A Low Cost Floating Upweller Shellfish Nursery System
Construction and Operations Guide

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Introduction
Land-based upweller nurseries for shellfish culture have been around since the 1960's. Upwelling is an efficient way to pass water vertically through a three dimensional mass of shellfish seed resting on a mesh in order to culture them from a hatchery size to a field nursery or growout size during the first season of growth. Land-based systems use valuable waterfront real estate, operate at relatively high heads which require expensive to operate centrifugal pumps and are limited in the number of seed the shallow "silos" of the majority of such systems can hold. A floating upweller system (FLUPSY) takes the silos and places them floating just above the surface of a water body or floating tank, thereby reducing the "head" that makes pumping water so expensive in land-based systems. FLUPSY's move water through the use of tidal flow, airlifts, paddlewheels or pumps. This document will deal with the pumped variety, which may be placed in a marina slip, or virtually anywhere that electricity is available. The system described below was developed over a five-year period and is designed for relatively calm areas. No promises are made of its usefulness nor do trade names mentioned indicate endorsement by Cornell Cooperative Extension.

The Cornell System
The Cornell Cooperative Extension of Suffolk Marine Program's FLUPSY was prototyped in 1995, using off-the-shelf components. This system operates without the tank of some others-silos simply float on the water body. The heart of the system is a submersible deicing motor/propeller for docks (a ¾ horsepower dual prop Ice Eater© rated at 1,050 gallons per minute, hereafter called the pump, shown in figure 1) turned on its side and installed in one end of a pipe to create an axial flow pump. Each module consists of ten 55-gallon plastic drums (silos) connected along the pipe's length (figure 2). The pump is constantly trying to empty the pipe, drawing water from each mesh-bottomed drum and creating flow through the seedbed. Modules can be combined to make a system tailored to the dock available, or a custom dock can be constructed around modules. The basic system described here uses two modules placed end to end between two 4-foot x 24-foot floating docks (figure 3). This catamaran design has proven very stable and provides a working platform that is low to the water, making servicing the silos easier. The total area required by the system is 16 feet wide by 24 feet long. Note that 8 feet is necessary between the floats to allow for the trunkline, drums as well as room to remove and connect the silos. The system draws 3½ feet if full-length drums are used. Short half-drums can be made, but these will reduce capacity for species such as oysters and scallops that can fill the silos to the outflow port. Also, a cut drum's shape is compromised unless reinforced.

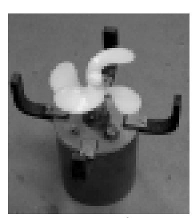

Figure 1
Axial flow pump

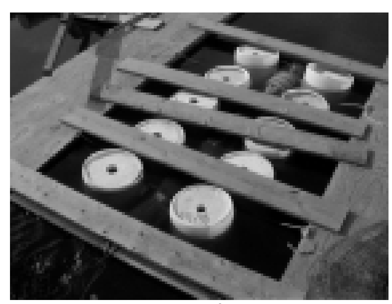

Figure 2
FLUPSY module

Construction
The Floats
Note that safety is the number one concern. Please be sure to follow safety rules when working with power tools and comply with any local building codes. Refer to table 1 for a list of materials and

figure 3 to visualize the following guidelines. The two hulls are constructed individually, placed in the water then connected by doubled 2x6's at each end using the carriage bolts that were inserted from the inside before plywood decking was added. Each 2x6 frame is built as a rectangular box with gussets nailed or bolted to make up the 24-foot total length for each side (alternately, full length 24 footers could be procured to make the job easier and stronger). Spacing of the "joists" is 24 inches on center so that the foam can be tightly placed between joists and the plywood edges will hit a joist. Two 2-inch and one 1-inch pieces of Styrofoam® are placed between each bay for a total of five inches of floatation. Cutting the foam to fit between the bays is accomplished with a jigsaw, reciprocating saw or scored and snapped with a utility knife. This latter technique produces less foam debris. Once in the water, the plywood deck will hold the foam from coming up; however, if the floats are removed, foam could fall out, especially with the weight of fouling organisms. Placing plywood on the bottom of the floats is one option, while running a few rows of treated furring or even a series of synthetic lines perpendicular to the joists would be cheaper. While we have not treated the floats with antifoulant paint, it is doubtful such treatment would affect the seed.

The Trunkline

The bell end of the 12-inch SDR pipe is cut off to make the length 12 feet. SDR is light green in color and used for sewer applications. The bell is then used as a removable end cap with foam caulked in place. Alternately, the foam can be put directly into the pipe end, and the bell discarded. The pump is supplied with four plastic brackets that fit inside the pipe. The pump can be bolted in place using the factory brackets and stainless steel bolts (ask for them when ordering). The pump's propellers should be placed at least 8 inches from the pipe ends so that the propellers are not drawing water from outside the pipes. A removable guard made of 2-inch vinyl-coated wire mesh is necessary to keep hands out of the pipe. Five 4½-inch holes are drilled in each side of the pipe opposite each other at a spacing of 27 inches on center, starting 27 inches from the pump end. Short nipples of 4-inch PVC pipe each about 6 inches long are secured into each hole in the trunkline (figure 4). There are a few ways to secure these "snouts" to the trunkline. Figure 4 shows a section of coupling (about 1-inch) cut off and glued both inside and outside of the trunkline. The snouts are first fitted with the inside section of coupling and then dropped into place one at a time. Then the outside section is added. Alternately, the snouts can be PVC welded in place or glued with PVC cement or 5200 without the coupling slices. The snouts go into holes in the side of the silo. A third way is to glue or weld 4-inch pressure couplings into the trunkline, which require a larger hole saw. These couplings will allow a six to 12 inch long by 4-inch diameter nipple to connect into the silo. Either way, the friction fit created makes removing the silos from the trunkline tool free.

Figure 4 – Four inch nipple in trunkline

The trunklines are suspended from the floats (or an existing dock) with either ½-inch line or by bolts passing through 2x12's, which also act as scaffolds to cross from float to float (see figure 3). This arrangement allows for vertical adjustment to maximize flow while avoiding water coming over the tops of the silos. The use of boards allows for hauling the trunkline out of the water by simply lifting the planks up and supporting them on blocks or drums.

The Silos

Silos for this system are made from readily found (often for free) 55 gallon closed-head polyethylene drums. Both ends are cut out, with the top (where the openings are) becoming the meshed bottom. Leaving part of the bottom (becomes the top) intact allows for the retention of foam floatation while keeping the silo round (figure 5). There are several methods for attaching the mesh to the silo. For small mesh (less than 2-millimeters) hose clamps and/or strapping can be used to temporarily hold the stretched mesh in place while the glue sets (figure 6). While different adhesives have been used, including silicone and hot glue, we have found 3M 5200 polyurethane marine adhesive sealant performs best.

Figure 5 – Foam being inserted into top of drum

Figure 6 – Temporary clamps on fine mesh showing leg band

The other method we use for attaching larger mesh for larger shellfish seed is by creating a frame using ½-inch irrigation pipe and attaching the mesh to the frame. The frame with mesh is then secured to the silo with solid copper wire or cable ties (figure 7). A bead of sealant around the inside of the silo where the mesh meets the drum wall helps secure the mesh and keeps seed from getting jammed in that space. Note that different types of drums lend themselves to this frame method more than others. Many drums have a ridge inside that the frame can rest against. This method makes changing screens due to damage or different size requirements easy. However, we have found that because the silos are so inexpensive and easy to make, having extra silos for different seed sizes or as quick replacements for damaged units is the way to go. Originally we used stainless steel mesh, which was screwed to the silo. This mesh is expensive and subject to electrolysis, especially when used in a marina setting. Silos should get three "legs" that will keep the mesh from getting damaged. Separate legs can be screwed/riveted on or a band made from a drum section with integral legs secured (figure 6).

Figure 7 – Coarse mesh held on by cable ties

A 4½-inch outflow hole is made in the side of each silo, centered about 12 inches down from the top. The hole can be placed lower, but this reduces the capacity of the silo. If the hole is higher, the trunkline must also be brought up, causing cavitation of the propellers. Centered above the outflow hole, a 3/8-inch hole is drilled about 2 inches down from the top to accept a short length of line that is knotted on the inside of the silo and attached to the silo across from it, keeping the silos from backing off the snouts.

Styrofoam® discs are made to provide floatation for each silo. A hole is cut in the center of the disc (the 4½-inch hole saw can be used here) to provide a handhold to place and remove the disc, while also allowing a visual inspection port. Discs are made from the same foam used to float the catamaran dock. By mixing 1 and 2-inch thick discs, silos can be kept floating as the shellfish grow. Discs are installed vertically through the cutouts left in the drum (figure 5), and then fall flat onto the seed. As the silos are lowered, they float up to rest against the drums' shoulders.

Operation and Maintenance

The system is operated and maintained much like a land-based system. Seed must be stocked so that no bare mesh is visible, otherwise "fountaining" will occur, allowing water to flow around the seed, rather than through it. During the growing season, the system is taken down, cleaned and the seed culled. Each silo's volume of seed is recorded and culled seed are replaced into silos, thinning as necessary. This is done at least weekly during the height of the growing season. It is difficult to recommend stocking densities, as these will vary with growing area and species. Generally, maximum volumes per silo approach 10 liters for clams and 40 liters for oysters in our system in Southold, NY. The seasonal throughput of a twenty-silo system could be in the millions of seed, depending on the species and growing area.

When initially stocked with small seed, there may be a tendency for the seedbed to fluidize to the point where the seed is tumbled. This may reduce growth and can be eliminated by either: leaving open ports without silos (you may not need all ten silos when starting); placing reducing bushings or rotating elbows onto the snout after the silo is attached; or using a motor speed control to reduce the voltage and hence the volume of water pumped. This latter method may damage the electric motor; be sure to check with the manufacturer before trying this. We have found that small seed (especially clams) on fine mesh provide the most resistance to flow in a system with mixed sizes and species. Placing these silos closest to the pump end may help even out flow. A disadvantage to most FLUPSY's is that one cannot see the flow through each unit as with land-based systems. While one could purchase or rent a digital flowmeter, an inexpensive substitute is a device used on small sailboats to estimate speed. A ball rises in a vertical tube as water flow increases. This will give at least an estimation of flow in each silo.

Fouling of the interior of the trunkline will occur during the season. Although the water has already been through the seed before it passes the fouling organisms, a buildup will restrict the flow through the system. With all silos removed and the pump unplugged, the capped end is pulled up, the end cap removed and a length of 2-inch pipe or a custom scraper used to dislodge fouling. Electrolysis can be a problem, depending on many factors. Make certain a zinc is mounted on each shaft below the propellers. It is a good idea to check the zinc weekly and have spares on hand. While the most expensive part of the system are the pumps, having a spare ready to go in case of failure is a good idea. Replacing a pump takes only minutes. When attaching the power cord to the motor assembly, we recommend putting dielectric grease in the connection and hand tightening only. The wire must also be well cable tied out of the way of the propellers.

Operating costs for the 20-silo system will vary with local electrical and labor rates. Electrical costs on Long Island are among the highest in the nation. With a commercial rate of almost $0.15 per kilowatt-hour, it costs $3.80 per day for each 220 volt, ¾ horsepower pump, or about $7.60 for the system. While both pumps may not be operated throughout the season, for the sake of simplicity, we estimate a seasonal cost of about $930 if operated for four months. Even so, the increase in value of the shellfish grown in the system more than pays for all costs, including initial construction costs.

At the end of the growing season, the pumps should be removed from the trunklines and stored propellers down. This ensures that the shaft seals don't dry out. It is also a good idea to remove the silos and trunklines from the water and store these out of direct sunlight. Most drums, especially the light-colored ones are susceptible to ultraviolet degradation. The expected life of this FLUPSY is between five and ten years, depending on how it is constructed and maintained.

Acknowledgements

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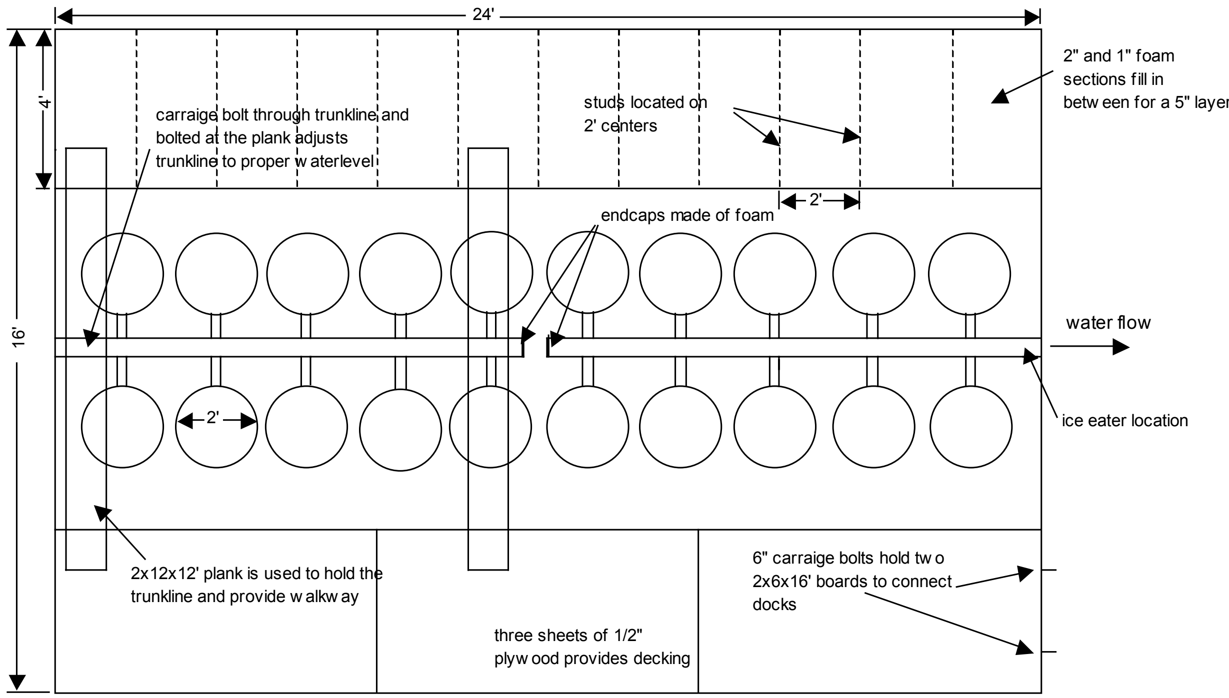

Figure 3- Diagram of a 20-silo FLUPSY with catamaran dock

Table 1- List of materials for a 20-silo FLUPSY with catamaran dock

Material	Quantity
2x6x24 (all 2x is treated)	4
2x6x16	4
2x6x8	13
2x12x12	4
4'x8'x½-inch treated plywood	6
½ x 6-inch HDG carriage bolts, nuts and washers	8
½ x12-inch HDG carriage bolts, nuts and washers	4
2-inch foam (2' width)	500 square feet
1-inch foam (2' width)	300 square feet
Power House© aerator F750DP (120 or 220 volt, motor assembly only)	2
12-inch diameter sewer pipe	24ft
12-inch end caps (can be foam)	2
55-gallon plastic closed-head drums	25
4-inch couplings	10
4-inch PVC piping	20ft
ADPI spat or Pecap mesh (2mm)	
ADPI OBC1 mesh (3/16")	
Other mesh as appropriate	
Nails or screws for 2 x frame and plywood	
10 gauge copper wire/cable ties	
3M 5200 fast cure caulk	

Notes