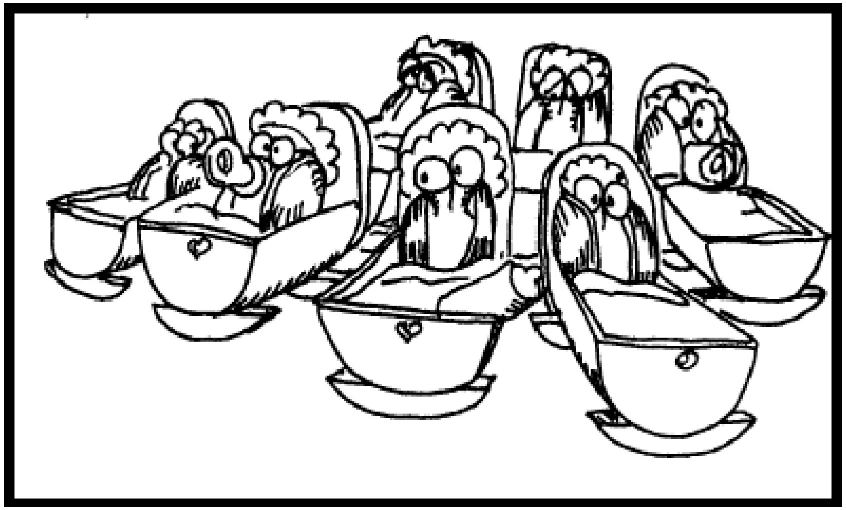
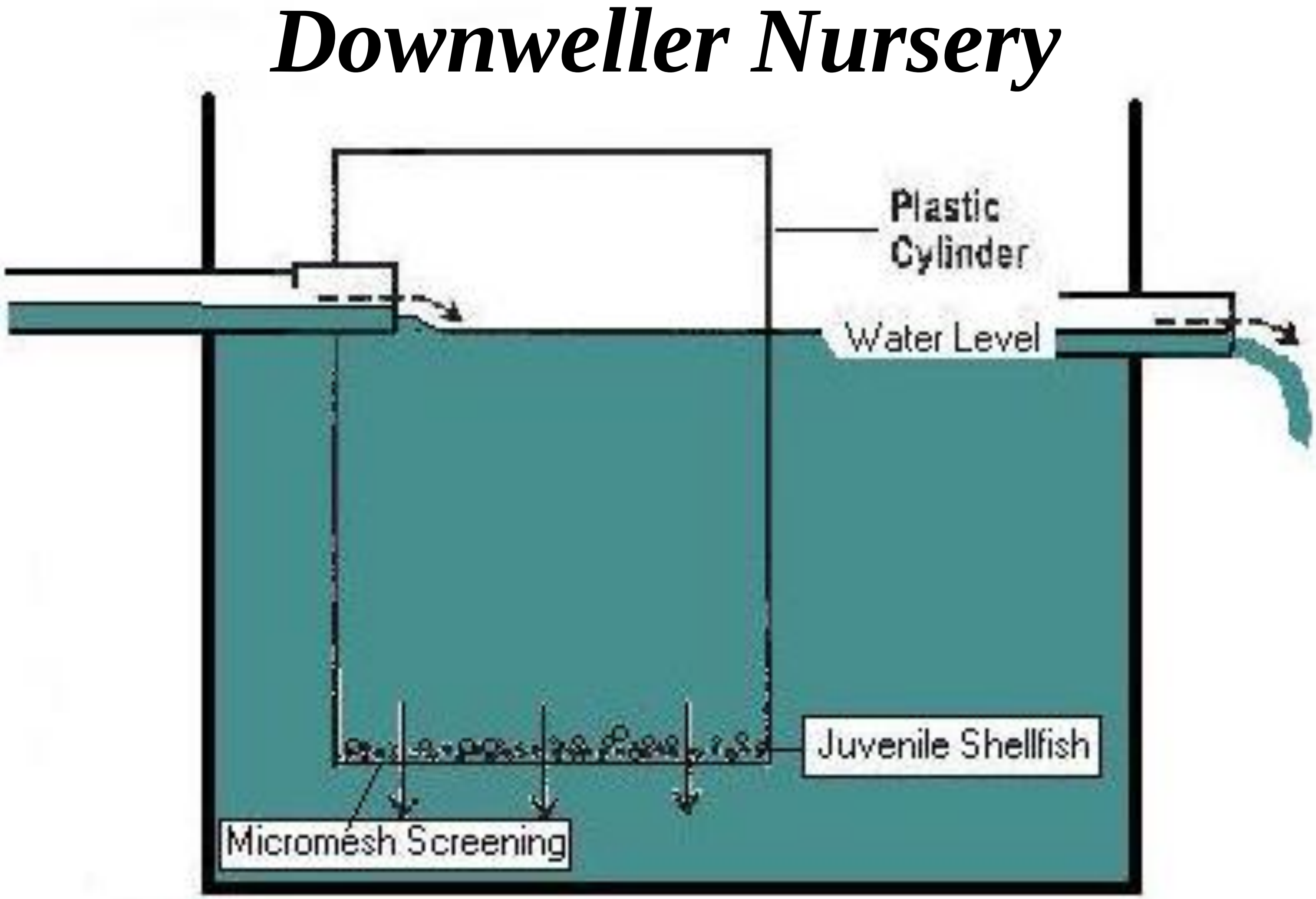


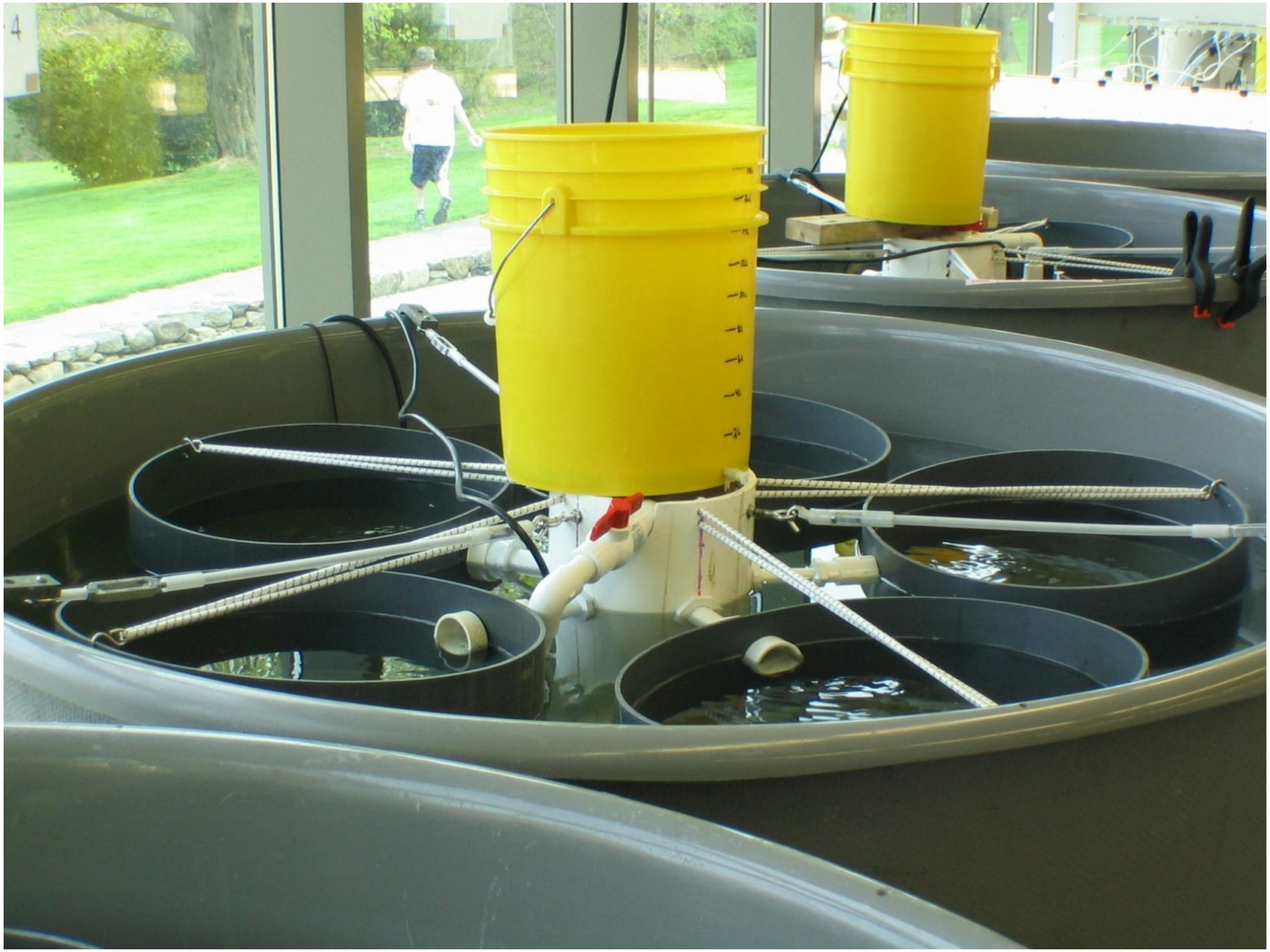
Shellfish Upweller Nurseries

Dale Leavitt
Aquaculture Extension Specialist

Technique for growing juvenile shellfish

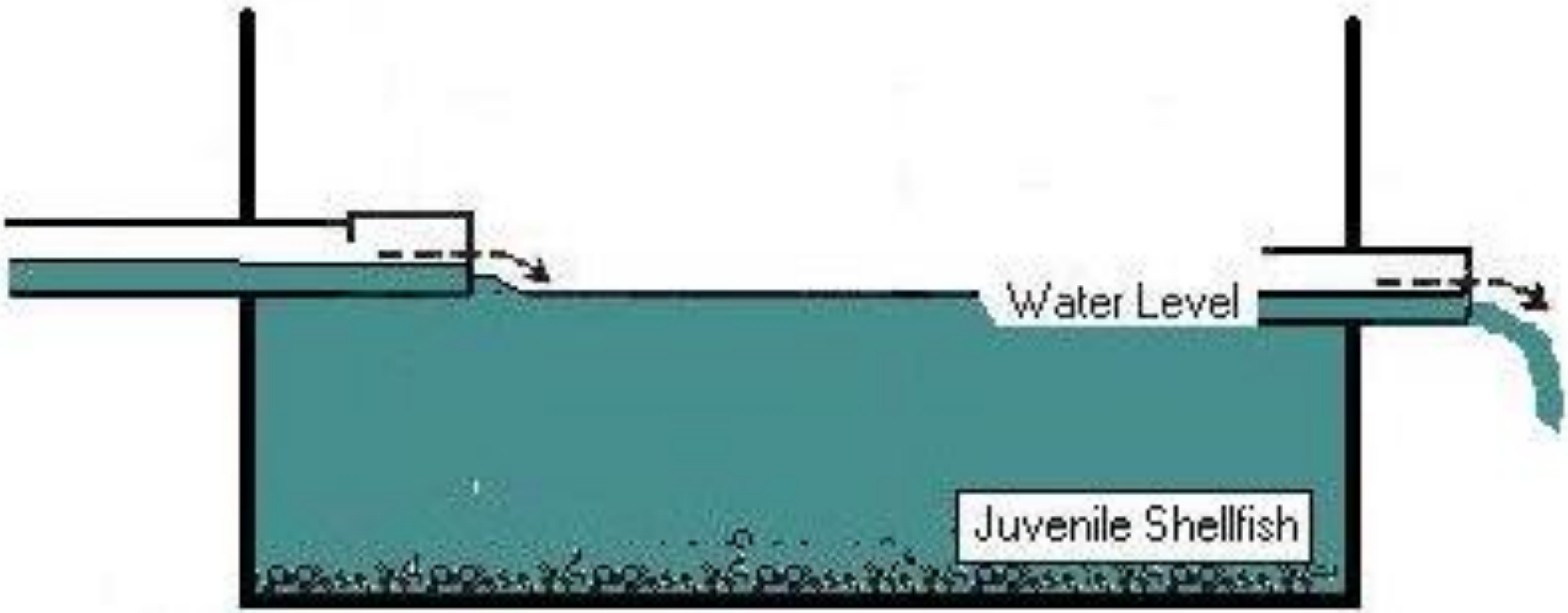


RWU Downweller



Technique for growing juvenile shellfish

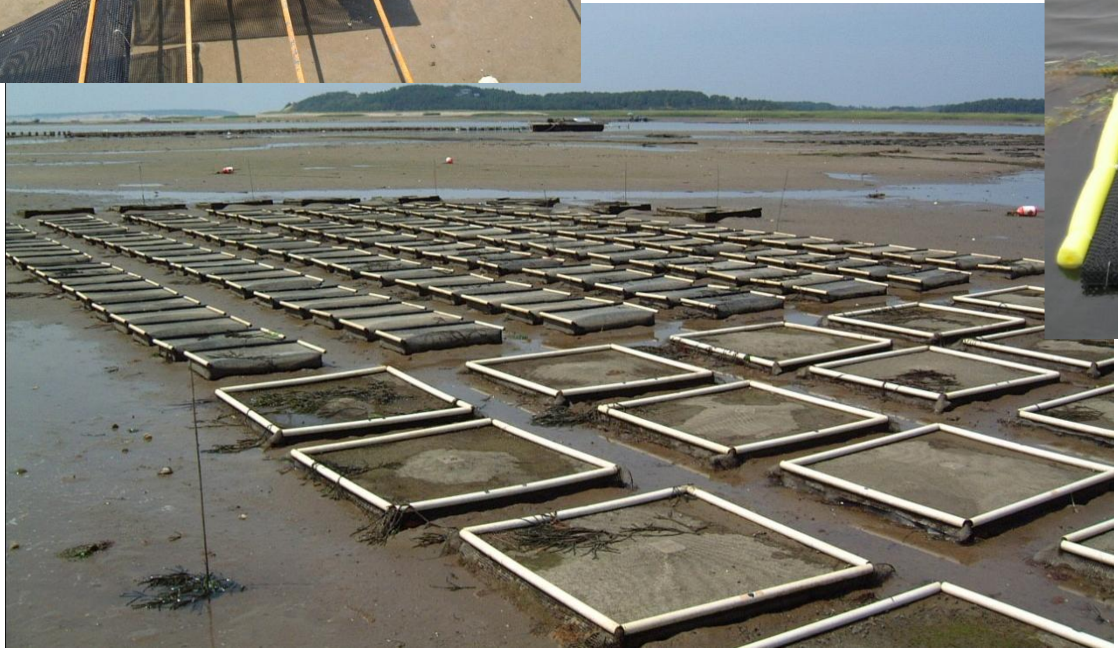
Raceway Culture Nursery



Raceway Culture System

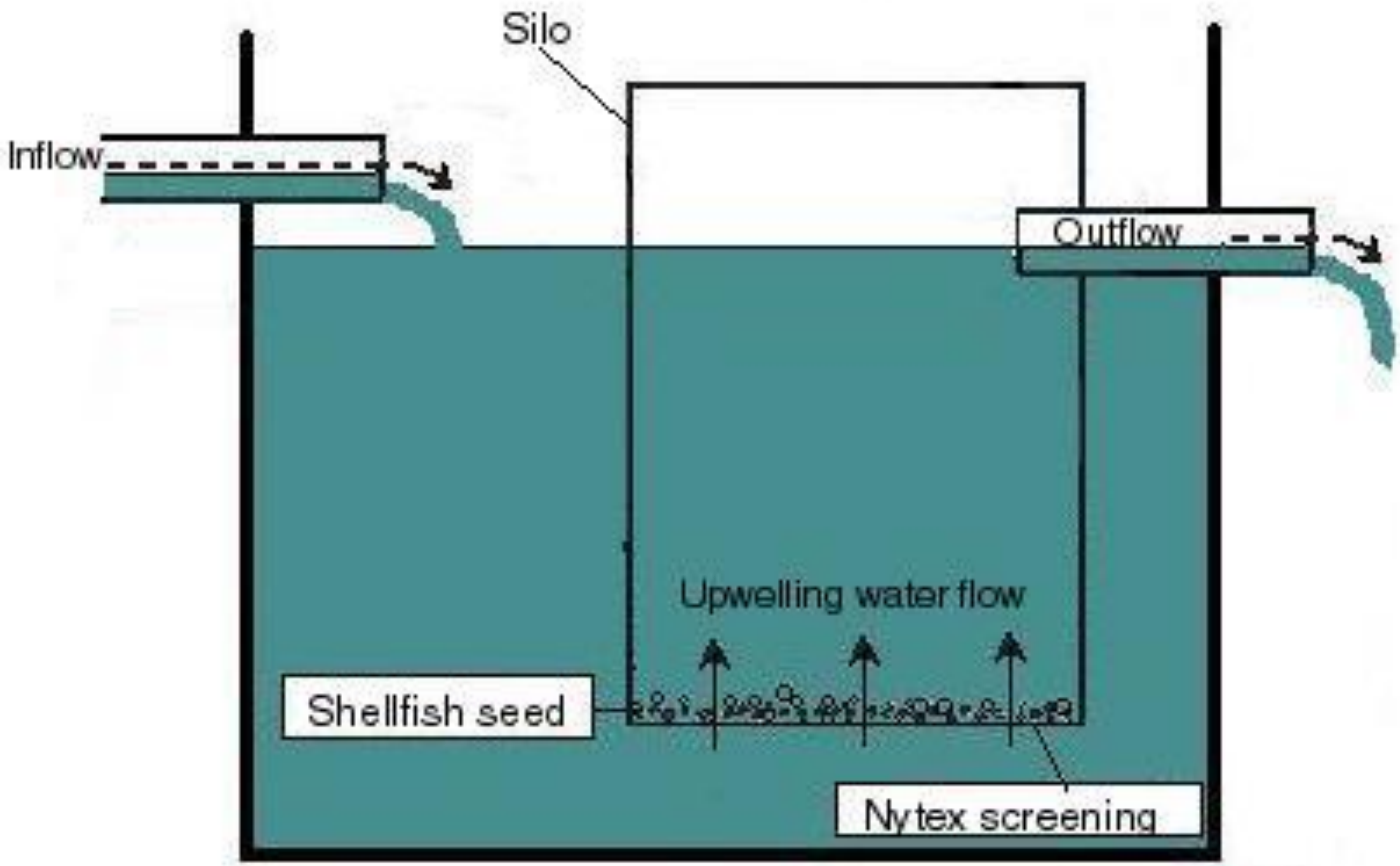
Technique for growing juvenile shellfish

Field Nursery

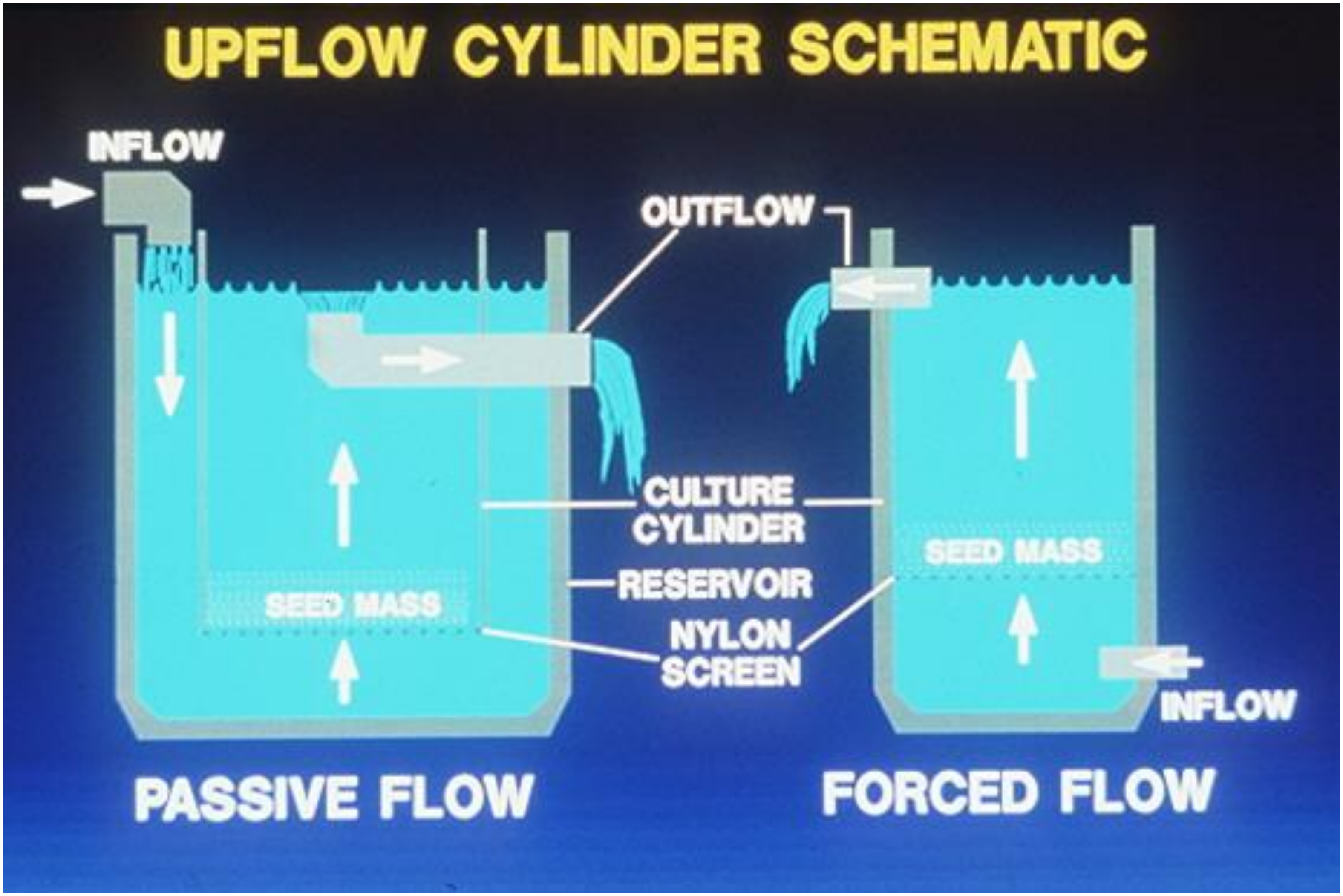


Technique for growing juvenile shellfish

Upweller Nursery



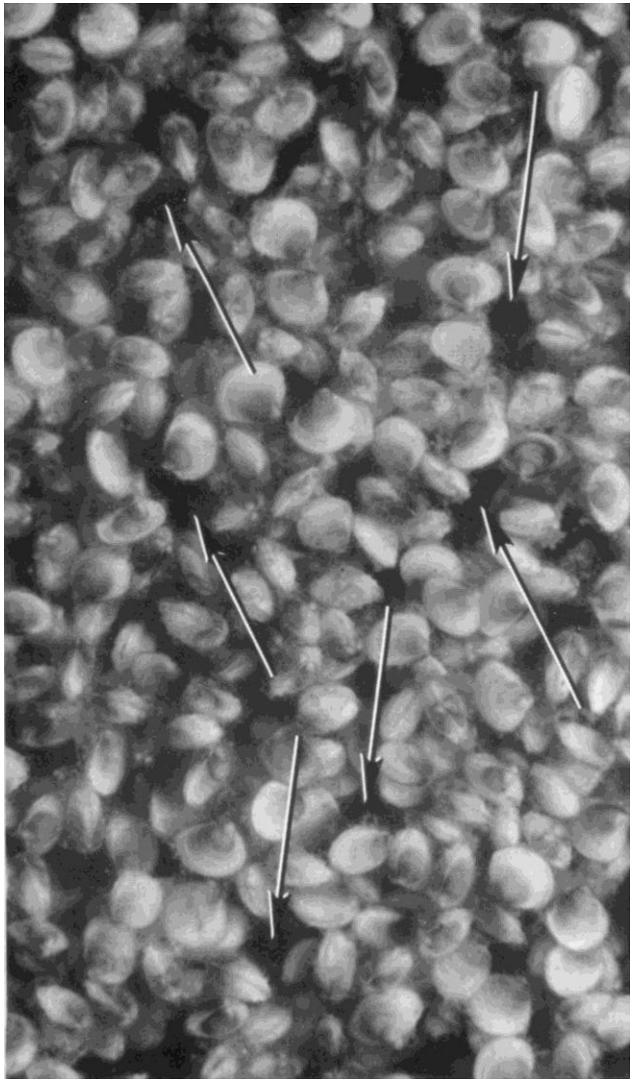
Upweller Nursery



Technique for growing juvenile shellfish

Upweller Nursery: advantages & disadvantages

- Advantages
  - good water flow pattern



Technique for growing juvenile shellfish

Upweller Nursery: advantages & disadvantages

- Advantages
  - good water flow pattern
  - high food flux
  - high stocking density
  - predators excluded
- Disadvantages
  - requires access to water
  - relatively high start-up cost
  - high maintenance

Upweller design strategies - four options

- Onshore within a structure
- Onshore exposed to weather
- Floating with shore power
- Floating without shore power

Onshore within a structure

Basically a building next to the water

- Protected from the elements
- Reduces biofouling
- Utilities nearby
- User friendly

Onshore within a structure

But….!

- Limited availability
- VERY expensive!!!
- Hard to justify for seasonal use
- Need to lift water

Onshore exposed to the elements

Land or dock space next to the water

- Less expensive than a building
- Somewhat protected
- Utilities nearby
- User friendly

Onshore exposed to the elements

But….!

- Limited availability
- Moderately expensive
- Mother Nature
- Exposed to outside tampering
- Need to lift water

Floating with shore power

On the water, frequently associated with a marina
FLUPSY - FLoating UPweller SYsyem

- At a water source
- Lower operating costs
- Utilities nearby
- User friendly

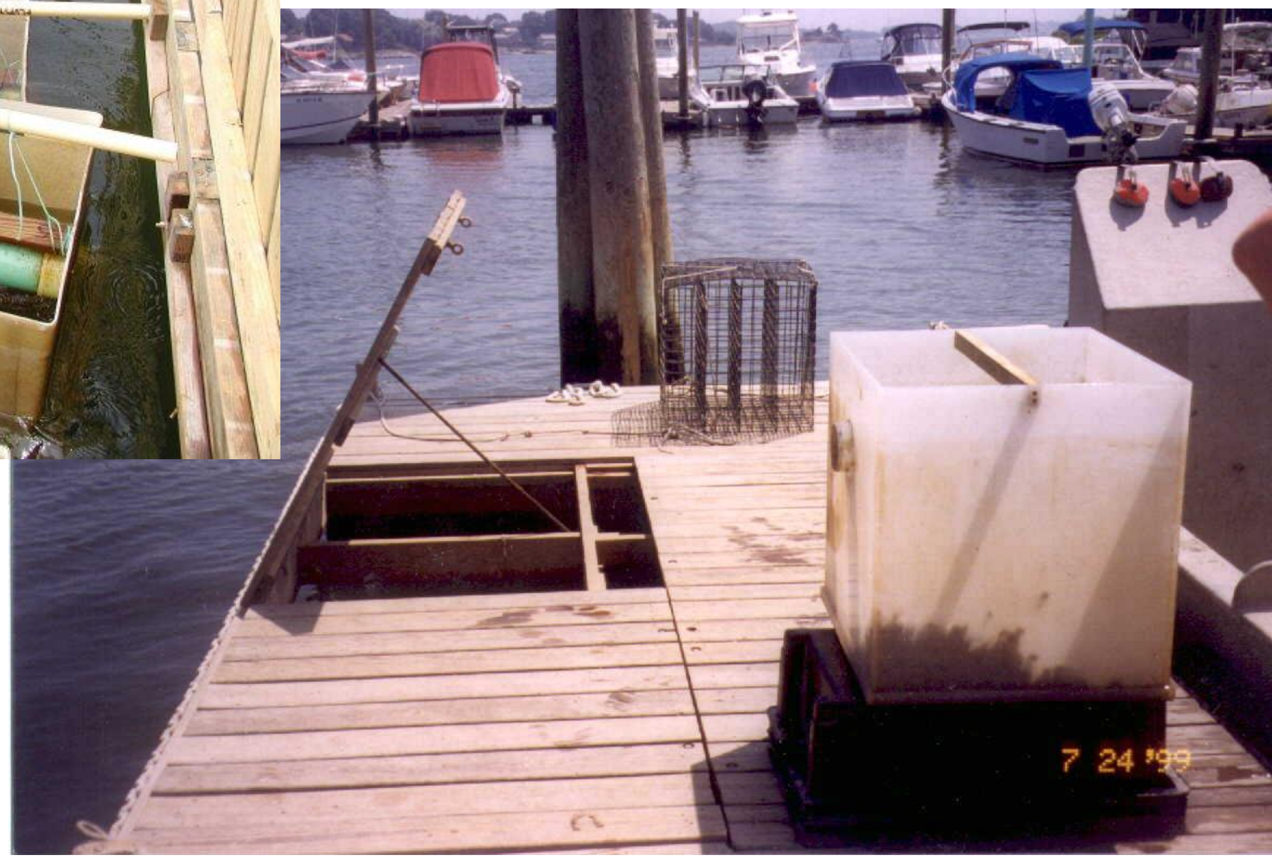
Roger Williams University
Learning to Bridge the World

Floating with shore power

But…!

- Limited access
- Mother Nature!
- Exposed to outside interference
- Water quality

Floating with shore power



Floating without shore power

On the water, frequently at a mooring.

- At a water source
- Mobile
- Not dependent on shoreside utilities
- Minimal operating costs

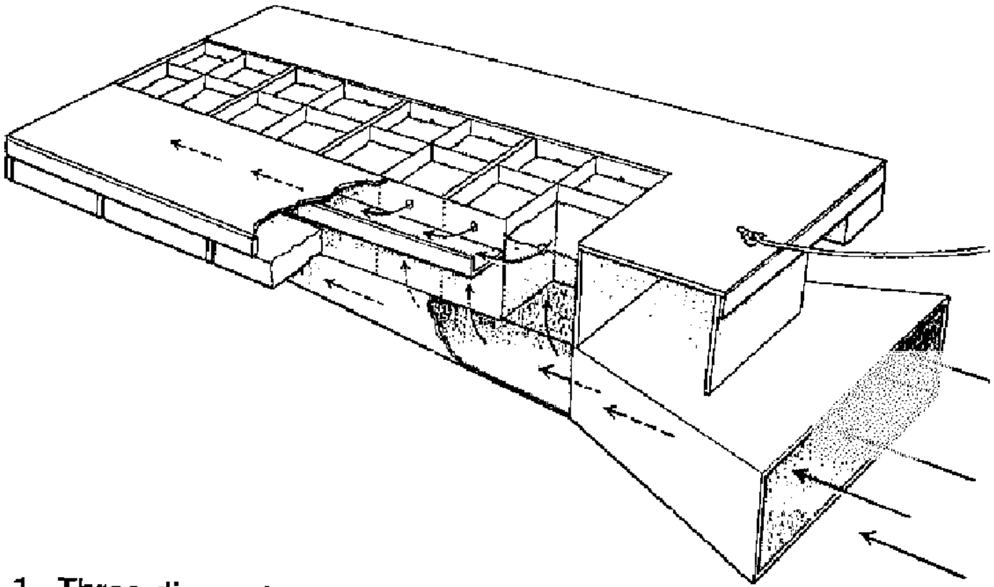


Fig. 1 - Three-dimensional schematic of the Tidal-Powered Upwelling Nursery System.

Floating without shore power

But…!

- Limited access
- Not protected from disturbance (nature and human)
- Utilities not nearby
- Not user friendly

Developing a shellfish nursery

- Purchase/acquire seed from hatchery
  - Size & amount?
- Nursery System design
  - Downweller (175 to 500 μm).
  - Upweller (500 μm to 25 mm).
  - Raceway (3 mm to 25 mm).
  - Field nursery (>3 mm)

Developing a shellfish nursery

How does one develop a shellfish nursery system?

- Assess your needs
- Identify your location
- Decide on your general design strategy
- Obtain permits
- Purchase and install system
- Get seed

Assessing your needs?

- What shellfish are you growing?
- How many do you want to grow?
- What size seed will you acquire?
- How large do you want to grow them in the nursery?
- How much time can you spend maintaining the system?
- How much money do you have to invest in the system?

Identifying your location?

- What space do I have available?
- What are the water characteristics?
  - For shellfish to survive?
  - For shellfish to grow?
- What utilities do I have on-site?
- What is my primary means to access the site?

Design considerations

Various options when designing the upweller

- Tank design
- Discharge placement
- Silo shape
- Silo construction material
- Pump design and placement
- Size

Design considerations

Tank design

- Generally square tank or trough

Design considerations

Alternate tank designs

- No tank

Design considerations

Drain placement

- Central trough vs Outboard discharge

Design considerations

Silo shape

- Square vs Round

Design considerations

Silo Material

- Wood vs. Plastic vs. Fiberglass

Design considerations

Materials for Silo Construction

- Duct Pipe

Design considerations

Materials for Silo Construction

- Duct Pipe
- Sewer Pipe

Design considerations

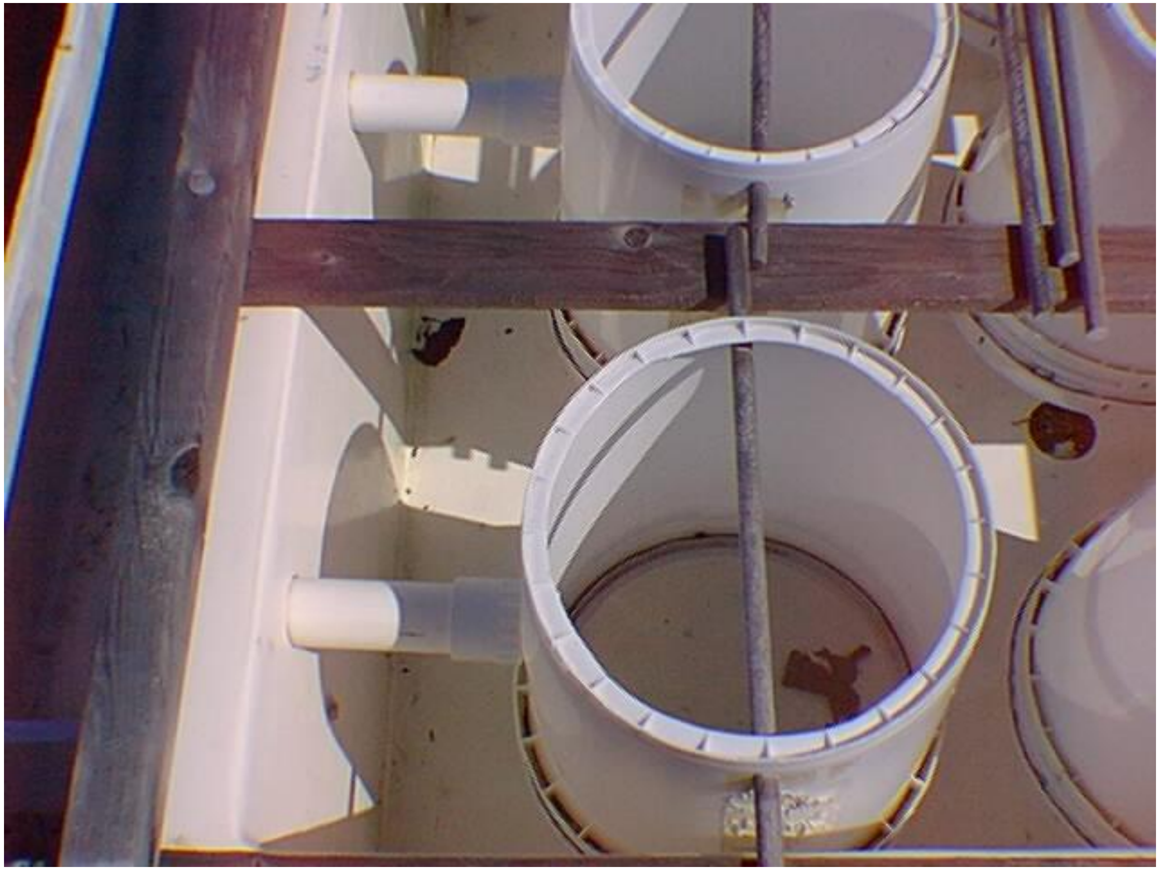
Materials for Silo Construction

- Duct Pipe
- Sewer Pipe
- Plastic Barrels

Design considerations

Materials for Silo Construction

- Duct Pipe
- Sewer Pipe
- Plastic Barrels
- Plastic Buckets



Design considerations

Materials for Silo Construction

- Duct Pipe
- Sewer Pipe
- Plastic Barrels
- Plastic Buckets
- Sheet plastic

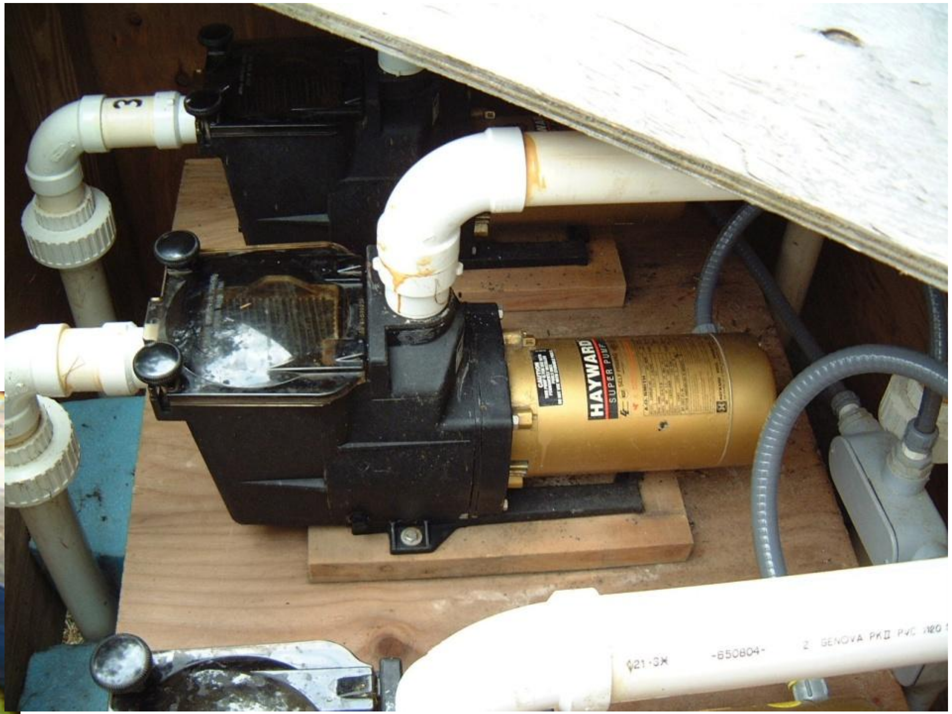
Design considerations

Materials for Silo Construction

- Duct Pipe
- Sewer Pipe
- Plastic Barrels
- Plastic Buckets
- Sheet plastic
- Fiberglass

Design considerations

Centrifugal Pumps

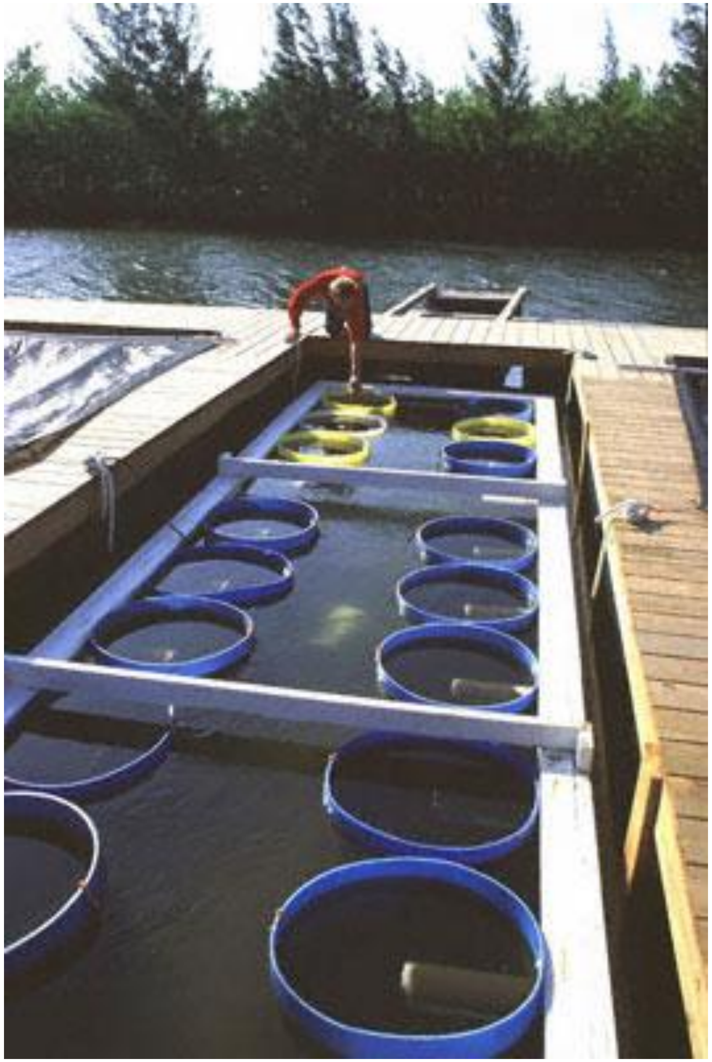


- Surface mount vs Submersible

Design considerations

Other Pumps

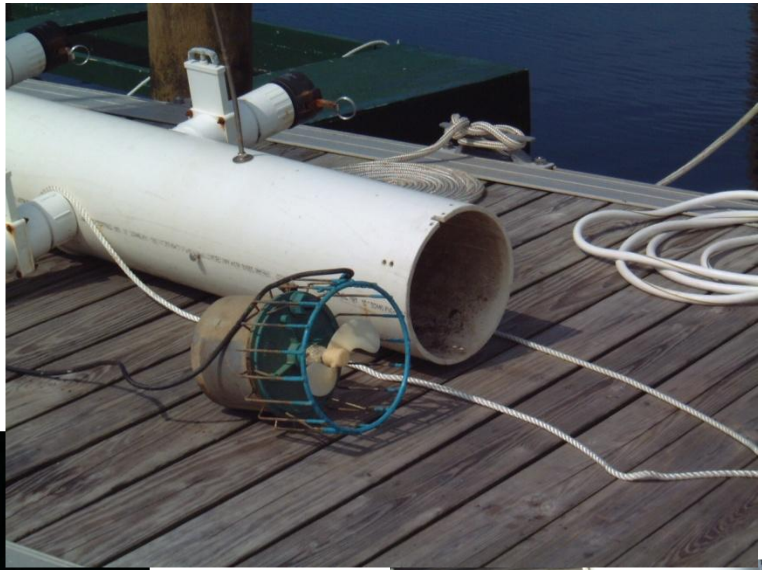
- Axial Flow Pump
  - upstream

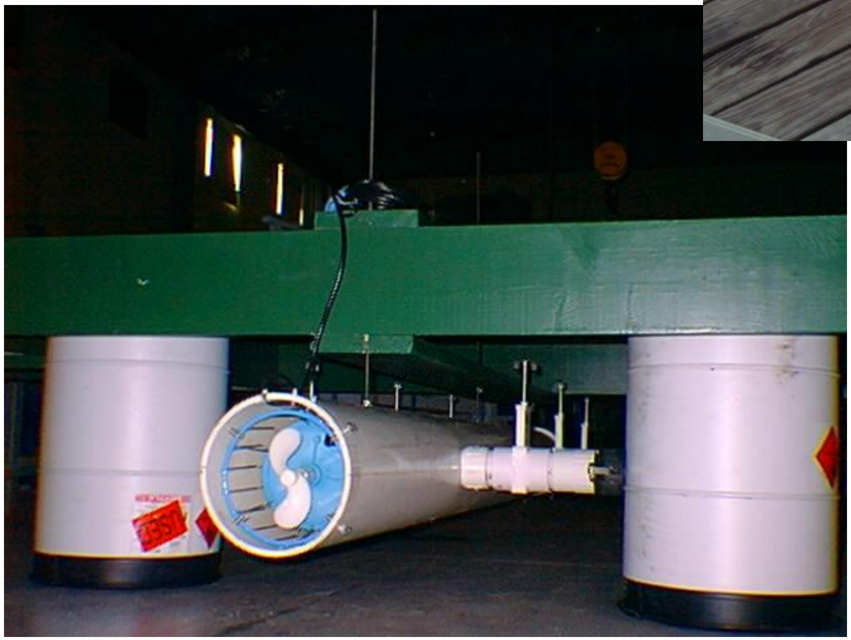


Design considerations

Other Pumps

- Axial Flow Pump
  - upstream
  - downstream





Design considerations

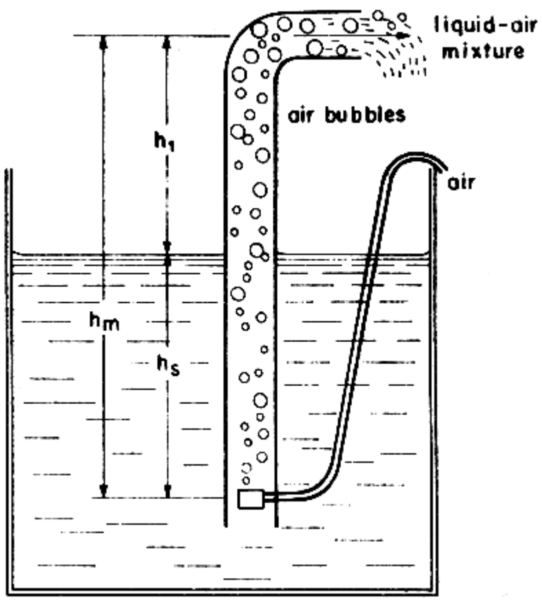
Other Pumps

- Axial Flow Pump
- Paddlewheel

Design considerations

Other Pumps

- Axial Flow Pump
- Paddlewheel
- Airlift



Design considerations

Scale

- Small

Design considerations

Scale

- Small
  to
- Not so small

Two questions seem to always come up!

- How much flow do I need to provide through the upweller?
- How many seed can I put in the upweller?
  or How big an upweller do I need for X million seed?
- Sometimes the answer to these two questions can be combined.
  - For example - a Rule of Thumb you may have heard
  - “100 gpm per 100,000 seed”
- However – we can do better than that!
- Need to think about
  - Flow
  - Stocking density

Upweller Comparison Data - flow

Upweller Data			flow (gpm / silo)	silo area (in^2)	flow/area (gpm/in^2)
Literature values					
*	Malinowski	1986	5.0	153.9	0.0325
*	Manzi *et al*.	1984	9.3	381.6	0.0245
Upwellers					
	Floating airlift	Harwich	21.0	153.9	0.1365
*	NC/Mook tidal raft	book	11.1	361.0	0.0307
*	Tidal raft	Eastham	13.2	324.0	0.0407
	Land-based - outside	Mashpee	5.8	176.6	0.0330
*	Land-based - outside	Falmouth	10.4	176.6	0.0589
	Land-based - outside	Yarmouth	6.3	254.3	0.0246
*	Land-based - inside	Chatham	8.0	254.3	0.0313
	Land-based - inside	Harwich	4.0	254.3	0.0157
	Raft-based - outside	Brewster	9.4	418.0	0.0224
*	Axial flow	SEMAC	83.3	254.3	0.3275
*	FLUPSY - conv	Leavitt	67.5	576.0	0.1172
*	FLUPSY - modifed	Leavitt	71.7	576.0	0.1245
*	FLUPSY - solar	Leavitt	79.4	576.0	0.1378

Average = 0.08 $gal/in^2/min$

Best = 0.10 $gal/in^2/min$

Calculating stocking density

How much seed can you put in an upweller?

- It is very site specific!
- Need to calculate a starting point.
- Adjust your stocking density as you learn your system and your waters.

Silo Stocking Densities (from Malinowski – 1986)

Sieve Mesh Size	Approximate Clam Size Retained	Number of clams per ml	Optimal Stocking Volume	Number of clams in Optimal Stocking Volume (approx.)	Weekly Volume Increase* (approx.)
Initial	0.75 mm	2,500	125 ml	312,000	100-300%
1.0 mm	1.50 mm	720	175 ml	125,000	100-200%
1.4 mm	2.50 mm	116	300 ml	35,000	100%
2.0 mm	3.30 mm	99	350 ml	35,000	100%
2.8 mm	3.90 mm	45	600 ml	27,000	90%
3.4 mm	6.00 mm	20	1,000 ml	19,500	50%
5.7 mm	8.30 mm	6	1,500 ml	9,000	35%

*Weekly increases in total volume of clams in a silo, as measured in a graduated cylinder

Silo Stocking Density (from Jones & Jones 1993)

- The following chart shows the number of individual upwell units required to produce seed of 6-8mm outplanting size, given a flow rate of 20 l/min/l seed.

UPWELLER DIAMETER	NUMBER OF CLAMS 10,000	20,000	50,000	100,000	500,000	1,000,000	2,000,000	5,000,000
inches								
6	1	1	3	7	33	67	133	333
8	1	1	2	4	19	38	75	188
10	1	1	1	2	12	24	48	120
12	1	1	1	2	8	17	33	83
14	1	1	1	1	6	12	24	61
20	1	1	1	1	3	6	12	30
22	1	1	1	1	2	5	10	25
25	1	1	1	1	2	4	8	19

Upweller Comparison Data - Density

Upweller Data			flow (gpm / silo)	silo area (in^2)	flow/area (gpm/in^2)	clams/silo (#)	clams/area ($\# / in^2$)	clams/area-flow ($\# / in^2$-gpm)
Literature values								
*	Malinowski	1986	5.0	153.9	0.0325	12,000	78.0	15.6
*	Manzi *et al*.	1984	9.3	381.6	0.0245	40,000	104.8	11.2
Upwellers								
	Floating airlift	Harwich	21.0	153.9	0.1365	5,000	32.5	1.5
*	NC/Mook tidal raft	book	11.1	361.0	0.0307	15,625	43.3	3.9
*	Tidal raft	Eastham	13.2	324.0	0.0407	12,500	38.6	2.9
	Land-based - outside	Mashpee	5.8	176.6	0.0330	41,667	235.9	40.4
*	Land-based - outside	Falmouth	10.4	176.6	0.0589	17,857	101.1	9.7
	Land-based - outside	Yarmouth	6.3	254.3	0.0246	41,667	163.8	26.2
*	Land-based - inside	Chatham	8.0	254.3	0.0313	17,045	67.0	8.4
	Land-based - inside	Harwich	4.0	254.3	0.0157	67,797	266.6	66.6
	Raft-based - outside	Brewster	9.4	418.0	0.0224	31,250	74.8	8.0
*	Axial flow	SEMAC	83.3	254.3	0.3275	83,333	327.6	3.9
*	FLUPSY - conv	Leavitt	67.5	576.0	0.1172	93,750	162.8	2.4
*	FLUPSY - modifed	Leavitt	71.7	576.0	0.1245	93,750	162.8	2.3
*	FLUPSY - solar	Leavitt	79.4	576.0	0.1378	93,750	162.8	2.1

Average = 13.7 $\#/gal/in^2/min$

Best = 4.8 $\#/gal/in^2/min$

Calculating approximate stocking density

- Surface area of 18 inch diameter round silo
  - $A = \pi r^2$
  - $A = 3.14 \times 9^2 = 254.3 \text{ in}^2$

- Flow rate is 75 gpm through each silo

- Target density is 5 clams/gpm-in^2 (@ 10 mm)

- Stocking density in a six silo system?
  - Stocking density per silo:
    254.3 in^2 x 75 gpm x 5 clams/gpm-in^2 = 95,362 clams
  - Capacity of upweller system:
    6 silos @ 95,362 clams/silo = 572,175 clams

The final product

Whatever the nursery system set-up, the objective is the grow the largest and healthiest animals in the least amount of time at the least cost.