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Aquatecture. Macro-design Projects on the Theme "Water": *Floating Fields*

Edited by Charles L. Owen

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Three additional **Aquatecture** project reports are available under the subtitles:

CrossRoads in the Sea
Patterned Energy
Mobile Offshore Industry

Detailed information on the Structured Planning process used for this project can be found in papers by Prof. Charles Owen on the Institute of Design web site: www.id.iit.edu

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Preface

Mankind is inextricably bound to the water. Beyond our own obvious physiological needs, there are its associations with other life forms of concern to us, its importance as a medium for transportation and commerce and, above all, its very omnipresence. Three quarters of the Earth's surface is covered by water, and a great percentage of the world's population lives close to large bodies of water.

The contrast between development of the resources of land and sea, however, is sharp. The disparity suggests that, as we near the new millennium, we consider thoughtfully how to extend to the seas the understanding we have gained in developing the land for human habitation and support of our societies. Activities that were conceived for and evolved on land might now be better conducted on the waters, given the maturation of our technological knowledge and the crowding of our land base.

Aquatecture is a conceptual systems design project. Drawing on the computer-supported techniques of Structured Planning, it explores possibilities for uses of water resources for food production, transportation, energy development and manufacturing. Four subprojects: **Floating Fields, CrossRoads in the Sea, Patterned Energy** and **Mobile Offshore Industry**, deal individually with these subjects. In separate project reports, each speculates on how a "macrodesigned" environment might be developed using known technology to expand the uses of the seas, lakes and rivers as space, media and sources of energy, food and raw materials. This report describes **Floating Fields.**

All four projects were done in the Fall 1986 Systems and Systematic Design course at the Institute of Design. This course is the final course in a three-course sequence for product design students beginning with Product Design, continuing with Environmental Design, and ending with the Systems and Systematic Design course. The Systems course is concerned with products working in concert to achieve goals; the development of comprehensive design concepts; the problems of teamwork in design; and the use of systematic, computer-supported design techniques (Structured Planning) for handling complex problems.

The topic for the fall 1986 course was the Japan Design Foundation's Third International Design Competition. Within the competition theme of "water", four study areas were set out: food production, transportation, energy and materials processing. Research in these areas evolved projects, collectively entitled "Aquatecture", which explore visions for uses of the oceans, lakes and rivers.

The projects were completed in four months and submitted to the competition in January, 1987. From a field of 2,281 entries representing 58 countries, 1,144 projects were actually submitted from professionals and students in 48 countries. All four of the Institute of Design projects survived the first round to be among 59 finalists. After another month of work to prepare final presentations, a second submission was made in June. Final competition results were announced in August: the four Aquatecture projects were together awarded the Grand Prize of 10,000,000 yen ($78,500). The award, made in Osaka on October 30, 1987, marked the second time in three competitions that Institute of Design students had won the Grand Prize.

The projects received considerable attention in the world press. Perhaps the best presentation of them was in the Italian international magazine of architecture: ***L'ARCA***. Its April 1988 issue (No. 15) contains a ten page article with a number of drawings and color photographs.

Charles L. Owen, Advisor and Editor

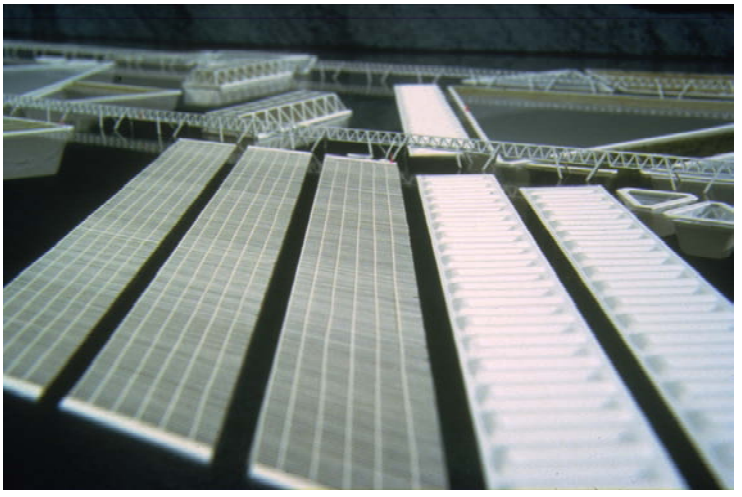

Figure 1 **Floating Fields**
A system of floating food production units connected with elements of a distribution spine creates a highly flexible mariculture and hydroponic system adaptable to a wide range of needs and conditions.

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Floating Fields

Overview

The water environments of the world provide ideal locations for the production of food. Aquaculture and mariculture successes already prove the potential for farming the seas, lakes and rivers. What remains is to design structural systems capable of incorporating the variety of processes possible into integrated production facilities tailored to the water environment, its nutritive qualities and the crop requirements of the farmers.

"Floating Fields" establishes farming in a new frontier. Land farming (in the form of hydroponics) as well as water farming is moved from increasingly crowded and valuable land locations to new sites on the water. Within an "Aquatecture" structure, a floating Distribution Spine anchored to the bottom connects a number of kinds of production facilities. The Distribution Spine organizes the system and provides a path for moving materials, seedlings and harvests between fields and processing facilities. Functional components are modular and designed to be incorporated in arrangements virtually unlimited by size or complexity—the sample organization shown is approximately one kilometer in length. Combined with other Aquatectural structures for wave protection, energy generation, desalination and processing of the harvest, Floating Fields can occupy a variety of environments.

Systems Elements

The elements of the Floating Fields system can be organized into two categories: Production Elements and Service Elements. The Production Elements are the elements which are directly linked to the growing of plants or the raising of stock. Service Elements are elements that support and sustain the production elements.

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Production Elements

Plankton Tube. Although naturally available foods are used as much as possible to feed all the species grown within the Floating Fields system, some supplemental feeding is required. Vast quantities of micro-organisms can be grown in a relatively small area, using human and animal waste, supplemented with minerals, for nutrients. The micro-organisms, both phytoplankton and zooplankton, are densely packed inside baffle-like Tubes formed between two membranes. The lower surface of each Tube is black, the upper one clear, forming a passive solar heating system which stimulates growth with higher temperatures. The Tubes come in manageable sized modules that consist of three serpentine loops. When micro-organisms are ready for harvest, the plankton rich water is circulated by a boat pump, and the plankton is filtered out and transferred to the Distribution Spine, Containment Pond or Mollusk Line through a suction hose. Excess plankton are used as biomass for methane gas production or shipped out for use in other industries.

Essential Features:

1. A serpentine shape crowds long Tubes into a manageable size and makes effective use of space.
2. Plankton Tubes come in manageable sized modules, units, that consist of three serpentine loops.
3. Tubes are black on the bottom and clear on the top to collect the sun's heat.
4. Nutrient lines run down the front of each unit, providing food for the micro-organisms.
5. Inflatable tubes on each side of the units provide flotation.
6. The Tubes provide a fully enclosed environment that excludes pests, predators and diseases.
7. Each unit has an access port for monitoring the plankton's growth.
8. Tubes can be deflated and rolled up for storage.

Related Solution Elements:

1. Containment Pond.
2. Mollusk Line.

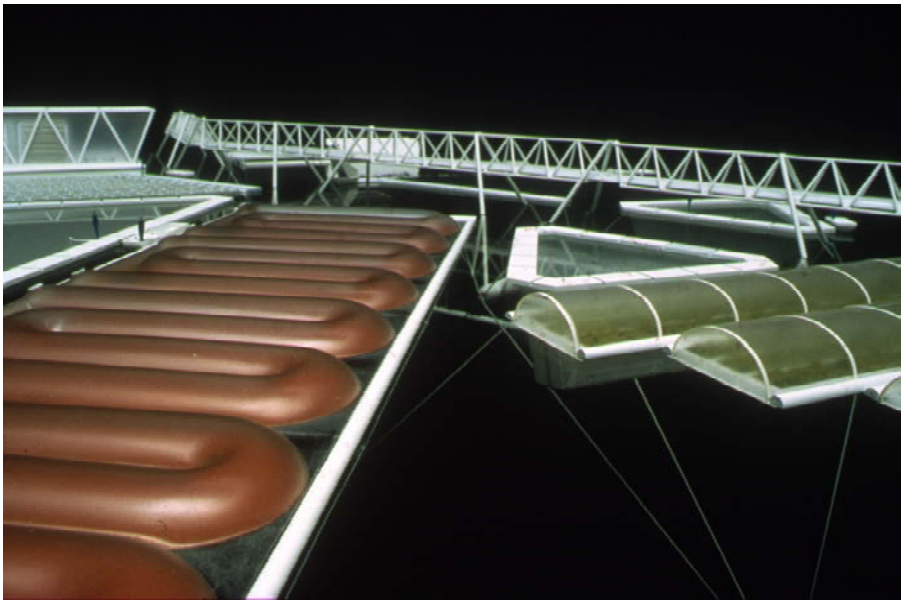

Figure 2 **Plankton Mariculture**
Serpentine-folded, modular plankton tubes project on the left from a Distribution Spine, which also services Containment Ponds and Inflatable Plant Beds on the right.

Kelp Stringer. Kelp is currently an established maricultural crop, providing an important food for humans and aquatic or land animals. The cultivation process is well developed and straightforward; it has simply been modified to fit into the Floating Fields system.

Essential Features:

1. The Stringer is a weighted cable supported at either end by sections of Float Walk.
2. The Stringer provides an anchoring point for large kelp plants.
3. Harvesting consists of cutting the top few meters of the kelp leaving the rest anchored to the Stringer so it can continue to grow.

Related Solution Elements:

1. Float Walk.

Aquatic Plant Screen. The cultivation of sea weed is an old and well developed form of mariculture, producing a valuable source of food for humans and aquatic or land animals. Where it can be economically marketed, seaweed may be a major cash crop for a Floating Field installation. In other cases, it is important as an environmental or food factor for growing fish or other aquatic animals. Excess sea weed may be used as biomass for methane gas production, or harvested for specialized uses in other industries.

Essential Features:

1. An Aquatic Plant Screen is a loose grid of ropes, supported on floats, that provides anchoring points for aquatic plants.
2. Aquatic Plant Screens are located in Containment Ponds.
3. Floating Screens provide a source of food and a more natural environment for some species of fish within the Containment Ponds.

Related Solution Elements:

1. Containment Pond.

Hydroponic Quilt. One of the advantages of moving from the land out onto the ocean surface is the vast amount of space available. The Hydroponic Quilt is intended to take advantage of that space for plants traditionally grown on land. Its component parts provide the shelter, support matrix and growing medium for raising plants without soil. Desalinated water, refortified with minerals selectively processed from sea water or, where necessary, imported from land-based sources, supplies nutrients in proportions that can be controlled for maximum yield in the shortest growing cycle.

Essential Features:

1. Hydroponic Quilts have three parts: an Inflatable Plant Bed, a Growing Medium Mat, and an Inflatable Cover.
2. Quilts form an enclosed environment suitable for Hydroponic cultivation.
3. Quilts can be deflated and rolled up for storage when not in use.

Related Solution Elements:

1. Controlled Environment.
2. Inflatable Plant Bed.
3. Growing Medium Mat.
4. Inflatable Cover.

Inflatable Plant Bed. The Inflatable Plant Bed is one of three parts that make up the Hydroponic Quilt. The Bed serves a dual purpose: first it provides the flotation to keep the other parts of the Hydroponic Quilt out of the water; and second, it acts as a barrier to prevent sea water from contaminating the growing environment.

Essential Features:

1. Inflatable Plant Beds measure 24 m. by 1.5 m. by .5m.
2. Material for Beds is plastic, deflatable for storage.
3. Inflatable Plant Beds support the Growing Medium Mats and form a continuous barrier between plants and the sea water.

Related Solution Elements:

1. Hydroponic Quilt.
2. Growing Medium Mat.
3. Inflatable Cover.

Growing Medium Mat. New techniques must be employed to grow land plants on the water's surface. The Growing Medium Mats are an essential component of the new methods. The Mats contain inert growing medium, which supports the plants while they are growing, and nutrient lines to distribute food to the plants.

The Mats are separate from the Inflatable Plant Beds so that they can be removed from the Beds for harvesting, cleaning and reseeding. Cleaning and reseeding take place in the Processing Hub.

Essential Features:

1. Growing Medium Mats measure 23 m. by 1.4 m. by 3 m.
2. Mats are baffle-shaped plastic tubes containing a growing matrix to support plant roots.
3. Built-in nutrient lines in the Mat's plastic tubes feed the growing plants.
4. After harvesting, Mats are cleaned, reseeded and reused.

Related Solution Elements:

1. Hydroponic Quilt.
2. Inflatable Plant Bed.
3. Inflatable Cover.

Inflatable Cover. Hydroponic cultivation works best in an enclosed, controlled environment. The ocean environment, with its salt water and salt spray is detrimental to most plants normally grown on land. Hydroponic Quilts, accordingly, need to be completely sealed from the outside environment. The Inflatable Covers, in conjunction with Inflatable Plant Beds, form an envelope that not only protects plants from salt and sea, but also provides a barrier against airborne seeds, pests and the diseases they might carry.

Essential Features:

1. Inflatable Covers measure 24 m. by 6 m. by 2 m.
2. Covers protect hydroponically-raised plants from the sea environment.
3. Support pontoons run the full length of a Cover along both sides.
4. Cover connections to Inflatable Plant Beds form a sealed, completely enclosed environment for Hydroponic cultivation.
5. Positioning of Hydroponic Quilts is maintained by Cover connections to the Distribution Spine.

Related Solution Elements:

1. Hydroponic Quilt.
2. Inflatable Plant Bed.
3. Growing Medium Mat.

Controlled Environment. Almost all plant and animal species require special environmental conditions at some point in their life cycles. This usually occurs in the early stages of their development. The Controlled Environment is where organisms are provided with the special environmental conditions necessary at these critical stages. Typical operations that take place in these greenhouse-like structures are: the breeding and spawning of stock, hydroponic production of

plant seedlings, implantation of plant seeds and shellfish spat on structural substrates, and experimentation with new strains of crops.

Essential Features:

1. A Controlled Environment provides an enclosure within which temperature, light, water salinity and all other environmental factors can be regulated.
2. Controlled Environments are primarily used for starting hydroponic and aquatic plantings and propagating fish and other animal stock.
3. Experimental cultivation of species (plant or animal) where special attention or environmental conditions are needed is conducted in a Controlled Environment.
4. Controlled Environments are constructed from standard Structural Modules, using panels to separate the internal environment from the external environment.
5. The structure has two levels, an upper level that is dry for growing plants, and a lower level flooded for aquatic species.
6. Flotation is provided by pontoons located around the perimeter and on the bottom of the structure.

Related Solution Elements:

1. Structural Module.

Mollusk Line. Mollusks are the oldest and still one of the most important of maricultural crops. The techniques for cultivating mollusks are well developed, but can be modified to improve processes of harvesting and seeding. Currently, mollusks are grown on strings hanging from rafts. To harvest the mature shellfish, a worker must travel from raft to raft raising individual strings, one by one. Harvesting efficiency is increased in the Floating Fields by using a system of floating Mollusk Lines that circulate to bring the mature mollusks to the worker. As the nets with the mature mollusks are removed, newly seeded nets are installed on the line, thus accomplishing both harvesting and planting in one operation.

Essential Features:

1. Mollusks are grown on nets that hook onto a buoyed cable.
2. Each Mollusk Line contains a continuous cable handling system that allows nets to be moved, harvested and seeded from one location.
3. Mollusk Lines are supported between Float Walks.

Related Solution Elements:

1. Float Walk.

Containment Pond.

Containing fish and other animals under cultivation in optimal-size environments is important for bringing stock to maximal size in the shortest time. Containment Ponds come in several sizes and are stocked at optimal densities to minimize the amount of work (movement) necessary for animals to keep healthy, while ensuring that they have enough food to support maximal growth rates. Densities reflect the tradeoff between the amount of naturally available food and the cost of supplemental feeds.

Essential Features:

1. Containment Ponds use a selectively permeable "Semi-Permeable Membrane" to keep cultivated species in and unwanted wild species out, while allowing nutrient rich waters to flow through.
2. A Pond's bottom surface is raised by Air-Actuated Lifters to harvest fish or other animals.
3. Ponds are triangular in form so that fish will be concentrated in one of the vertices when the bottom is raised for harvesting.

4. Ponds are anchored to the Distribution Spine to maintain their position.

5. Buoyant Float Walks support the Containment Ponds and serve as walkways for workers to use during harvesting, inspection, repair and maintenance operations.

Related Solution Elements:

1. Distribution Spine.
2. Semi-Permeable Membrane.
3. Air-Actuated Lifter.
4. Float Walk.

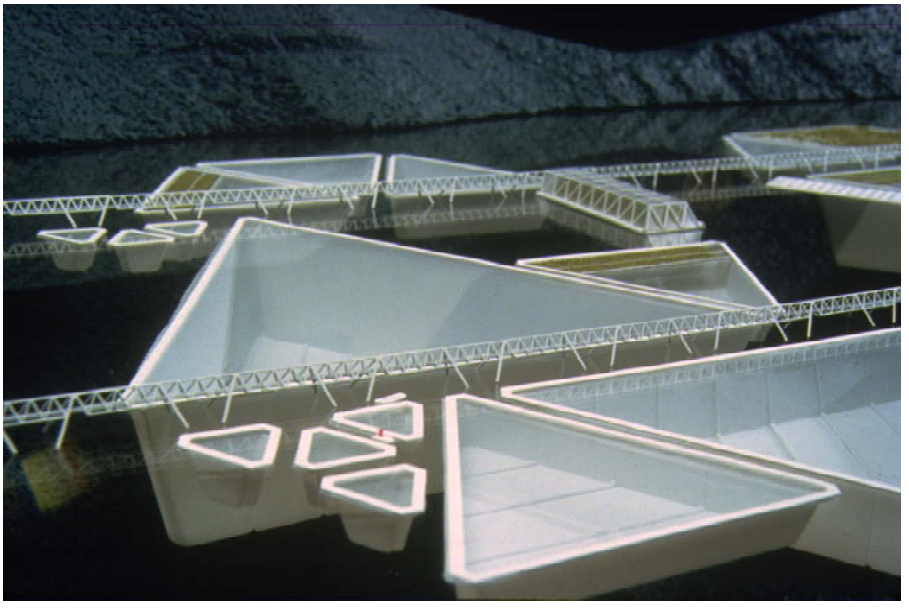

Figure 3 **Containment Ponds**
A series of Containment Ponds of various sizes are positioned and linked by sections of Distribution Spine. Ponds are fitted with Semi-Permeable Membranes to allow water interchange.

Semi-Permeable Membrane. The Semi-Permeable Membrane is used in place of traditional netting to avoid gill-netting cultivated stock or wild species. Netting also is not very effective for excluding predators, and deteriorates strand by strand, making inspection and maintenance difficult. These problems can be avoided by using a tough plastic membrane pierced with a pattern of small round holes. The holes are large enough and close enough together to allow free flow of water into and out of a Containment Pond, but are small enough to exclude wild species that might harm the stock or have a detrimental effect on their growth and development. Since the parameters of selectivity will vary with the size of the stock under cultivation, Membranes may have different hole sizes, and stock may be transferred as they grow to Ponds with Membranes having greater permeability. Plastic materials for Membranes must be very tough to repel large predators.

Essential Features:

1. Holes of appropriate size in a Semi-Permeable Membrane keep cultivated species in, while allowing smaller, prey species to enter.

2. The Membrane keeps unwanted species out—by the size of the perforations and the toughness of the material (larger predators).

3. Oxygenated water with plankton flows through the Membrane into a Containment Pond; water contaminated by cultivated animals flows out.

4. Sections of Membrane snap together for easy assembly.

5. Membranes, as components of Containment Ponds, are supported by buoyant Float Walks.

Related Solution Elements:

1. Containment Pond.
2. Float Walk.

Air-Actuated Lifter. For efficient harvesting, it is necessary to concentrate stock into a confined area. Land-based fish farms simply drain their ponds until the fish are concentrated in a deep section of the pond built especially for harvesting. Raising the bottom of a floating Containment Pond does essentially the same thing as draining a land-based pond; it decreases the distance between the water surface and the Pond bottom and reduces the volume of water contained within the Pond. Using air, the bottom of the Pond is raised —without recourse to machinery—by simply inflating a system of tubes molded into the Semi-Permeable Membrane. The tubes are called Air-Actuated Lifters.

By starting at one side of the Pond and raising a section at a time, fish or other animals can be forced into a continually reduced area until they are concentrated enough for harvesting. After harvesting the Membrane can be inspected and repaired before the air is released from the Lifters and it is allowed to sink back to its original position.

Essential Features:

1. Air-Actuated Lifters are tubes which can be filled with air to raise a Containment Pond's bottom for harvesting.
2. Lifter tubes are molded into the Semi-Permeable Membrane.
3. Lifters can be actuated in sequence to herd fish or other animals into a corner of the triangular Containment Ponds.
4. Using air pressure for harvesting eliminates the need for winches or other heavy machinery.

Related Solution Elements:

1. Containment Pond.
2. Semi-Permeable Membrane.

Float Walk. There is a need for a common flotation element to provide buoyancy for other system elements. The use of a large rectangular float has an advantage over traditionally shaped floats because it provides a surface upon which personnel can walk while performing the various tasks required about the facility.

Essential Features:

1. Float Walks provide buoyant support for Semi-Permeable Membranes, Kelp Stringers and Mollusk Lines.
2. Float Walks create a work surface around each Containment Pond for inspection, harvesting and repair operations.
3. Construction is of light-weight plastic foam encased in a hard plastic shell.
4. The rigidity of the Float Walk elements helps to define the shapes of Containment Ponds.
5. Top surfaces have a non-skid texture for good footing in wet conditions.
6. Float Walks come in sections 3 m. by 1.5 m. by .5 m for easy handling.
7. Sections are joined to the Semi-Permeable Membrane and to each other with snap connectors for easy assembly.
8. Specially shaped Float Walks are used to form the vertices of the Containment Ponds.
9. A special "Gate" module composed of flexible barriers allows the Work Boats to pass freely while still retaining the stock.

Related Solution Elements:

1. Containment Pond.
2. Semi-Permeable Membrane.
3. Mollusk Line.
4. Kelp Stringer.

Service Elements

Structural Module. All structures within the Floating Fields system are built from the same structural components. A module of 3 meters is a comfortable dimension for human scale, and it can be expanded without loss of modularity to 6 and 12 meter lengths for larger structures. By using the same Structural Module throughout the facility it is easy to link elements together at any point in the system and add new elements where and whenever necessary.

Essential Features:

1. The Structural Module sets the dimensions and is the building-block element for the infrastructure of the Floating Fields facility.

2. In shape, the Structural Module is triangular in vertical section and square in plan. Each side of the module is 3 meters long.

3. Structural Modules are supported by submerged SWATH (Small Water-plane Area Twin Hulls) pontoons. This form greatly reduces the motion effects of wave action.

4. The ratio of flotation (air) to ballast (water) can be adjusted within the pontoons so that the correct amount of support is provided for each structural element.

5. Structures are held in position by anchor cables attached to the submerged SWATH pontoons and anchored to the sea floor.

6. Panels can be fixed to the structural framing to create environmentally protected enclosed areas.

Related Solution Elements:

1. Processing Hub.
2. Distribution Spine.
3. Worker's Dwelling.
4. Controlled Environment.

Work Boat. Because a Floating Fields installation can be very large, it is necessary to have a specialized transportation system able to move personnel and equipment to locations of work activity. A Work Boat is the aquatic equivalent of a combined tractor and pick-up truck. The basic Boat is simply a shell which can be used as an unpowered barge for bulk items; a standard pump is mounted inside the Boat to provide power and propulsion. Boats can be modified to perform different tasks by the addition of interchangeable inserts. Since the machinery of the Floating Fields system is powered by air or water pressure, the Work Boats not only provide the means of transportation to a job site, they also supply the power to run equipment once the workers arrive. Not only does this reduce requirements for machinery, it makes maintenance and repair by allowing work on all power sources to take take place at take place at a specialized location—the Work Boat service center.

Essential Features:

1. Work Boats are molded of flotation foam encased in a hard plastic shell. Boats are unsinkable, even when swamped.

2. Work Boats are the primary means of transportation for Floating Fields personnel.

3. Boats are operated by removable engine-driven pumps that pump water and compress air. Water pump propulsion moves the Work Boats over seaweed beds without damage to plants, and provides a means of generating flows of water for maintenance operations with minimal danger to working personnel or animal stock.

4. Compressed air from the Boats' pumps runs auxiliary equipment such as harvesters, Air-Actuated Lifters, hand tools, etc.

5. Work Boats are used for all construction and rearrangement jobs requiring the towing or movement of structural components.

6. Boats are powered by methane gas produced in the Floating Fields system.

7. The pump can be removed for easier maintenance, and the boat (with the additional space) can be used as a barge to transport bulk items.

8. Interchangeable inserts, powered by the standard pump, are used to modify the function of the Boats for the different harvesting and planting jobs about the system.

Related Solution Elements:

1. Air-Actuated Lifter.
2. Mollusk Line.
3. Kelp Stringer.
4. Hydroponic Quilt.

Distribution Spine. The Distribution Spine is the main artery through which material of almost all kinds is transported from one part of the Floating Fields facility to another. Bulk materials are moved primarily through the Spine's Transport Troughs; pipes in parallel move liquids and gases. During construction, modules of the Spine are anchored to the sea floor, turning the Spine into a central "pier" to which other components can be connected. The SWATH hull pontoons which support the Spine are submerged deep enough below the water surface and the Spine itself is raised high enough above the water that there is no interference with Work Boat surface traffic.

Essential Features:

1. The Distribution Spine contains the means for conveying materials from one part of the Floating Fields facility to another.

2. The Spine is constructed from standard Structural Modules assembled into sections 24 meters long.

3. Spine sections are connected by ball-and-socket pivot joints to permit motions in harmony with wave action.

4. A walkway along the Spine acts as an auxiliary path for personnel and an access platform for maintenance.

5. The height of the Distribution Spine over the water is great enough to allow Work Boats and their tows to pass underneath without interference.

6. Because it is anchored to the sea floor throughout its length, the Spine acts as a stable, central structure for positioning other elements of the system.

7. Pipes within the Spine distribute gases and liquids throughout the facility. Pipe joints every 24 meters contain a flexible connector to prevent rupture during storms.

8. Transport Troughs within the Spine are the primary means for distributing bulk materials.

Related Solution Elements:

1. Processing Hub.
2. Structural Module.
3. Transport Trough.

Transport Trough. Water or air is used to power most system elements because of the dangers and maintenance problems associated with electro-mechanical equipment in an ocean environment. The Transport Troughs are a good example of this. Troughs supply a shallow volume of fast moving water within a slick-surfaced container that moves items much like logs in a chute.

Most bulk materials that must be moved are already wet (harvested fish, seaweed, mollusks, etc.) or are soon to be wet (feeds, fertilizers, processed wastes). They can either be moved directly or can be containerized in small packages weighing less than 50 kilograms and readily supported by a small amount of water. Small items that are desirably kept together are placed on special saucers whose bottom matches the interior contours of the Trough; materials which must be kept dry are loaded into water-tight reusable plastic bags before being put into the Trough.

All the harvesting methods used in the Floating Fields system are directly linked to use of the Transport Troughs. Some harvesting methods require a temporary link between remote field locations and the Distribution Spine. This is accomplished by floating a string of Trough sections out into the field. As soon as a plant or animal crop is harvested, it is transported by the Trough to the Processing Hub.

Essential Features:

1. The Transport Trough is constructed of light-weight foam covered by a tough plastic shell.
2. Within the shell, embedded in the foam, are small, high pressure water pipes. Directional jets from the water pipes cover the interior of the Trough with a moving layer of water that provides support and locomotion for bulk materials.
3. Trough sections are 3 meters long and have quick disconnect fasteners for joining water pipes.
4. Materials that must be kept dry are transported in reusable plastic bags.
5. Materials to be kept together are transported on "saucers" which fit into the contour of the Trough.
6. Troughs are buoyant and can act as temporary links between the Fields and the Distribution Spine.

Related Solution Elements:

1. Distribution Spine.

Processing Hub. The Processing Hub is the heart of the Floating Fields system. Made from standard Structural Modules, it can be expanded or diminished in area according to the needs of the individual facility. It provides the extensive work surface area necessary for processing crops or preparing materials for distribution throughout the system. It also serves as the junction point linking the facility to outside transportation. Sections of the Processing Hub are enclosed by panels to provide protection from the elements for workers and goods.

Essential Features:

1. The Processing Hub is a sheltered work area where crops are processed for market and supplies are prepared for use in the system.
2. The Hub is the central point for the propagation of new Distribution Spines.
3. The Hub provides the physical link between the outside world and the Floating Fields facility through its boat dock and helicopter pad.

Related Solution Elements:

1. Structural Module.
2. Distribution Spine.
3. Worker Dwelling.
4. Controlled Environment.

5. Transpac.
6. Transpac Storage Grid.

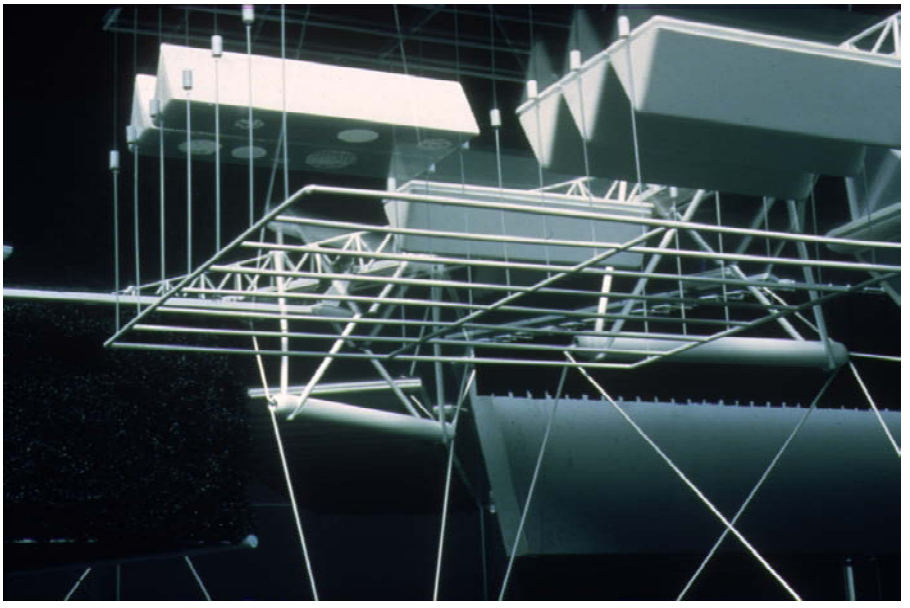

Figure 4 **Transpacs**
Transportation and Storage Packages (Transpacs) are the materials handling units for Floating Fields. As shown here, a number are in temporary storage under water in a Transpac Storage Grid.

Transpac. Transpacs (transportation and storage packages) are modular containers for storing and shipping crops and supplies. Like train cars, they are used to ship crops and materials between the Floating Field facility and remote locations. Some Transpacs are specialized to handle liquids, perishable items or other difficult materials, but most are box containers suitable generally for crops and supplies. Use of the standard Structural Module for their construction enables the Transpacs to fit the structural grid of the Processing Hub and become temporary components of the system.

Transpacs have a double walled construction that ensures enough reserve buoyancy to float them when they are full. When Transpacs are not being actively loaded or unloaded, they simply float in a holding area until needed. To keep them from floating away, they are attached from below to the Storage Grid.

Essential Features:

1. Transpacs are the basic storage and transportation units for crops and supplies.
2. A Transpac can be specialized to hold a variety of different items such as liquids, perishable goods and live animals.
3. Constructed from the standard Structural Module, Transpacs are compatible dimensionally with other facility structures.
4. Double-walled construction provides insulation and ensures buoyancy.

Related Solution Elements:

1. Processing Hub.

Transpac Storage Grid. The Transpac Storage Grid is a submerged structure anchored to the sea floor. Transpacs are moved about and organized above it by a remotely-controlled trolley that uses the structural members of the Grid as tracks. Moving around like a railroad-yard shunting engine, the trolley arranges

Transpacs and brings them to and from the Processing Hub for loading and unloading.

Essential Features:

1. The Transpac Storage Grid provides a means for positioning Transpacs that are being temporarily stored, or are being held for processing.

2. The Grid provides a means of "warehousing" Transpacs while they are part of the system inventory.

3. The Grid marshals Transpacs for shipment.

4. Transpacs are moved about on the Grid by means of a submerged, remotely controlled trolley.

Related Solution Elements:

1. Transpac.

2. Processing Hub.

Worker Dwelling. Depending on its proximity to land, the Floating Fields facility is operated by permanent residents, or crews working shifts of several months at sea, followed by several months on land, in a manner similar to the residence patterns of workers on oil platforms and nuclear submarines. The number of workers varies with the size of the facility. Comfort in a floating living space is a complex problem by itself, and the Dwelling portrayed in this proposal is simply a schematic representation of the facilities necessary for permanent housing.

Essential Features:

1. Worker Dwellings are constructed from standard Structural Modules.

2. Panels mounted on the structural framework enclose a Dwelling completely for protection from the elements.

Related Solution Elements

1. Structural Module.

Floating Wave Break. Floating Wave Breaks, by dampening the power of incoming waves, reduce the structural requirements of the facility. The wave energy is transformed into electrical power for the Floating Fields system. Reducing wave action is important not only for storm protection, but for the stabilization of normal working operations that a calm surface permits. Wave Breaks are anchored to the sea floor, but can be moved or rearranged as system additions or reconfigurations require. If available, units of the Patterned Energy Aquatecture system may be used as Wave Breaks. Another energy producing unit of the Patterned Energy system, the OTEC (Ocean Thermal Energy Conversion) unit, produces distilled water as a byproduct of the conversion of the power generation process.

Essential Features:

1. Wave Breaks prevent or reduce damage from storms by greatly reducing the size and energy of incoming waves.

2. Under normal conditions, Wave Breaks provide an area of calm water for the facility, aiding routine operations and the loading/unloading of ships.

3. Wave energy is used to produce electrical power for the system.

4. Each section of the Wave Break is anchored to the sea floor.

Related Solution Elements:

None