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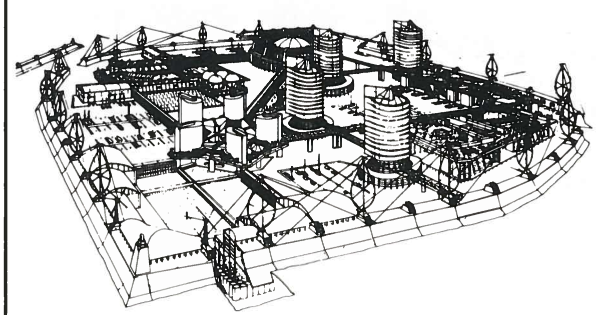
Special Design Project Issue

SICSA OUTREACH
Sasakawa International Center for Space Architecture

Ocean Communities

Oceans, like space, offer vast frontiers for scientific exploration and resource development. SICSA is dedicated to programs that advance exploration and conservation of precious environmental resources and beneficially apply those resources through appropriate technologies. The water environments which constitute approximately two-thirds of our planet's surface warrant priority attention in this regard. They are vital sources of food, materials and energy, as well as key and very fragile elements of our world ecosystem.

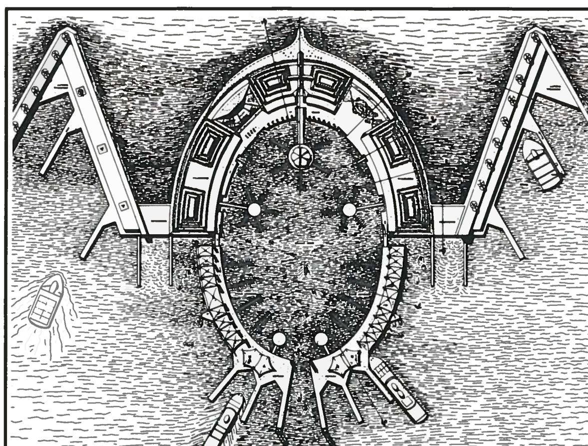
SICSA and the ***Experimental Architecture*** graduate program have pursued a variety of design studies associated with underwater and ocean surface habitats. The two ocean projects presented in this issue are recent examples undertaken between September, 1986 and February, 1987.



Oceanapolis Project

Oceanapolis is a development concept for a large offshore research, living and entertainment facility envisioned to be located 80 miles southwest of Key West, Florida.

Great Isaac proposes a man-made island for similar purposes to be located on the northern tip of the Great Bahama Bank, due east of Fort Lauderdale, Florida.



Great Isaac Project

Both studies emphasize self-sufficiency through local power generation, and planning approaches that will protect the ocean ecology.

Oceanapolis

Development Concept

Oceanapolis is conceived as a commercial off-shore development for marine research, industrial processing of ocean-derived materials, and resort living. International banking, duty-free shopping, celebrity entertainment and gambling are featured to attract business and tourism.

The location 80 miles southwest of Key West, Florida was selected to take advantage of desirable ocean currents for power generation, aquaculture and an outstanding sun belt climate for residents and visitors.

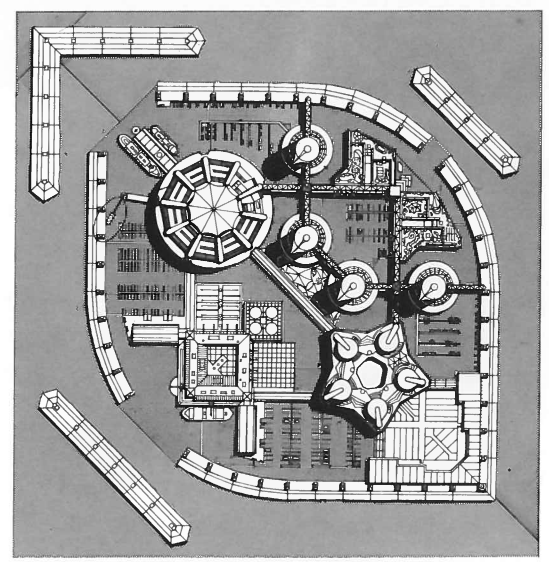
The plan projects a daily population of nearly 9,000 people. Living facilities include 1,200 resident apartments and 2,150 visitor hotel rooms. More than 1,500,000 square feet of research space and 200,000 square feet of industrial cargo/storage space are envisioned to be built within the 200 acres enclosed by the Oceanapolis breakwater.

Site Plan

The Oceanapolis site plan is shaped to optimize benefits of northeasterly flowing gulf stream currents and prevailing southeast winds. The marine research facility located at the bow is positioned to receive the freshest water, while the residential area on the southeast will benefit from the cleanest ocean breezes.

The utility zone is located downwind to remove potential odors. The entertainment facility at the stern is placed at the closest point to land.

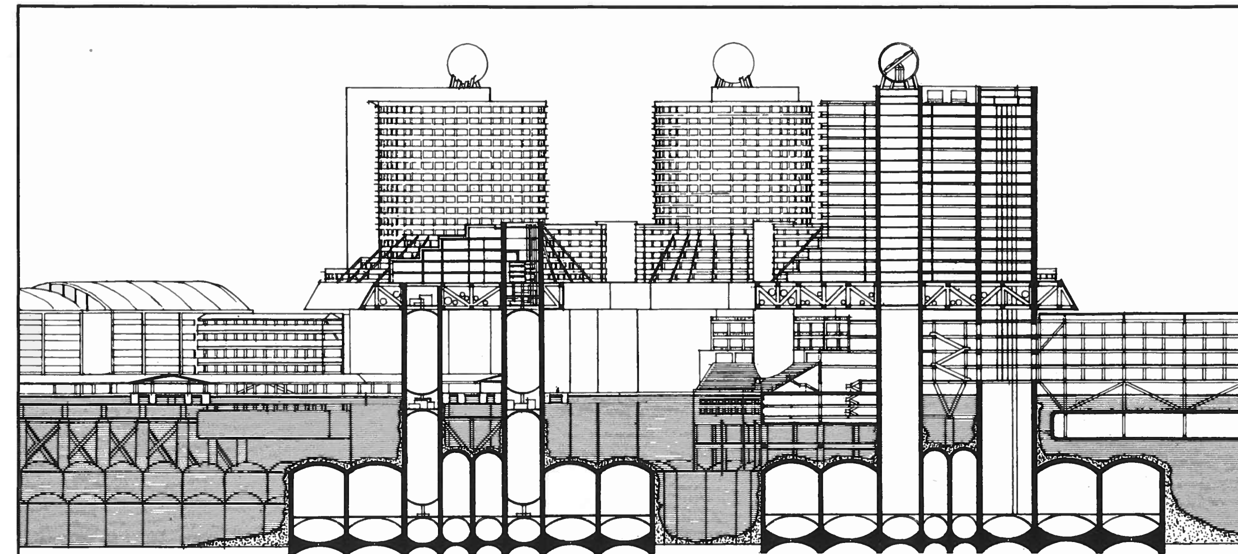
Generous, shaded public spaces and diverse community facilities are provided to enhance resident satisfaction. Special amenities include attractive marinas, shopping areas offering international products, gourmet restaurants, and theaters that feature internationally acclaimed performers.



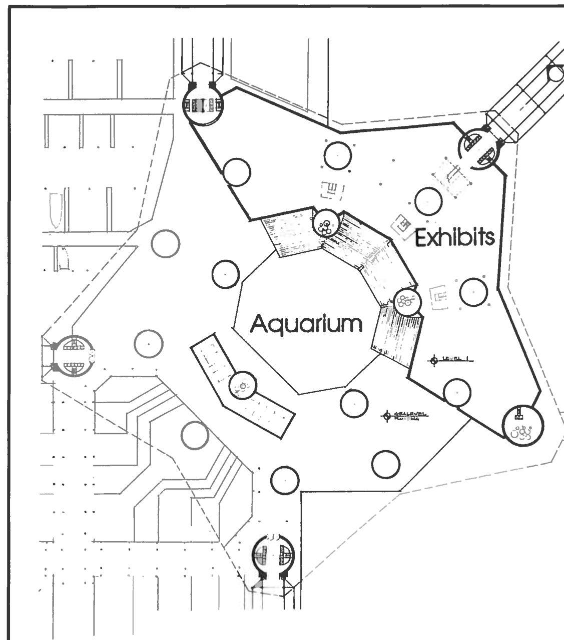
Site Plan

Key Development Elements

1. **Research Laboratories:** for studies including power production and genetics.
2. **Fish Pens:** to support commercial seafood harvesting and aquatic farming.
3. **Research Office Towers:** headquarters for technical and management staff.
4. **High-Rise Living Facilities:** luxury properties for executives and investors.
5. **Low-Rise Living Facilities:** to house families of the general employee population.
6. **Civic Center:** features hotel, retail, convention and casino facilities.
7. **Marinas:** boat docks are supplemented by perimeter vertical boat storage.
8. **Utilities Zone:** water storage, desalination, waste treatment and power systems.
9. **Cargo Port:** for import and export of materials and products.



Section Through Research Office Towers



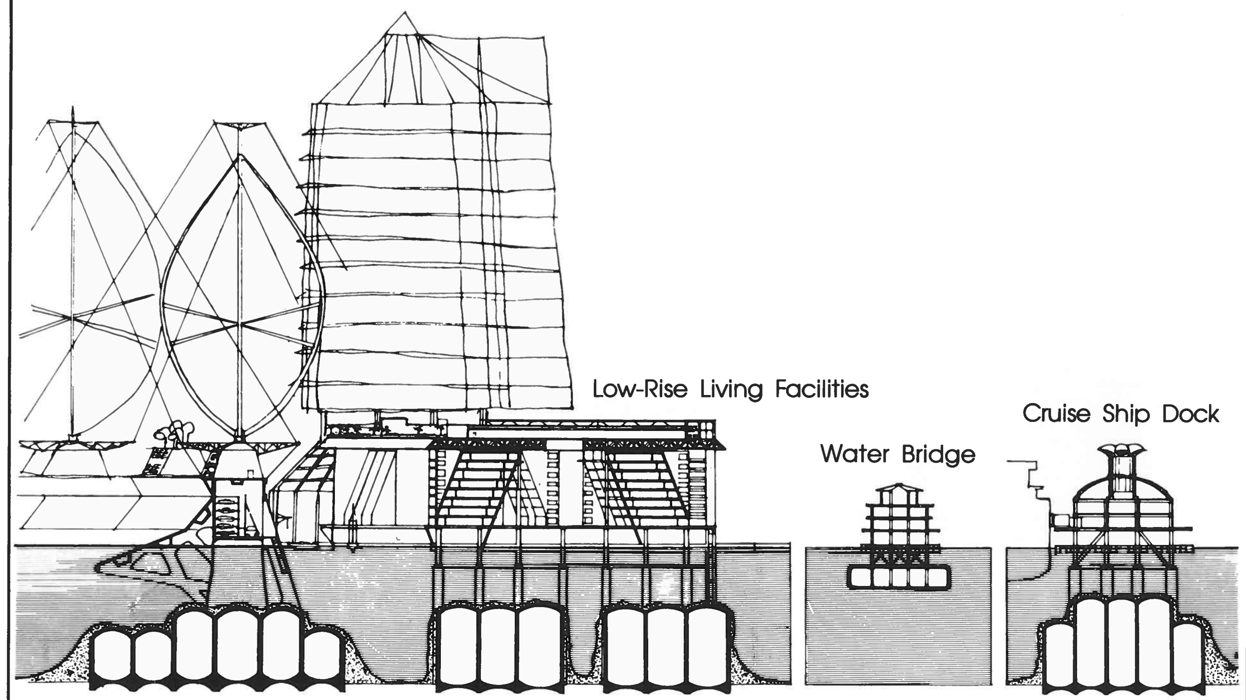
Concourse/Exhibit Plan

Research Facilities

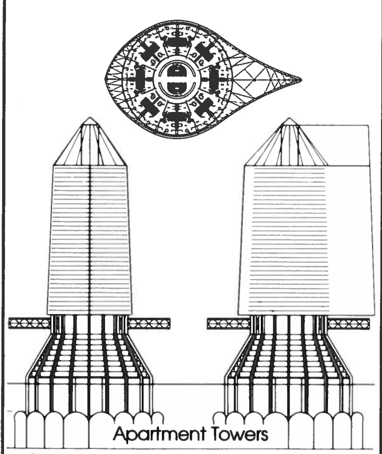
Approximately 500,000 sq. ft. of laboratory space is located inside the breakwater bow. This area will support implementation of experiments and pilot demonstrations related to genetic engineering and growth/processing of sea life products grown on the Oceanapolis aquatic farm.

Large indoor ship docks on the north and east ends of the laboratories accommodate research vessels up to 150 ft. long. Fish pens are provided for marine biology and aquaculture studies. A public aquarium display area connects the pens.

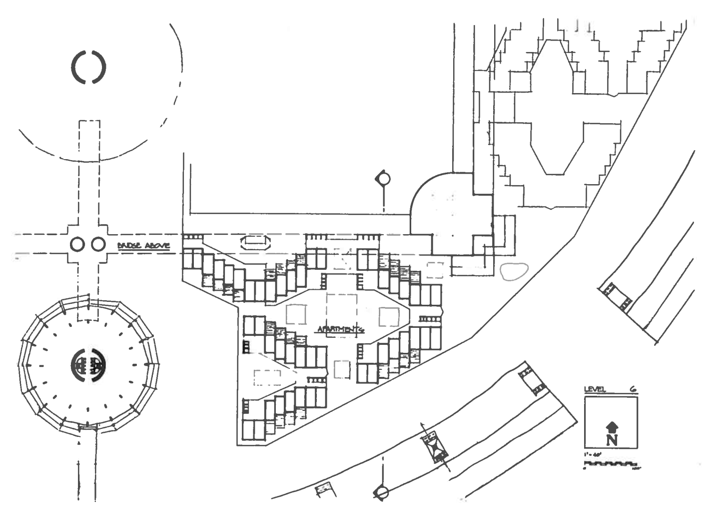
Five high-rise research towers provide more than 1,000,000 sq. ft. of office space. Some mechanical systems, mini-sub storage and access to aquatic farms are contained within 40-60 foot diameter columns and caissons that support the towers.



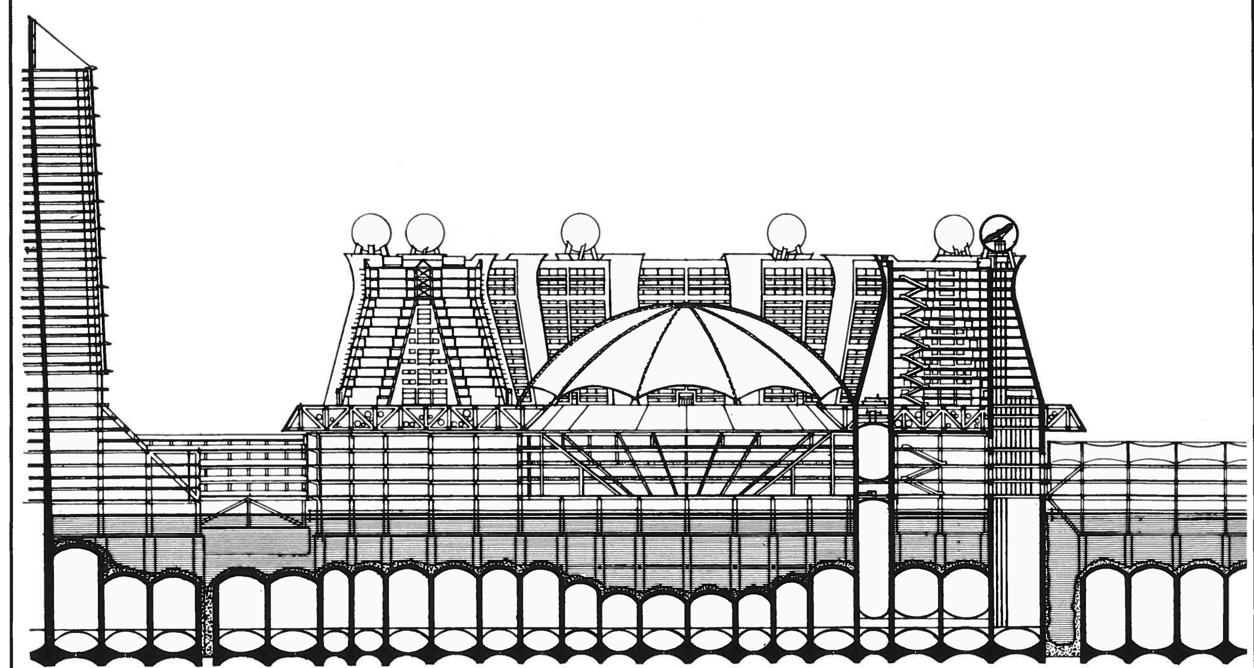
Section Through Breakwaters and Low-Rise Living Facilities



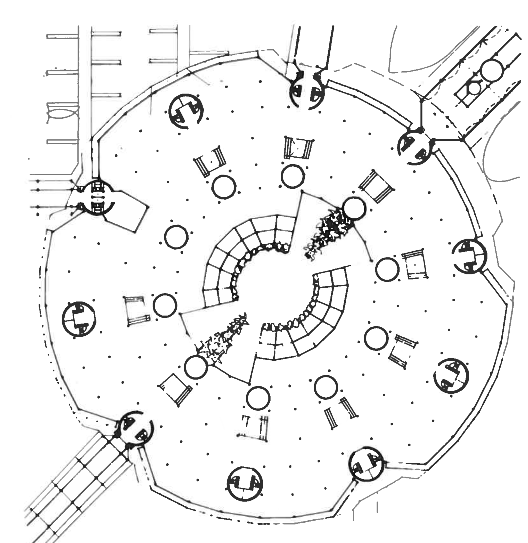
High-Rise Living



Low-Rise Living



Section Through Entertainment Facility



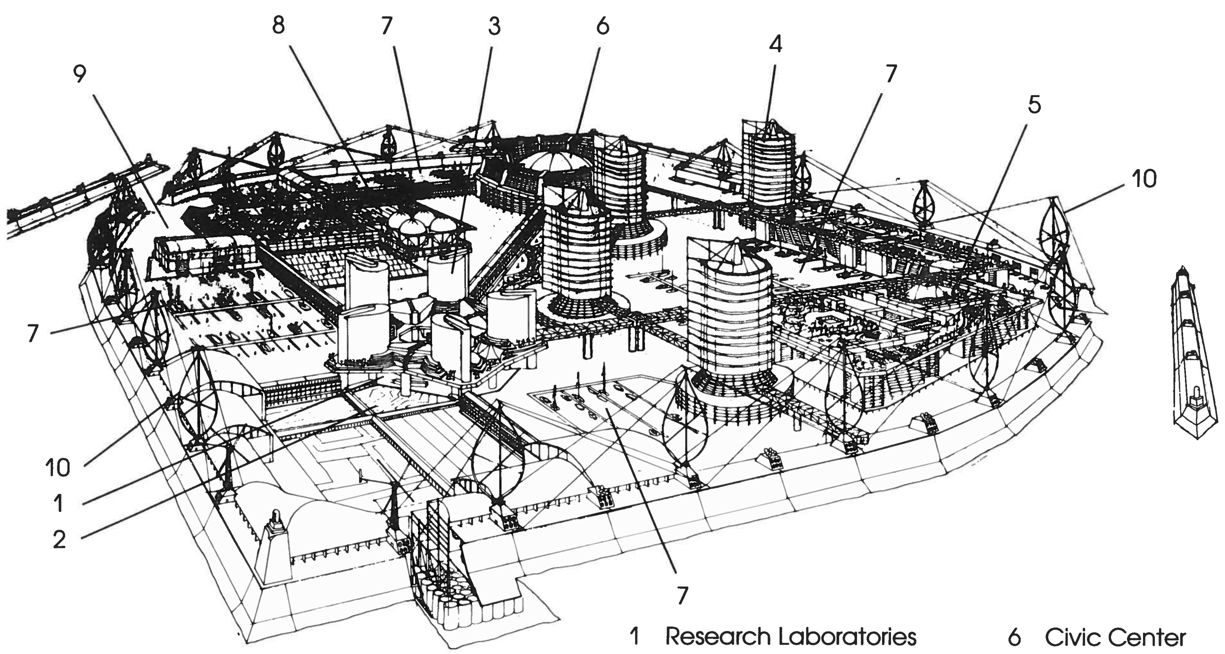
Atrium Plan

High-Rise Living Facilities

Four 33-story apartment towers provide a total of 1,856 units averaging 2,400 sq. ft. each. A 60 ft. diameter concrete column containing stairs, elevators and mechanical systems extends to the top floor of each tower, then tapers to a diameter of 40 feet. Perimeter columns and a diagonal bracing system assist in resisting wind loads.

Streamlined space frame shields surround the towers to deflect hurricane wind loads. These structures are roller-mounted to enable rotation for optimum leading edge orientation into the wind. Clear tensile wind shield coverings allow unobstructed views.

The 10-story base of the towers provides 200 additional living units along with community facilities.



1	Research Laboratories	6	Civic Center
2	Fish Pens	7	Marinas
3	Research Office Towers	8	Utilities Zone
4	High-Rise Living Facilities	9	Cargo Port
5	Low-Rise Living Facilities	10	Wind Turbine

Low-Rise Living Facilities

Inside the southeast breakwater sector are 736 units of low-rise residential housing averaging 900 sq. ft. each. These prefabricated modules are set into an 8-story concrete framework. The apartment units enjoy close access to boat docks and to a community center with cabanas, meeting rooms, recreational sports facilities and a public park.

Large covered areas between residential blocks are afforded natural lighting by openings in the upper deck. The deck provides generous open space with swimming pools, green areas, and a variety of other community amenities.

A floating park located between the residential blocks and the two northeast high-rise apartment buildings functions as a metropolitan recreation area.

Civic Center

The Civic Center features a 12-story, 2,150-room hotel containing retail shops, restaurants, banks, convention space and gambling casinos.

A 300 foot diameter central atrium covered by a graphite composite truss system is protected from high winds by rooms which encircle it. The hotel registration office and visitors' center are adjacent to a ship terminal. A blimp dock is also provided.

The ocean floor base under the Civic Center contains service and storage facilities for minisubs used for sport diving excursions to artificial reefs and other marine sights. Public open areas around the hotel perimeter provide additional recreation space with access to a sports facility for hotel guests on the southeast side, and to a marina with a vertical boat storage facility on the northwest side.

Utilities Zone

An industrial area serving the entire complex provides facilities for water desalination, storage and heating; refuse incineration and waste treatment; and power storage and distribution. The desalination plant will remove salt from the ocean water by reverse osmosis. The plant should be capable of producing an estimated 20,000 tons of fresh water per 24 hour period. The fresh water can either be directly stored, or pumped up through a caisson riser system for storage and use as potential energy.

Cargo Port

Freighter docks and an automated cargo storage/distribution warehouse are central elements of the Cargo Port. Solar water heaters and desalination systems float nearby. The Cargo Port has a control tower, tracked crane system and warehouse capable of servicing two 300 foot container ships at one time.

Refuse and Tidal Power

Incineration of refuse can produce valuable energy. This process can reduce the mass of original waste by as much as 90 percent or more depending upon composition.

Power generation by a typical refuse facility is approximately 5,000 btu/pound or 450-500 kWh/ton. Accordingly, a 50 ton/day facility might be sufficient to serve Oceanapolis disposal needs and provide nearly 25,000 kWh/day of electricity. Treated by-products can be used to build artificial reefs.

Oscillating water column generators housed inside breakwater caissons can function as supplementary or alternative electrical power sources. Wave and tidal action would force air trapped within the columns up and down, creating pressure to drive generators. Such generators, capable of producing an average 0.5 megawatts of power, are projected to cost approximately one million dollars each.

Wind and Solar Power

Vertical axis "eggbeater" type wind turbines are proposed to be placed at 400 foot centers all along the top of the breakwater. These high speed airfoils can convert 40-45 percent of the incoming wind energy to electricity. The lightweight graphite composite blades require little start-up power and can produce 3,000 megawatt hours of annual power under average wind speed conditions of 9 meters/second.

Horizontal axis wind turbines at the breakwater bow can provide supplementary power for the research area. While less efficient than the vertical axis turbines, their low turning speed makes them ideal for pumps and other high torque applications.

Solar collectors placed upon floating barges are proposed to be used for centralized water heating. One of the main water storage tanks is heated in this manner. The other three contain water stored as potential energy for emergency power.

Ocean Thermal Power

The Oceanapolis plan envisions that an ***Ocean Thermal Energy Conversion Facility (OTEC)*** will be located approximately 20 miles off-site on the continental shelf for access to cold water at a depth of 3,000 feet below the surface. This will provide a temperature differential of 20°-30°C which is sufficient to support a thermodynamic cycle to drive a heat engine of 2-3 percent efficiency.

Since the energy reservoir provided by the water is very large, even a relatively inefficient system built at a modest 400 megawatt scale might supply the complete power needs of Oceanapolis and export electricity to the Florida Keys and South Florida.

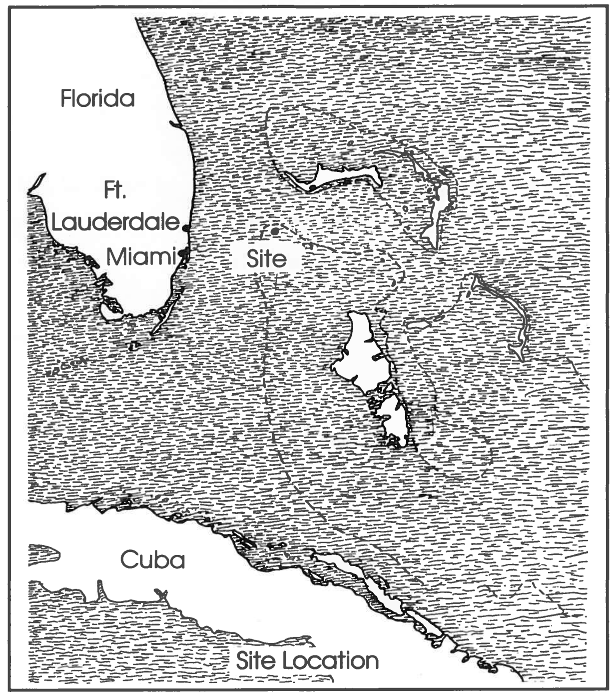
In addition to power, the OTEC can support harvesting of valuable materials from the thermodynamic cycle. As much as 300,000 metric tons of aluminum and 410 metric tons of ammonia can potentially be reclaimed each year.

Great Isaac

Development Concept

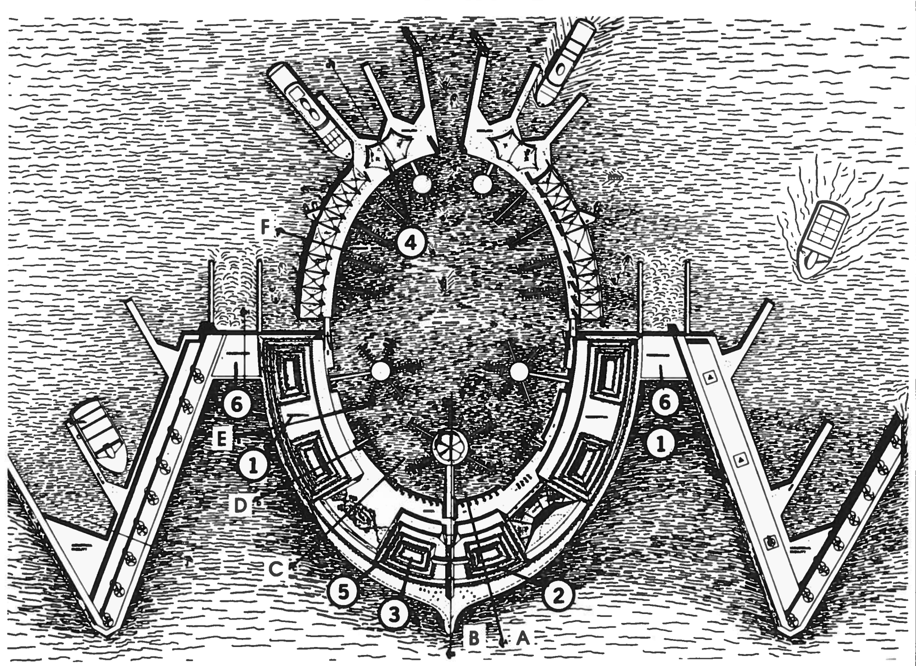
Great Isaac is the name of an existing lighthouse for ship navigation. The site is located on the northern tip of the Great Bahama Bank about 65 miles due east of Fort Lauderdale, Florida. The Northwest Providence Channel is to the northeast and the Straits of Florida to its west. This strategic location is readily accessible to passenger and merchant ships from around the world and is close enough to Florida and the Bahamas to allow short intermediate trips. The city of Freeport on the Grand Bahama Island is northeast about 44 miles.

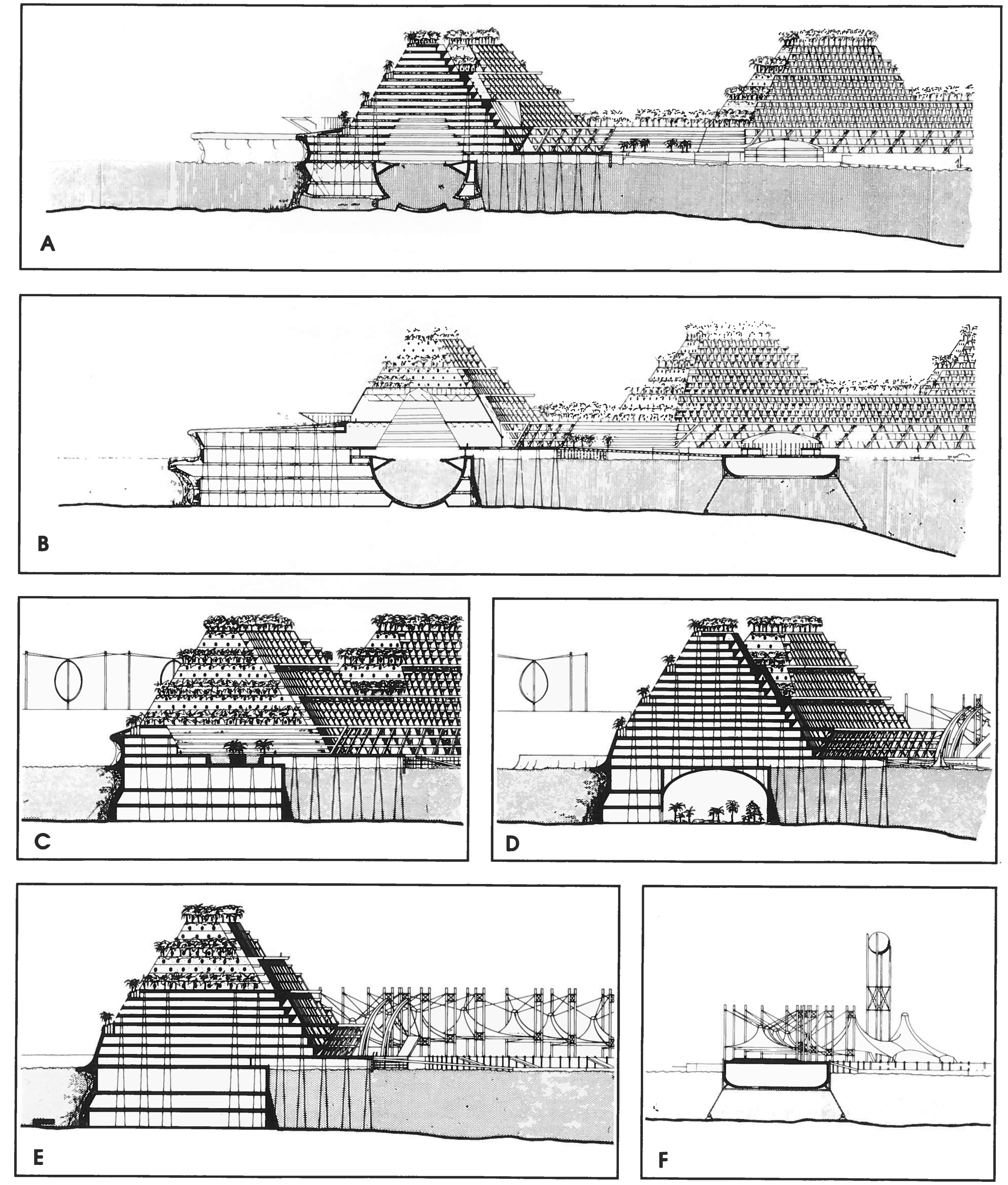
Indigenous to this location are coral reefs which are popular for diving and other recreational sports. Warm, tropical weather and beautiful scenery make it a desirable year-round vacation area. The development concept proposes that a self-sufficient island be created for research and recreation within this ocean setting.



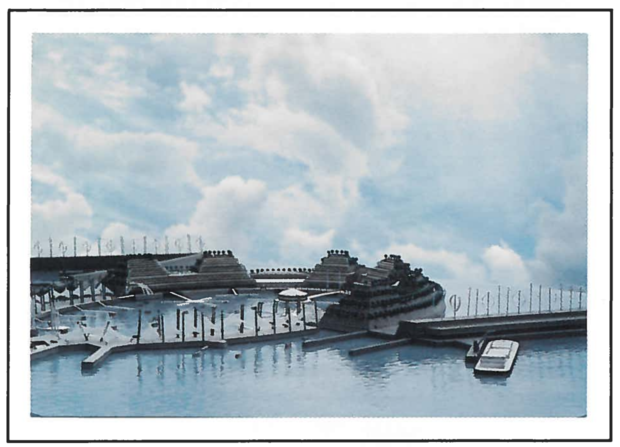
Key to Site

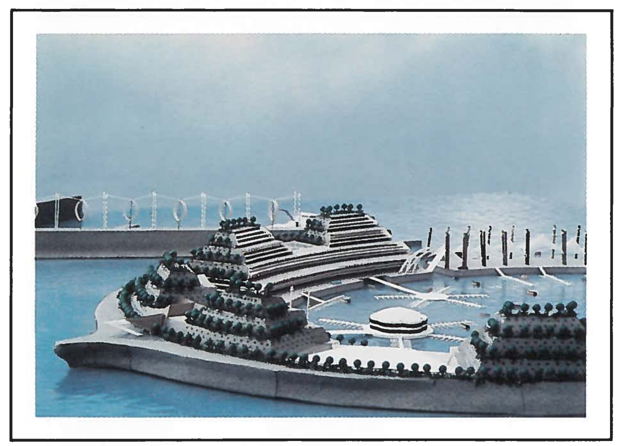
1. **Housing Blocks:** apartments for 8,000 people (total).
2. **Research Center:** facilities for Great Isaac University.
3. **Hotel:** 500-room facility for conventions/tourists.
4. **Entrance Pavilion:** information center and exhibition area.
5. **Retail Area:** shops, restaurants, theaters and casino.
6. **Hydrogenerators:** convert waves/tidal currents to power.





Section Views (See Key to Site Opposite Page)





Research Facilities

The plan proposes creation of a major offshore university where international scholars will work to develop ways to unlock and apply the ocean's vast resources.

Programs will explore ways to harvest marine foods without upsetting the ecological balance of the ocean; advance biotechnology research; develop improved methods to collect/process ocean minerals and organic compounds; and demonstrate closed-loop ecological systems.

Research facilities feature two 600 ft. diameter biospheres for development and testing of advanced food production methods to achieve self-sufficiency. Fish research/production farms utilize algae grown from processed island wastes.

Recreation and Living Facilities

A 20-story, 500 room hotel caters to tourism and convention trade. Accommodations include a gambling casino; theaters for live entertainment; a convention hall with restaurants and retail shops; and a large indoor swimming pool that connects to the reef outside. A public aquarium and natural oceanography museum are located near the hotel and research facilities.

Apartments for a total permanent resident population of approximately 8,000 people are provided in four multi-story housing blocks. Two of these blocks flank the hotel on east and west sides of the 69 acre inner harbor development. Housing on the east side is directly accessible to research facilities located below. Many of the townhouse units are provided with terraces which overlook the boardwalk and harbor area.

General Architecture

The overall site development boundary area is proposed to be 6,150 ft. wide (east to west) and 4,030 ft. deep (north to south). The structure is set in 100 ft. deep water. The windward side of the island is sloped to provide vegetated terraces and controlled water collection for local consumption.

The inner harbor structure incorporates pile supports set into the ocean floor. The outer harbor, on the other hand, is supported by barge-like floating platforms anchored in place by tension cables.

Major elements of the structure are accreted and steel beams, columns and skin designed to distribute ocean forces and hurricane loads through a diagonal frame system. The underwater skin is shaped to form natural caves and reefs that attract marine life for scientific studies and recreational viewing. Standard steel and concrete construction is proposed above the water line.

Power Sources

Energy generation is proposed to include both hydro-power and wind sources.

While not directly in the Gulf Stream, the Great Isaac location in the Straights of Florida can take advantage of large amounts of kinetic energy afforded by 2.5 - 4.5 nautical mph currents.

The development's breakwater in combination with floating outer harbor sea walls will capture and channel wave and tidal currents into 50 ft. diameter water turbines (three on each side). It is estimated this can provide, on an average, more than 200,000 horsepower.

Vertical axis wind turbines placed on top of the sea walls will provide supplementary power. The annual average energy output of each of the 17 proposed turbines is estimated to be 140,000 AKwh (2,380,000 AKwh total).

Early provisions for wind-generated power can provide the electricity required to "grow" the primary underwater inner harbor structure by means of an accretion process.

Accretion Construction Approach

Much of the development's underwater structure is proposed to be created through the same natural process that produces oyster shells and coral reefs. Through this accretion process, an electrically conductive material (e.g., steel rebars and expanded mesh) is connected to the negative pole of a direct current power supply, making it a cathode, and placed in sea water. Small pieces of graphite or carbon are connected to the positive terminal, the annodes, to create a galvanic cell in the electrolyte sea water. Positively charged calcium carbonate and magnesium ions in the sea water are attracted to the cathode, forming a hard framework of desired configuration and thickness.

Accretion for man-made applications has been pioneered and demonstrated by Wolf Hilbertz, president of the Marine Resources Company. The approach has proven effective in building artificial reefs; breakwater and building components; experimental devices of many types; and even art works. Applications currently planned by Hilbertz include large cold water pipes for Ocean Thermal Energy Conversion (OTEC) plants; fresh water pipelines and pipeline protection mats; aquaculture facilities; storage tanks; dams and jetties; and new islands for industry and recreation.

Accreted structures have demonstrated a compressive strength of 4,260 psi. Means to increase this value to 12,000 psi are believed feasible in the near future. Electrical power expenditure is about one kilowatt hour per pound of accreted mass. Typical electricity requirements range from 2-16 volts, and 3-300 milliamperes per square foot area of cathodic material.

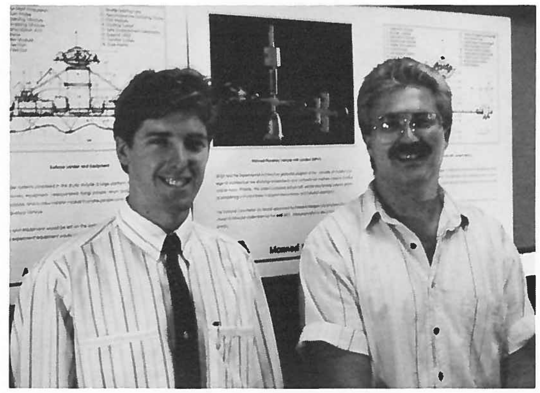
Slow accretion, usually taking several months, yields harder material than fast growth. The settling of marine organisms in and on an accreted structure (referred to as "biofouling"), actually provides free-of-charge material benefits. Damage to a structure can be "healed" by simply adding rebars and reapplying electricity. Since electrical resistivity is lower at broken points, preferential accretion occurs there.

SICSA Background

SICSA is a nonprofit research, design and educational entity of the University of Houston College of Architecture. The organization's purpose is to undertake programs which promote international responses to space exploration and development opportunities. Important goals are to advance peaceful and beneficial uses of space and space technology and to prepare professional designers for challenges posed by these developments. SICSA also works to explore ways to transfer space technology for Earth applications.

SICSA provides teaching, technical and financial support to the ***Experimental Architecture*** graduate program within the College of Architecture. The program emphasizes research and design studies directed to habitats where severe environmental conditions and/or critical limitations upon labor, materials and capital resources pose special problems. Graduate students pursue studies which lead to a Master of Architecture degree.

SICSA Outreach highlights key space developments and programs involving our organization, our nation, our planet and our Solar System. The publication is provided free of charge as a public service to readers throughout the world. Inquires about SICSA and Experimental Architecture programs, or articles in this or other issues of *SICSA Outreach*, should be sent to Professor Larry Bell, Director.



Project Designers
Sean Nolan (Oceanapolis)
Kriss Kennedy (Great Isaac)

Oceanapolis and ***Great Isaac*** are two representative offshore development study projects undertaken within the UH Experimental Architecture graduate program. The projects emphasize design to optimize self-sufficiency and ecology. Similar goals apply to planning facilities in space and other remote locations.

Graphic panels, models and full-size mockups illustrating these two project are on display in the Arnold Space Hall of the ***Houston Museum of Natural Sciences.***

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