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SEA WATER SYSTEM FOR AQUACULTURE OF ESTUARINE ORGANISMS AT THE SKIDAWAY INSTITUTE OF OCEANOGRAPHY

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INTRODUCTION

As a result of mariculture activities at the Skidaway Institute of Oceanography, Savannah, Georgia, a sea-water system has been developed capable of delivering over 100 gallons (380 liters) of clean sea water per minute. This system has combined the features of several marine aquaria systems and, in addition, has several unique features for use in local estuarine waters.

The Atlantic coast of the Southeastern United States is typified by low lying coastal islands and adjacent salt marshes. The dominent macrophytic flora include *Spartina alterniflora* and *Juncus*. As a result of the tremendous amount of plant biomass produced each year in these marshes (on the order of 5-10 tons per acre per year; Teal and Teal, 1969) large amounts of decaying organic matter are found in the water. The organic material as well as the clay particles which enter the estuaries from land runoff serve as templates for bacterial colonization in addition to creating extremely high turbidities. Control of the quality of the water is a necessary precursor to any laboratory culturing of marine animals.

It is the purpose of this report to describe the water system in use at Skidaway Institute of Oceanography in detail including a cost accounting. The description is designed to aid interested persons in the development of similar systems in areas with similar water quality problems.

THE SEA-WATER SYSTEM

There are several unique features within Skidaway's sea-water system, the most important being the back-up components for use when electrical failure occurs. Salt water (23‰ ± 3‰ salinity) is taken one meter below the surface of the Skidaway River by a 7.5 horsepower, (h.p.) 220 volt pump[1]. An auxillary gasoline-powered pump[2] (5 h.p.) is located near the electric pump to serve during malfunction of the electrical pump or during power failure. Water is pumped via a flexible hose from a floating dock where the pumps are located to one of a pair of three inch PVC (polyvinyl chloride) delivery pipes which in turn deliver the water the length of the stationary dock to an epoxy sealed cement block primary filter. Only one half of the dual pipe system is used at a time while the other half is being drained of salt water and refilled with fresh water. Such treatment conducted on a biweekly basis efficiently eliminates growth of undesired marine fouling organisms.

The primary filter consists of four bays (4 ft. 10 in. x 8 ft. x 4.5 ft. deep) which removes particles down to approximately 1mm in size (Figure 1) One bay is cleaned daily by a process described in Appendix 1, thus giving uninterrupted water flow.

Each of the filter bays has two sets of PVC pipe in the bottom. One of these (1" PVC), carries compressed air and is used only during the backflushing operation; the other ($1\frac{1}{2}$" PVC), carries filtered water to the reservoir bay in the filtration process and, with a change in direction, is also used during backflushing. (See the procedure for backflushing in Appendix 1). The water line has one sixteenth inch

FIGURE 1

Primary Filter. Skidaway Institute of Oceanography

Valve Description and Function

Valve A - Sea-water Supply Valve (supplies water to the individual filter bay from the main upper sea water supply system).

Valve B - Filtered Water Transfer Valve (allows filtered water to pass from the network of collecting pipes beneath the filter medium to the storage reservoir.

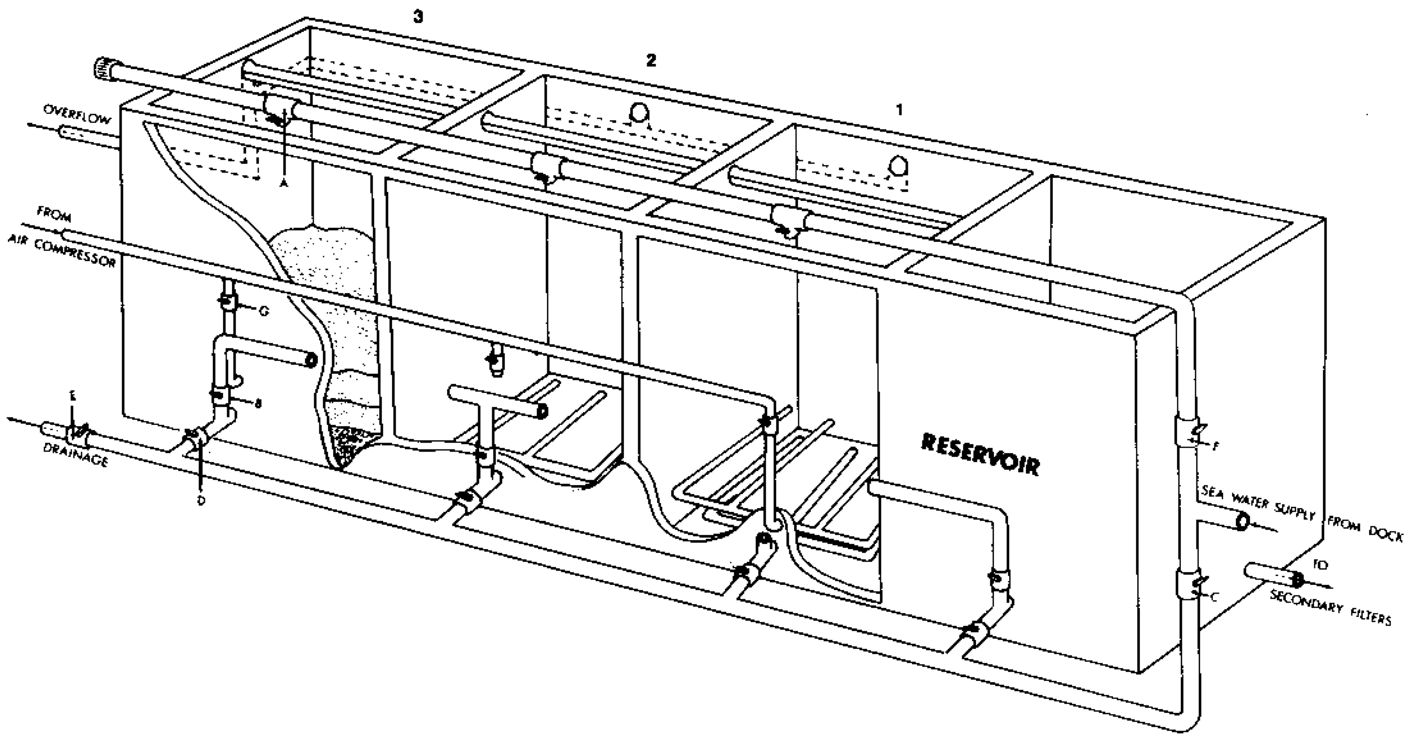
Valve C - Master Backflushing Valve (shunts seawater to the bottom of the filter medium to carry away suspended particles).

Valve D - Bay #3's Drainage Valve and Secondary Backflushed Sea-Water Supply valve.

Valve E - Master Drainage Valve (when open allows all tanks to be drained when closed diverts backflushing sea-water from valve C, up through the filter medium).

Valve F - Master Sea-water Supply Valve (supplies water to the main upper seawater supply system.

Valve G - Compressed Air Supply Valve.


3
2
1
OVERFLOW
A
FROM
AIR COMPRESSOR
G
B
E
DRAINAGE
D
RESERVOIR
F
SEA WATER SUPPLY FROM DOCK
C
TO
SECONDARY FILTERS

slits in the lower side which become more frequent toward the distal ends beginning at two inches apart near the inlet and narrowing to ½" apart. The air line has two rows of holes, beginning with 1/16" and enlarging to 1/8" then to 3/16", placed about 1" apart on the lower side. The arrangement distributes the filtering process in each bay over the entire surface rather than over an area nearest the outlet pipes as well as creating equal agitation over the entire filtering surface during backflushing. The filter bays are all connected by a common overflow pipe that evenly distributes unfiltered water and carries away excess.

The filter medium within each bay consists of three 25 cm layers. The bottom layer consists of 1.0 cm diameter rock and is distributed around the two pipe systems described above. The second layer is 0.5 cm gravel and the upper layer is 0.2 cm gravel.

A second 7.5 h.p. electric pump (and auxillary 5 h.p. gasoline powered pump) sends water from the storage bay via another dual three inch pipe system to four secondary filters. These rapid-rate filters[3] are made entirely of inert material and filter at the five micron range via pressure-sand filtration. Two filters operate at all times, allowing the second set to be repaired or backflushed. Each pair delivers over 100 gallons per minute of clear sea water.

From the secondary filters, water is pumped through a single two inch PVC line to an ultra-violet (UV) sterilization chamber[4] which kills the majority of remaining bacterial organisms. Using four replicates of three geometric dilutions of the most probable number technique it was found that total coliform counts of 210/100 ml were reduced to 36/100 ml after primary filtration and to 0/100 ml after secondary filtration and UV treatment. From the sterilization chamber, water flows to a 2.3 million BTU capacity fuel oil heater[5] (equipped with a stainless steel heat exchanger). The heater is used when needed to heat water to a desired temperature.

AQUATIC EXPERIMENTAL FACILITIES

Facilities supplied with running sea water include two 1440 square foot buildings and a smaller mariculture annex containing forty 20 gallon all glass aquaria. A new mariculture building is now under construction and will be supplied within a year of this writing with sea-water from this system.

The floor plans of our present building are given in Figure 2. Both buildings are predominently open space in which tanks of varying size may be arranged at will, however, normally the floor space is taken up by one meter diameter culture tanks illustrated in Figure 3. The buildings are made of corregated metal siding painted on the outside and sprayed with polyurethane foam insulation interiorly. The foam, in addition to its insulating properties protects the siding from corrosion caused by the salt water mist always present inside the buildings. Interior lighting is supplied by double bulb, 40-watt, four foot, fluorescent fixtures attached to crossbeams. Each fixture is enclosed in a water-tight wood casing fitted with a $\frac{1}{4}$" plexiglass panel on the bottom. The plexiglass and first few centimeters of the water column in each tank remove all ultraviolet radiation from the fluorescent bulbs.

PVC water lines in both culture buildings are fitted with numerous unions to facilitate changes in the system. At several positions within each building mixing valves are located by which water from the heater may be mixed with water of ambient river temperature in desired amounts.

The floors of both buildings are sloped and crowned concrete with several drainage systems as illustrated in Figure 2. All drains not in use are covered by

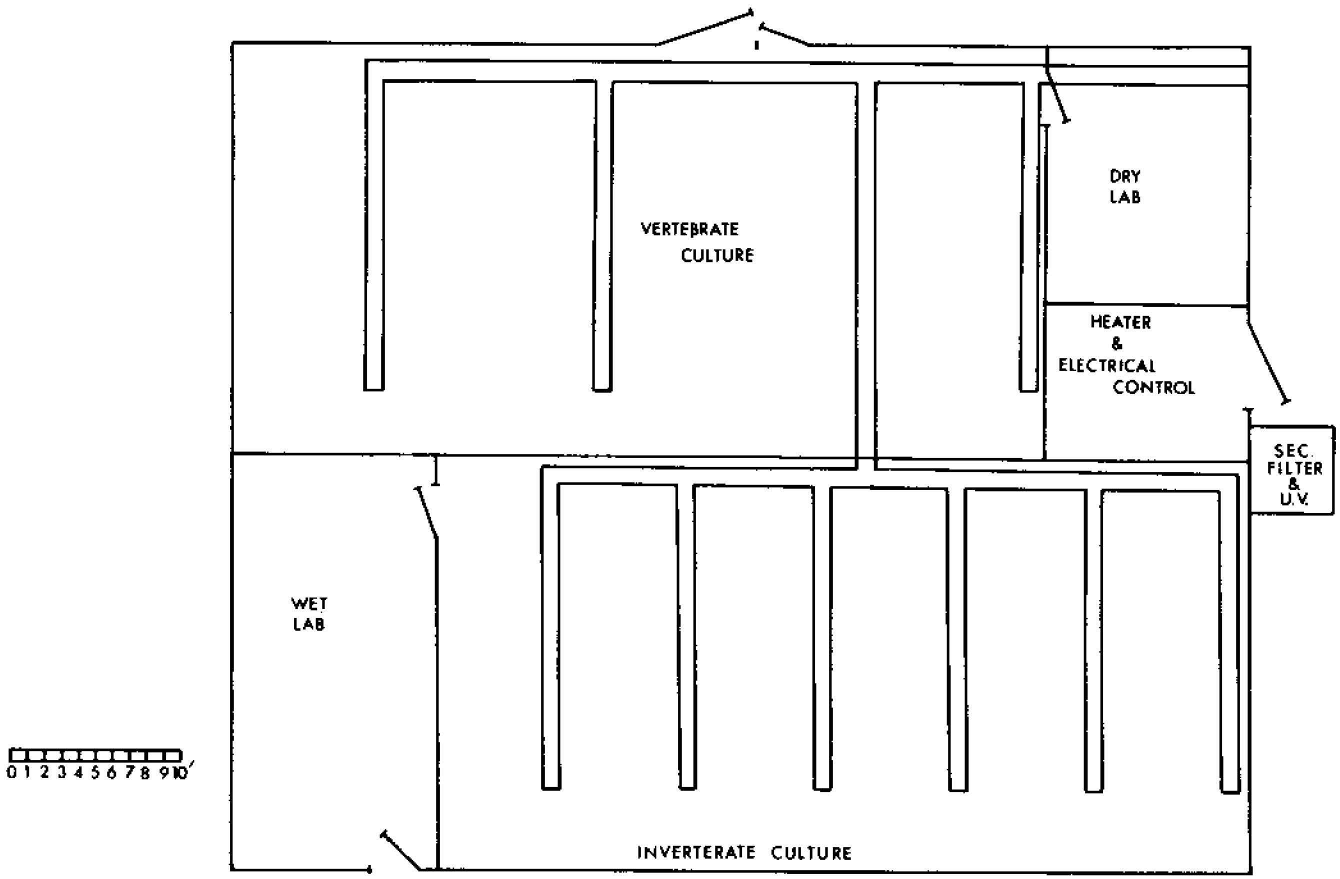


Figure 2. Floor plan of present culture facilities, Skidaway Institute of Oceanography, Savannah, Ga.

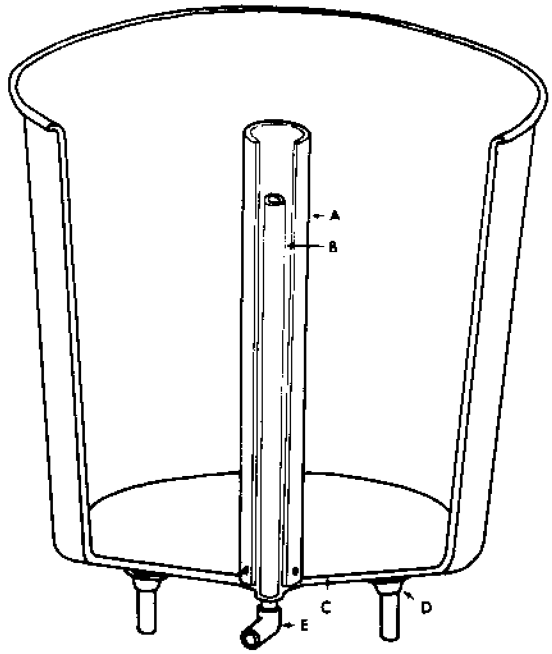


Figure 3. One meter culture tank. A. 6 inch outer stand pipe. B. $1\frac{1}{2}$ inch inner stand pipe. C. Floor of tank with slope toward the center. D. $1\frac{1}{2}$ inch threaded P.V.C. flange with leg inserted. E. $1\frac{1}{2}$ inch elbow with flexible hose connection for drain.

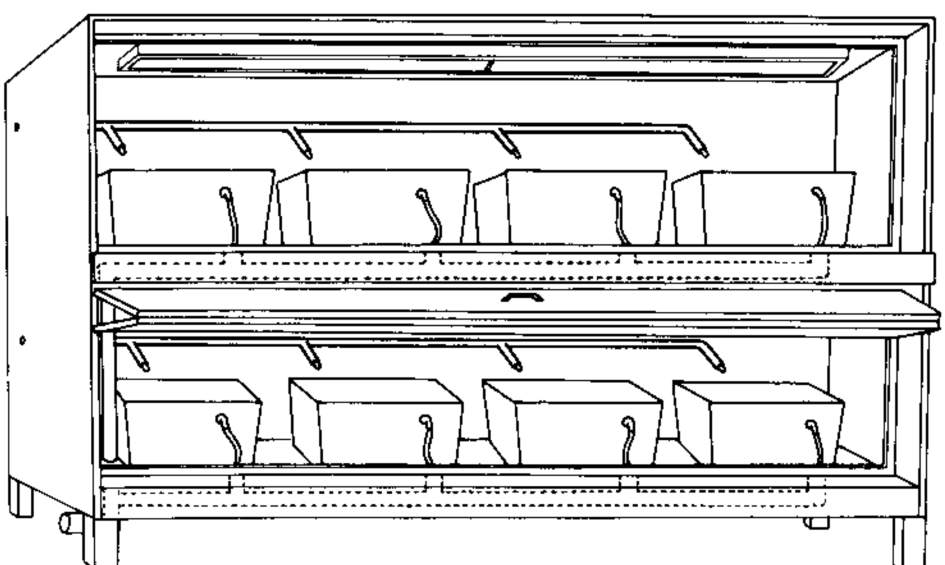


Figure 4. Environmental control box (top door removed).

12" x 3/4" epoxy painted exterior plywood. Flow of water into groups of tanks may either be regulated by several PVC valves placed at various positions or the water supply to individual tanks may be controlled by stainless steel control valves[6]. Salt mist is removed by exhaust fans in each building.

A section of the invertebrate culture building is a wet lab which is supplied with running salt water, fresh water and compressed air. It is used primarily in invertebrate larval rearing work. A small section also serves as a feed preparation room.

The vertebrate culture building also has a room with running fresh and salt water, as well as aeration but is primarily used as a dry lab and feed preparation room. Both of these smaller rooms are supplied with heaters and air conditioners to maintain desired room temperature.

Aeration is supplied by a 208 volt blower[7] capable of delivering 58 cu. feet of air/minute at 4 psi. The blower is also equipped with a 1 h.p. D.C. motor which operates during power failures at a somewhat reduced volume of air. Air is conducted via 2" flexible plastic hose from the blower to both buildings, the mariculture annex and the primary filter. In each of these it is reduced to a 1" plastic flexible hose and distributed to desired locations. Tapping into the line for air is easily done by drilling a small hole in the line and inserting standard aquaria air flow valves. From these valves air is supplied to tanks through $\frac{1}{4}$" flexible plastic aquaria tubing and air stones. Despite this air system being used to aerate all aquaria in both buildings and the mariculture annex, as well as delivering air for backflushing of the primary filters, the capacity has not yet been taxed.

SPECIAL APPARATUS

ONE METER CULTURE TANKS[8]

Figure 3 illustrates the 1 meter diameter culture tanks described earlier. As demonstrated, the tanks have a central venturi drain system. Addition of water to the tanks causes a slight circular velocity to be maintained in all tanks. Uneaten food and solid wastes flow to the center by centrifugal force and through the holes in the bottom of the outer stand pipe, after which they are carried out of the tanks through the smaller central stand pipe. Height of the water column may be adjusted by changing the length of the central stand pipe. Normal flow rates for all tanks in our culture system are between 5 and 10% of the tank volume per hour.

ENVIRONMENTAL CONTROL BOXES

In an attempt to design flexibility into our system, three environmental control boxes, 8 ft. x 4 ft. x 7 ft. tall, were constructed (Figure 4). Each of these consists of an upper and lower section. Each section contains four 30 gallon opaque fiberglass aquaria with drains. Each level of each box may have individually controlled light intensity, photoperiod, temperature and, with a few minor modifications, salinity; hence, a total of six levels of any one of these parameters may be controlled at one time in quadruplicate. Temperature is controlled by manual mixing of "hot" and "cold" water with mixing valves located on each level. Light intensity is controlled by switching on one or more fluorescent fixtures within each level. Photo-period is controlled by clocks[9] located on the master electrical lines for each environmental chamber. All lighting fixtures are sealed inside water tight boxes with $\frac{1}{4}$" plate glass on the lower side. If one wished to use floor space differently the environmental control boxes can easily be removed from the building after turning off master valves to each, uncoupling two P. V. C. unions and severing the air supply to each chamber.

ACKNOWLEDGMENTS

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END NOTES

1	Deming Model 4358 * Size 2 L 7½ h.p. 200 volt 3 phase TEFC motor Deming - Crane Co. 4100 S. Kedzie Chicago, Illinois 60632	$375.00 each
2	Sears Roebuck Company No. 42F2636N 4 Cycle heavy duty self priming 5 h.p. pump Sears Roebuck Company 5093 Buford Highway Doraville, Georgia	$170.00 each
3	Seablue rapid rate fiberglass filter Model FG30 Seablue Corporation 2630 Brenner Dr. Atlanta, Georgia	$355.00 each
	2 h.p., 3 phase, 208 volt A.C. motor (for the above) Sta-Vite Ind. 6000-75	$245.00 each
4	C-12-PVC Aqua fine water sterilizer U.V. Systems Services and Ind. Corp P.O. Box 6088, Station C Savannah, Georgia	$3200.00 each
5	Oil Heater Iron Fireman Model 35-4-240 Oil Fired Steam Boiler Combustion Equipment Company 3071 Peachtree Rd., N.E. Atlanta, Georgia	$3900.00 each
6	Dole Control Valve Available in several sizes and models The Dole Valve Company Morton Grove, Illinois 60053	about $2.00 each

* Use of a trade name does not imply endorsement by Skidaway Institute of Oceanography

7	Model 1704 J Whispair Blower 58 C.F.M. at 4520 r.p.m. Pye-Barker Supply Co., 231 Pryor St., S.W. Atlanta, Georgia 30303	$560.00 each
8	One Meter Culture Tanks Engineered Fiberglass Products, Inc. P.O. Box 815 Estill, South Carolina 29918	$ 93.50 each
9	Paragon Time Controls Paragon Electric Co. Two Rivers, Wis. Model, 1015-ORS	$ 30.00 each

Approximate Cost of Representative P.V.C. Plumbing Material

Size	Sched. 40 pipe (price/foot)	Sched. 80 Doub. Union Sock. Ball values (price/each)	Sched. 80 Sock. (90° elbows) (price/each)	Schedule 80 Socket T's (price/each)	Threaded Caps
3"	.84	73.80	3.37	3.94	-
2"	.41	41.44	1.09	1.26	-
$1\frac{1}{2}$"	.32	30.24	.71	.92	-
1"	.19	18.05	.52	.65	-
3/8"	-	-	-	.25	.35

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Teal, J. and M. Teal. 1969. Life and Death of the Salt Marsh. Little, Brown and Company Bostom: 278 pp.

APPENDIX I

FILTERING AND BACKFLUSH INSTRUCTIONS

The primary filter shown in Figure 1 consists of three filtering bays and a reservoir. The following instructions for changing from filtering to backflushing operations and back again are given for bay number 3 but are also used for bays 1 and 2 by manipulation of corresponding values. Only one bay is backflushed daily while the other two bays are filtering; thus an uninterrupted water flow is supplied to the aquaculture facilities.

Under normal filtering operations the following values are open in bay #3 (as well as corresponding valves in bays 1 and 2):

Valve F
Valve A
Valve B

During filtering, water is supplied to each bay via the overhead seawater supply system. It then passes through the filter medium, out the bottom of the filter, through the filtered water transfer system and into the water reservoir.

To backflush the following changes are made:

Close: Valve A
Valve B
Valve E

Open: Valve C
Valve D
Valve G

Now seawater is travelling up through the filter medium carrying away particles suspended by the compressed air. Plugs are placed in the common overflow trough between the bay being backflushed and the other two bays to prevent backflushed material from being carried into them. Suspended particles are carried out the overflow pipe located in each bay.

To resume filtering operations:

Close: Valve G
(in 15 to 20 minutes)
Close: Valve C

Open: Valve A
Valve E

Now water is again being filtered. The first hundred gallons or so are extremely dirty and are shunted to the drainage basin. When the filtered water becomes clear the following procedure resumes normal filtering operations:

Close: Valve D

Open: Valve B