to the lowest dry moat barriers, were the large water reservoirs. Although the dual use of the Mapping Terraces was ingenious, and the water system revised, the interior was a typical reconstruction of Victoria aquaria transposed into reinforced concrete. Beneath the free forms of the Mappin Terraces' peak, the



ator and prey separated
invisible trenches.

aquarium was just defined by straight line and cuboid shapes. Much of the place is unchanged to-day. The volume in the building includes a darkened central passage running the whole length of the building and divided into three halls (salt water, fresh water and tropical temperature-zone fresh water). Their walls are lined by nearly one hundred exhibition tanks - singing a monotonous tune all the time. Behind the tanks are two long corridors serving the display tanks on one side and quarantine tanks on the other side. Natural light is excluded from the Public Hall, since it is no longer necessary for the system - the fish and weeds survive under artificial lighting levels higher than had previously been ever considered suitable for a balanced system. Of course excessive weed growths are removed by maintenance staff regularly.

Unfortunately the interior of the Regents' Park aquarium was aesthetically poor, although considering the age

of the building, being more than sixty years, it was an architecturally formative example for future developments of such buildings, especially in Britain. A resurgence in aquarium building followed in Britain and abroad. Scientifically, the importance of the aquaria was now firmly established on proper foundations, and the American aquaria mania developed - most American aquaria designed in the classical and semi-classical style, the style "suitable to buildings of educational and scientific values, of beautiful and dignified architecture."

In 1939, at Charlottenlund, Denmark, an aquaria based on the functionalist views - the 'new wave architecture' was constructed and opened. This was a new turn from the usual classical or the gothic style of architecture for the aquaria - The style which had been the order of the day.

The plan of the Charlottenlund aquaria is very

interesting, showing the unique arrangement of the exhibit tanks typical of this period and the lengthy corridors to service them. To the right of the main entrance are offices and laboratories, at the far end of the main hall is the hot house used when breeding animals and plants. The main Public Hall contains cubic tanks placed opposite each other on parallel walls, with no variety in the disposition, and hardly any variation in tank sizes.

Not only are the sizes of the tanks limited, but also the limits of the public space are instantly obvious to the visitor. There is clear definition between the elements of the interior, emphasized by the hard internal surface, and lack of moulding. The public and the fish are kept firmly in their respective places.

The Charlottenlund's attempt at unnovation was successful, and the new type of aquaria was immediately popular. Thus the aquaria became a trend setter in the pre-war period.



AQUARIA TODAY AND TOMORROW

AQUARIA - TODAY AND TOMORROW

The introduction of advanced communication systems has made a tremendous change in human experience. The systems involved make use of

- books/journal;
- the cinema and television;
- telephones and wireless;
- rapid transporting systems by land, sea and air;

in today's communications. A different outlook and attitude towards life - a more broadened outlook, more knowledgeable, in the human sphere is evident.

Unfortunately this strange outlook has had a detrimental effect on the common popularity of animal displays and aquarias. The advent of modern networks, facilitates most people to travel easily to the natural habitats of the animals - especially with countries like Kenya offering, the best game reserves in the World - where traveller on 'Safari' can watch lions mating in the natural surroundings oblivious to him; or perhaps watch



a lion on a tree in Manyara, all wild and dangerously free, is any time more preferably and exciting than seeing it in a semi-caged atmosphere, almost tamed.

But the visiting of such countries and of such game parks are for the privileged few rich people who can afford it. Even for the rich and the privileged, disappointments are in store, because those visiting such places hope they may glimpse a lion or two - but come out more than frustrated after having roamed for hours and having not chanced a single lion - or rhinoceros. This is why, the Nairobi Animal Orphanage which happens to be a sort of miniature zoo is more popular than the Nairobi National Park. Similarly even marine parks can be disappointing and also not satisfying, due to the lack of a greater variety, especially the flesh eating creatures like the legendary shark, the most talked of, and feared of all sea creatures. Moreover with mass communications media,

without much personal effect, most people can now watch the films and documentation on wildlife and other creatures - films which are a result of the culmination of months of hardwork.

These film shows and television programmes would be more informative and educative, showing certain aspects of animal life which are impossible to see without the aid of special equipment, cameras, telephoto-lenses, and mechanical aids, Animals shown are always occupied in some form of activity - feeding, fighting, mating or wooing etc... activities that illustrate a particular part of their life. Moreover it is specialists, with detailed 'expert' knowledge who edit and direct these films, thus a precise and accurate information is presented to the public - allowing it 'to see it all happen'.

Watching the aquatic life in aquaria, there is hardly any 'action packed' display. Many species of the

aquaculture would hardly seem to be moving, and they only become active if disturbed or when there is feeding time.

To make an aquaria a success story, an interesting place which attracts most people again and again is the most formidable challenge to designers of the aquaria, and aquaria keepers. Fortunately two main factors have contributed towards the creation of an increasing interest in aquarium display. First some visitors are attracted with the help of the mass-media that constitutes such a challenge. The television programmes and the documentaries - especially those for the children, generate an interest that is most easily satisfied by watching or touching the immediately accessible animals and fish in zoos and aquariums.

Secondly the changing modern society with its increased leisure time that results from increasing population, income and mobility, and expanding industrialization,

has somehow, enhanced the intrinsic value of animal display, together with other cultural activities as a recreational resource.

DISPLAY TECHNIQUES IN AQUARIA

New technical innovations, newer materials, such as polythylene, perspex, and fibre-glass, reinforced fibre-glass materials that can withstand the corrosive action of water better, have encouraged the rise in the standard of display techniques, and changing the methods and levels of information exchange.

Increasing knowledge on animal behavioural science has led to a change in architectural understanding of display technology. An aquaria isolated from associated and allied subjects with which aquaculture interacts, would somehow seem incomplete. The institution must simultaneously have an expanding association with closely connected subjects, and

contract in certain fields to show the details of animal life.

"For instance the inclusion of birds, insects, amphibians and plants, and their relation to aquatic life, stressing the delicate balance between them, making a whole ecosystem - would give a wider meaning to aquaria"

aims of: National Aquarium

Washington; U.S.A.

The unfortunate aspect of designing of the aquaria is the disadvantage of it not being able to accommodate physical changes. Unlike modern museum practice, the aquarium shows all its stock, and in permanent display cases. Several factors of course are responsible for such a trend.

- (a) need to connect each tank to multiple servicing.
- (b) need for permanent supports and service links
- (c) weight of exhibit vessels and delicate-fragile materials.

(d) very few temporary displays.

To overcome these disadvantages,

(a) removal of an exhibit from display vessel or changing of tank interior.

(b) graphic displays.

Art galleries and museums have realized the need for change, both in exhibition content, and methods of presentations. Developing displays that could be moved, and altered in an aquaria would generate continued interest and persuade visitors to return. The need for change must be answered fully within the plan and presentation of the exhibits. The aquaria is not exactly exempt from this, and despite the difficulties, certain attempts at this principle must be made for future developments.

PLAN TYPES

Most aquaria designed during the last century and the

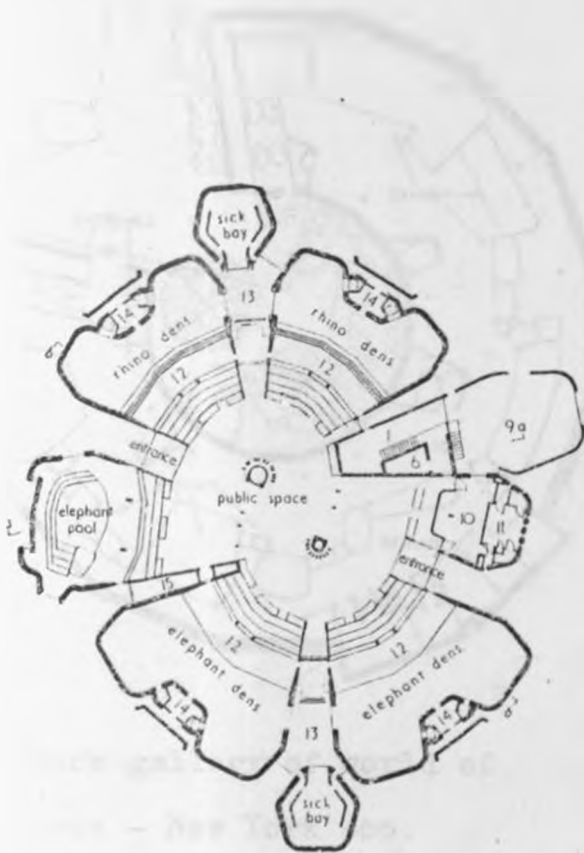
beginning of this century were stereo-typed affairs, with a progressive circulation pattern. The visitors had just to follow the route without having the opportunity of being selective. This plan-type, with similar interiors proved to be very discouraging in attracting the visitor again to the aquaria.

Therefore, it is necessary to employ a 'plan' where a choice of alternative routes is offered to the visitors, using a variety of display techniques to show the different exhibits. Dramatic changes in these 'different routes,' with changes in levels and colours, would give the impression of the place being something different upon every re-visit.

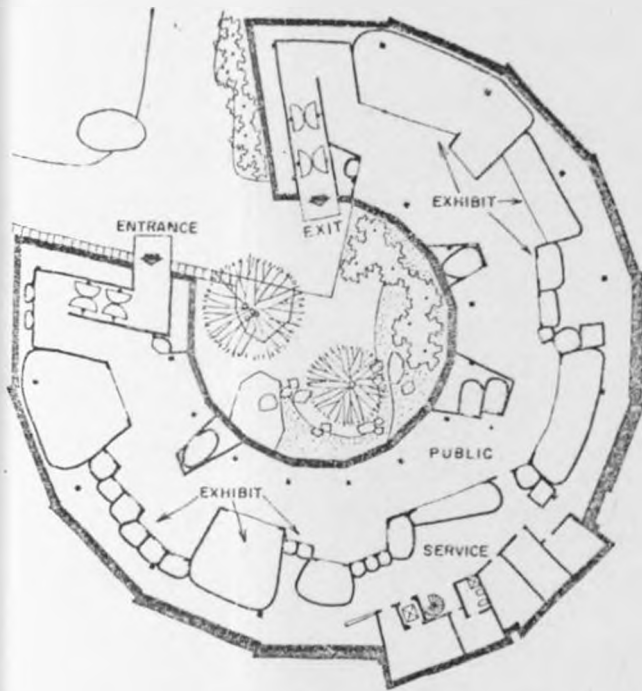
Labelling of the specimens has to be carefully presented. Some people are satisfied only by the common name of the fish, whilst others require a mass of specialised information, scientific details, like biological, behavioural and geographical information.

To place both sorts of presentation in adjacent with sensational graphics to attract the eye has worked out very well indeed. The display or the information presentation should be such as to create an immediate interest to a casual visitor, so as to attract his attention, and encourage him to more advanced material.

The general layout of aquaria displays must allow for viewing variations - from distance as well as close view, from different angles, and even a general view of complete ecological displays if possible. The case of a few visitors obstructing total view of others should be dealt with also. After all a visitor should be able to see without feeling he is obstructing others for as long as possible. The Elephant House in London, and big cat houses in Wilhelma Zoo, Stuttgart have terraced steps which allow a large crowd to watch the animals with ease and clearly.



Elephant House, London



The dark-gallery of world of darkness - New York Zoo.

Certain species, are more appealing and active, like the sea-horses or sea mammals and sharks. In such cases, terraces could be placed beside the selected popular displays. But one must bear in mind the different scale of exhibits and the necessity of careful lighting to show the change of levels in terraced areas, since the interiors, i.e. the viewing galleries, in the aquaria are usually dark, with most of the light being focused on the display tanks, and thus there is hardly sufficient lighting to show any change in levels to the visitors.

The route of the visitors should be planned as such as to grip the visitor's attention. By playing with the devices of circulation and presentation and lighting effects, the route varies psychologically, so as to maintain continuous curiosity and attention. The visitor must be given the chance to determine his own path, a freedom of investigating any section in

depth, and may be have variable routes on re-visits, whilst still following the main organisational system.

INTERIOR SPACES

The interior spaces and the movements of the people within them should try to be flowing, fluid, so that there is already a direct analogy with the liquid medium. Doors and abrupt steps, directed lighting, spoil the feeling of continuity and any sudden changes assumes greater importance in the darkened environment and can destroy the illusory mood. Direct lighting or reflected light resulting in the public being illuminated should be avoided or all that the visitor will see through the glass is his own reflection. To eliminate this reflection, it must be ensured that the visitor is never defined sufficiently to cause reflections. By correlating the level of illumination within the tanks, and reflected light from them, it can be decided that the public areas are

sufficiently lit by reflected light.

This method is necessary for display, for not only does it identify with the darkened sea-depths, but it also creates clusters of light emphasising separate displays themes. The localised light spots effectively focus attention on themselves, emphasising their importance. The public fade into the background, even when numerous, and leave the fish as the most obvious element.

The low level of illumination restricts sight and other faculties and the senses must compensate for this. Sounds and textures assume greater importance under such circumstances, and the interaction of these variables would accentuate various sections of displays, and emphasise the whole character of each portion with the rest, and create a micro-emotional environment.

The surface treatment in most aquaria is chosen for

ease of maintenance and durability. But this means that certain hard and polished surfaces would probably cause reflection and acoustic problems. Although it creates a distinctive mood, it is a man-made mood, not a natural aquatic atmosphere and - especially with the use of materials such as glazed tiles. The place becomes physically and psychologically unpleasant. The acoustic design, and choice of finishing should if possible be related to produce spaces pleasant to the ear and the touch.

The surfaces within reach of the public are the walls and floors. The walls in most cases are filled with display tanks and labels of perspex and glass, so the floor covering should be chosen with care. Carpeting can help to muffle impact noises at source, and reduce the reverberation time within the public halls.

Underwater sound is restricted, so by intensive

acoustic treatment it should be possible to indicate this phenomena in at least some galleries. Similarly, sound of machinery within the service area should be reduced, so that it does not impinge on the display spaces. The use of new material technology should help even more to replace the ubiquitous concrete and terrazzo, and at the same time help acoustically.

In all animal displays, techniques are subordinated to providing a landscape unspoilt by technical pressures. To create the illusion of 'animal in habitat', it is a common practice in zoos to eliminate all obviously mechanical aids and services, and to disguise as many of the buildings and barriers as possible. In the aquarium however, though many of the services can be disguised, the building itself is a life support system, and thus cannot be easily hidden. The fish appear to have been transferred from their own surroundings to those of man, but they cannot be assimilated into

their new background. Although alive, they inhabit a medium foreign to man, and are divorced from him. The glass barrier between them becomes much more noticeable than in outdoor exhibits, and the fish now occupy an uncomfortable position divorced from their original, natural habitats.

To try to construct convincing natural surroundings for the exhibits that will overcome sense of man-made environment, is very difficult. The visitor is restrained by a mental barrier as well as a physical one but the communication of ideas can overcome this. The simplest and most specific level of instruction is the label, but an exhibit can lose any value it has if it is not experienced properly. Common name, latin name and location are not sufficient, by describing the behavioural aspects, the territories being defined, the pairing of fish, resting periods etc. The visitor wishes to become involved in the life

of the individual fish. Even if the fish don't seem to be doing anything, the visitor will know why. The simple label will have to become a more complex aid, capable of expansion and change as the exhibit changes.

More advanced mechanical aids, for the general public include the 'Talking Label' machines commonly used in zoos, that give a verbal taped account of the exhibits. Slide shows and recorded commentaries can be used, either in central information centres, or at points throughout the display. At Frankfurt the quiet of the aquarium is not disturbed, as individual head-phones and tape packs guide silently-absorbed visitors. At the Steinhart Aquarium, San Francisco, imaginative demonstration and communication techniques include the use of oscilloscopes, polarizing screens and volt-meters, by which means the visitors become involved in individual displays.

As many of the physical barriers as possible should be removed and some pools left open to the touch. In displays of aquatic mammals, the glass may be removed altogether above water-level, and a more open barrier substituted. Special windows onto the same exhibit can give unusual and unexpected glimpses of the animals swimming underwater. Unusual viewpoints of this sort can so engross the visitor that he forgets the division between himself and the animal.

Once the barrier is forgotten the interest of watching these activities for oneself far outweighs that of seeing a similar sight second-hand, on television, or in a film.

To attempt to present the fish effectively in its own element, the tank design, construction and furniture are manipulated to give as close as imitation of limitless space as possible. This entails design expertise to counteract the refractive properties of

water and glass, and also the suppression of all traces of artificial origin, and technical servicing. For this reason artificial vegetation should be excluded. As W.A. Lloyd remarked 120 years ago, artificial surroundings cast aspersions on the reality of the animals. This is particularly important in the aquarium, where the flora and fauna can maintain a true balance.

Most problems in aquarium tanks arise from the use of cubic tanks. The cube is mathematically rigid and not so natural shaped, and thus the straight lines define the limits of the space provided for the fish. The effect of the refraction of light through the water then makes the back wall of the aquarium look closer than it is, so that the fish appear to be trapped in a small box. Curators have spent time disguising corners with quantities of rockwork, that sometimes only help to emphasize the limits of the tank.

Displays, with the possible exception of small 'jewel' tanks, should now be designed according to the perspective theories of Dr. Garnaud, who discovered methods of counteracting the refractive properties of water, thereby increasing the apparent capacity of the tank. The elimination of straight lines by curving the base and walls of the tank till they merge imperceptibly into each other, further helps to increase the illusion of freedom. With correct lighting the tank can "disappear" completely. This seems to be a very obvious improvement especially as reinforced concrete is such a tractable material, but as the design of Charlottenlund shows, it is a recent one.

'De-limited' tanks correspond more closely to the natural movement pattern of the fish. They will certainly be easier to landscape, to clean, and probably structurally more efficient, taking the water pressure more evenly. Also more pleasing in visual

terms.

Hexagonal tanks, designed on Dr. Garnaud's theories, are used at Bergen aquaria, and they show some of new display techniques possible. The basement indicates the freedom and complexity that can be achieved in plan, and the ground floor shows how several tanks with obliterated limits may be used to give a broad panoramic effect, particularly valuable when designing wide ocean exhibits.

The realistic landscaping of the smaller aquarium tank is a well documented process. Since 1960, a better understanding of fish ethology has resulted in larger, more complex ecological exhibits. Some of the most effective of these were first designed because the fish could not survive in rectangular tanks. For instance, deep sea fish, unaccustomed to solid obstacles, continually knocked against the landscaping features and the tank sides. Thus

injuring themselves. By providing a deep circular tank, with a central pillar of landscape, and strong directional water circulation, the fish continuously swim against the current, in large circles. This is particularly so with trout. At Wilhelma Zoo, Stuttgart, a similar free-standing tank is raised above floor level, and is a very popular exhibit.

Free-standing displays such as this incorporate their own central service area, and it is possible that they will have their own service attendant too. Fisher fore-saw that the future animal displays would support a staff ratio similar to that of a superior school, and the aquarium is one of the most labour and service intensive of all animal buildings.

The least complicated aquarium display and service systems are those utilised by oceanariums, and coastal aquariums, in which the sea-water is pumped directly into the tanks, and then discarded. Oceanaria make

no attempt to present their animals in naturalistic surroundings. They accept that they are commercial enterprises, and specialise in action-packed circus-type shows that present the marine mammals in anthropomorphic situations. These "stars" can be trained to perform a whole series of "human" activities. They can play tunes on horns and drums, haul small boats, 'say their prayers', 'give political speeches' and do simple arithmetic. They successfully compete against the architecture and the bikini-clad-assistant-beauties, for attention.

One must bear in mind that these institutions are something of an anomaly, for they are not purely flamboyant commercial undertakings. American Oceanaria have worked on serious research programmes, particularly with the bottle-nosed dolphin, testing this animal's capacity to learn. The discovery of the dolphin's ability to talk to one another, has

been one of their best publicised findings.

Most forms of aquatic display are moving towards the re-creation of an environment, in which the animal can display natural patterns of behaviour, rather than 'performing tricks'. However, any aquarium is free to fulfill the needs of the public in the way that it thinks will best appeal as long as this balances with the functional needs of the exhibits.

THE SEA AND ITS
CREATURES

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The sea is a vast and mysterious world, teeming with life. From the tiniest organisms to the largest whales, the ocean is a complex and interconnected system. The creatures of the sea have adapted to their environment in remarkable ways, allowing them to thrive in the most diverse and challenging conditions.

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THE SEA AND ITS CREATURES

Life originated in primeval seas and the dependence of life on water has remained unchanged. Without water, no living thing could survive.

All waters are abound with living creatures, whose distribution is determined by many factors. The most important of these are temperature and salinity. Cold blooded animals such as fish, whose body temperature is not regulated internally, require a stable environmental temperature level. Since water loses and gains heat slowly, aquatic cold-blooded animals living in large bodies of water are not subjected to sudden or extreme temperature variations which could be fatal to them.

Fish tend to stay within temperature regions congenial to them. Around the poles are the cold water zones, at the equator the tropical zone, and in between the North and South temperate zones. There are no fixed



dependence of life on water-
 imo hunting a seal.

boundaries, however, since tides, currents, and seasons all have their effect.

Regions of salinity include salty tropical seas, brackish estuaries, and fresher Arctic waters. A basic physiological problem of fish is the maintenance of a balance between the salt content of their body fluids and that of the surrounding water. Few fish can go back and forth between salt and fresh waters, and in general those that can do so only at certain times in their lives.

With these considerations, the fish at any Aquaria, have to be divided into salt water and fresh water communities, and further sub divided according to the temperature of the water.

Fish are the oldest and most diversified class of vertebrates. They range in size from very minute creatures to the enormous length of twenty metres, sometimes attained by the largest of all fishes, the

whale shark. One of the smallest vertebrates, a species of goby, is only a couple of cm. long at maturity.

In adapting to their widely differing habitats, fish have evolved an amazing variety of colours and shapes. A 'typical' fish shape is streamlines and fusiform. However fish may be elongated (eel), truncated (ocean sunfish), flattened from side to side (flounder), or flattened from top to bottom (skate). The beautiful sea-horse of course does not correspond to what a fish should look like at all.

In addition to seeking food, a fish must avoid being itself food. Methods of survival are numerous and varied. Some species are experts at camouflage, while others defend themselves by transmitting electric shocks or injecting poison. Still others escape by high speed swimming. Puffers (totofu) inflate themselves by gulping water, thus becoming too large a mouthful for a hungry predator. Food habits

range from straining plankton - plant like organisms through gill rakers (Whale shark) to grazing on seaweed (parrot fish) to preying on other fish (cod). Fish use fins to crawl, walk, jump, or fly, as well as for swimming.

These differences in locomotion reflect variations in fin shape, placement and strength. The remora is able to "hitch hike" on other fish because its dorsal fin has been modified into a suction disc. Fins may also be used for camouflage often resembling seaweeds or growths on surrounding rocks. Variation in behaviour are most evident in reproduction and choice of living quarters. Some species have elaborate courtship procedures and display intense parental care; many of these are territorial and accordingly pugnacious. Others gather in large groups at spawning time, and abandon their offsprings to the mercy of the environment. These fish are

often gregarious and have comparatively mild natures. Despite their differences, however, fishes have certain characteristics in common. Almost all fish are aquatic, gill-breathing, and cold-blooded. All have a backbone, a head with an encased brain, a nervous system, sense organs, muscles and fins. Most fish possess a lateral line, an additional sense which enables them to detect nearby objects in the water.

OTHER AQUATIC ANIMALS.

Fish are by no means the only aquatic animals. Many invertebrates, and certain amphibians, birds and mammals spend part or all of their lives in water. Life originated in the sea, and the ability to live on land evolved over millions of years. Some animals, such as fish, never left the water at all. Others, having gone to land, eventually returned to water.

Some animals retained or developed features appropriate to an aquatic existence. These include the webbed feet of frogs, turtles, ducks and others; keen underwater vision; and in the case of warm-blooded animals, some form of insulation to conserve body heat. The blubber of seals and whales, the fur of otters, and the feathers of birds all serve as insulation.

Most animals which have returned to water nevertheless maintain some degree of dependence on the land. This is most evident in habits of reproduction and birth.

The eggs of amphibians have no shells. They must therefore be laid in water or they will dry up. The shelled eggs of reptiles and birds, on the other hand, are not subject to desiccation. Sea-turtles come ashore to lay their eggs and the baby turtles, once hatched, rush directly into the water. Aquatic birds lay their eggs either on land or in floating nests.

Most aquatic mammals breed and bear their young on land. Some, however, such as whales, bear their young at sea. Whales in fact, are so completely adapted to the water that they never leave it at all.

Although they have flippers, fluked tails, and fusiform bodies, they are true mammals, for they are warm-blooded, produce milk and nurse their young.

The waters which lie between the coldest and warmest zones are called temperate. As the word implies, their qualities are mid way between those of more extreme climates.

Seasonal fluctuations of temperate waters are more pronounced. Thus the same waters may harbour fish from cold climates in winter and others from tropical climates in summer.

Most inland waters are fresh rather than salty. They include ponds, lakes, rivers, and streams in all temperature zones. As in the case of salt water

animals, freshwater fish show specific adaptations to the characteristics of the waters they inhabit.

Some fish live part of their lives in fresh water and part in salt water. Salmon, born in fresh water, go out to sea but at spawning time return to the stream where they were born. Other anadromous fish, as this type is called, include sturgeons, lampreys, striped bass and alewives.

More life is supported in cold waters than in any others, in part because of the seasonal turnover of cold water. As the colder, heavier surface water sinks in spring time, bottom water rich in phosphates and nitrates is brought to the surface. These salts, as well as other minerals, are necessary to the diatoms, the "grass of the sea" which make up most of the plant life of the plankton. Larva and adult stages of marine organisms which feed on the plankton

provide nourishment for fish which in turn are eaten by a variety of other fish, mammals and birds. In cold waters, there are likely to be fewer species of animals but greater number of individuals within a species. For this reason, cold waters are productive fishing grounds.

Tropical waters teem with beautifully coloured, oddly shaped fish.

Diversity seems to be the dominant factor here: the many animal species have adapted to their environments in a variety of ways. Ingenious methods of survival and preying exist, and often lead to strange appearances.

The bumblebee fish wears alternating stripes of yellow and black, used as disruptive colouration or for territorial warning; the black spots near the tail of the four eye butterfly fish look like eyes and may confuse predators; the pipe-fish is so-named because

of its distinctive shape, which camouflages it among seaweed fronds; the weatherfish, extremely sensitive to the approach of storms, has been kept by some people to predict changes in weather. Most 'cleaner' fish are tropical wrasses which remove parasites from larger fish.

Coral reefs can live only in shallow sunlit waters such as are provided by tropical seas. Formed over a long period of time, these colonies of millions of living and dead coral polyps may reach for considerable distances from the ocean floor toward the surface, and may extend across the ocean for hundreds of miles. Their strange formations provide homes for many animals.

AQUARIUM
NEEDS AND ASPIRATIONS

AQUARIA NEEDS AND ASPIRATIONS

AQUARIA: NEEDS AND ASPIRATIONS

Techniques for maintenance of marine animals in captivity for large-scale systems are constantly under investigation and new systems come up virtually everyday. The simplest method of maintaining water quality in aquaria consists of the constant replacement of the medium, thus an unlimited supply of sea-water is required. The investigator must consider variations in temperature, salinity, turbidity and the possible introduction of toxins in the seawater supply.

The chemical condition of the water in which fish and aquatic invertebrates are kept is vital to their existence. Anything that is in suspension or dissolved in the water comes into direct contact with these animals. There is little they can do to prevent harmful substance from entering into their bodies and bloodstreams.

The following factors effect the quality of the aquarium water:

- (a) Water source.
- (b) Chemical constituent in the water.
- (c) Adequate circulation, filtration and aeration of this water.
- (d) Regular cleaning and clearing.
- (e) Controlled feeding.
- (f) no overcrowding.

The major changes in the chemistry and biology of captive bodies of water may be summarized as follows:

1. Dissolved oxygen decreases while carbon-dioxide increases.
2. Inorganic nitrogen compounds increase.
3. The alkaline reserve of the seawater decreases with an associated drop in pH.
4. The concentration of phosphate, sulphate, calcium, and potassium ions increases.

5. The total organic content of the water increases.
6. Bacterial numbers increase, but species diversity decreases.

Changes in the partial pressures of the named gases and in pH first become critical to the survival of captive animals.

The water source must be checked to make certain it always has the proper chemical composition. Potable (drinkable) freshwater, for instance may be too hard, excessively chlorinated, or contaminated with traces of brass or galvanised piping. As far as the visitor is concerned, the only necessary water quality is clarity. In large tanks (900 litres or more) this is a very important, the milky appearance of water with colloidal clay in suspension makes viewing unsatisfactory. Sometimes it is necessary to treat the water as soon as it enters the aquarium, and natural seawater should always be filtered

before being put into reservoirs, or closed systems, this is to remove the plankton, which could otherwise die and decompose, making the sea water toxic to larger aquatics. However, for the great majority of exhibits, fresh filtered seawater may be used at once as long as its source is unpolluted, and the system contain at least 5000 litres. In open-systems, natural seawater can be used completely untreated, making the exhibition of plankton-feeding animals very easy.

Disposal of aquatic animal and plant wastes are not very easy. Most methods are uneconomical, labour intensive and not totally efficient. Ammonia, the principal excrete of fish and invertebrates is the most important waste. Ammonia in slight excess is exceedingly harmful to fishes.

Treatment of the water is effected in filter beds, whose layers of sand and gravel contain nitrifying

bacteria that can change the ammonia by oxidation into nitrate, a much less harmful chemical. This is known as biological filtration. The water should be aerated before and after filtration to produce oxygen for the nitrifying bacteria, and replace that used by them.

The longer the water system is in operation, the more nitrate accumulates in the water. This is not as toxic as ammonia but it does have an inhibitory effect, especially on marine invertebrates. The only practical way to remove it, is by replacing the water. To change all the water at once would be a great chemical shock for the fish, so part of the water is replaced at regular intervals.

A final culminative change is an increase in acidity. Oxidation is an essential-life process, but one the by products of oxidation is acid. To prevent the system from suffering acidosis, it must be alkalisied.

This is especially essential in dealing with closed seawater systems, and is accomplished by keeping the water in contact with calcium carbonate e.g. by using coral sand, marble chips etc...

Ozone can be used to oxidize organic compounds containing unsaturated double bonds, and is effective in inhibiting bacteria. Ozone is toxic to marine animals, however, and must be introduced into the system in such a manner that it has been reduced to molecular oxygen before the water is returned to the main culture system. In view of the danger of ozone to humans, its use in invertebrate culture is not recommended.

WATER SYSTEMS

Various water systems are employed by different aquaria in different places. Basically the water-system incorporates the supply line; the cleansing or sterilizing plant; needed especially in polluted

areas; storage reservoirs; the pipe-work which provides for temperature and salination of water serving the different sorts of display tanks; the tanks themselves; overflow and drainage; and filters.

The two main systems used are (a) Open System where the water is used and discarded, and (b) the Closed System.

(a) CLOSED SYSTEM


Used in cases where an adequate source of disease free, unpolluted water is available. This method is very simple for application. Metal pipings can be used in such a system, as the animals are exposed to water that has passed over the metal only once. Toxicity may also decrease due to the formation of inert oxides as insulating barriers in the pipes. If economics are considered, open circulation water

is discarded after only one round, but the rate of flow through the tanks could be reduced. The rate of turnover usually need not be as great as in closed systems, waste products being continually carried away. There would be added costs if the water had to be heated or cooled. Some means of recirculating the water might be included in the event of an emergency involving the water source.

A settling tank for the water, is always needed. Even then, there will still be no proper control over the type of water in terms of the quality, the result being cloudiness in water. This type of system is employed by the Kenya Marineland.

(b) CLOSED WATER-SYSTEMS

This system means the total recirculation of water stored in reservoirs. The water is continuously fed into the aquarium tanks, possibly from a high level gravity feed tank, which then overflows back to the

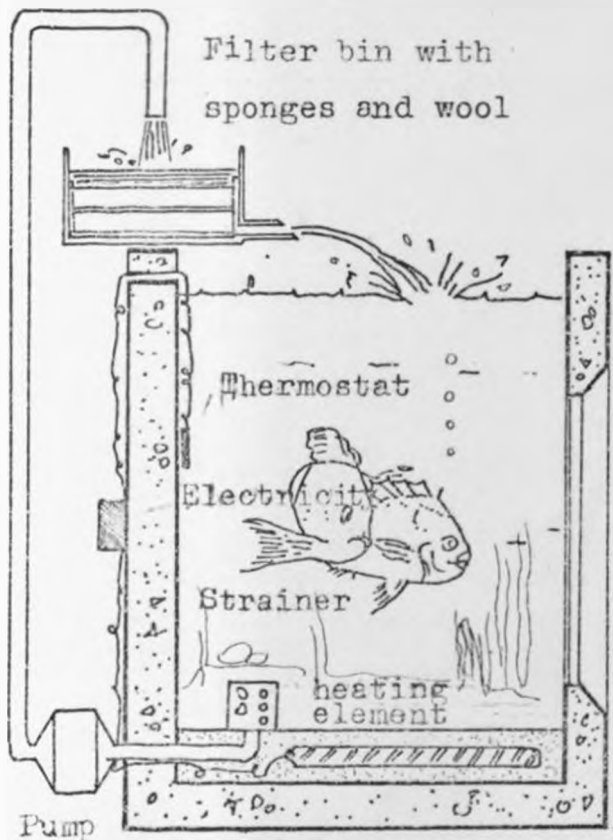


reservoirs via filters. In theory, this method requires only the replacement of water lost by evaporation, or during tank and filter cleaning. Nevertheless, as previously observed, the water needs to be replaced constantly, to prevent the build up of nitrites, nitrate and urea. The system can be continually checked and monitored, and the quality of water is assured.

One big disadvantage of the closed system is the possibility of disease organisms circulating to all tanks, filtration will not be sufficient enough to remove many of these. Ultraviolet radiation is used to destroy organisms. It offers an alternate means to bacteriostasis in culture systems.

The Boston Aquaria, the Montreal Aquaria, and Regent's Park Aquarium works on the closed system, whilst Steinhart, San Francisco operates a 'semi-closed' system.

To avoid the constant chemical analysis of water, Steinhart replaces its water at least once a month, hence its designation 'Semi-Closed'.



CLOSED SYSTEM

individual recirculation

The closed water system can also have individual water recirculating instead of a centralised system. Each display tank is provided with its own recirculating water system. Filling and minor replacement is from the main supply lines. In operation the overflow passes through a biological filter, and is pumped back to the display tank. Heating and cooling units can be placed in the line of supply.

The main supply lines of water, are also continually circulating at a low rate, to produce dead water and the growth of organism in the pipes. This system is used at the National Fisheries Centre, Washington D.C. Display tanks up to 9000 litres can for some species be recirculated through bottom filters, with air-

pumps controlling the water circulation.

At least 10% of the fresh water - in fresh water tanks, and 40% of the sea-water in sea-water tanks should be replaced monthly. However, with the regularity of cleaning of tanks and filters, this replacement is carried out.

FILTRATION

The filtration of water in aquarium of all kinds, even home-aquarium is most essential. Filtration reduces turbidity, and removes contaminants or pollutants.

Unfortunately filtration designed to remove particulate matter, will do little to remove colloids or dissolved substances. Popular aquarium filters have evolved from three main principles, with specific applications.

(a) mechanical

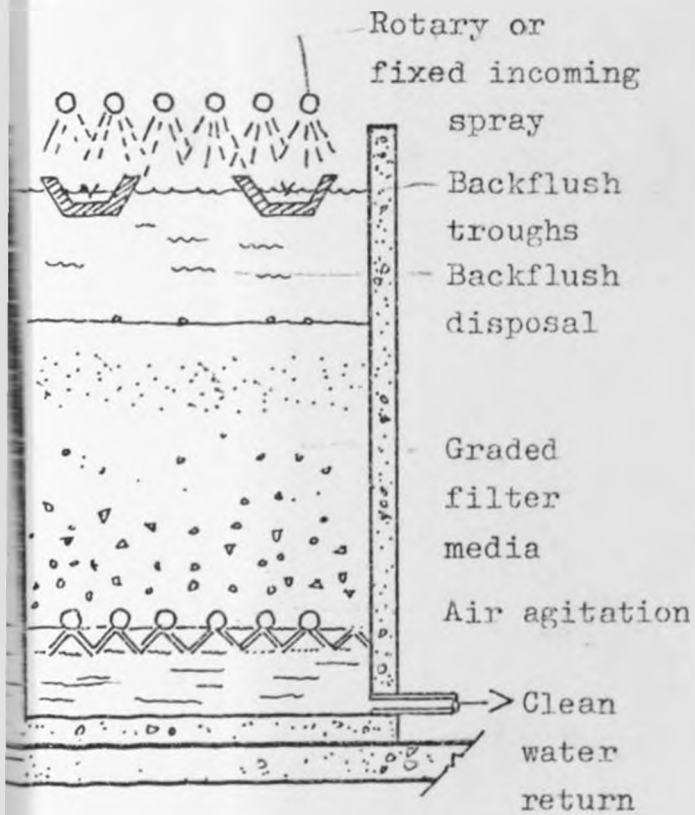
(b) chemical

(c) biological.

No single method, by itself, does simultaneously provide water that is physically, biologically and chemically clean.

(a) MECHANICAL FILTERS

These types of filters are in general use, the most common are diatomaceous earth (D.E.) and permanent media (P.M.) units. These remove particulate matter, and both are used in swimming pools. D.E., filters use irregular particles of diatom skeletal silicon to trap suspended material, which must be discarded after use, this presents a problem as it cannot usually be placed into sewerage systems. P.M. filters contain sand over graded and bonded anthracite carbon.. These systems can be backwashed, without losing any of the filter media.



Biological filter

(b) CHEMICAL FILTERS

These are of the activated carbon type, designed to remove dissolved contaminants. The absorption life of the carbon is limited, but this does not produce its use in aquarium systems.

(c) BIOLOGICAL FILTERS

These filters, which are used by most modern aquaria with closed or semi-closed water systems, have a large surface area, and are filled with stratified material usually sand and gravel in which a bacterial culture develops that turns ammonia to nitrites and nitrates. These filter beds are external to the display tank, and can be used in normal or reverse flow.

A recent innovation is the electro-static filter, which removes protein. It uses a venturi system to create foam, largely comprised of protein and some particulate matter, that can be discharged easily.

Also called protein skimmers, these units depend on the electrostatic charge produced on small bubbles to attract and carry off charged particles. They are effective in removing proteins, amino acids, and other surface-active compounds, but are less effective in removing carbonhydrates. Suspensoids become entrapped in the foam and are partially removed.

PIPE INSTALLATIONS

Unfortunately, in this case, water is the greatest dissolvent of all liquids. A wide variety of toxic substances which may adversely effect the aquatic life can dissolve in water. Under such circumstances, the plumbing system should be chemically inert. The contact of water with metal should be avoided unless absolutely necessary. Metals like copper, aluminium and brass should be, in particular, excluded. Although all plastics are not safe, "Vulcanite" and "Ebonite" are safe to use and plastic piping is very common.

So also is fibre-glass. Some of the large sized plastic pipe fittings may not be able to withstand specific pressures. The most economic freshwater system is still cement lined galvanized iron. Pumps and valves are also of plastic or rubber lined.

All the pipe work, aeration lines and electrical conduits should be exposed or readily accessible. Moreover, sharp turns should be avoided, and all turns and lengths of pipe should be reinforced externally, and include fittings for cleaning.

THERMAL CONTROL

Economic considerations make it desirable to maintain an even temperature throughout the aquarium structure. Air-conditioning, with mechanical ventilation may be used to adjust the relative humidity.

The different geographical locations of fish and aquatic animals require different temperatures.

1. Cold fresh water - below 12°C
2. Warm fresh water - 20°C - 30°C
3. Cold Marine - below 18°C
4. Warm Marine - 20°C - 30°C
5. Mammalian - warm-blooded creatures

Heat exchange units can be provided for individual's tank when warmer or colder water is required. If a whole area requires warmer or cooler water, it has been suggested that the work area may be sealed off and kept at the appropriate temperature. Heating units attached to main line of supply also helps to maintain temperature. Sometimes, cooling is required if the water is recirculated, If required, refrigerating plants with evaporators, condensor, compressors and brine pump can also be used.

AERATION

Like most life, fish also need oxygen to stay alive, and simultaneously give out carbon-dioxide. If there

is not enough oxygen dissolved in the water, and too much carbon-dioxide, the fish will die. To make sure this does not happen, aeration of the water is carried out.

Aeration of water is easily achieved, by exposing it to the air at some point in the system, so that the exchange can take place at a sufficiently rapid rate.

Aeration can be combined with filtration, either as the water enters the filter or at the discharge pipes. Most of the air get sucked into the water before it enters the tank. If the main circulation stopped, air-lines are provided to help aerate the water.

Air-stones, pervious stores, are used to aerate water, with air being pumped in by generators. This system is very common in home aquaria, and also used by larger aquariums in emergency cases.

LIGHTING PRINCIPLES

The lighting in aquaria can be either natural or artificial, or even a mixture of both.

Natural lighting is very suitable for the display of plants and grasses, as it is effective biologically. Artificial light overcomes the variations in natural light and a wide range of fluorescent and incandescent lamps may be combined to regulate its quality. It is usual to design for as close an approximation to daylight as possible.

10,000-20,000 lumens is a good average level of illumination, above 30,000 lumens, photo-synthesis no longer takes place.

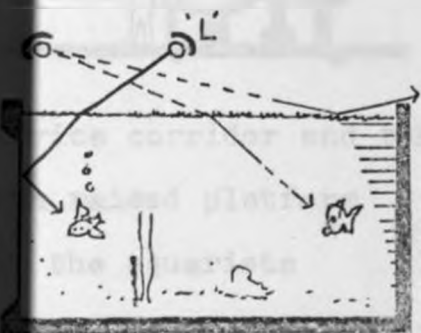
Incandescent lamps are best used for planted aquaria, or fish with iridescent colouring, their use inhibit the growth of green algae.

Fluorescent lamps are best suited for plantless tanks,

or for large fish which are not iridescent; e.g. Sturgeon fish. They do not stimulate the growth of brown algae, and can be used close to water surface, as they have low heat emission, good diffusion, with little shadow and absence of glare.

Flashlight, for photographs, can frighten the fish so they cause themselves injury when dashing across the tank. If the public are allowed to take photographs, some provision must be made for additional lights to the tanks. Additional incandescent lights, operated by the public could give a gradual increase and fade in illumination.

The best position for the lights is close to the water, near the front of the glass. In this position the background is subdued and the tank sides virtually 'disappear.' An additional light will illuminate the fish close to the front glass. Fluorescent fittings should be mounted with counter weights, or rise and fall fixtures, so they can be removed to facilitate tank servicing.

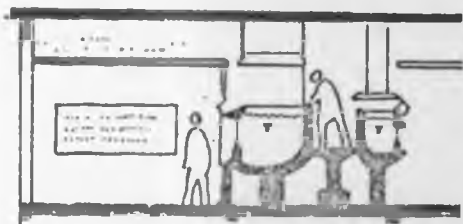


Front lighting by
total internal reflection.

THE SERVICE AREAS

The floor of the service area is generally higher than that of public hall, to give the aquarist attending the tanks a waist height to work over the tanks (1 metre). A clear passageway, without stairs should extend behind all exhibition tanks, and its floors should have a non-skid furnish. Floor drains with sand-traps are absolutely necessary, and the floor should slope to the drain. To reduce the possibility of flooding, automatic cut off switches, built-in overflow drains and failsafe devices should be planned in connection with tanks and reservoirs that are periodically drawn down and re-filled.

The work area should be separated acoustically from the public areas. However, viewing windows may be desirable to permit visitors to view the more interesting features.



Service corridor and tanks
with raised platform
for the aquarists

AQUARIUM IN KENYA

The most important reasons in support of a National Aquarium in Kenya are as follows:

- (1) Conservation
- (2) Education
- (3) Tourism.
- (4) Prestige.

CONSERVATION

It has been calculated that in the year 1600, there must have been 4226 species of mammals roaming the Earth. Since then 36 have become totally extinct and at least 120 others are now threatened.

Man is the highest evolutionary animal on this planet, but that does not mean that he has a right to selfishly exploit and ill-use all the creatures of the world which are on a lower evolutionary scale than himself. It means that he has a duty to preserve and protect them within the limits of self-preservation.

The whole complicated and interacting balance of nature which has been built up over millions of years of evolution has frequently been threatened in the past by the actions of man - often with disastrous results.

The interdependence of living forms and their complex relation to the physical environment constitute critical factors in the development of conservation policies.

Man is dependent not only on the other humans and on the physical world but also on the other creatures - animals, plants and microbes - that have evolved together with him. Man will ultimately destroy himself if he thoughtlessly eliminates the organisms that constitute essential links in the complex and delicate web of life of which he is a part.

We must use our increasing knowledge to avoid such errors in the future. Kenya is one of the leading

countries in the world involved intensively in the field of conservation of wildlife. The policy of the government is to enforce wild-life conservation. Huge national game-parks and game reserves have been set up, and more are envisaged. Nairobi - the "City in the Sun" has thus been appropriately chosen as the headquarters for the United Nations Environmental Programme.

A constant reminder of increasing national concern for the natural environment - conservation is achieved through education, and education is achieved through presentation, and display.

The aquarium can reach a maximum number of people to whom it can present the case for conservation. The majority of these urbanites have little contact with wild animals, and accept mans mastery over nature, without having more than a superficial and selfish insight into the structure of life-systems and the

interrelationship of man and other animals. It is these people who will have most effect on the policies of conservation in the future.

Kenya has established the first Marine National Parks and reserves in Central Africa. Marine Parks within reserves exist at a mere handful of places in the world. Most are very successful and produce considerable benefits in terms of conservation, fisheries development and tourism.

Kenya's part of the coast has some of the finest unspoiled white coral beaches, and coral gardens in the world. But preservation of these gardens and the coral-habitat is of utmost importance - from an ecological point of view.

ENDANGERED SPECIES: DUGONG AND GREEN TURTLE

Formerly, both were plentiful along Kenya's coast. However, both species are greatly reduced in numbers.

Green turtles have been decimated by hunting on beaches and capture by 'remora' (sucker fish). Also egg hunting has considerably reduced numbers. Green turtles are currently controlled under the Wild Animal Protection Act, so is the dugong, which was formerly abundant, but is becoming very hard to see.

The case for conservation is serious, and all sorts of means to get the message through to the public should be utilised.

Rather than police the public is better to educate. Thereby the public will help to formulate progressive action - and one aid to this is the aquarium.

EDUCATION

To too many people the oceans are still alien. Man should be made aware of his dependence upon the sea and re-educated to protect it for future use as one of the greatest remaining world resources.

It is no longer sufficient to show that an animal exists but it is necessary to show what it is, what it does, and why it is ecologically important. The aquarium introduces the visitor to aquatic life and creates contact with it. One of the easiest ways to communicate popular information is by visual display.

Nothing can be more educative than learning with pleasure. Most zoos, and aquaria not only aim at showing or exhibiting the wide variety of animals, birds and fish; but also try to depict their unique characteristics. The rapid technological evolution and change in man's concept of animals, animal management and preservation, comes at a time when environmental education - the message of possible doom - is receiving some attention. There is a growing awareness of man and ecological balance - the balance that must be maintained.

In the midst of this realisation, the aquarium is

now in an ideal historical situation from which to develop in the future, a fine example to follow. The aquarium has a sound educational and scientific basis. To help children understand the importance of water and teach them of its inhabitants, aquarium displays can be very useful tools.

Most schools have science, especially the study of creatures, in their curriculum. Science courses in the school could be geared to appreciate and take advantage of aquarium displays. Education at the aquarium becomes a flexible process, appealing because it differs from the conventional schools teaching methodology. Keeping of aquaria at schools and home is encouraged by a National aquaria - which act as an incentive.

For the more advanced students, the aquarium, particularly linked with a research station would provide lecture courses, on such subjects as

oceanography, and the importance of the sea-food and industry. Youth Leaders, teacher, other interested groups could be made to participate on seminars and discussions with regards to aquaria and connected topics.

"A substantial amount of educational work was undertaken in 1973-74 to further public awareness of the value of wildlife. The number of school children and college students who were active members of the Wildlife Clubs of Kenya reached 12,000 in 1973, compared with 7,000 in 1972. The Wildlife Clubs aims is to encourage youth participation in Wildlife Conservation through seminars, films and slide shows, radio programmes and field visits".

an extract from the Five Year Development

Plan 1973-74 - Kenya.

From this quotation, it can be seen that there is an increasing amount of interest shown by the youth of Kenya towards wildlife. A national institution would draw the members to participate in activities in which they are interested.

TOURISM

The growth of tourism has been particularly rapid in Kenya in the recent years, as the government promotes various schemes to realise its potential. Perhaps the significant of the economic benefits derived by the country from tourism is the foreign exchange earned. A dramatic measure of its expansion in the recent years is the series of visitors. Comprehensive data on visits to Kenya for the last five years show an increase in this period of 67%; total visits reached 430,000 in 1972 - 11% rise.

Tourists to Kenya come to see the wildlife, and to

enjoy the beautiful beaches, and the sun. Attractions offered by historical sites - Fort Jesus, Gedi Ruins, Lamu archipelago, the indigenous cultures, traditional dancing etc... complete the tourist's tour!

A national aquarium on the coast would prove to be an extra attraction especially together with corresponding facilities of marine sports.

PRESTIGE

Apart from being a tourist booster, an institution like an aquarium would help to create an image of prestige, something to make the people of Kenya to be proud of.

OTHER REASONS

Physicians and psychiatrists tell us that keeping fish as a hobby, has a highly soothing influence upon the mind and the nervous system. Many high-power

executives and the people of other stressful occupations who have tried the 'aquarium therapy' on the advice of their doctors have found the healing and soothing effects of the silent under water world beneficial.

Colour psychologist tell us that sea green is a remarkably relaxing colour, combined with other colours, it induces a high degree of physical and psychic well-being.

How true this is of an aquarium with its emerald-green aquatic plants, its shimmering, gold-green water, and its fish moving silently about, bright but not obtrusive specks of colour. The therapeutic value of aquaria has long been recognised for problem children, and old age can also find some relief in aquaria.

The tranquillity that emanates from the sound of the world of water has a special effect upon people

suffering from psychological difficulties.

URBAN SITUATION

The importance of all recreational and cultural facilities offered in urban situations play more and more role day by day. To escape from the daily routine into which man has imprisoned himself, the urban dweller is in constant need of stimulus recreation.

To go back to nature has been the trend in most cities and town settlements. Man has not been able to divorce his link with nature, and shut himself in the man-made environment, however beautiful and functional. Institutions like zoos, aquaria and arboreta claim special places in this hunger for nature and natural environment.

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INTERESTED BODIES

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Many people, from the private as well as public sector would be interested to undertake the erection of an aquarium project in Kenya. But the most interested bodies would be:

- (a) Ministry of Wildlife and Tourism
- (b) Ministry of Education
- (c) Municipal Council of Mombasa - (the most appropriate site for such a project lies on the coast).
- (d) Private Associations & Societies.
- (e) Private Investors.

MINISTRY OF WILDLIFE AND TOURISM

The ministry is directly responsible for:

- (i) The National Parks: the total visitors in 1973 were 475,000, with particular reference to the Marine Park where the visitors numbered over 30,000 in 1973-1974.

(ii) The Nairobi orphanage and animal camps at game parks: are very popular and nearly 160,000 people visited them whilst visiting the game parks in 1974.

(iii) National Museums: are popular with tourists and children producing over 150,000 visitors annually.

The Snake Park: attracts over 90,000 visitors annually.

From the above statistics it can be seen that a large number of people visited museums, the snake park and the game parks. A large number of visitors consisted of tourists. The Nairobi National Parks happens to be visited by nearly as many visitors as the National Museum. Moreover, despite the fact that people were visiting 'wildlife in its own habitat' the Nairobi orphanage was more popular the reason being that the animals could be watched from a nearer distance, and with ease, avoiding the frustration of roaming the

park for hours, in the heat without perhaps having a glimpse of any exciting wild-life eg. white rhino or the leopard.

Similarly, a Marine-park also has its limitations. A marine-park cannot offer a visitor the big, dangerous fish, which are always more terrifying and interesting to watch and nor does it contain other forms of aquatic life, like fresh water fish etc... Moreover, the marine parks are extra fascinating and attractive to divers and snorklers only.

Glass-bottom boats are very disappointing to most people because of their limitations, with unclear vision and immobility of the boat, which has to be anchored due to currents.

To make sure that the tourist, who comes to see our wild-life, and sees it in a wider range of species, the ministry of wild-life and tourism could do well to maintain an aquarium on a national level as an

added attraction to the thousands of tourists who come in increasing numbers every new year.

FISHERIES DEPARTMENT

Marine Pollution Centre - the ministry has already planned to put up a marine pollution research centre. An aquarium which serves as an educational - recreational building, could also serve as a research centre on marine pollution, which has become an increasingly serious problem. The fisheries department under the circumstances can erect an aquarium and serve dual purposes.

MINISTRY OF EDUCATION

The Ministry of Education would have an indirect interest in an aquarium on a national scale.

An institution like this would be useful, on a smaller scale related to schools and science education, whereby

a practical life demonstration of aquatic life can be studied, and a larger scale at University level, where a marine biology department could be established, concerned with marine studies. Presently, the students of the Science Faculty department of biology, have a two-week course in Kanamai concerned with marine life - but unfortunately they lack appropriate facilities.

A department of marine biology has not yet been established, though marine biology has a wide-scope not only in the future of Kenya, but the world as a whole, with the sea possibly becoming the major future resource of food supply to humans.

In the interest of research and education the ministry of education should see the potentialities of a National Aquarium.

The number of schools in Kenya are increasing at a

momentous rate. More and more children are enrolling in the primary schools. As shown from statistics, lots of school children visit National Parks and the National Museum - both having educational as well as recreational values. A National Aquarium would also create a similar situation, and would be stimulating as something new and unique.

THE MUNICIPAL COUNCIL OF MOMBASA.

Mombasa is the most appropriate place to site an aquarium, for apart from the vicinity of the sea, the island has the advantage of infrastructural facilities and a central position for tourists.

In the master-plan of Mombasa, 1962, one of the proposals is an aquarium to be located on the island, to adjoin with an amusement park planned on the south side.

Mombasa is expanding rapidly, with the increasing trend in tourism. The growth of the island has

accelerated - especially in the last few years. The harbour has almost doubled its facilities and the air-port is soon to become international, to meet with the expanding traffic of tourists flowing into the town.

Tourism has become one of the major industries of Mombasa, resulting in the need for providing further amenities. An increasing number of hotels are springing up along the coast. Although the tourists mainly come to the coast to enjoy the heavenly beaches, a need for some extra attraction on the island can not be dismissed. Mombasa can offer only Fort Jesus and 'Old Town' as interesting sites for visitors. An added attraction, relatively connected with coast in the form of an aquaria would be welcome and beneficial.

PRIVATE ASSOCIATIONS AND SOCIETIES

The Aquarist Club of Kenya is a very active group, with many enthusiasts as members. The group holds regular

meetings where members have discussions and exchange ideas. The club also publishes a periodical 'the Aquarist' - One of the aims of the club is to have some sort of institution like a public aquaria.

The wild-life club and other such organisations could always team up with some international organisation, or the aquarist club, to sponsor an aquarium.

PRIVATE INVESTORS

In America, Oceanariums and marineland's are very profitable concerns, where shows and exhibits attract thousands to watch the tricks of dolphins and other trained aquatic animals.

An aquaria in Kenya could be sponsored by businessmen who would invest in such a venture with a profit making motive. The aquarium would then become more of a commercial undertaking, and possibly lose its

educational and conservation role. But the possibility of an aquaria run for profit cannot be overlooked, and such a project could well be commercially successful.

CASE STUDIES

CASE STUDIES

OUTLINE DESCRIPTION

Three case-studies have been selected: each a different kind of aquarium, each in its own way unique.

CASE A

Study of the New England Aquarium, Boston: One of the most successful aquaria in the World. This institution is run by a private non-profit making organisation. It is very modern in its approach and has a large variety of aquatic animals. Amongst the important features, are the giant ocean tank, which houses the lesser ocean giants, and the children's aquarium.

CASE B

Study of Aquarium de Montreal: The aquarium is unique because it was built as a part of the Expo '67 Montreal programme. It is the part of the Amusement Park. Moreover it is now maintained and operated by the City of Montreal. The Montreal aquarium is also

different from the two other examples because it has a dolphin pool, where dolphin shows are programmed, and a spectator amphitheatre is provided for the visitors.

CASE C

Study of the Kenya Marineland: This aquarium is maintained by private owners, whose aim is commercial. The first of its kind in Africa, the Kenya Marineland is a very small project, with one big tank only. However, the venture is an interesting and bold attempt by the owners, who could well run at a loss, since the maintenance is very costly.

The three examples are analysed on a comparative basis. Synthesis conclusions are established leading design determinants.

SYSTEM OF ANALYSIS

- 1.0 Historical Background
- 2.0 Social and Cultural context
- 3.0 Economics and product demand
- 4.0 Geographical location
- 5.0 Site considerations
- 6.0 Organisational factors
 - 6.1 Circulation - micro level
 - 6.2 Space utilization
- 7.0 Environmental factors
 - 7.1 Acoustics
 - 7.2 Visual
 - 7.3 Thermal/humidity
- 8.0 Communication Systems
- 9.0 Systems technology
- 10.0 Services.

CASE A



THE NEW ENGLAND AQUARIUM

HISTORICAL BACKGROUND

Project: New England Aquarium for New England Aquarium Corporation; Boston,
Massachusetts, U.S.A.

Boston was one of the first American cities to have a public aquarium. Enthusiasm for the new aquaria of Europe led to the development of similar institutions in New York and Boston by the 1860's. The South Boston Aquarium opened in 1912, but in 1954 was forced to close its doors for lack of funds.

The New England Aquarium was founded in 1957. At that time, an independent, non-profit making organisation was created to "establish, maintain and operate an aquarium in or near the city of Boston." Ensuing years brought extensive research into question of size, scope, location, and costs - as well as into the specialized technical needs involved.

Since 1954, when the old aquarium was closed down the institution had been planning to erect an aquarium, with the following aims and requirements.

"The exhibition building that would:

- (a) contain and organize a wide variety of living and museum exhibits in a close relationship.
- (b) accommodate both a moderate flow of visitors on weekdays, and overflow of visitors

on weekends.

- (c) exploit the water front site and relate the aquarium to the urban plan of the Boston Redevelopment Authority. The aquarium is to be the focus of the pedestrian oriented waterfront plan.
- (d) to improve aquatic environment through the Aquarium's commitments in research and education."

In 1965, the architects, the Cambridge Seven Associates. Inc., won a "Citation" in Progressive Architecture for their initial design of the aquarium, in the 1965 Design Awards programme.

The architects were commissioned by the Institution to undertake the project and it was completed and opened in June 1969.

Since no aquarium had existed in Boston since 1954, the programme was for an institution starting from scratch. Research and the collecting of ichthyological materials was done by the curatorial staff while the building was in the design and construction stage.

The Aquarium program aims at exhibiting not only fish, but as executive direction Donald M. DeHart explains, "to make known the world of water ... as it relates to our communities in the areas of health, recreation, aquaculture, industry and commences since man's proper utilization of water is crucial to his survival on this planet!"

SOCIAL AND CULTURAL CONTEXT

The people of Boston are known to be famous for their cultural and intellectual pursuits, and experience. They are famous also for their "Boston Tea Party" the first rebellion against colonialism in America.

One of the best known university in the world the Harvard University is in Boston, Cambridge. The residents of Boston show 'extraordinary' interest in social and cultural activities. Plays and theatres are regular features in their life. Museums, Art galleries, Ballet etc... are very popular.

New England affords a particularly rich local source. Ponds and streams yield a wide variety of fresh water fish, and numerous temperate and cold water fish live off the coast of Massachusetts. Even some tropical fish may be found at Cape Cod during summer months. Fishing has been an arduous industry in Boston. Local hobbyist and anglers form a large group. Boston also has several parks, an arboretum of international repute, and even a marine-park.

In this colourful atmosphere of cultural humanism, it is of no wonder that the New England Aquarium attracts crowds up to 6000 per day since its inception. The citizens of Boston have absorbed the Aquarium into their system with typical vigour with which the city is famous.

ECONOMICS AND PRODUCT DEMAND

The New England Aquarium has been drawing crowds of upto 6000 per day since it opened in June 1969.

There is a public transportation system by the MBTA, blue line to "Aquarium" station which transport facilities to the people of Boston to the aquarium. The aquarium which is run and maintained by the Boston's New England Aquarium Corporation, a non-profit making organisation, depends upon the income from the visitors, members and well-wishers, for operational costs.

HOURS OF VISITORS

Weekdays: 9 a.m. - 5 p.m.

Saturdays: Sundays and holidays: 10 a.m. - 6 p.m.

GENERAL ADMISSION

Adults: \$2.00

Children 5 through 14: \$1.00

Children under 5: Free.

MEMBERS ADMISSION

Individual and family members,

Adults: 50¢

Children 5 through 14: 25¢

Master Mariner, Commodore and Quartermaster are admitted free. Group rates: available on request.

MEMBERSHIP OPPORTUNITIES

Family - \$15

Discount of $\frac{1}{4}$ off the regular price of admission for all members of the immediate family.

Individual - \$10

Discount of $\frac{1}{4}$ off the regular price of admission for the individual in whose name the membership has been issued.

Quartermaster - \$25

FREE ADMISSION IMMEDIATE FAMILY

Commodore - \$50

Friends of the Aquarium contributing to the education and research programs. Free admission for immediate family and two guests per visit.

Master Mariner - \$100.

Concerned individuals contributing significantly to our education and research programs. Free admission for immediate family and up to five guests per visit.

MEMBERSHIP PRIVILEGES

Aquarium guide book, Aquarium publication Aquasphere, Aquarium newsletter Aqualog.

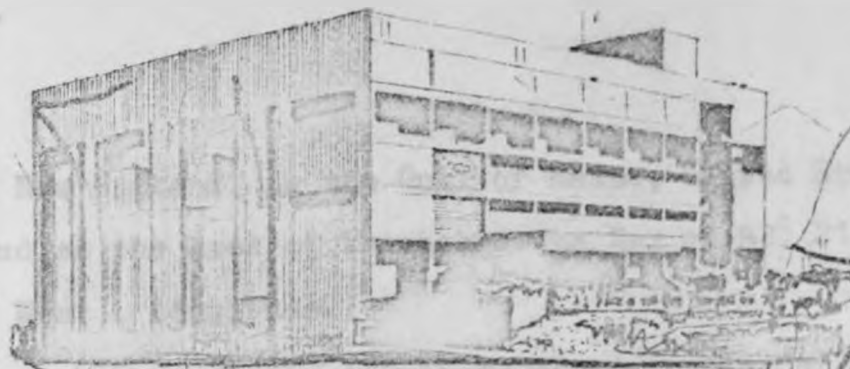
Discount of 20% on special gift shop items as listed in Aquarium symbol.

Immediate entrance (no waiting in Qs).

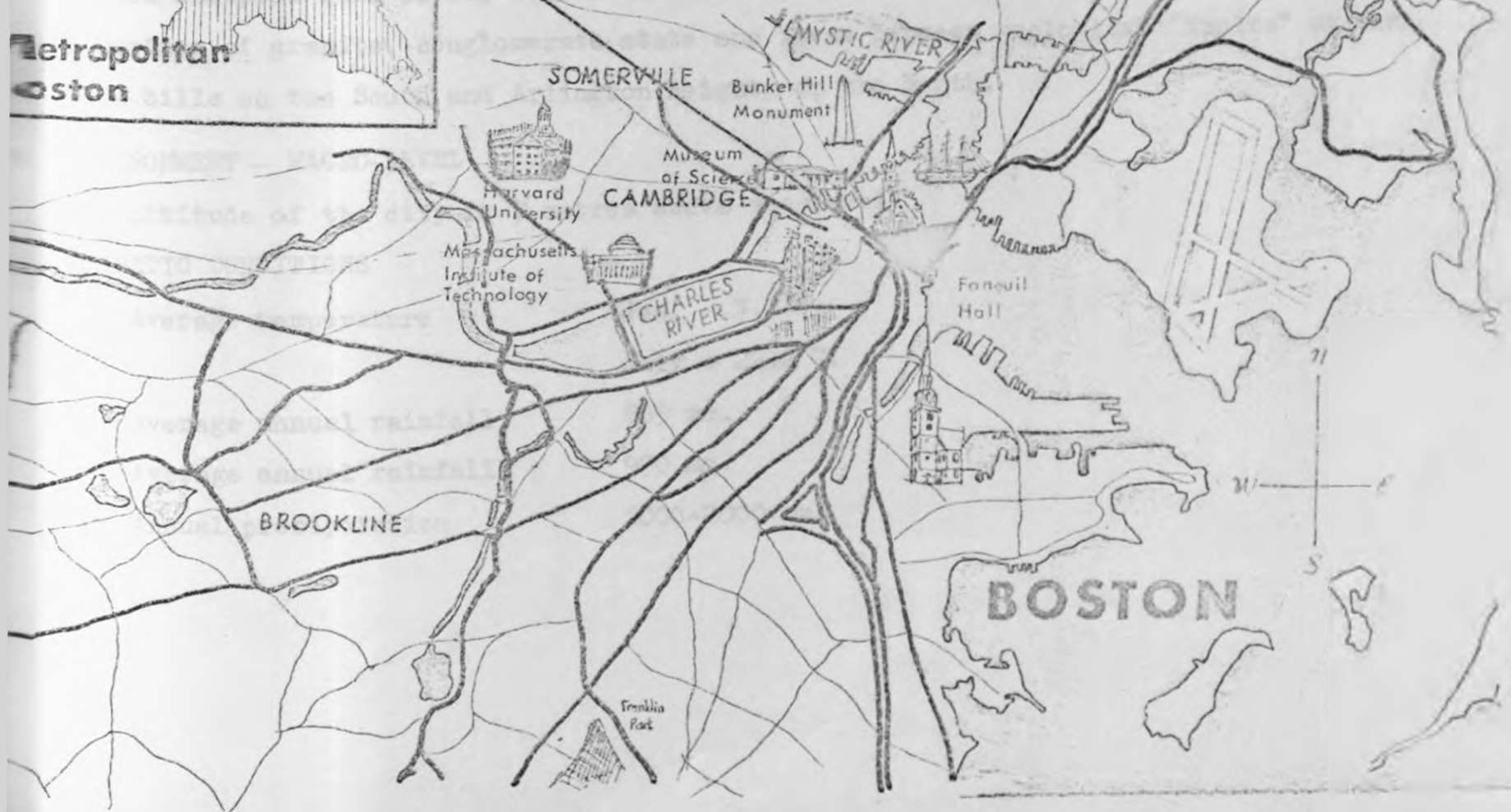
Memberships valid for one year.

This system makes the place popular as well as financially advantageous. The opportunities and privileges offered by membership would encourage many visitors to participate in the Aquarium program and to come often, as well as bring along others who are sceptical about aquariums.

New England Aquarium



Metropolitan
Boston



SOMERVILLE

Bunker Hill Monument

Museum of Science

HARVARD UNIVERSITY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE

CHARLES RIVER

FANEUIL HALL

BROOKLINE

BOSTON

Franklin Park

GEOGRAPHICAL LOCATION

The City of Boston lies in New England, in the Gulf of Maine, United States of America. Boston and its harbour stand at the head of Massachusetts Bay of $42^{\circ} 21' 27''$ - North., latitude, and $71^{\circ} 31' 30''$ - West., longitude.

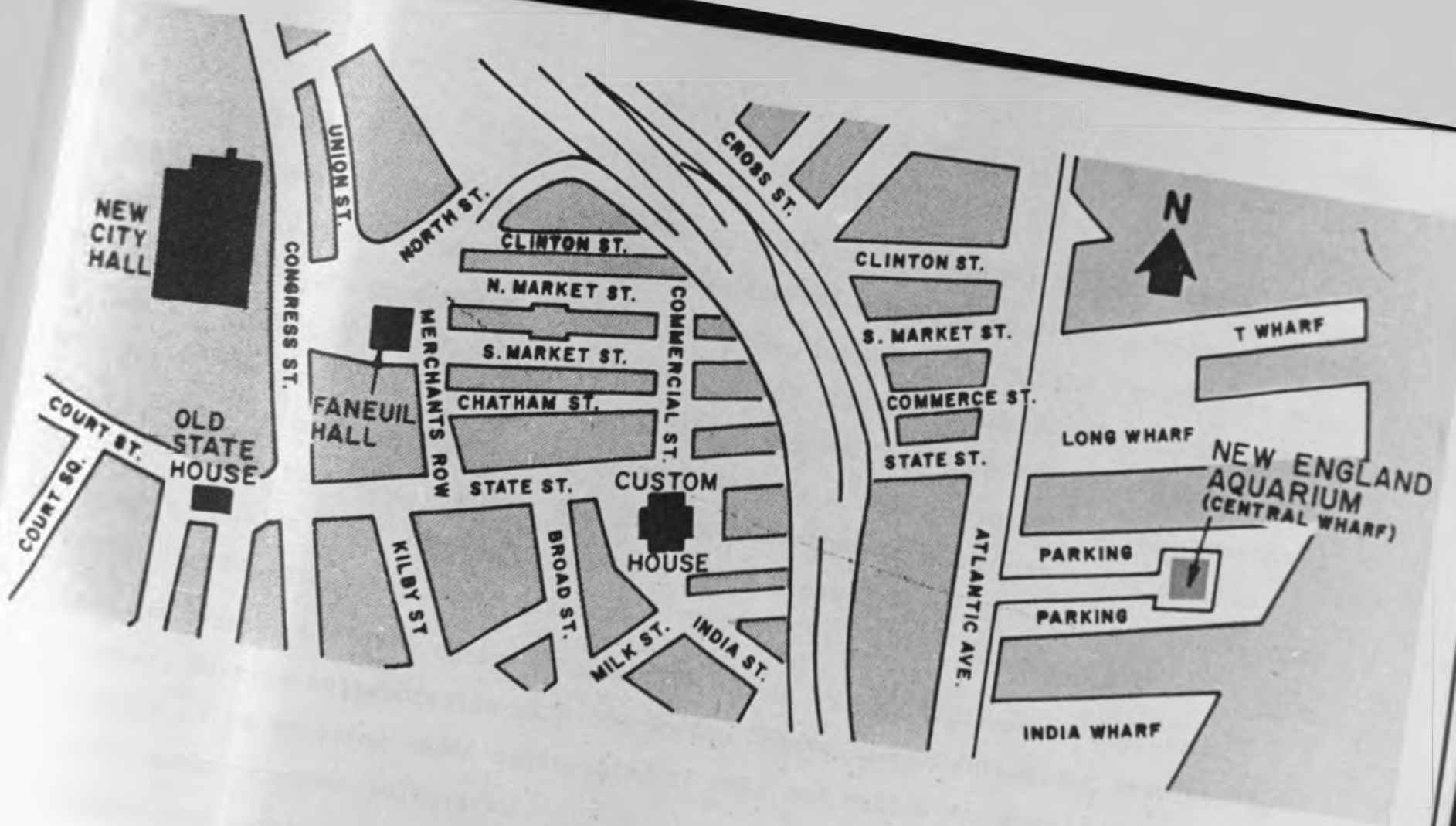
Boston occupies much of the Boston basin, a territory within a ring of hills. It stands on a surface of granite, conglomerate state and lavas between geological "faults" at the Blue hills on the South and Arlington heights on the North.

ENVIRONMENT - MACRO-LEVEL

The altitude of the city is 7 metres above sea-level.

CLIMATIC CONDITIONS

Average temperature	Jan. - 1.7°C .
	July - 22.2°C .
Average annual rainfall	889 mm.
Average annual rainfall	990 mm.
Annual precipitation	1000-2000 mm.



THE LOCATION PLAN-

SITE CONSIDERATION

The New England Aquarium is built on the water front on the Central wharf of Boston's Harbour renewal area. Urbanistically, the New England Aquarium is sited with magnificent appropriateness. Out on a wharf, created Boston's fishing industry, the Aquarium is not far from the Custom House, Faneuil Hall, and the new Boston City Hall. The Aquarium is the focus of the Boston Redevelopment Authority's renewal plan for the water-front, which is to include the restoration of the granite bulkheads of the warves which will provide a promenade along the water's edge. The Boston Redevelopment Authority refer to this walkway as a "public edge" that will make the water accessible to the people -- rather than to automobiles as in so many other cities.

The aquarium becomes a lively centre of activity within walking distance of down-town. Site studies, done in collaboration with the Boston Redevelopment Authority, resulted in the selection of an existing wharf constructed of fill and rubble and retained by nineteenth century granite bulkheads.

The building, was conceived as a multi-storey structure that would straddle the wharf, use a minimal land area, and thus present a strong simple appearance not unlike the old granite ware-houses, many of which are being restored. The land area in front of the building is preserved for the entrance plaza, and in the rear of the building, i.e.

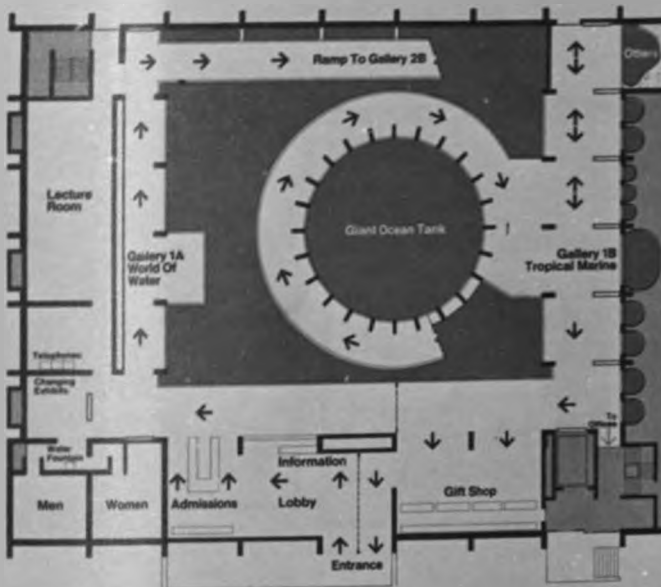
facing the sea for future expansion.

1 Site access - the down town location of the aquarium amidst the central public area, together with the bus transport facility, makes the aquarium easily accessible to most people. Moreover the pedestrian oriented water front plan, makes the place all the more attractive. Levels: the building is multi-storey, due to site restrictions.

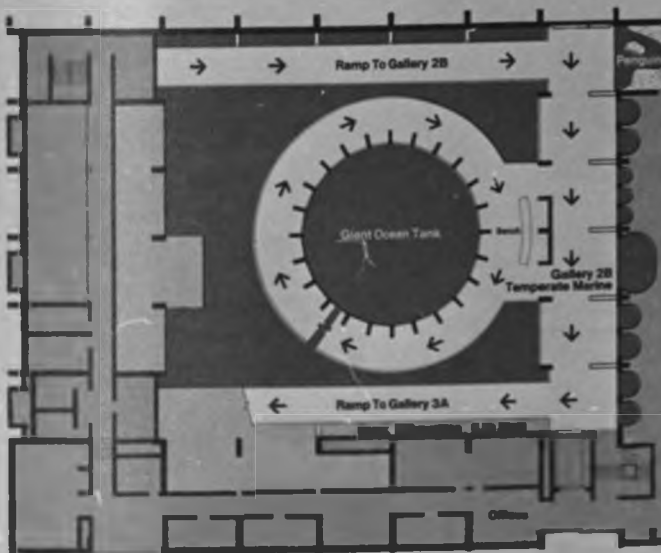
2 Circulation of people, goods and traffic-servicing, is well controlled due to the provision of the entrance plaza, and parking facility adjacent to the building is only for service cars and staff executives. Parking for public is provided on the either side of entrance road to the wharf, in front of the entrance plaza.

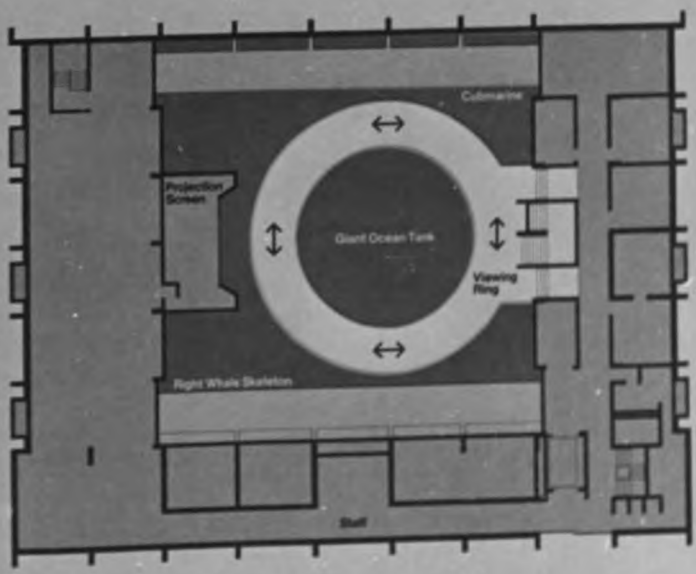
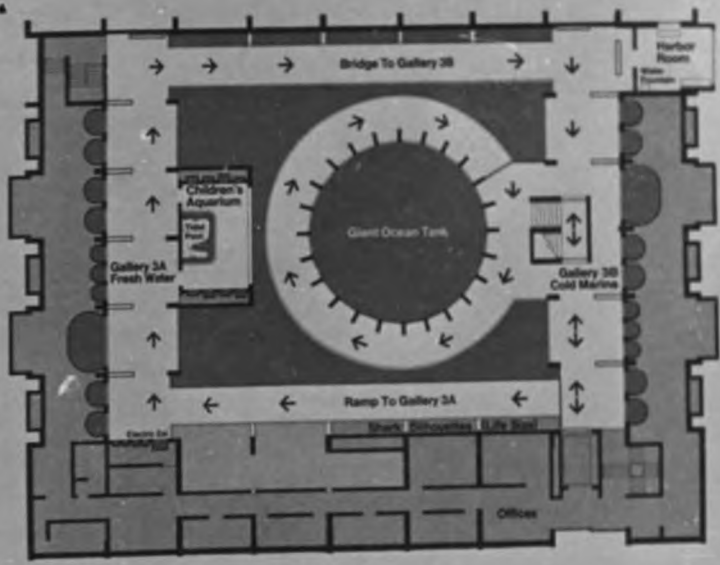
Topology: the wharf, like any other wharf, is a flat area; constructed, of course, artificially to fill and rubble. The wharf is 2 metres above sea-level.

1ST
LEVEL

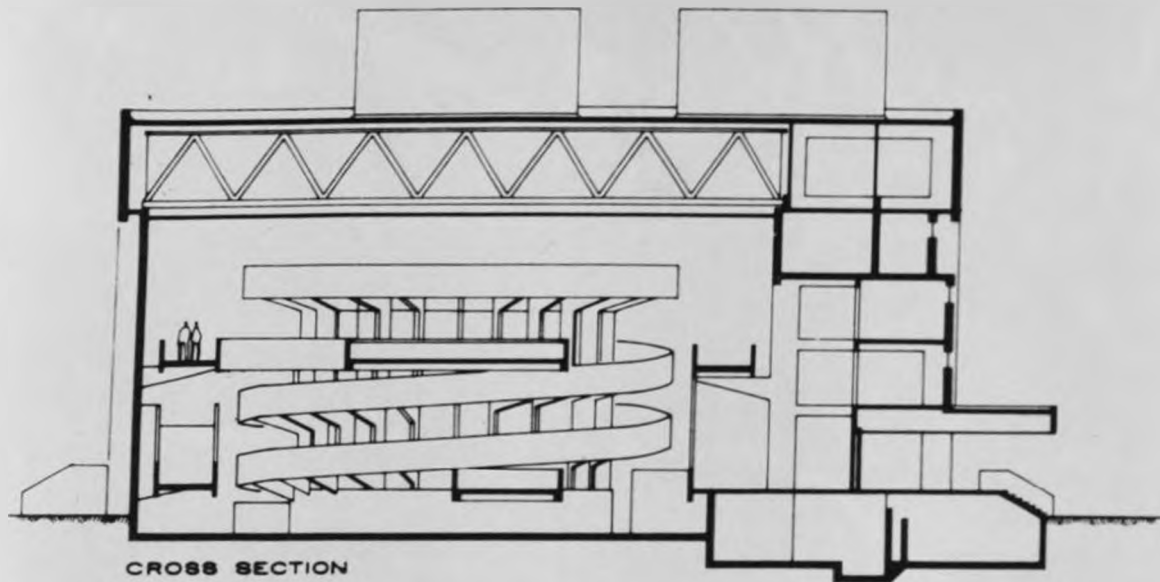


2ND
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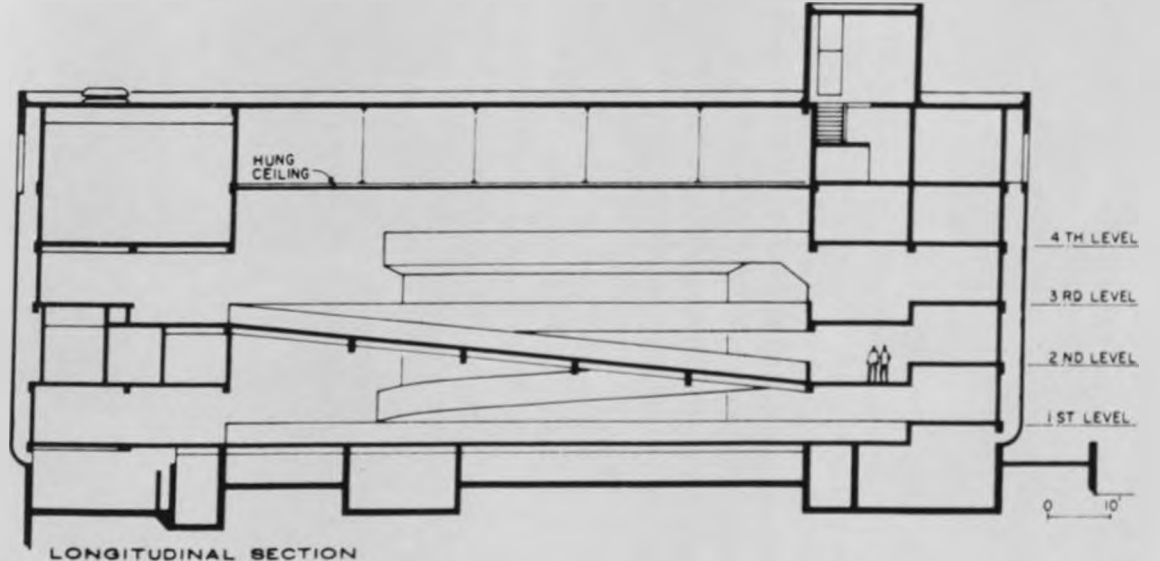




THE NEW ENGLAND AQUARIUM - BOSTON PLANS:



CROSS SECTION

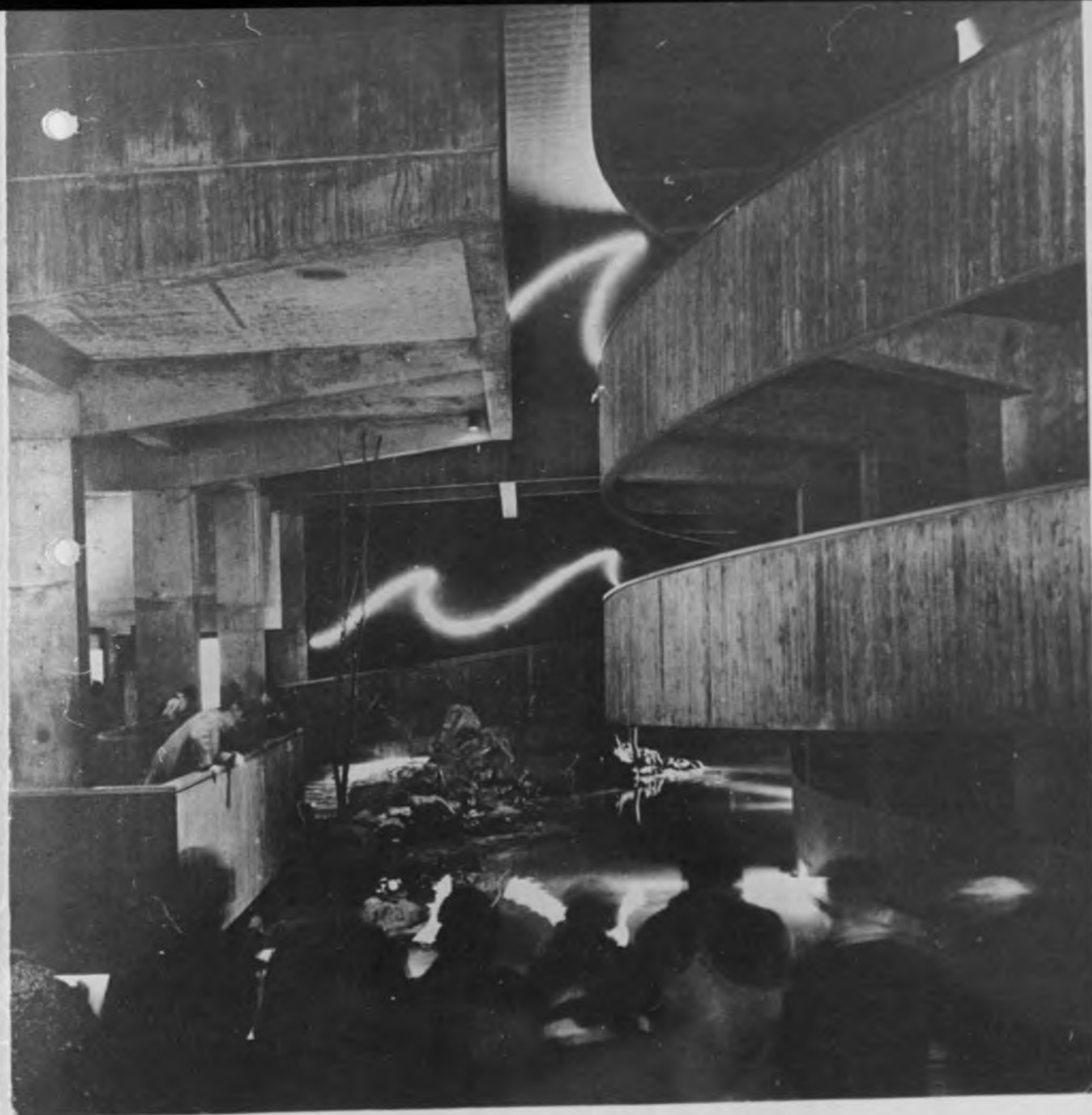


LONGITUDINAL SECTION

THE NEW ENGLAND AQUARIUM - BOSTON



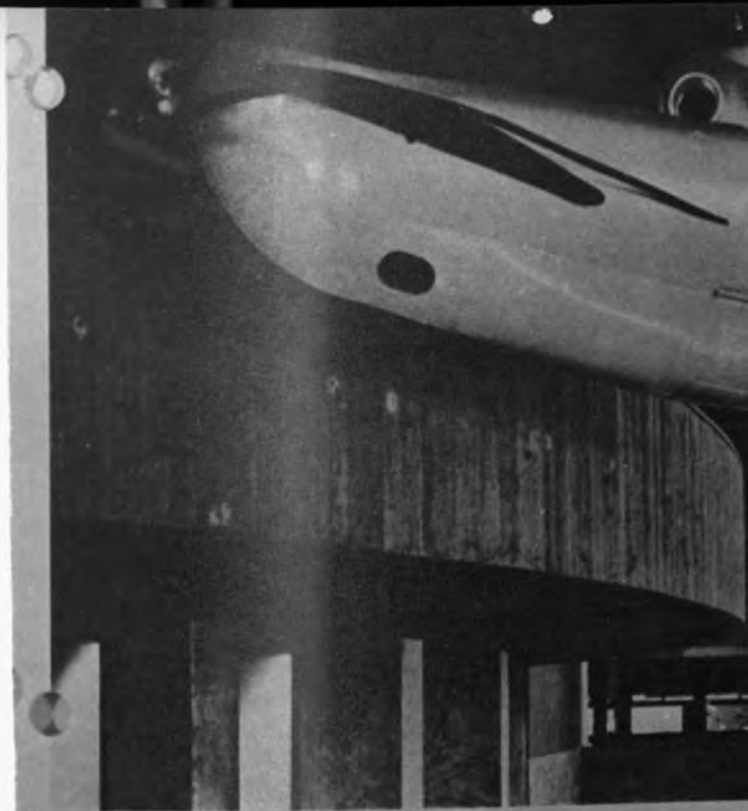
THE PHOTO MURALS AT NEW ENGLAND AQUARIUM



THE GIANT TANK ON THE WATER TRAY
AT THE BOSTON AQUARIUM
NOTE THE NEON WAVES ON THE WALL



THE INTERIORS AT THE NEW ENGLAND AQUARIUM





A yellow submarine floats in space among the ramps near a blue neon wave outline against a cork wall.



From the gift shop (left) one can see both the entry counter and the photo transparencies of the introductory exhibit beyond.

TWO TANK BAY DETAILS

FISH IDENTIFICATION STRIP
PLASTIC LAMINATED SURFACE

AIR PIPING BACK PANEL

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TYP ELEVATION OF TWO TANK BAY

GLASSPANEL TANKS

LETTERS OF IDENTIFICATION
PLASTIC LAMINATED SURFACE

4'-10"

8'-11 1/2"

4'-10"

10'-14"

4'-10"

4'-10"

4'-10"

4'-10"

4'-10"

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4'-10"

4'-10"

4'-10"

4'-10"

4'-10"

FLOOR BELOW TANK
TANKS ARE FINISHED WITH
1/2" EPOXY COATING

1/2" POLYESTER BOARD
GLASS ON FACE
UP TANK HELD IN
PLACE WITH
PRESSURE

1/2" PARTICLE
BOARD BETWEEN
GLASS LAMINATE
LAMIN. PLASTIC

WOOD BLOCKING
METAL CLIP ANGLE

1/2" PARTICLE BOARD
WITH 1/2" AIR
SUPPLY SUCT

3/4" PARTICLE BOARD
CORNER
WITH 1/2" AIR
SUPPLY SUCT

3/4" PARTICLE BOARD
CORNER
WITH 1/2" AIR
SUPPLY SUCT

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WITH 1/2" AIR
SUPPLY SUCT

SCHEMATIC CROSS SECTION

WATER AIR & BLEED
SERVICES

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FISH LABEL STRIP

GLASS

1/2" BLACK
FLUORESCENT
ALUM FIXTURE

1/2" BLACK
FLUORESCENT
ALUM FIXTURE

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ALUM FIXTURE

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FLUORESCENT
ALUM FIXTURE

LIGHT FIXTURE
DETAIL AT B

VERTICAL SECTION A-A

CONCRETE FACE

WOOD HANDRAIL

FRONT RAILING

WOOD BLOCKING

1/2" PARTICLE BOARD
WITH 1/2" AIR
SUPPLY SUCT

3/4" PARTICLE BOARD
CORNER

1/2" PARTICLE BOARD
WITH 1/2" AIR
SUPPLY SUCT

1/2" BLACK
FLUORESCENT
ALUM FIXTURE

1/2" BLACK
FLUORESCENT
ALUM FIXTURE

1/2" BLACK
FLUORESCENT
ALUM FIXTURE

UNDER TANK

CONCRETE

1/2" CLEAM

3"

1/2" CLEAM

1/2" CLEAM

1/2" CLEAM

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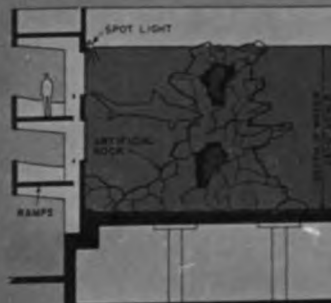
1/2" CLEAM

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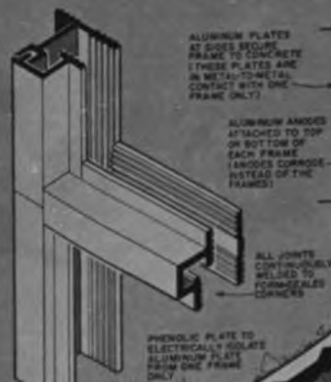
1/2" CLEAM

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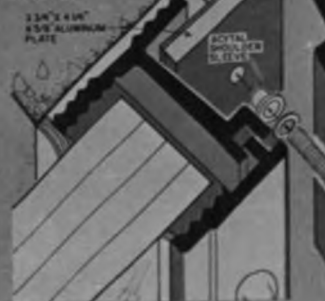
GIANT TANK DETAILS

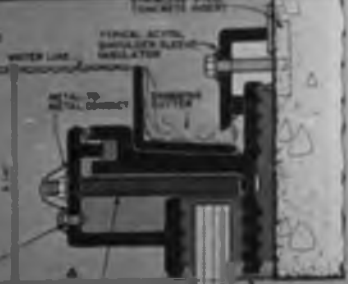
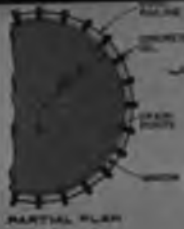


TYPICAL CROSS SECTION

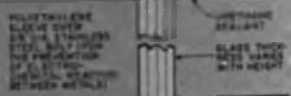


ISOMETRIC
DETAIL OF
INTERMEDIATE
MUNTIN

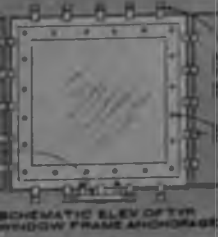
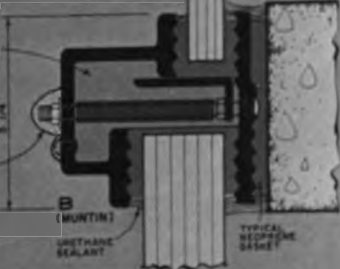




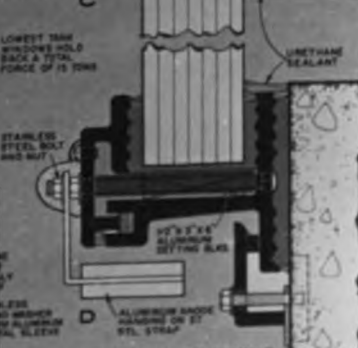
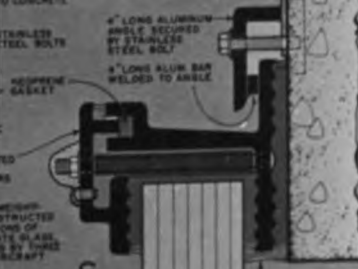
5/8" DIA HOLE IN FRAME FOR INSERTION OF POLYMER SEAL. HOLES PLUGGED WITH STUBS BACKWELD TO TOP OF GLASS AND TOP BEARING OF THE GLASS.



POLYMER SEAL FILLER INJECTED INTO JOINT OF FRAME TO PREVENT CORROSION CAUSED BY SALT WATER LEAKS AND TO PREVENT THE GROWTH OF ANTIMONY SULFIDE FROM METAL FILLS TO FRAME.



PHENOLIC PLY INSULATOR (INSULATES THE ANGLE CLIP FROM THE CONCRETE & THE STEEL INSERT)



LOWEST POINT OF TANK PLAN SECTION AT COLUMN

VERTICAL SECTIONS OF TYPICAL DETAILS

ORGANISATIONAL FACTORS

CIRCULATION-MICRO LEVEL

Theme: the changing rhythm of circulation and presentation as a basic organising principal of the design. Upon entering the Aquarium, one passes the information centre onto the admissions gate. Passing the entry counter, one comes face to face with one open volume, the huge Giant Ocean Tank that circles down to the fresh water tray. You enter the introductory exhibit, which introduces and acclimatizes the visitor to the world of water, by use of photo transparencies. High colour transparencies, by wild life and underwater photographers alternate with the tanks, with which they have an affinity since they have the same quality, often related content, and back lighting. The gallery overlooks the freshwater tank on the other side to the photographs.

From the gallery of 'world of water' you move up the ramp to other galleries. The visitor follows a one-way route through the building, ascending and then descending along ramps, bridges, and exhibits galleries, from which he has constantly changing views. At the top of the main space the visitor can look down directly into the depth of the large ocean tank, and throughout the building he looks down into the metre depth of the fresh water "tray" which acts as a floor for the main space.

Within the exhibit sequence, at the third level, there are two special exhibition rooms

that give variety to the visitor's experience, and a sense of separation from the main flow. One of these, called the Harbour Room, is an airy day lit room with benches and floor-to-ceiling glass, giving the visitor a chance to pause and rest with sweeping views of Boston Harbour. The second room called the children's Aquarium, contains small tanks with tiny animals, and an open tidal pool that allows children to have direct contact with water, rocks and animals.

The top most point of the Aquarium tour is the circular area, known as the Viewing Ring from which one looks down onto the surface of the Giant Ocean Tank. From the Giant Tank, proceeding down the ramp, the visitor may observe the animals in the tank.

Leading through these exhibits, the circulation pattern is basically the corbursier museum scheme of a rectangular spiral of narrow ramps on the perimeter of rectangular plan for traffic moving upward. The ramps, according to the architects, "minimize the distance of the viewer from the exhibit" as they ascend the four levels past the tanks in the four main exhibition galleries:

- (1) tropical marine life
- (2) temperate marine life
- (3) fresh water - marine life
- (4) cold water marine life.

From the top level, traffic descends via a spiral ramp surrounding the central Giant Ocean Tank. This one-way circulation route speeds overflow crowds on week ends. "It is like putting the Guggenheim spiral inside the Corbusier scheme and fitting the centre space of the Guggenheim with water." Peter Chermayeff, Principal-in-charge observed. The circulation pattern successfully achieves the architects' goal of "general emphasis on volume and three dimensionally."

Circulation is forced especially on peak days in a one-way flow up a ramp through the big space and past three large tanks to an exhibit gallery above. The constricting views are mirrored on a smaller scale by the gallery exhibits, where sequential tanks of live animals and graphic units containing detailed information from viewing alcoves, and help to vary the traffic pattern. The basic organizing principle of the design is an AB AB AEA rhythm of visitor movement, an attempt to combat "museum fatigue" through an alternation of the small side galleries, with the large (main space). 'A' is the exposure to the main space, with large scaled, undemanding simple exhibits, and 'B' exposure to the alcoved galleries, with smaller scaled demanding detailed exhibits. Whereas A's purpose is environmental mood settling, B's purpose is to provide content that can be explored in depth.

Another important design concept is the adjacent relationship of living exhibits and inanimate exhibits, part of an attempt to generate a new kind of institution, neither

"zoo" nor "museum", but a mutually reinforcing and more effectively communicating combination of the two.

1 SPACE UTILIZATION

ENTRANCE

The entrance to the aquarium faces the entrance plaza. On the left side of the entrance, the seals are exhibited in an open pool. On the right side, the entrance for staff and servicing (loading platform). The entrance has a canopy cantilevered over the entrance space. The entrance door, 4 metre in width, is divided into two spaces, by rope-line, one space acting as an entrance, while the other as exit.

LOBBY

The entrance lobby consists of information desk and admissions entry counter. Upon entering the lobby, one would face the fusiform symbol mural on the facing cork wall. Seating is provided for waiting in case of a 'full-house'. The lobby is naturally, as well as artificially lit by incandescent spot lights.

GALLERY 1A

World of water - this is the introductory exhibition space, where the visitor is made familiar with the 'world of water' - the main theme of exhibits. The exhibits are inanimate, high colour photo-transparencies of wild-life and underwater photo-sceneries,

which are lit from backside, giving the same effect as aquarium tanks. The gallery, like all other galleries in the aquarium play dual roles. On one side of this long gallery, we have the smaller detailed exhibits, while on the other side, a concrete railing, from where he can observe the bigger scale exhibits, have a panoramic view of the whole spiralling, ramped, aquaria.

A cantilevered 'viewing point' coming out from the gallery is also provided to give a better view of the fresh water tray from above.

GALLERY 2B

Temperate marine: the visitor from gallery 1A move up the ramp which leads him up toward gallery 2B, which houses temperate marine exhibits including the penguins. The exhibits along the gallery are divided by alcoves at the structural grid of 5 metres. Along the half-way of gallery 2B, the visitors have a choice of diverting towards the spiral ramp around the Giant Ocean Tank or continuing straight on to the ramp to gallery 3A. The ramp to gallery 3A has a blacklighted mural of life-size shark silhouettes, showing the varying species in vibrant ocean-deep lighting effect.

GALLERY 3A

Fresh water life: before entering the gallery, small tanks exhibiting eels of all kinds are seen at the end of the ramp leading to the fresh water gallery. Like the other

galleries, this gallery has exhibits on one side of small detailed scale, whilst a balcony on the other side overlooking the fresh water tray and the gallery 1A underneath.

CHILDREN'S AQUARIUM

In the centre of the fresh water gallery '3A', opposite the gallery exhibits is a children's aquarium, cantilevered out from the gallery is designed to delight the young ones as well as adults.

The aquarium of 5x10 metres area, contains a tidal pool and small tanks. Water in a central pool ebbs and flows in imitation of the tides, and plants and animals found in tide pools are displayed here. Youngsters may actually pick up and examine living starfish, crabs, and sea urchins. Along the walls of the children's aquarium are small tanks for various species of fresh water and marine fish. On wall are murals of octopus and other fish painted in colourful graphics.

Various native amphibians are also exhibited here. Seasonally, the eggs and larval stages of frogs and salamanders may be seen.

This colourful children's aquarium adjoins the fresh water gallery. So after this aquarium, one continues along the gallery towards the bridge which connects this gallery to gallery 3B.

GALLERY 3B

Cold Marine life: the cold marine gallery is same as others, but for the stairs in the centre area of the gallery leading upto the top most point of the Aquarium. This top most area is known as the viewing ring, from where one can look down onto the surface of the Giant Ocean Tank.

From this ring platform, one returns back down the stairs, and descends the spiral ramp which encircles the Giant Ocean Tank.

GALLERY 1B

Tropical Marine: upon reaching the first level, the ramp melts into galler 1B, where tropical marine fish are exhibited. Otters are also exhibited at one end of the gallery.

GIFT SHOP

At other end of the tropical marine gallery, the visitor comes across the gift shop. An open shop with a service counter and shelves, the gift shop deals with literature of aquatics, brochures and gift items. From the gift shop, the visitor departs via the exit.

TOILETS

The public toilets are provided on the first floor only. The toilets space is big enough to deal with quite a number of ladies and gentlemen. Comparable with the public toilet space provided in big cinema houses. A water fountain is also fixed before the toilet

entrance. The staff have separate toilets on 2nd level, 3rd level and 4th level. The second level has toilets for ladies and gentlemen separately provided, whilst the others have single toilet rooms.

LECTURE ROOM

The lecture room is situated behind the gallery of 'world of water', along with the telephones and changing exhibits area. The 5x15 metres lecture room is designed for informal lectures, slide shows, etc. The telephones and rest of the area is for relaxation.

GIANT OCEAN TANK

The focal point of the interior is the huge cylindrical tank at its centre. This glass and concrete structure contains 900,000 litres of ocean water, to a depth of 7 metres. It is 12 metres in diameter and is encircled by a cantilevered walkway.

In this Giant Ocean Tank are the largest water animals at the Aquarium; big green, hawksbill, and loggerhead turtles, leopard and nurse sharks, and various other fish including stingrays, moray eels, stripers, and species of angelfish, grouper, snappers, spadefish, parrotfish, grunts, and porcupinefish.

FRESHWATER 'TRAY'

A huge rectangular basin on the ground floor, the 'Tray' occupies an 24x27 metres area at the base of the Giant Ocean Tank. It hold 675,000 litres of water and is filled to a depth of one meter. This intriguing water environment was designed as a unifying highlight throughout the Aquarium and can be viewed with a different perspective from each level of the building. The 'Tray' has the built-in flexibility of being either a fresh or salt water environment depending on its ecological theme.

SERVICE AREA

All the servicing to the small tanks is from the backside of exhibits. The service area floor is one metre above the gallery floor level. Service ducts are provided on the periphery of the either sides of the building; which lead to the basement.

All the mechanical plants, filters, settling tanks, pumps are situated in the basement.

ADMINISTRATION

Administration and other staff have offices on second and third level of the building, access to all service areas from the offices is easy. Two staircases at opposite corners are used for vertical movement by the staff. A lift at one corner, near the staff-service entrance is also provided.

2 The interior is conceived as a single space, illuminated almost exclusively by glowing tanks and exhibits. Apart from the exhibit tanks, the building has spectacular permanent exhibits. From the Viewing Ring, it is possible to view a number of exhibits at close range including a mock-up of the Perry Cubmarine - a sort of submarine, a whale skeleton and audio-visual programmes using slide projection. New exhibits being added from time to time. A huge earth globe, over 2 metres in diameter is suspended from the ceiling between the second and first floors, the first of its kind to depict in relief the ocean floors as well as exposed lands, the globe rotates on the angle corresponding to that of the earth's axis and orbital plane.

Boston's Aquarium provides a single environment, that would sustain the continuity of experience whilst simultaneously surprises the visitor through contrast, unlike many aquaria that are too fragmented outside and inside, inhibiting involvement and concentration.

"I am a believer in opposites - something intense, at one spot and something airy at another" - Stone; D.B.

The single interior space is arranged and illuminated so that visitors are virtually immersed in the dark, fascinating world of underwater creatures.

The varied comprehensive exhibits cover the full range of water environments.

Elsewhere exhibits like penguin and otterpool are as open as possible, to involve the visitors in the marine life environment. These open exhibits, act as punctuation marks, to terminate one gallery section and lead the visitor on to another, "like illustrations to open and close chapters of a book" say the architects.

0 ENVIRONMENTAL FACTORS

1 ACOUSTIC:

The architects aim to a silence of underwater darkness in the inside of the building.

All external noise has been successfully eliminated by the use of a buffer system at openings in the building, while the rest of the building enclosed all around.

NOISY ZONES

Apart from external noise, the machine rooms, entrance lobby, Harbour Room, Children Aquariums and rest area are the main sources of disturbing noises. The machine rooms are accommodated in the basement and on the top-level, with the machines fitted on sound impact absorbers. The entrance lobby has a cork wall acting as a sound barrier.

The Harbour Room is fitted with soft carpet on the floor and the cork-wall gives the room a softening effect and the absorption of disturbing noise is successful. The segregation of the Harbour Room, and the Children's Aquarium, from the rest of the tour, and the enclosing of both rooms play an important role in reducing the spread of noise to the other parts.

The rest areas on the ground level, are juxtaposed next to the toilets and the lecture room. Acoustic treatment of wall - cork - walls, and ceiling try to absorb sound.

A Small partition is fixed dividing these parts from the exhibits area physically as well as acoustically, with openings.

ACOUSTIC TREATMENT:

All the interior walls, and the ceiling has been treated. The wall surface has been treated with cork with - sound absorption coefficient - 0.05; c/s 1000. The suspended ceiling is fixed with acoustic tiles with openings for vents.

Sound absorption coefficient - 0.100; c/s 1000. The larger part of the building is exposed concrete and the flooring is of p.v.c. - cork tiles. Due to the volume of the building, and the inter-linking of ramps and bridges, the over-all reverberation time R.T.=1.00 creating the right sort of atmosphere for mood-setting buildings.

VISUAL

The interior of the building, the exhibits area, excludes daylight so that the glow of light from tanks and other exhibits dominates the view and creates an underwater mood. Although the building dark inside, minimum lighting has been installed, (incandescent spot-lights directed towards the concrete surface, facing away from the visitors eye, to avoid glare) to reduce absolute darkness within the building.

All murals and transparencies are lit by a backlight fluorescent fixture. The murals in the "World of Water" gallery are illuminated by angled fittings, 100 watt bulbs local

lighting spot lights - four on each grid i.e. 0.75 metres centres. The photo transparencies are lit by backlight fluorescent fixtures.

The Giant Ocean Tank - is illuminated by spot lights on each structural concrete mullion (24 mullions in total), so that the viewer does not get direct light - since the mullion acts as a shade. The 100 watt incandescent spotlights are angled to face the base of the tank, as well as the simulated rockwork in the centre of the tank.

CHILDREN'S AQUARIUM

The children's aquarium is lit by the sophisticated spot lights mounted on an electrical trunking system on the ceiling, on rails, to give flexibility to the illumination of the tidal pool. The children's aquarium is a bright exhibit area in the building.

THE 'TRAY'

Spot lights illuminating rock, directed on rocks from the underside of the galleries, angled to avoid direct glare, and reflected glare from the water, are fixed at different places. Lighting fixtures are also fixed underwater facing the tray floor, making the crystal clear water brightly illuminated to show clearly any life.

AQUARIUM TANKS

All the other tanks are illuminated by incandescent as well as fluorescent fixtures,

fitted above the tanks. The lighting is directed towards the back and front of tank, with shades protecting the viewing from direct lighting glare. Different tanks have different levels of illuminations depending on the size, exhibits and temperature conditions.

CFTERS AND PENGUINS

Diffused floor and ceiling fluorescent fixtures illumate the animals and their habitat. Spot-lights are used to illuminate the fixed exhibits like the globe, whale skeleton and the submarine. Angled fittings, with a flow of light directed at the exhibits, illuminates them from different angles.

But for the Harbour Room which has the large window, ceiling-to-floor, and the small windows in the offices on second level, the whole building depends on artificial lighting.

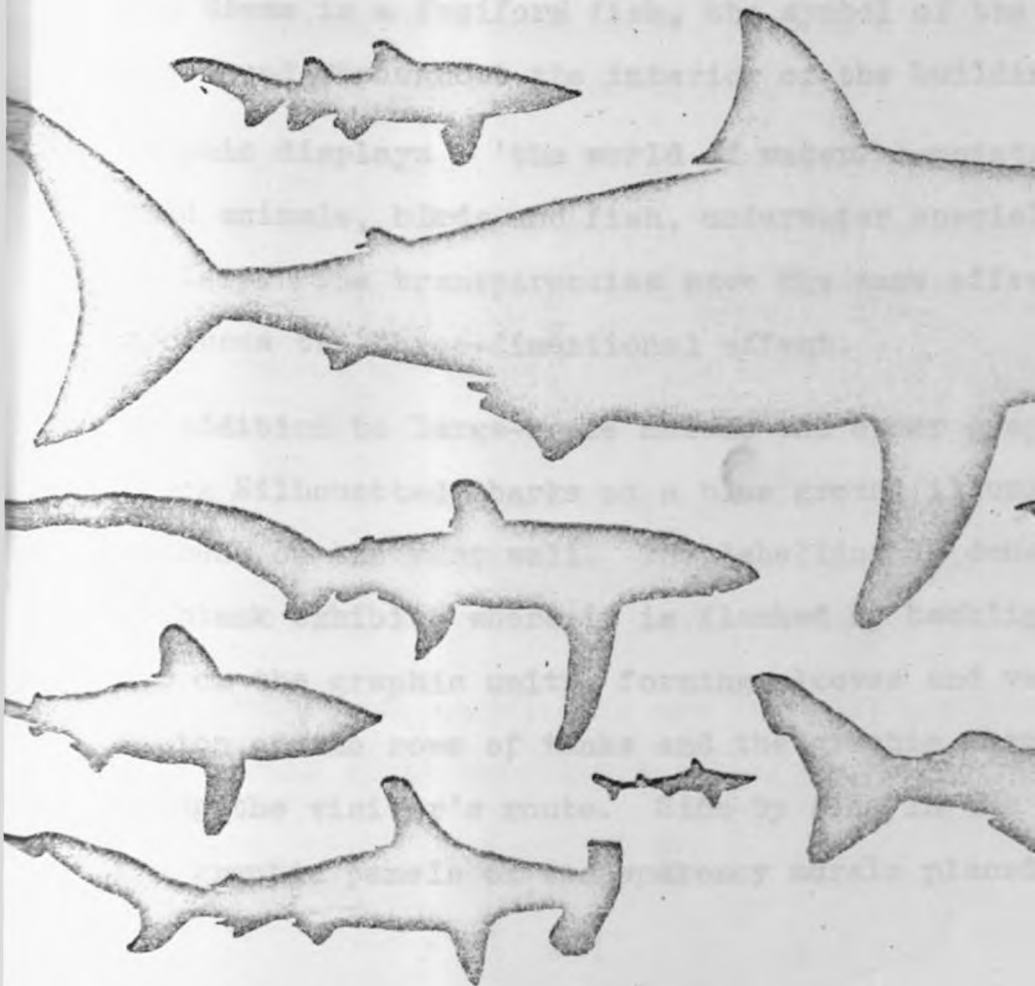
3 THERMAL

The enclosed building stops any draughts and prevents external temperature changes from effecting the building, while the air conditioners, with extract system in the ceiling, keep ventilation, humidity and temperature in control.

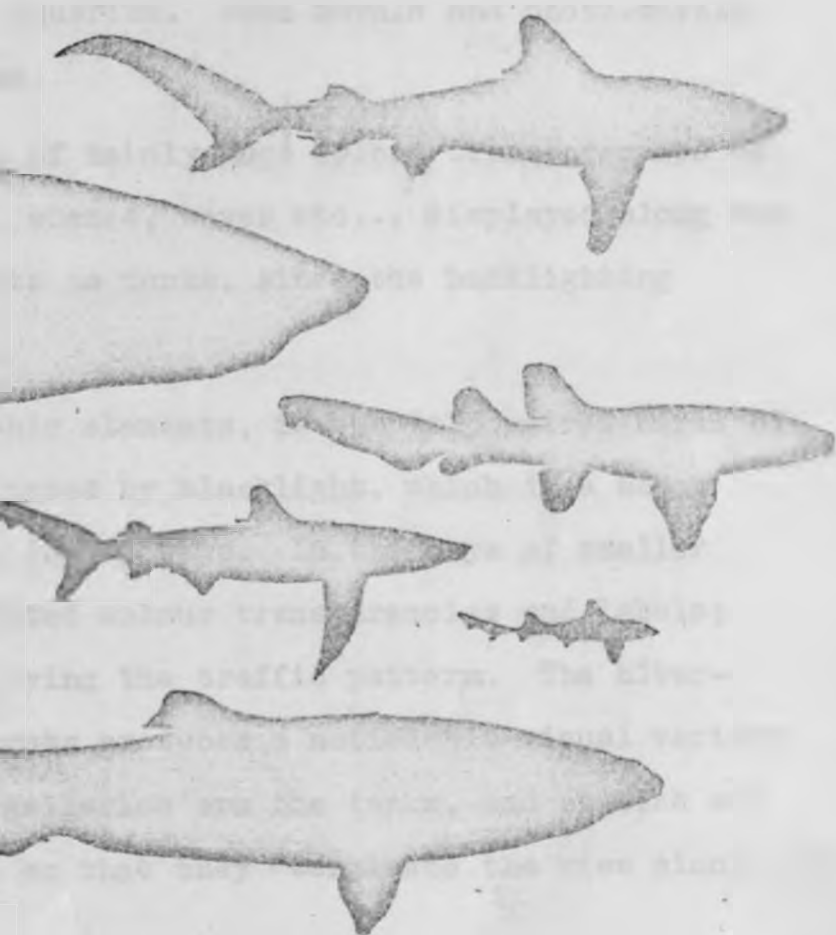
Different temperature zones are planned to give temperature control in different species envrionment. All the tropical fish are kept along one gallery, whilst cold marine, temperature climate fish, etc... are all in a different gallery. The temperature control

is localised in each gallery and individual tanks in special cases, by use of thermostats.





A wall exhibiting life-size
shark silhouettes in the New
England Aquarium



TWO METRES 

8.0 COMMUNICATION SYSTEMS

The graphical designs and communications in the aquarium play an important role in emphasising the design concepts of the aquarium.

Upon entering the aquarium a huge mural is fixed on the wall opposite the entrance door. The theme is a fusiform fish, the symbol of the aquarium. Such murals and photo-murals are found throughout the interior of the building.

Graphic displays - 'the world of water' consists of mainly huge colour transparencies of wild animals, birds and fish, underwater special scenes, waves etc... displayed along the gallery. The transparencies have the same effects as tanks, since the backlighting produces the three-dimensional effect.

In addition to large-scale murals and other graphic elements, is the 7x15 metres mural of black Silhouetted sharks on a blue ground illuminated by blacklight, which is a major element on the west wall. The labelling is done in two ways. In the bays of smaller fishtank exhibits where it is flanked by backlighted colour transparencies and labels: and on the graphic units, forming alcoves and varying the traffic pattern. The alternation of the rows of tanks and the graphic elements produces a noticeable visual variety along the visitor's route. Side by side in the galleries are the tanks, and at each end are graphic panels or transparency murals placed so that they "terminate the view along

the galleries and lead the visitor on from one exhibit area to the other." The alternation of exhibit tanks containing live animals is a small-scaled version of alternation of "small and detailed exhibits with the large and undetailed main space" as the architects point out.

An interesting blue neon light, forming a wave out line against a cork wall dominates the ramps connecting the different galleries.

Hung from the beams, black box with backlighted white letters and arrows as a sort of sign board to act as a guide to the visitors, to certain areas of the building, e.g. to the Gift Shop, Exit to plaza, toilets, lecture room, telephones, etc....

.1 Use of chains and ropes, for the control of traffic, act as barriers, to stop the visitors from overflowing the place, or going into closed places. The floodlighting of the aquarium on the outside, with spot-lights fixed under the beams on the ground level and fourth level at night time, outlines the structure, as it stands on the central wharf on the waterfront.

The incandescent spot-lights are fixed at the niche formed by the column and beam, throwing the light onto the walls of the building.

SYSTEMS TECHNOLOGY

9.0 STRUCTURE

The main structure of the building, inside and outside is poured-in-place, 'in-situ' and precast reinforced concrete, exposed to view and textured by rough-sawn form boards.

The structural grid of 5x5 metres, with columns (900x300 mm) and beams based this structural grid. The ramps and galleries are all cantilevered structures, of reinforced concrete, supported by the columns.

The childrens aquarium is cantilevered projecting out from the third level fresh water gallery, supported on cantilevered beams.

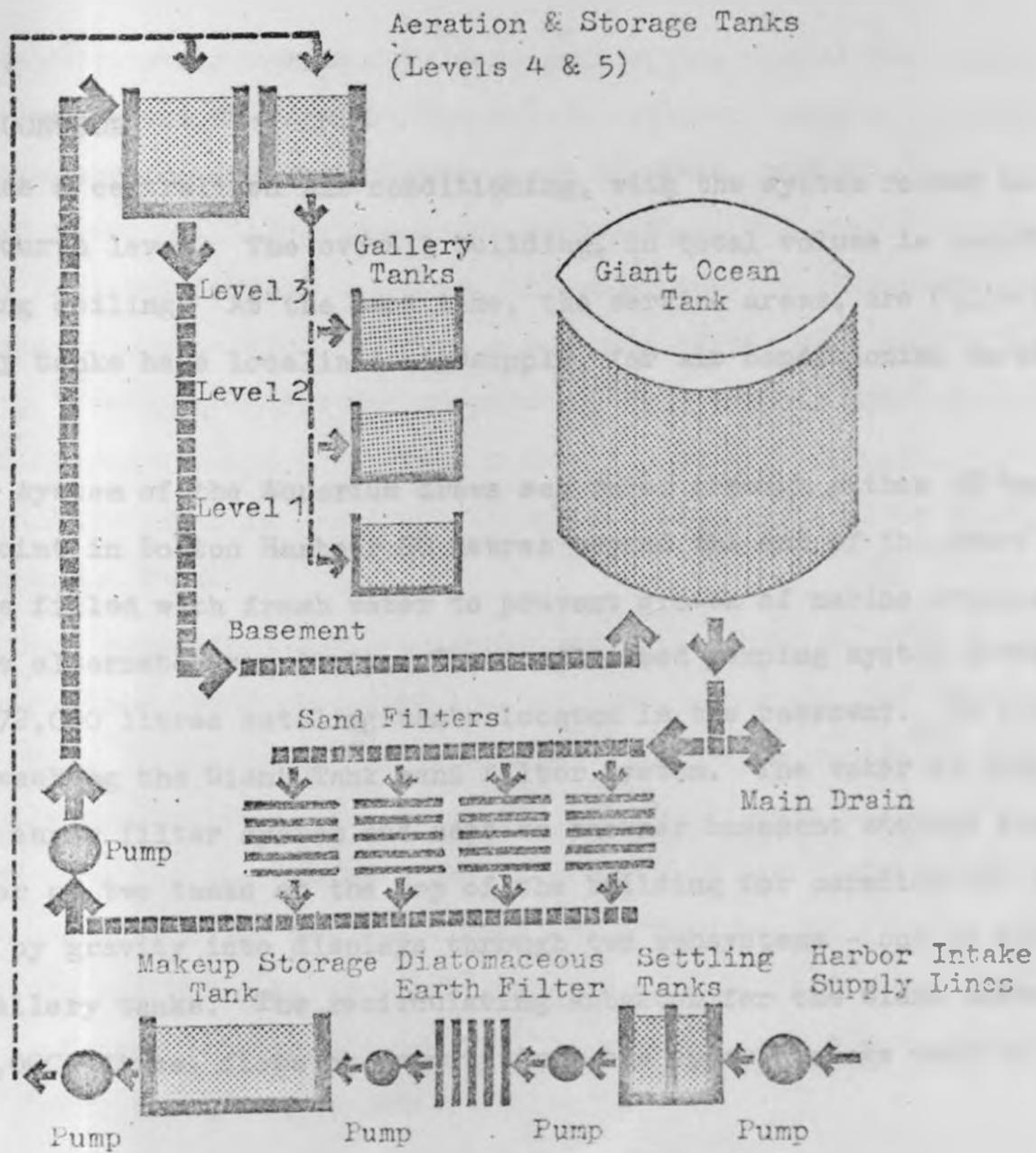
2 The roof structure in the building is made of a concrete slab supported by steel Warren trusses. A hung ceiling is suspended from the roof, made up of acoustic tiles and supported by brackets.

3 The Giant Ocean Tank is, according to the architects, "a large basket of glass and concrete. It's precast concrete columns are tied together by compression rings to support the outward pressure of 7 metres of water. The glass windows surrounding the tank are 1372 mm wide by 1880 mm high. At the bottom of the cylinder, where the pressure on each panel approximates 15 tons, the glass is 100 mm thick and is made up in four laminations.

9.3 Pressure caused some delay in stocking the Giant Tank, not because of its structure but because of its piping system. P.V.C. piping was originally used for the Aquariums special process system but, according to the mechanical engineers "was not able to meet pressure test specifications"; as a consequence glass-fibre piping was substituted.



SALT WATER SYSTEM



2.0 SERVICES

2.1 ENVIRONMENTAL CONTROL

The building has a centralized air conditioning, with the system roomed in the service areas of the fourth level. The overall building, in total volume is ventilated by extract fans on the hung ceiling. At the same time, the service areas, are fully air conditioned, and the display tanks have localized air-supply, for air conditioning in the public gallery.

2.2 WATER SYSTEMS

The salt water system of the Aquarium draws sea water through either of two 355 mm intake pipes from a point in Boston Harbour 60 metres beyond the end of the wharf. One of the intake pipes is filled with fresh water to prevent growth of marine organisms; the two intakes will be alternated regularly. The complicated pumping system moves 9000 litres a minute to two 72,000 litres settling tanks located in the basement. It also provides the water for backwashing the Giant Tank sand filter system. The water is then filtered by a diatomaceous earth filter system and sent to another basement storage tank. Water is pumped to either of two tanks at the top of the building for aeration and storage. From there it feeds by gravity into displays through two subsystems - one to the Giant Tank, the other to the gallery tanks. The recirculating subsystem for the Giant Ocean Tank, which contains 1,180,000 litres, flows by gravity from the upper storage tank to the Giant Tank

then passes by gravity through sand filters and is then pumped back again to the upper storage tank, completing the cycle. The smaller gallery tanks are recirculated by airlift pumps through individual filters, each of which consists of a layer of sand held on a perforated sheet of fibre-glass a few inches above the bottom of each tank. The sand acts as a filtering medium, allowing the water to pass through to the space below. It is then drawn into a vertical tube in one corner of the tank and is recirculated by compressed air. Fresh water for the fresh water tray and the fresh water exhibits on the galleries is filtered through a separate diatomaceous earth filter as it is recirculated continuously; makeup water is provided through a piping system from the fourth floor aeration and storage tank.

Water temperatures range from 10°C for cold water fish tanks to 27°C in the tropical tank. The cold water exhibit tanks are maintained by circulating chilled water through 'karbate' heat exchange units in the tanks and warm water with quartz immersion heaters. The penguin and otter tank exhibits are supplied through separate diatomaceous earth filter systems. Water from those exhibits flows by gravity to the diatomaceous earth filters located in the basement under the Giant Tank and after passing through a filter it is pumped back to the exhibit. Water to the penguin exhibit is pumped through a karbate shell and tube heat exchanger located adjacent to the exhibit in the services gallery and cooled to 10°C before being introduced to the exhibit.

3.3 COLLECTING THE FISH

Many of the animals at the Aquarium have been collected by the staff. Acquisitions are also made by purchase or in exchange with other aquaria. Unusual examples are often received as gifts from local hobbyist or anglers, and fishers. However, most of the collecting is done by the staff. When collecting, the men generally stake out an area of water, such as a cove, where they plan to work. First they sweep the area in a reconnaissance survey, spotting points of interest to which they will return. Then following designated paths, they collect the animals, proceeding until the entire area has been covered. The staff may go as far as the Amazons for species.

3.4 DUCKS AND DRAINAGE

The plan of the building, with the service area in the periphery of the two side of building makes the servicing, pipes and ducts simpler. Three huge ducts on each side, leading down to the basement carry supply pipes and drainage pipes. The water, air and electrical services in the service galleries are all run along the ceiling, exposed to workmen and staff, for control and repairs. The floor is sloping, with the flow drain leading down the duct shaft.

CASE B



View of the development with the dolphin pool to the left and the aquarium right

AQUARIUM DE MONTREAL

1.0 HISTORICAL BACKGROUND

The Aluminium Company of Canada Ltd decided to build an aquarium as its contribution to Expo '67 in April 1965. The architects and engineers were appointed and it was found that considerable research was needed even to establish criteria for design.

Several research trips were organised and slowly relevant information began to emerge. At that time the general consensus by all aquarium experts was that it was important to design and build an aquarium in less than two and a half years, whereas according to critical path schedule this aquarium had to be completed from design to completion of construction by January 1967, a year and eight months period to allow approximately four months before the opening of the Expo in April for the aquarium to be populated and become evident that aquaria and aquatic exhibits fall into two general categories: A museum like exhibit with galleries of fish tanks placed side by side in conformity to a building plan of a different era, or marine land type shows where the emphasis is more on the entertaining factor and handling of masses of people.

1. In the meantime, as a result of the research it had been decided that both from the point of view of Expo '67 and from the point of view of a supporting element for the permanent aquarium complex in Montreal, a dolphin pool should be added. The programme having been increased by 100 per cent, the element of time had become even more significant. At the

same time it was obvious that the original budget for Alcan's Expo contribution could not possibly cover the programme. At this point Alcan invited the city of Montreal to become partners in this venture and decided to turn over the whole complex to the city permanently after the exposition i.e. Expo '67, programme was over. The city of Montreal, agreed with the proposal, and the construction of the aquarium began in October 1965. Despite several problems, (the cold months, and 'red-tape') the aquarium was completed in time, stocked and ready for thousands of visitors who flowed in when Expo '67 officially opened.

1.2 After the exposition, Alcan officially handed over the buildings to the authorities, city of Montreal; who upto this date maintain, and finance the institution.

2.0 SOCIAL AND CULTURAL CONTEXT

The City of Montreal is a dynamic growing downtown city, the largest of Canadian areas. The city is bi-lingual, with both the French and English speaking populace, though being in the state of Quebec, the French population dominates. The city is a famous business centre, obviously so, with its strategic advantage geographically and a huge harbour.

Expo '67 had a tremendous impact of the general growth in the city. In the way of planning building and transportation, new developments took place. The impetus of Expo was responsible for bringing to fruition the ambitious scheme for the improvement of Montreal.

The city's elaborate new highway system is the typical example, which might have taken years to reach the stage it has if Expo had not set a short-term target. The visitors to Expo '67 appreciated the up-to-date transportation system with which Montreal was equipped.

The social and cultural impact of Expo '67 drowned any impact caused by the Aquarium and Dolphin pool. But the potential of the Aquarium as a part of the entertainment which the city could offer, was well recognised by the authorities, and today aquarium enthusiast, as well as tourists come to visit the institution, whilst large crowds always participate in the dolphin shows.

3.0 ECONOMICS AND PRODUCT DEMAND

The original reason for which the Aluminium Company of Canada decided to undertake the aquarium project in Montreal Expo '67 was of course that it should become its contribution towards Expo, as one of Canada's foremost manufactures. Prestige and glory were the main factors which probably induced the directors of 'Alcan' to embark upon such a project. Although, the company must have realised the potential of aquaria to any urban situation, and the aquarium in the Expo would also become a feature of varied interest in Montreal. Incidentally, Alcan was definitely not expecting to make a permanent project, to maintain and operate the aquarium. Nor was its aim profit making from the proceeds. And so it was decided to include the city Authorities in their plans, and later, after the Expo '67 programme, to hand over to the city the responsibility of maintenance.

3.1 The construction of the aquarium is by no means 'low cost'. The use of certain materials, and methods of construction, e.g. Aluminium and Bronze claddings, though specified by the Alcan people made the aquarium an expensive project. This was evidently so, for the building was built as a contribution to Expo world trade fair. Expo '67 was and is a laboratory for architectural experiment. A proving ground and a show window in which ideas, structures, styles and personalities have first been presented to the world. Amidst such tough grounds, the aquarium competed with the rest, and turned out to be an ambitious

project. It was due to these reasons, Aican could not meet any extra expenses and had to ask the city of Montreal to become partners to the project.

Despite the architectural form and finishes, the maintenance of the aquarium was designed to be economic. The aquarium charges for entrance, and so does the Dolphin Pool, though this hardly covers the cost. The rest of the expenses are covered by the city of Montreal.

4.0 GEOGRAPHICAL LOCATION

The Aquarium and Dolphin Pool is one of the adjoining buildings in the La Ronde (amusement) area, as one of the permanent contributions to the city of Montreal by Expo '67.

Montreal, is the largest city in Canada. It lies on the triangular Island of Montreal at the junction of the Ottawa and St. Lawrence rivers, in Southern Quebec. The Island is about 50 kilometres long and between 10 to 15 kilometres wide. The metropolis covers 90 sq. Km in the total 300 sq. Km of the Island.

It lies approximately on latitude 45° , longitude 74° , —

On the Quebec plateaus in the lowlands. The city is away from the sea, with the rivers flowing into the sea. The soils around the Islands are mostly sediments. Due to the rivers flowing into the Montreal area, the soil consists mainly of clays, loams, sands and silts. Some traces of limestone can also be found.

4.1 Macro-environment

Climate: annual average rainfall 76 to 102 cm

range of temperature	Minimum	Maximum
	-18° to 12°C	24° to 29°C

EXPO 67 PLAN

DU HAVRE

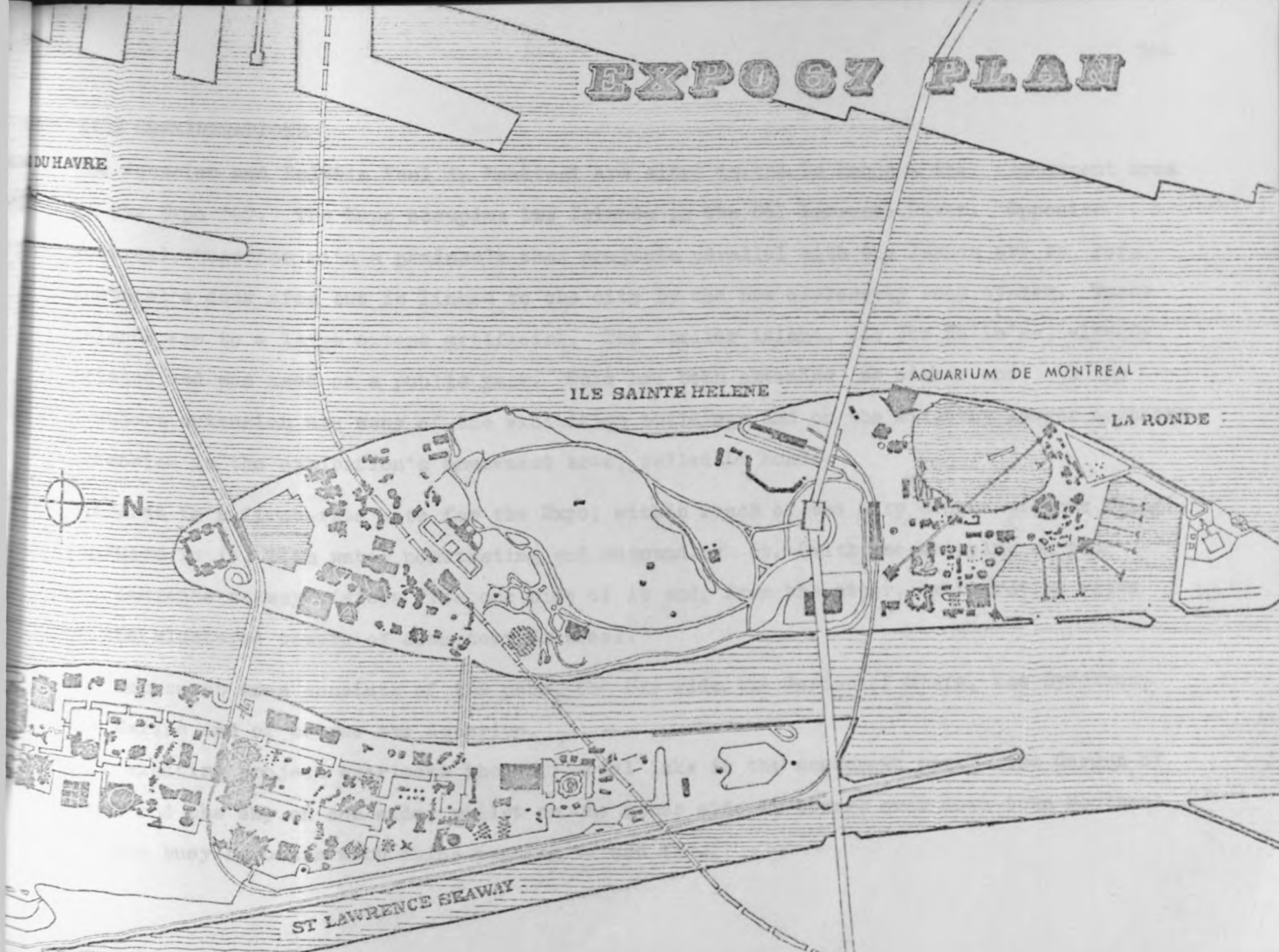
ILE SAINTE HELENE

AQUARIUM DE MONTREAL

LA RONDE

N

ST LAWRENCE SEAWAY



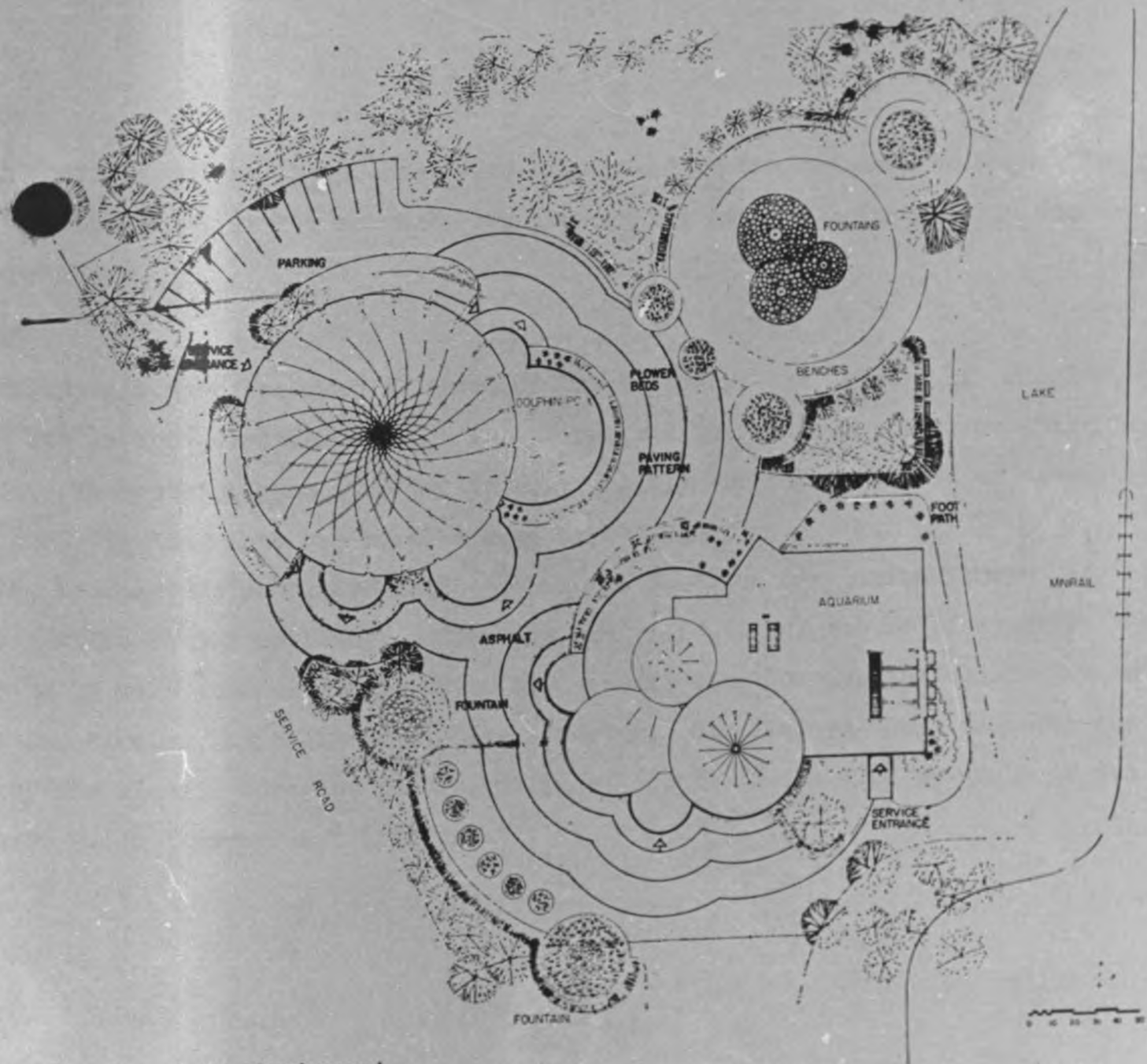
5.0 SITE CONSIDERATIONS

The Aquarium and Dolphin Pool in Montreal are sited in the La Ronde - the amusement area of the Expo '67. The Expo occupies two Islands in the St. Lawrence River. Opposite Montreal, together with a peninsula that projects parallel with the Islands are to form Montreal's dock area but is linked to the city by the new expressway road system. These islands are to a large extent artificial. The smaller island, Ile Ste Helene, already existed and was used as a public park. This has been extended at either end. On the southern extension are many of the exhibition buildings and on the slightly larger northern extension is the exhibition's amusement area, called La Ronde.

The area is a first-rate site for the Expo; within reach of the city centre without being confused in it, with water penetrating and surrounding it, (with the shipping on the St. Lawrence scaway visible from one side of it and, from the other, exhilarating views of the clustered towers of down-town Montreal.

The amusement area consists of the park, the Sky ride, the Garden of Stars, the Gyrotron, the Marina and of course the Aquarium.

This exciting project overlooks the artificial lake in the amusement park - the Garden of Stars and the sky on one side, whilst on the other side it towers over down-town Montreal and the busy harbours with ships passing to and fro.



site plan of the development

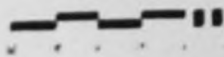
5.1 TRANSPORT

The main road and railway line connecting the Island to the mainland on both sides passes just by the aquarium, with a service road linking the site with the railway and expressway lines.

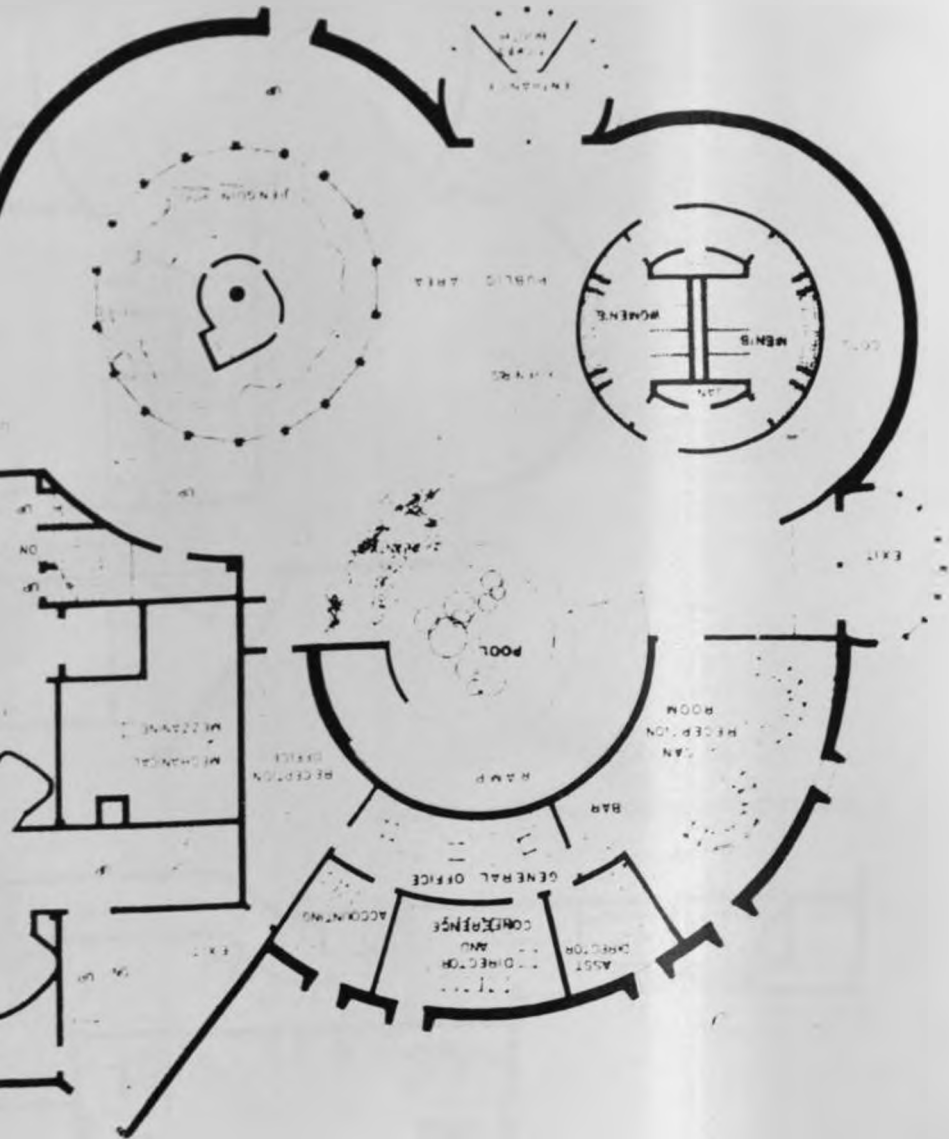
5.2 LANDSCAPE

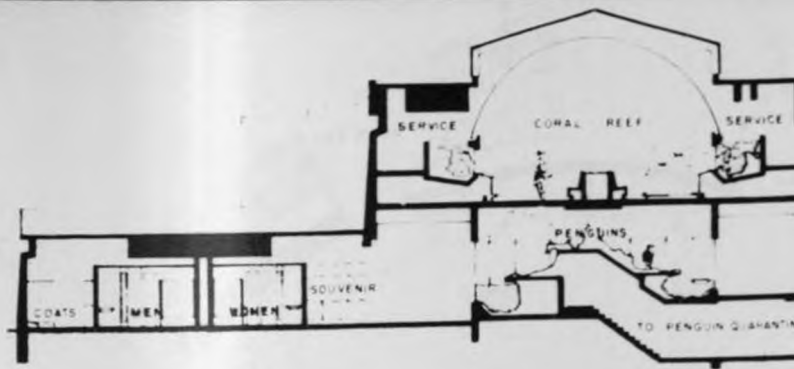
The landscaping echoes the overall shape of the building, the pattern of ripples in ever widening and interpenetrating circles emanating from the centre of each building component. The parking space for twelve cars, mainly for the staff, is adjacent to the Dolphin Pool, leading into the service road to the aquarium.

Fountains, benches and paved footpaths within the Aquarium site, with flower beds give additional charm to the building, reflecting the recreational nature of aquaria. The landscaping is very carefully related to the overall concept with its connecting and intersecting circles, symbolizing ripples of water. Circular patterns dominate the paving of the plaza. Care has been taken in allowing for the free movement of the very crowds which flow through this area.



aquarium main floor plan

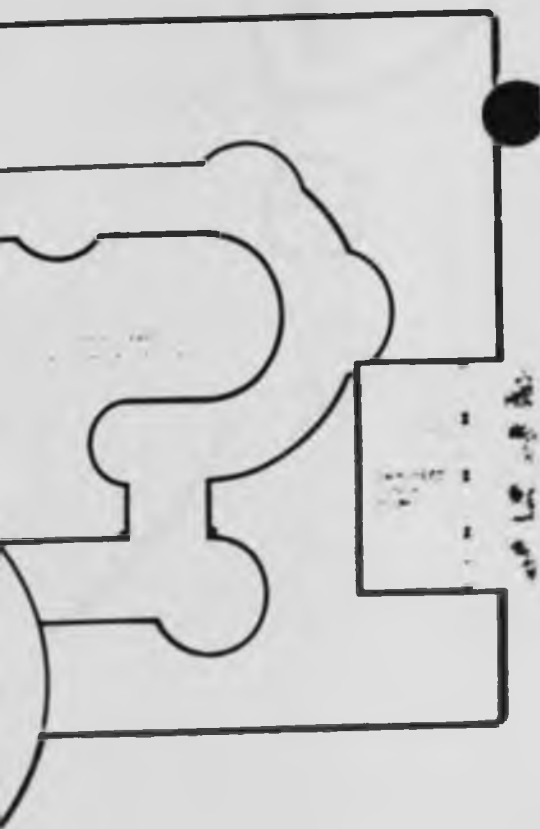
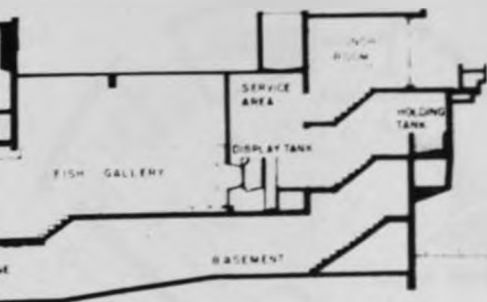


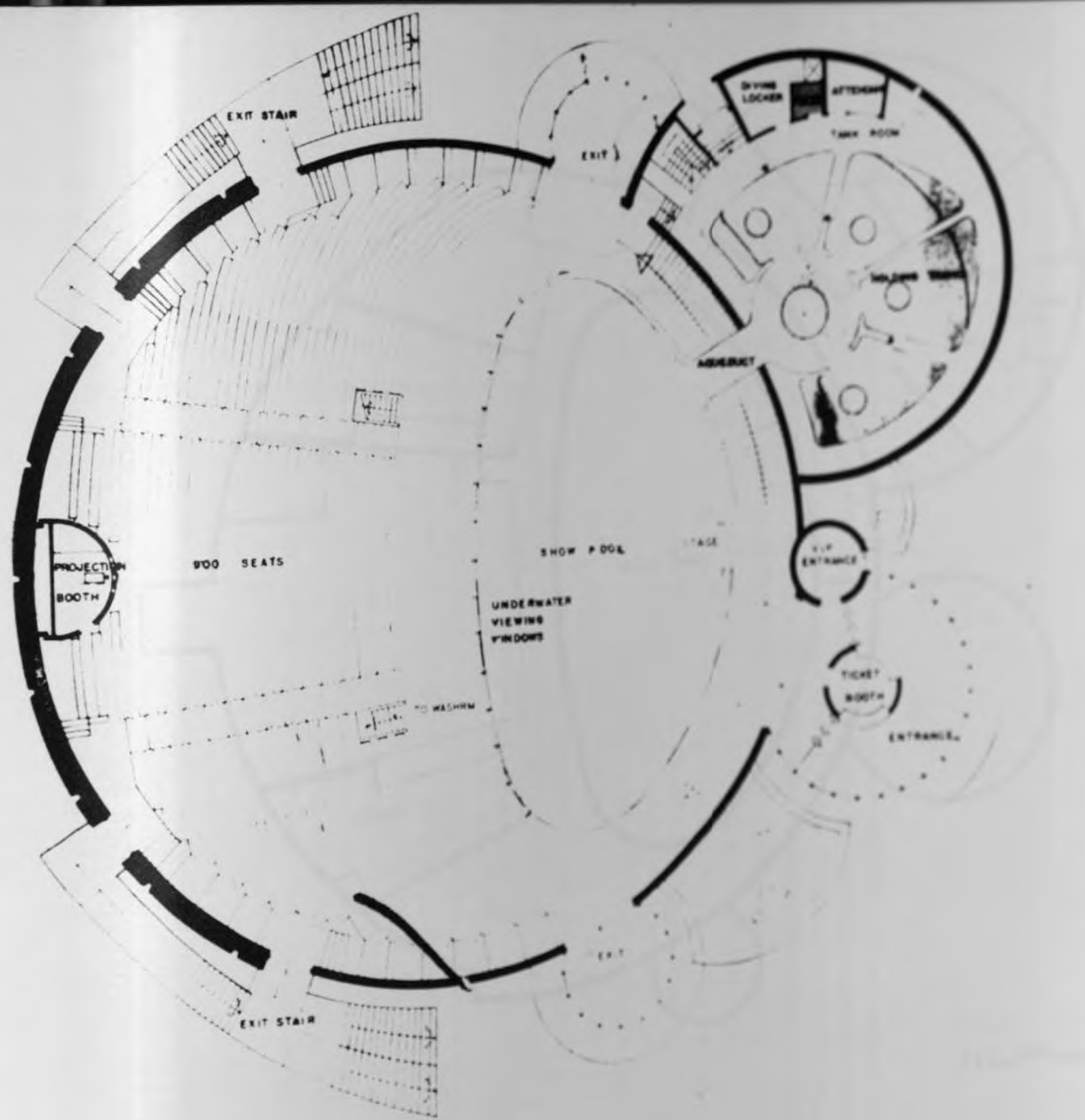


longitudinal section through aquarium

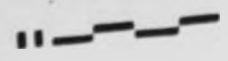
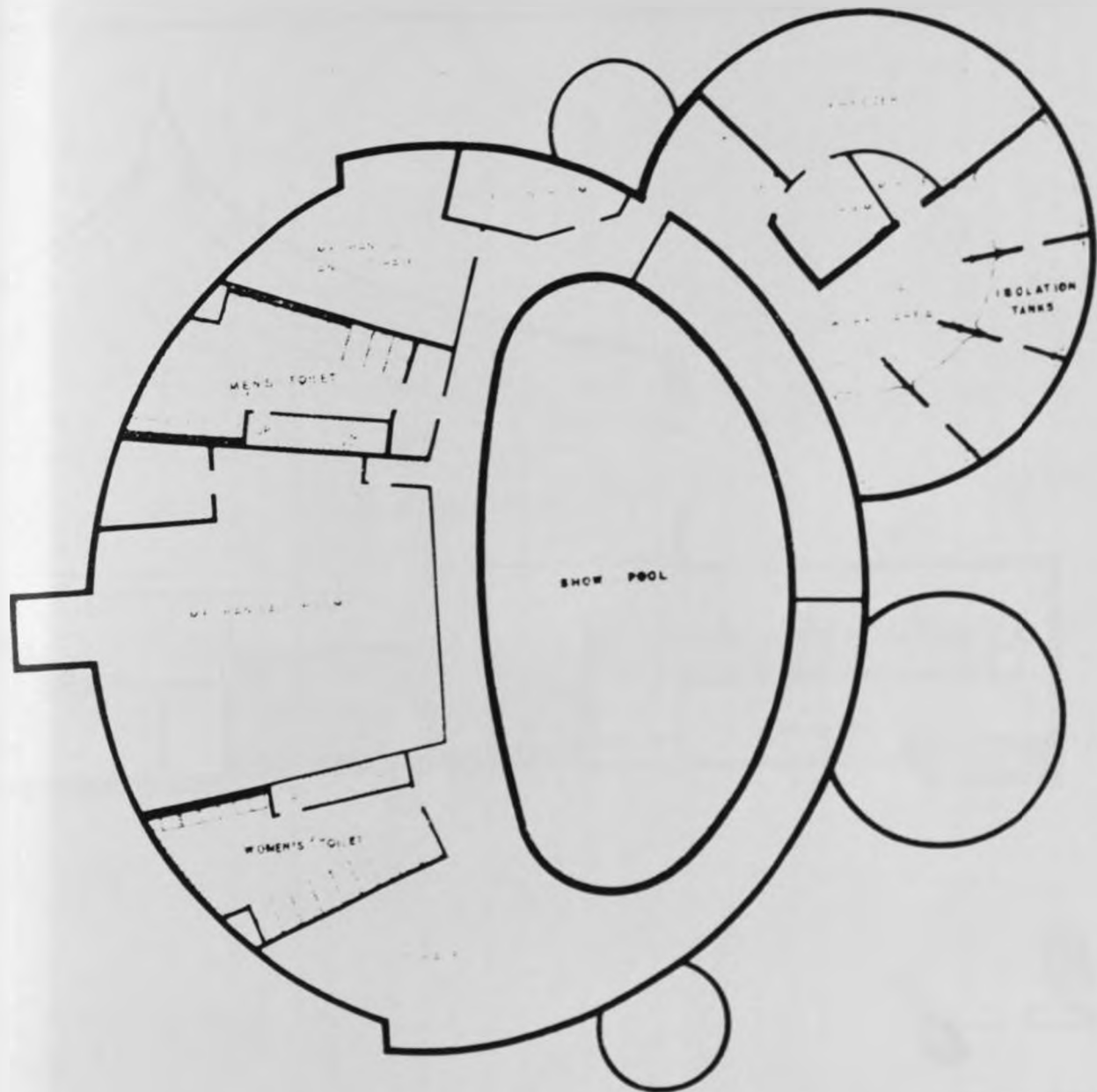


aquarium upper floor plan

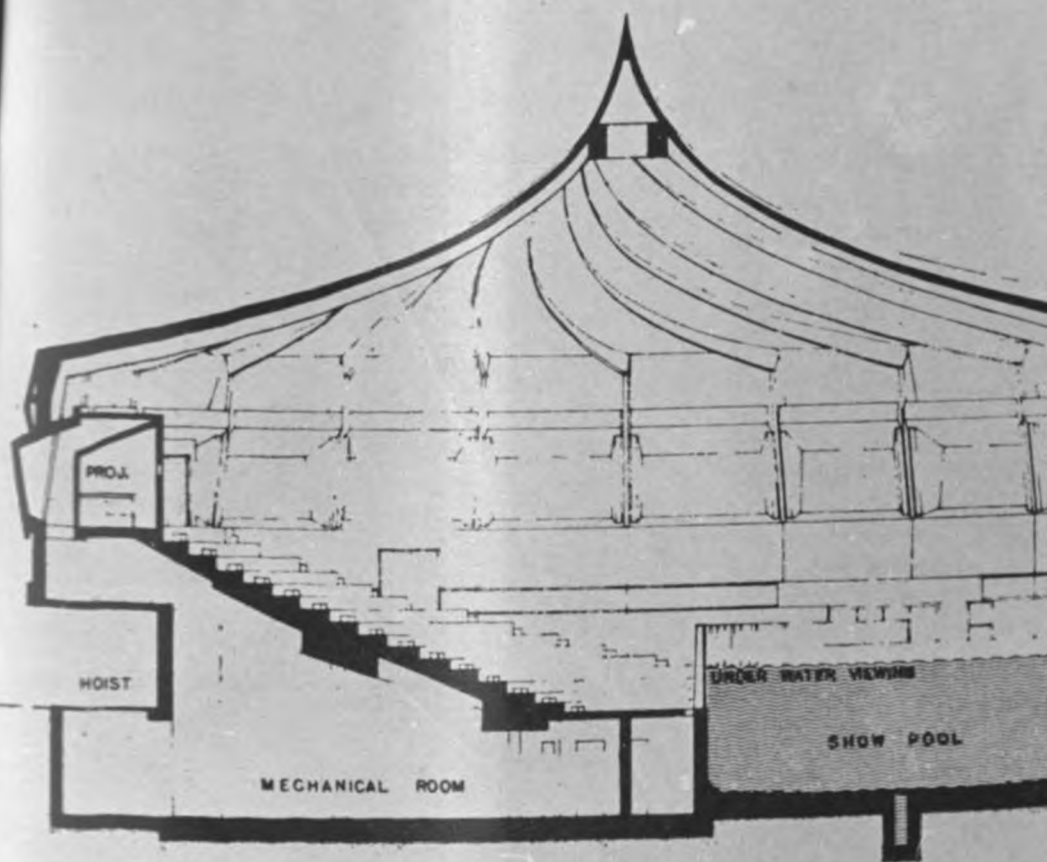




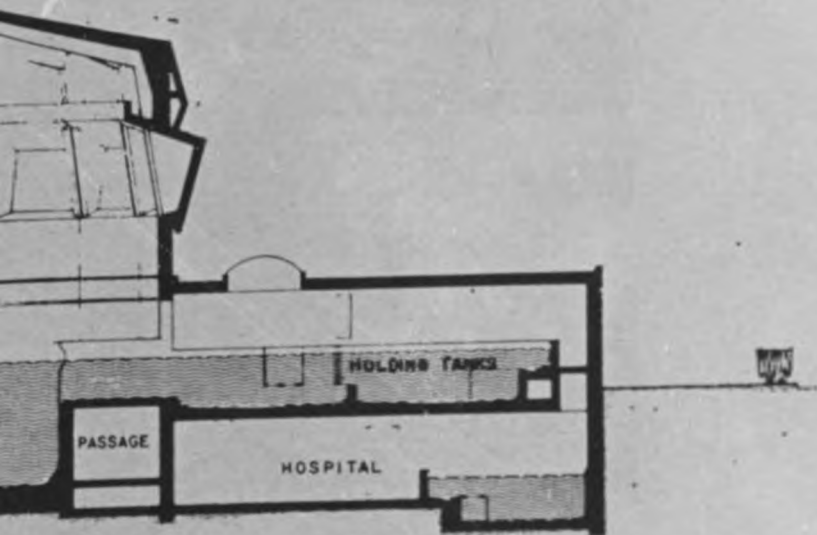
dolphin pool. main floor plan



Analysis of a bathroom plan



Section through dolphin pool





aquarium exit ramp



above, exit ramp and penguin pool

below, the main fish gallery



below, the penguin pool



ORGANISATIONAL FACTORS

CIRCULATION - MICRO LEVEL

The design of these buildings consists primarily of composition of cylindrical shapes of varying heights, interpenetrating and presenting an overall sculptural effect. These shapes are reminiscent of wave patterns in water, created by pebbles. The landscaping further echoes this pattern of ripples.

Several considerations, the type and function of the buildings, the requirements of their layout, the need for three-dimensional planning as well as aesthetic requirements, indicate that concrete was the most suitable material for the project. Concrete offered architectural and structural solutions to the proper treatment of the buildings many levels and to the expression of their plastic forms. The Aquarium was designed basically to take in the flow of large numbers of visitors, as expected, since the aquaria was part of Expo '67. The emphasis in design was more towards entertainment, and towards the handling of large masses of people, who flood into the aquaria.

The layout and facilities of the aquarium were based on scientific principles. The constraints caused by the servicing and traffic flow were dealt with on the basis of scientific logic. This did not mean that it did not feature attractions in such a way as to continuously build up the interest of the visitor, absorbing him into the enthralling

world of water, and drawing him onwards through the various parts of the building.

The flow of traffic has been organised with a definite direction, with a main attraction, the circular penguin pool and underwater viewing area at the beginning of the giant shark pool at the centre of the fish gallery and the circular undersea coral reef exhibit at the end of the tour.

Spectators on entering the aquarium building, would come to the penguin pool area, where penguins are displayed under Artic conditions, which is necessary for these creatures to survive, while on the other hand the human viewer could watch the penguins from an appropriate human environment aided by air conditioning. The penguins, with their almost human antics, are exhibited in a glazed enclosure. The visitor can view the penguins in the artic white background, from the outside of the glass window casing.

Traffic within the building flows naturally to a higher level where there are twenty-three separate aquaria containing a variety of fresh and salt water marine life. On a still higher level is the coral-reef exhibit which surrounds the viewing area with exhibits of tropical fish in their natural habitat. As viewers descend by a circular ramp to the main floor they obtain a second view of the penguin area, this time higher up and then exit through the souvenir area.

Behind the ramp, also in a semi-circle, are the reception rooms and offices. Behind the

public viewing areas, along the perimeter of the building, are the generous service areas. On a small mezzanine with its balcony overlooking the Dolphin Lake, the staff lunch room is located. The basement contains large water reservoirs as well as mechanical services, freezers, food preparation and laboratory spaces.

The Alcan Dolphin Pool is in a separate cylindrical building. The pool itself is of modified elliptical shape which provides maximum viewing from each of the 900 seats in the stands. As there was one complete dolphin show every hour during the Exposition, exit facilities from this building have been designed in more double the capacity of the legal requirements, to pour out the 900 visitors in a matter of minutes at the end of each show.

The pool is about 25 metres long, 13 metres to 2 metres deep, with the top one metre of the pool stand above floor level, and have a glass side to allow spectators to see the dolphin darting under the water. The pool contains some 1500 cu metres of water and the dolphin trainer works from the centre of the pool in a highly manoeuvrable seat.

Among the important features in the basement of the dolphin pool are the dolphin hospital and quarantine station. Facilities are also provided for scientists to study both dolphins and fish. A 180 cu metre capacity deep freeze holds 60,000 kg. of frozen fish for the dolphins, being almost a year's supply. Connected with the main pool are a series of holding pools for the dolphins when they are not performing.

10 ENVIRONMENTAL FACTORS

11 ACOUSTICS

The building is enclosed to stop any sort of disturbing noise from the external areas.

The internal areas:- The mechanical rooms are in the central part of the building.

Buffers have to be provided to absorb the disturbing sound from the machines and motors, which cause a continuous low humming sound.

Soft carpet has been laid in the building, to act as a sound absorption medium, especially the impact sound of foot-steps - Coefficient of absorption = 0.30 c/s 1000. The ceiling is suspended, of acoustic tiles; with extract fan inlets and out-lets.

There is a general aura of silence, an emergent silence, which is occasionally broken by the muffled voices of the visitors.

DOLPHIN POOL

The ribbed roof structure and niches in the circular wall act as sound diffusion elements.

The plan and seating arrangements of the dolphin pool together with the ribbed roof structure helping to reflect sound. The shapes being dispersive and absorbent. The soffit of the roof forms the main reflector of the speaker at the stage.

The reverbration time $RT = \frac{1}{4} - 1$ sec.

The room when full of people, brings a compromise period of reverbration.

The curved and splayed arrangement of the seating helps the demonstrator, from the stage, to communicate to the audience.

Tiered seating makes the acoustics good, corresponding with good sight lines for the lantern screen and demonstration bench. The screen behind the demonstrator acts as a reflector.

2 VISUAL

The overall aquarium: dark interiors with almost no external lighting penetrating into the building, give the aquarium a 'warmth', with the lantern 'like aquarium displays glowing, and illuminating the public passages.

The penguin pool is lit by fluorescent lighting from above, the lamps not being visible to the visitor and thus no glare. The penguin pool looks like a white lantern in the surrounding dark.

Similarly the fish gallery is not illuminated by any fixtures along the passage. The dark gallery with fish tanks lit from the front, makes sure that the visitor disappears in the darkness and hence the fish become the total 'stars'. An analogy to this would be a cabaret dance in a night club.

The exit ramp, from the coral reef exhibit down to the pool is lit from a single fixture, an incandescent lamp in a diffuser bulb of 100 watt fixed on the ceiling, above the ramp,

the light spreading around the ramp, with the pool at the top, and the flower bed at the bottom of the ramp.

The souvenirs section is lit by two 75 watt lamps set in angled fittings. The reception (Alcan) room and bar, plus offices have windows, as well as supplementary lighting of fluorescent fixtures offering diffused light .

THE DOLPHIN POOL

The dolphin pool is well illuminated by fluorescent lights, fixed on each structural rib. The lights are shaded by concrete fascia in the interior. The light is directed upwards towards the ceiling, which reflects the light to the rest of the building. While the show pool and the stage is illuminated by stage lights projected from the projection room, the use of flood lights and filters, as in circuses, is employed to produce interesting effects.

3 THERMAL:

The Aquarium is fully air-conditioned with a centralized system, aiming to

- (a) minimize the vapour pressure elevation above the out door level by directed ventilation
- (b) provide the thermal resistance sufficient to keep the internal surface temperatures above the dew-point of the indoor air.
- (c) prevent cold bridges in the design and construction of the building.

AQUARIUM EXHIBITS

Local heater systems, thermostats and heat exchanger units are used by the display tank to control the temperature of the vessels, for different species. The penguin pool is kept under arctic conditions, by use of refrigeration plants, vital to penguin environ.

0 COMMUNICATION SYSTEMS

The labelling system: the various aquarium tanks in the project have photo-engraved back lighted labels, elaborating on the life-systems of the each specimen. The labels are in the front of display aquaria, along with the hand rail.

1 IDENTIFICATION GRAPHICS

On the outside, near the entrance, a "plaque" AQUARIUM DE MONTREAL has been engraved on the concrete surface with the details of the background history and sponsor's details. The dolphin pool has bronze letters fitted to the concrete surface - going round and round the external surface of the pool - in the level with the staircase landing. The letters also form the 'Aquarium de Montreal' monogram six times around the building.

0 SYSTEMS TECHNOLOGY

- 1 Structure: The Aquarium and the Dolphin Pool is made mainly of mass and reinforced concrete - cast in-situ, since concrete offered architectural and structural solutions to the proper treatment of the buildings' many levels and to the better expression of their plastic forms.
 - 2 Process: The very extensive basement concrete work for both the aquarium and dolphin pool were carried out during the severe winter in 1965/66 under two giant polyethelene enclosures which were erected over the entire site of each of the two buildings. To provide temporary heating in these enclosures during a period of time a temporary boiler house was built and since no water supply was available on the site, the water was drawn from the nearby lake. The aquarium itself is constructed of exposed, strongly textured, structural in-situ concrete walls and roofs.
 - 3 The floors throughout the aquarium are covered with carpets, the walls plaster painted and the large fish tanks have 40 mm thick plate glass window with the exception of the coral reef exhibit which has heavy "plexiglass" windows.
- On the exterior, in addition to the windows of aluminium the concrete walls and roofs, there are two bronze coloured sheet aluminium, covered wall sections. Two of the fascias on the two major cylindrical elements of the building are constructed of bronze coloured

heavy aluminium sheathing. The two-storey concrete structure is carried on concrete bearing walls and internal columns supported on expanded base concrete piles.

4 The basement slab is also carried on piles to contend with settlement and cracking of the slab and the water tanks. Exposed concrete walls have expansion joints at 10x12 metres intervals to allow for the large variation in temperature. The roof slab is mainly flat with two circular openings bearing steel dome roofs, covered with aluminium cladding. A spiral ramp leads from the ground floor to the highest floor level, cantilevered out of the reinforced concrete wall.

5 The Alcan dolphin pool is in a separate cylindrical building. The entire pool is constructed of in-situ structural exposed concrete walls. The arena seating consists of laminated wooden benches mounted on concrete steps. All entrances and exits are constructed of light bronze coloured frames of Alcan aluminium with bronze coloured solar glass windows.

The most unusual feature of the arena is its roof. The playfully twisted conical shape reflects both on the inside and on the outside, the playful atmosphere of the building, and symbolises waves emerging from the pool. It consists of a set of spirals, rising towards the centre, rotating in the same direction. These spirals are inspired by intricate shapes of nature, and add to the gay atmosphere of the building. The roof is

constructed of a helically curving concrete shell and supported by a 38 metres diameter in-situ concrete tension ring and a much smaller compression ring at the centre. The exterior, covering of the conical roof is bronze coloured 'Hypaton' roofing and the spiraling beams are covered with bronze anodised heavy aluminium plates. The pinnacle into which all spiraling beams concentrate is a 5 metre high spun aluminium cone finished to match the beam coverings.

Exposed concrete walls and the slab are built similarly to the aquarium, the whole structure being carried on an expanded base concrete piles. The upper portion of the outside walls are cantilevered 4 metres from the walls below and these circular walls enclose a 35 metres diameter space. The feature of the 35 metre diameter circular space is the concrete shell roof, springing from a 1.5 metres high, 450 mm to 750 thick tension ring at the top of the walls to a 3 metres diameter compression ring 15 metres above the pool level. The angle between the bottom of the shell and the horizontal surface is 11 degrees. Thickness of the shell varies from 70 mm on top to 300 mm at the bottom ring. (The analysis takes into consideration, apart from the dead load, 43 psf snow load, 20 psf wind load and Zone No. 3 earthquake loading).

In order to analyse the edge perturbations and the problem of stability, the dome, of which the direct stresses refrain in compression under dead and snow loading, is

calculated like spheres of corresponding curvature. The shell is reinforced with 24 ribs running spirally from bottom to top providing stability against buckling. The roof is separated from the supporting walls below by means of rubber pads. Diagonal cables crossing this joint are provided for the possibility of seismic loadings.

SERVICES

The Aquarium is fully air-conditioned.

A centralized air-conditioning system maintains a constant optimum temperature for the visitors comfort in the winter as well as the summer months. The air-conditioning system also provides ventilation and humidity control. The distribution of the air is via duct-shaft over the suspended ceiling at calculated intervals.

WATER SYSTEMS

There are both salt and fresh water systems to enable sealife from all part of the world to be displayed, these water systems embrace the latest scientific knowledge and techniques to provide the best possible environment for each particular specimen. Water is continuously circulated, filtered, heated or cooled as required aerated and treated chemically to control algae and disease. The aquarium has its own manufacturing plant to make sea water (salination plant). The 'seawater' is stored in settling tanks located in the basement. From there it travels through a diatomaceous earth filter and into a storage tank. As needed each day, water is pumped from the basement to the top of the building for aeration and storage. From this level it descends by gravity, one system distributing salt water to the smaller tank and another to the shark tank.

Pre-filtered water supplies the smaller tanks, each of which recirculates its own water

through an individual filtering system. Most of these display tanks contain a layer- of sand held on a perforated sheet of fibreglass a few cm. from the bottom of the tank. The sand acts as a filtering medium, allowing the water to pass through to the space below. It is then drawn into a vertical tube in one corner of the tank, and recirculates with the aid of an air stone.

2 The dolphin pool has separate water treating equipment with special emphasis on control of the salt content in the water.

Dolphins are air breathing mammals who require the buoyancy of salt water to keep them from having to struggle to the surface for air.

Servicing of tanks and the coral reef is done from the service areas in the back of display area. Also spare holding tanks are provided in the service area for emergency cases.

The penguins are serviced down from the basement, with a penguin quarantine provided in the basement under the penguin pool.

3 ANCILLARY FACILITIES

Toilets are situated near the entrance in form of a round enclosure for males and females, together with storage space. Between the toilets, a drainage duct, with pipes going to basement, serves the toilets.

CASE C



THE COMPLETE VIEW OF THE
KENYA MARINELAND, MOMBASA

HISTORICAL BACKGROUND

The Kenya Marineland was opened in August 1974 in Mtwapa creek about twelve miles north of Mombasa. The Marineland was opened by private investors, who were already running a deep-sea fishing organisation.

The Marineland was built as an additional project to an already existing deep-sea fishing and scuba diving programme, all based upon profit making motives. The designing and construction was carried out by the owners, since the building system together with Bar-restaurant comprises of simple structures making use of local traditional form and building techniques.

The Kenya Marineland, before its opening, was well advertised in newspapers and television, and since the opening in August 1974, hundreds of people have visited the place.

As far as tropical fish is concerned, Kenya Marineland claims to be the third of its kind in the world.

SOCIAL AND CULTURAL CONTEXT

The Kenya Marineland has been designed to attract both the tourist visiting Kenya and local visitors. The roof structure resembles a traditional hut structure, conical and made of traditional makuti finish, with the same roofing material for the adjacent lounge and bar.

The bar is becoming a popular meeting place for scuba divers and deep sea fishers; a sort of exclusive club for the 'sea-adventure' enthusiasts. The place is also popular with the large number of visitors as well as non-visitors to the aquarium.

However, the educational potential of such an institution has not been exploited yet. It is understood that the aquarium owners are expected to compile some scientific information for the visitors on the species displayed, which they expect from the fisheries department. The Kenya Marineland indirectly encourages people to participate in fishing and related sports.

Certain families and groups of people chose the area surrounding the aquarium as a picnic-site. However, the management does not encourage this, since this means extra maintenance.

The aquarium has also attracted learned professors of marine biology from many parts of the world - together with university students.

ECONOMICS AND PRODUCT DEMAND

Owned by the Kenya Marinas, the Kenya Marineland is a profit making project. Designed to attract tourists, the aquarium is also visited by many Kenyans. Since its inception, over 40,000 visitors have seen the awe - inspiring underwater world of the Indian Ocean and its marine life.

The entrance charges are as follows:

	Overseas	Local
Adults	10/=	5/=
Children	2/=	

- 1 The Kenya marinas also offers big game fishing, water ski-ing, boating trips, and scuba diving.
- 2 During the weekends and public holidays huge crowds filter into the aquarium to quench their thirst for something new in Kenya.
- 3 The visitors always appear during the feeding time, considered the highlights of the day at Kenya Marineland, when at eleven in the morning and four in the afternoon, a scuba diver drops into the aquarium to feed the fish with his own hands.

GEOGRAPHICAL LOCATION

The Kenya Marineland lies to the North Mombasa, across the Mtwapa Bridge in the Kilifi District. It is built on a raised spacious ground near the creek, and access to the sea is very easy by descending down stone steps. The building is above sea level.

The Coast Province, which lies between the equator and latitude $40^{\circ} 50'$ South is bounded on the West by longitude $37^{\circ} 30'$ East; and on the East by the Indian Ocean. The land rises gradually from the sea-level. Geologically, the area is diverse and this is reflected in the wide variations of soil type.

The coastal plain consist of corals and sands which have been formed in recent geological periods. These rocks have given rise to a variety of soils. Coral soils and sands overlie the raised coastal reef.

MACRO CLIMATE

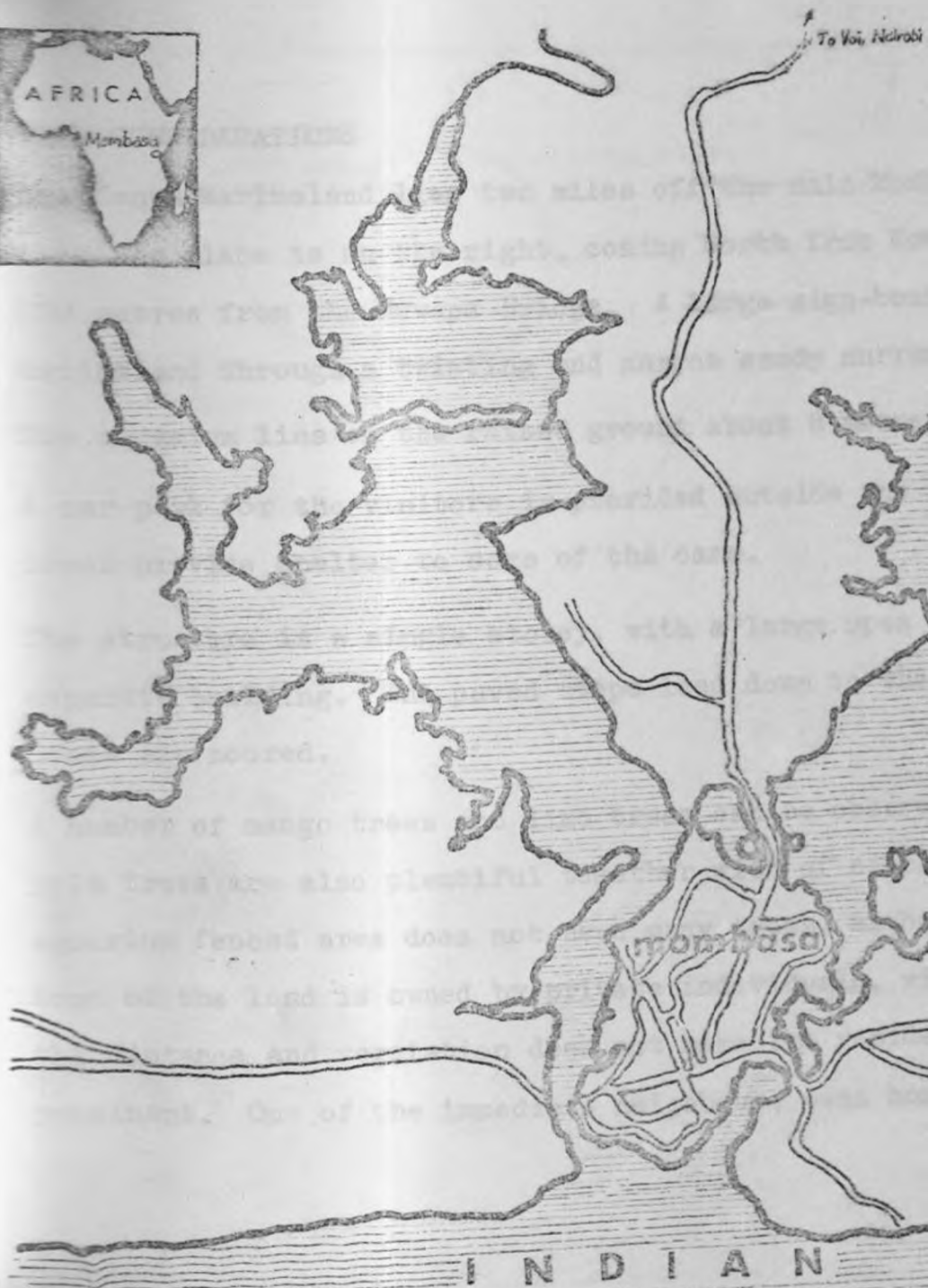
Temperature

Kilifi area Maximum 37°C to Minimum 22°C giving a range of 10°C .

Relative Humidity at 12 noon = 70%

Mean Annual Rainfall = 941.3 ml.

Mean Number of rainy days = 46.3 days.



MOMBASA

* THE KENYA MARINELÄND.



SITE CONSIDERATIONS

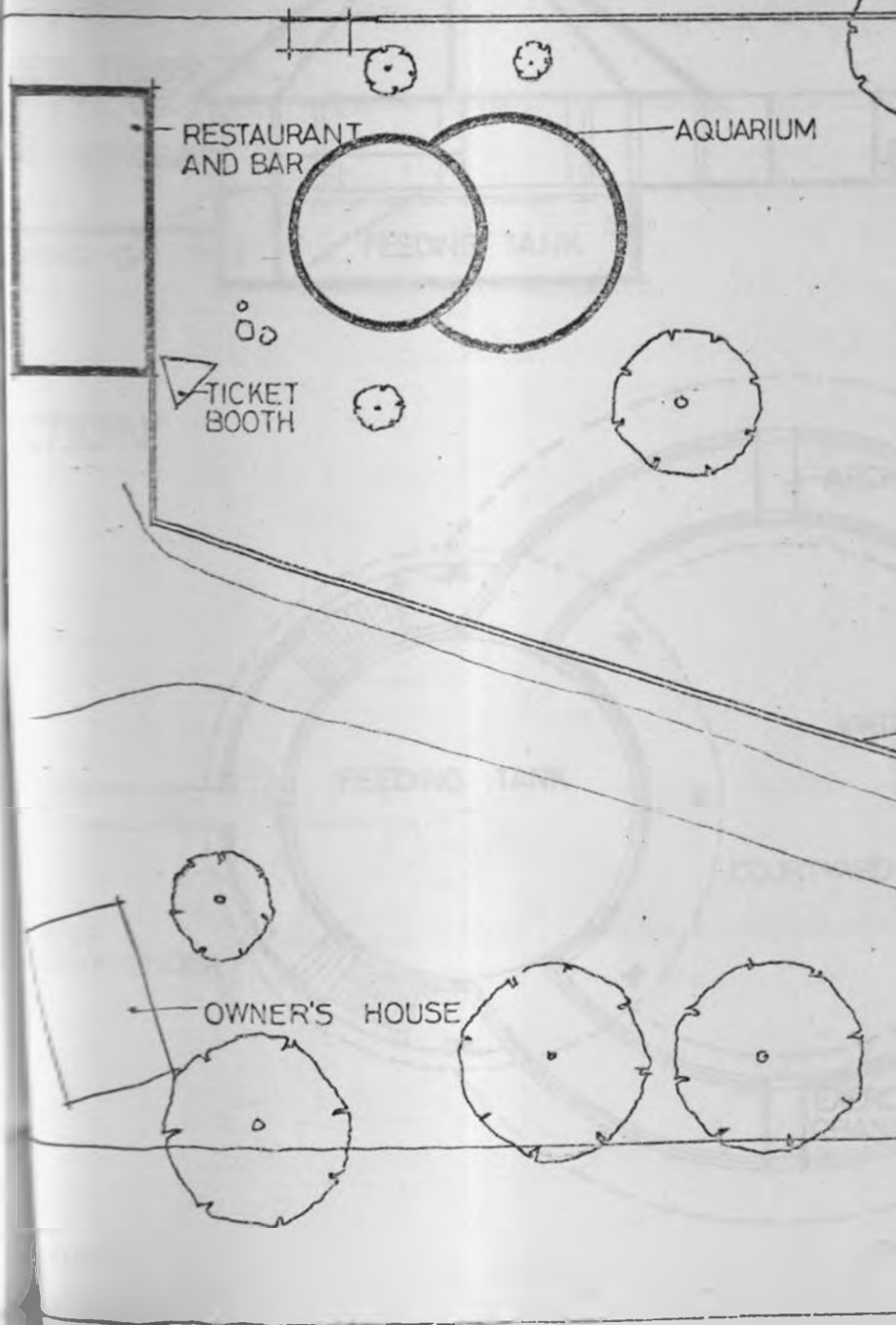
The Kenya Marineland lies two miles off the main Mombasa-Malindi road. The road leading into the place is on the right, coming North from Mombasa, the junction being about 200 metres from the Mtwapa Bridge. A large sign-board directs visitors towards the Kenya Marineland through a twisting and narrow sandy murram road.

The aquarium lies on the raised ground about 8 metres above sea-level.

A car-park for the visitors is provided outside the fenced aquarium grounds. A couple of trees provide shelter to some of the cars.

The structure is a single storey, with a large open space around it, and a lounge bar as a separate building. The paved steps lead down to the boat house and a pier, where several boats are moored.

A number of mango trees and limb trees can be observed in the neighbourhood. 'Makoma' palm trees are also plentiful together with of course coconut trees. Unfortunately the aquarium fenced area does not have many trees, although some have been planted recently. Most of the land is owned by private individuals, with houses and cottages on them, though the distance and vegetation does not make the residential nature of neighbourhood very prominent. One of the immediate neighbour, owns horses, a rare sight in Mombasa.

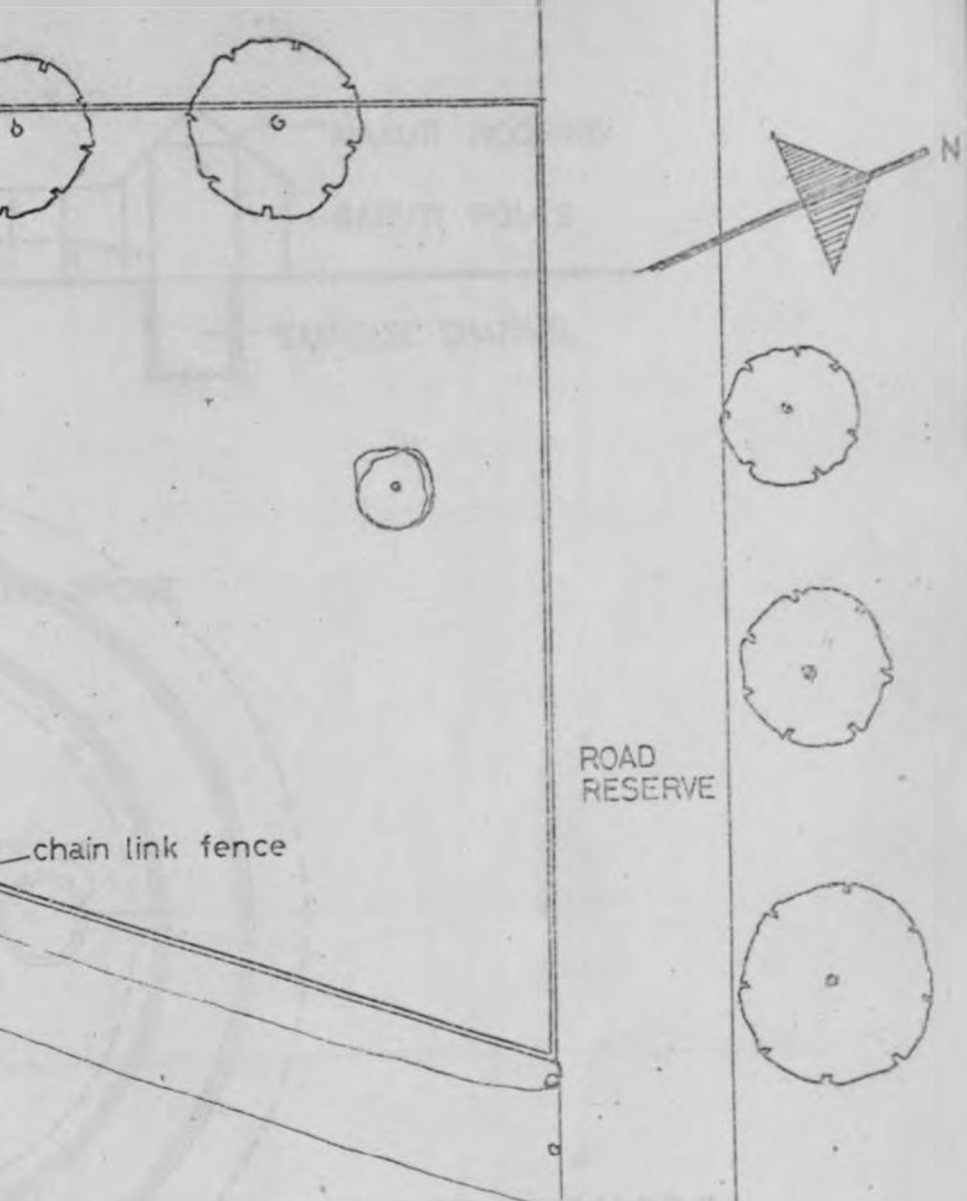


RESTAURANT
AND BAR

AQUARIUM

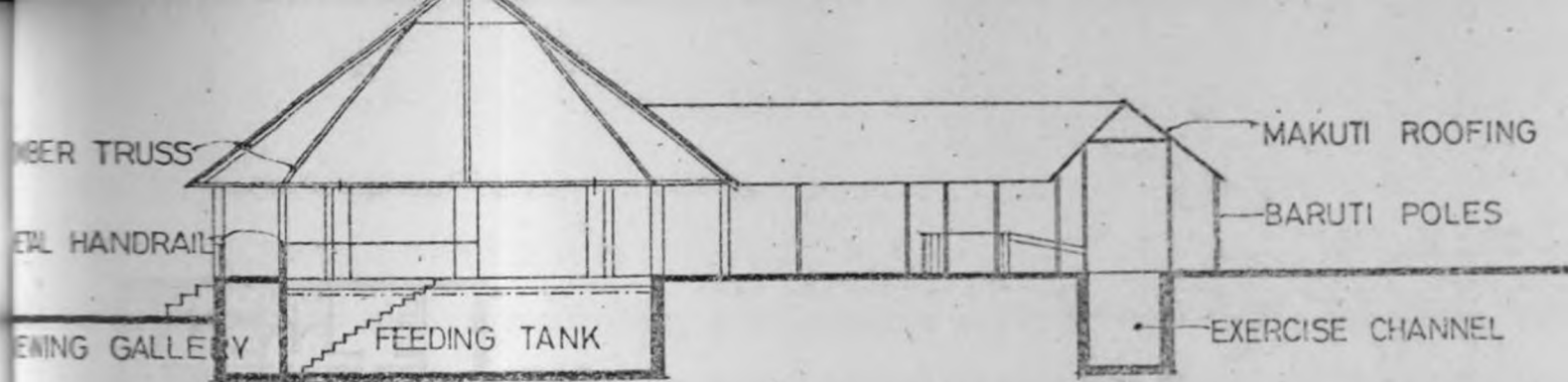
TICKET
BOOTH

OWNER'S HOUSE

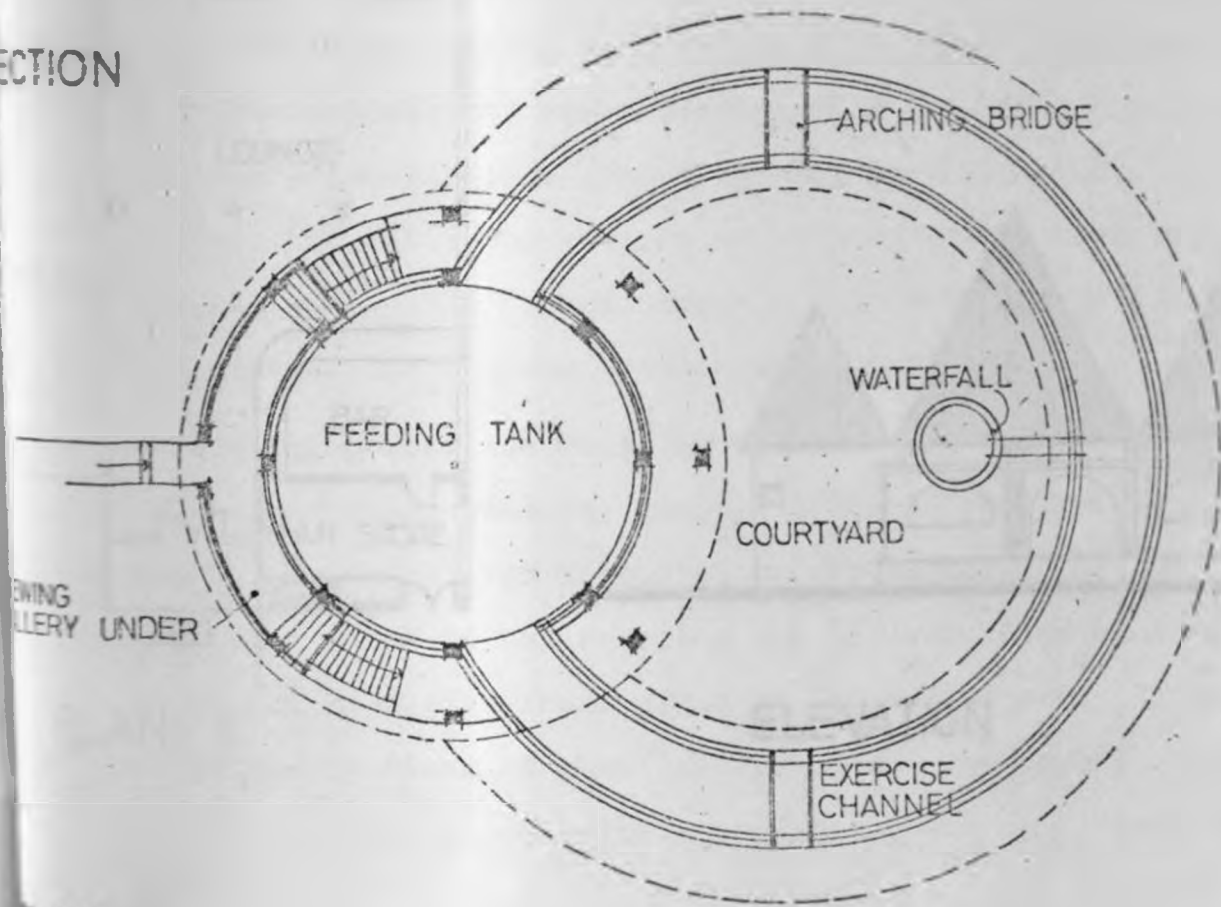


SITE PLAN^o 1:1000

KENYA MARINELAND
MOMBASA



SECTION



PLAN

THE AQUARIUM
KENYA MARINELAND
MOMBASA



ELEVATION



THE LOUNGE
KENYA MARINELAND
MOMBASA

ORGANISATIONAL FACTORS

CIRCULATION - MICRO LEVEL

After paying at the ticket booth, a triangular covered box kept in the open, with a fence around the aquarium's spacious grounds, the visitor walks up to the aquarium building. After negotiating a couple of steps into the aquarium, he arrives at a platform. At this point, the visitor is given a choice to make, one of the two options of route. He can either follow a number of steps leading down to a dark tunnel, the viewing gallery which moves in semi-circular form around the big aquarium tank. Or he can go straight on further from the platform, across an arching bridge over the exercise channel which flows into the big tank. The channel forms a loop with the centre becoming a landscaped courtyard, and both ends of the channel meeting the aquarium tank.

The visitor going down the steps in the curving 'tunnel' viewing gallery, comes across three different glass windows, through which he can view a nose-to-nose, fierce looking fish sharks, groupers, red snappers, triggers, moray eels and some fascinating baby turtles. Also found in the aquarium are the repulsive looking sting and electric rays, as well as exotic reef fish found close to Kenya's shores. If he moves about the gallery, he gets different views of the fish from different angles, through different windows. The gallery, which forms a semi-circle around the big tank, leads the visitor out at the other

up similar steps and out into the open. The visitor comes across a symmetrical, arching bridge over the opposite side of the channel. This second bridge, is of the same size and shape as the one encountered initially on the other side. Crossing the bridge the visitor comes to the central court. The court is landscaped with tropical plants, and loose coral stone gravel forming the floor. In the centre of the circular court, is a fountain and a waterfall. This round fountain is connected with a filter pump, and filtered water passes the fountain and falls into the channel. The exercise channel encircles the court and the visitor looks over the channel and the big tank from the court.

A different path along the outer periphery of the channel can also be followed by the visitor from where he can watch standing by the railing, facing the other visitors who may be standing opposite, across the exercise channel on the court yard side. A railing is provided on all sides of the aquarium and the channel, for visitors to lean upon, and to prevent them falling into the tank or the channel.

Certain fish, like the sting-ray and the sand shark as well as the green turtle are a delight to watch from above, as they glide along the channel, or dart back into the big tank. A visitor can follow the movements of the fish along the channel.

A higher platform above the viewing gallery, with steps leading up to it, overlooks the

big tank, giving a panoramic view of the big tank, and the interior as a whole. The platform was designed for performing aquatic creatures, with the trainer standing on the platform, which would act as a stage.

Once the visitor has exhausted his curiosity, he walks down the steps towards the entrance gate, which is also the exit gate.

5 The bar, known as 'Samaki' bar - meaning fish bar, with a lounge, verandah and toilets, can be entered from the side away from the aquarium building. The visitor cannot enter directly from the aquarium, but has to first come out of the exit gate.

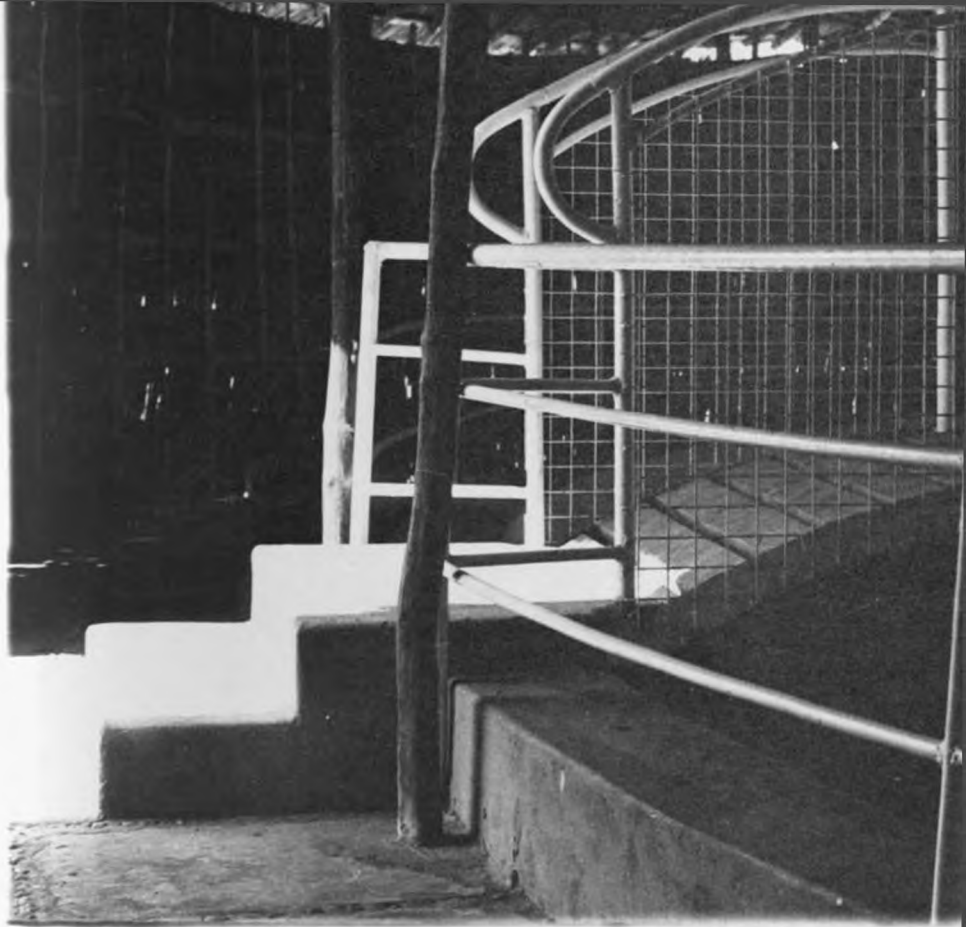
The reason for segregating the bar - lounge from the aquarium is to provide the bar facilities not only to the aquarium visitors but also, to the fisher-men, to the scuba divers, and other visitors who do not intend to see the aquarium.



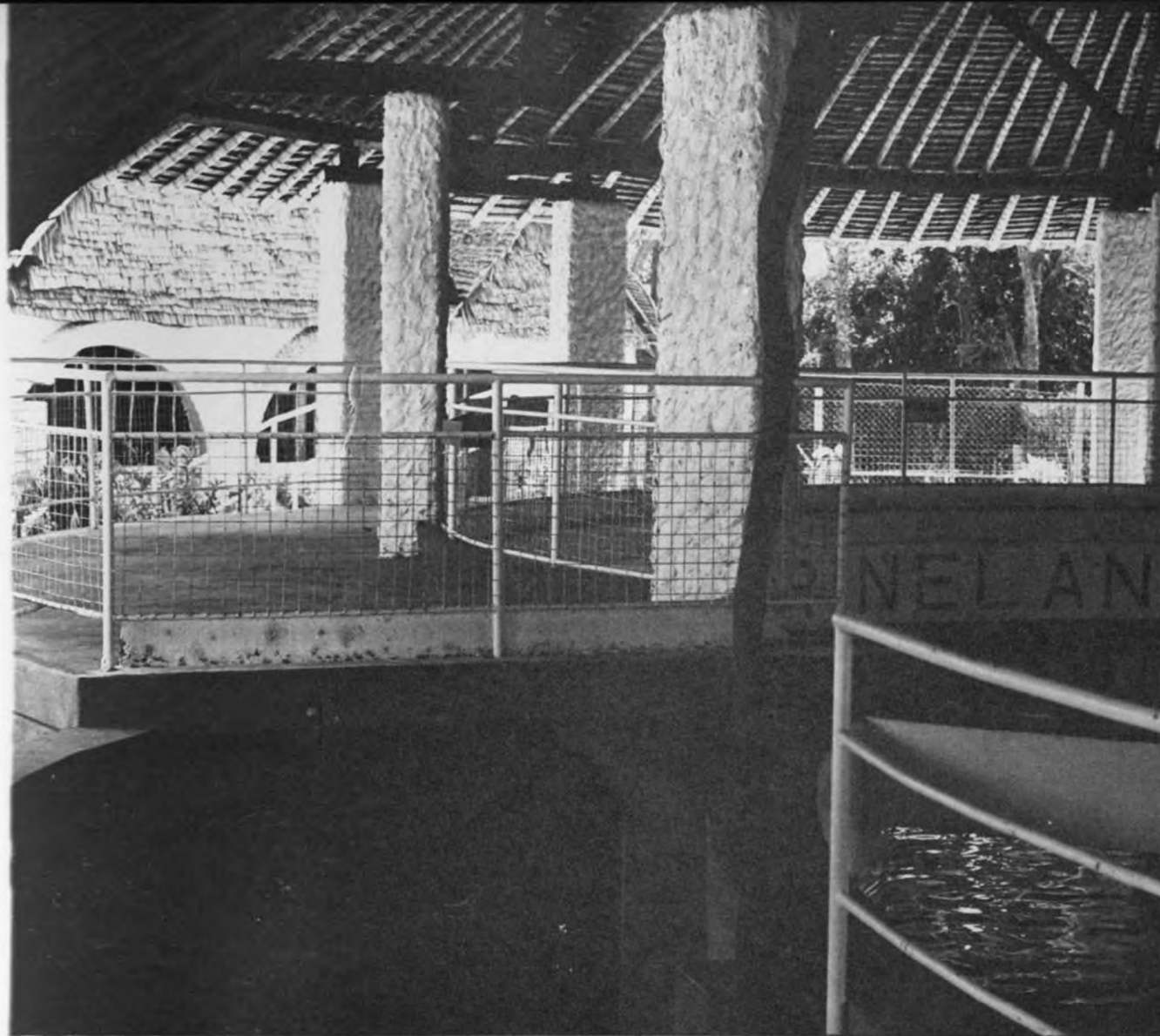
THE AQUARIUM FROM THE ENTRANCE



THE LOUNGE-BAR AND THE TICKET BOOTH.
NOTE THE ADDITIONAL TANK UNDER CONSTRUCTION



THE ARCHING BRIDGE



THE VIEWING PLATFORM OVER THE
GALLERY AROUND THE BIG TANK



THE INTERNAL COURTYARD





THE WATERFALL IN THE COURTYARD





THE BAR TERRACE FROM THE BEACH

ENVIRONMENTAL FACTORS

1 ACOUSTICS

The aquarium premises is not designed for acoustics, nor is there any acoustic treatment provided. Although in general it is not disturbing to the visitor, an echo of voices and foot steps can be heard inside the viewing gallery which sometimes can be amplified to an intolerant level.

2 VISUAL

The gallery, incorporating the glass windows is small and the opening on both sides and ends of the gallery gives adequate light to the interior. There are no artificial lighting fixtures. The tank is not illuminated artificially and so it lacks brightness. The dependence upon natural lighting makes the observing of species difficult - especially noticeable as the turbidity in the water increases or the natural lighting fades due to cloudy or sunset conditions.

The exercise channel being more open has adequate natural lighting.

3 MICRO-CLIMATE

The micro-climate of the aquarium is almost similar to the macro-climate of the coastal plains. No artificial air conditioning is provided in the building. Since the building is mostly open, with a cool palm-frond makuti roof and sides, the interiors are cooler

than the outside, and quite comfortable. A cool breeze from the sea maintains a constant humidity level equivalent to the outside level.

Relative Humidity = 70% (average).

.0 SERVICES

.1 WATER SYSTEMS

The aquarium contains only the salt water species, and is based upon the 'open system' of servicing of the tank.

The tank is serviced by the water, which is drawn from the sea, pumped up to the filtration plant, and thereafter pumped into the tank. The filter plant is the same as the one used for an average sized swimming pool. There are no settlement tanks and the water tends to become turbid and grey (brackish). The huge aquarium holds 409,000 litres of salt water.

.2 The species are fed by fish and sea-creatures (dead) caught by the owners. Different sizes of fish have corresponding diets.

.3 The filter plant is constantly working, and the water-falls at the fountain aerates the water. The water in the tank is changed completely once in the month with the species transferred during this operation into a small holding tank built near the boat house. This small holding tank is also used for holding new species - to acclimatise before being transferred to the large tank.

Date	Description	Particulars	Balance
1921	To Balance b/d	1000	1000
1922	By Balance b/d	1000	1000
1923	By Balance b/d	1000	1000

CONCLUSION

2.0

SOCIAL AND CULTURAL CONTEXT.

Effectiveness

Case A

very high.
comparable to
theatres

Case B

good. emphasis
on entertainment
e.g. Dolphin Pool
Shows.

Case C

fair. aimed to
attract tourist
in particular.

<p>Educational impact</p> <p>tremendous.</p> <p>very effective to</p> <p>marine pollution</p> <p>curbs.</p>	<p>Grouping</p> <p>membership system.</p> <p>very encouranging.</p> <p>good in group</p> <p>gatherings</p>
<p>fair</p>	<p>attracts aquarists</p> <p>in large numbers</p>
<p>very little.</p> <p>still needs to be</p> <p>improved</p>	<p>attracts mostly</p> <p>fishermen and</p> <p>scuba-divers.</p>

4.0 GEOGRAPHICAL LOCATION

	Vicinity of sea	Micro Climate	Climatic effect upon fish	Climatic effect upon visitors
Case A	yes: situated on a wharf.	cold temperated	most fish need no special treatment except tropical fish.	air conditioned building provides optimum comfort zones
Case B	no. provided with salination plants	very cold winters and warm summers	tropical fish need warming and special care.	air conditioned
Case C	yes - situated near a creek.	hot humid tropical climate.	water temperature suitable for the fish displayed - (mostly tropical fish).	open building - sea breeze acts as cooling agent in the tropical climate.

5.0 SITE CONSIDERATIONS

	Accessibility	Vegetation landscape	Topology
Case A	good situated in down town; public transport available.	non-very poor. a barren site.	flat site. on a wharf
Case B	fair. public transport available.	some, with landscaped site.	flat site. most of the land reclaimed from the river.
Case C	bad. out of town. no public transport available.	some vegetation on the aquarium site, and plenty on the surrounding.	slope. aquarium on a flat site, though on the edge of the sea, a sharp slope.

7.0 ENVIRONMENTAL ASPECTS.

	Acoustics.	Visual.	Thermal
Case A	- could be improved. external disturbances successfully eliminated.	very good. right sort of visual impact for the visitors.	air conditioning controls internal climate.
Case B	very well done but for the noise from the bar. External sounds eliminated.	some tanks well lit. some areas of viewing galleries too bright - reflections of visitors show.	air conditioning
Case C	non. needs acoustic treatment in the viewing gallery	natural lighting used throughout supplementary artificial lighting in the giant tank essential.	natural environ. the palm fronds provide cool sheltered areas, with the complex.

8.0 COMMUNICATION SYSTEMS.

	Graphics	Labelling.	Display techniques.
Case A	very good.	good system. use of alcoves for each display interesting	well developed.
Case B	not utilised very much	good.	fairly good.
Case C	need for improvement.	non yet	interesting, however the viewing gallery is very poorly designed.

9.0 SYSTEMS TECHNOLOGY

	Form	Structural system	Constructional materials
Case A	cubic, very strong and rigid.	the aquarium is fitted into a box, the roof being a steel truss, a rectangular structural grid used in design.	concrete is the dominant material used. Though the internal walls have cork facing.
Case B	fascinating, cylindrical. very organic.	concrete walls structure, a complicated roof structure for the dolphin pool	mass concrete and RC, aluminium and bronze.

Case C

Tradition African
hut form

Simple structure,
R.C. columns to
support the main
roof timber truss.

Mass concrete, RC,
and barutti poles,
plus makuti palm
fronds.

10.0 SERVICES.

	Water systems	Public contact
Case A	direct open system, very efficient and sophisticated.	very little.
Case B	a salination plants makes the place unique. The overall system quite good.	some.

Mechanical and
electrical

Environmental
control

very complex and
well designed,
with miles and
miles of
mechanical and
electrical ducts
and pipes.

air conditioning

good.

air conditioning

Case C.

Swimming pool
filter - serves
the purpose but
a better system
necessary.

very good

very simple
system, not
much in-
stallation

non.

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DESIGN BRIEF

ELEMENTS

- A. Public Spaces:
 - 1. The plaza
 - 2. Reception area,
entrance foyer
 - 3. Exhibition hall
 - 4. Aquarium display
areas.
 - (i) Giant tank
 - (ii) Marine tropical
fish.

REQUIREMENTS

near the entrance

reception desk, -cum-ticket booth, and sovenir shop.

flexible exhibition space:

round tank with minimum capacity of 300,000 litres of sea-water.

display tanks of various sizes and shapes, salt water supply. Servicing areas.

- (iii) Fresh water tropical fish display tanks of various sizes and shapes, salt water supply. Servicing areas.
- (iv) Coral reef fish a large tank.
- (v) Fresh water ponds and marshy land ecology open air display.
5. Lecture space flexible space for various functions, from seminars and lectures to film shows and slides.
6. Projection space area for projectors, and close T.V. circuit control room.
7. The library reading space and furniture. magazines shelf, book shelf. catalogue desk, librarians

8. The restaurant.

(ii) Kitchen

(iii) Storage space

(iv) Toilets

(v) Office

B. Private spaces

1. Administration

(i) Directors office

(ii) Curators office

(iii) Secretary's office

(iv) General office

counter plus storage space.

eating area, bar - counter.

cooking and servery area.

spirits store, cold store, and
linen storage.

for management.

office furniture - chairs,
tables, and cabinets.

storage space for records.

Staff common room

2. Laboratories

3. Quarantine room

4. Mechanical room

5. Maintenance room

6. Storage spaces

toilet and tea room plus rest areas for staff.

for research on marine pollution and aquarium species. water systems with marine and fresh water supply.

with tanks for hospitalized species.

for settling and storage tanks, fitters, pumps, generators, and air condition plant.

a workshop for minor repairs and general maintenance of the aquarium.

cold-storage for fish food,

- refrigeration equipment,
and other equipment store
e.g. diving, saling etc.
7. Operation areas a high platform easy access to
service pipes, spare tanks
for emergency situations.
8. Ancillary facilities toilets - for ladies and
gentlemen.
9. Parking facilities
and service yard.

SITE PHOTOGRAPHS

SITE

PHOTOGRAPHS



46











