Comparative Study of Four Popular Grow Out Methods

February 15, 2001 through May 15, 2003

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Executive Summary

The '*Comparative Study of Four Popular Grow Out Methods*' was undertaken to examine four promising grow-out methodologies for a small aquaculture operation and to compare them with regard to costs, convenience, maintenance and performance. Its objective was to determine whether any system emerged as more cost effective and efficient than the others, and whether a clear choice exists. Stated more simply, it was an opportunity to explore the "pros and cons" of the various systems in use.

The study was divided into four phases: a Fabrication Phase where the applicant purchased materials and assembled equipment for the above-mentioned methodologies; a Nursery Phase where 40,000 oyster seed were to be grown to one inch size; a Grow-Out Phase commencing with placement of long-line rigs of the four systems in the water with 10,000 seed each; and a Harvest Phase where oysters were harvested and records kept of harvests and mortality. During the Grow-Out Phase observation data was compiled on growth/survival rates, system convenience and durability, predator and fouling rates/types and maintenance time/costs.

The experiment had a duration of over two years and yielded a wealth of good information about strengths and weaknesses of specific systems but it failed to distinguish any particular equipment as superior over the others. The objective of the project was to engage in a comparison to see whether a clear choice exists. It doesn't. Rather, important considerations were identified and explored in greater detail and information was recorded that will help lead an interested party through the steps and considerations that will help him or her select equipment that is best for a particular situation. All aspects of the experiment were completely performed and all stated objectives and goals were met. Probably the most valuable lesson from this study is to work through a process of identifying needs and tailoring equipment to meet them.

Introduction

Aquaculture is becoming an increasingly important component of the shellfish industry and reliable techniques and equipment need to be developed for the particular needs of specific estuaries. The Chesapeake Bay and its tributaries has the potential to once again become one of the pre-eminent sources of high quality oysters, but only if individual growers can be encouraged to invest in the production of this valuable and important food source.

The '*Comparative Study of Four Popular Grow Out Methods'* was undertaken to examine promising grow-out methodologies and to compare them with regard to costs, convenience, maintenance and performance. Its objective was to determine whether any system emerged as more cost effective and efficient than the others, and whether a clear choice exists. Numerous factors impact the decision as to what system is best suited to a particular operation and location. This report examines these four grow-out systems in the context of a soft mud bottom, medium flow, sheltered-water aquaculture location.

Prior to this study, little quantitative and qualitative data on oyster growing technologies and costs was publicly available. The comparative information on technology cost and performance contained in this study will allow growers to make educated decisions on best practices that will maximize their return on investment.

Description of Experiment

Four grow-out systems that show promise for use by a small aquaculture operation were selected for comparison. The well known "Taylor Float" designed by VIM's Jake Taylor utilizes a 2 foot x 10 foot, 1"x 1" PVC coated wire basket attached to a rectangular four inch schedule 20 PVC float. The "Oyster King" of the author's design, inserts an end loading 36"x 18" PVC (1"x 1") coated wire box inside a compact (36"x 18") PVC float that is similar to the "Taylor" design. The "Oyster King Bottom Rig" utilizes the same end loading wire box as above, with feet instead of the float so that it can be placed on the bottom. The "Circle C Floating Oyster Reef " consists of a ten foot PVC float of the Taylor design which attaches five ADPI bags directly to the float utilizing cross-stress harness' instead of a wire cage. *(See Appendix 1: Oyster Grow-out Systems Utilized in Study*)

Fabrication and Nursery Phases

During a "Fabrication Phase", the applicant fabricated the four grow-out systems described above. The four types of equipment were built in sufficient numbers to grow ten thousand oysters each, translating into: A) 10 Taylor Floats; B) 30 Oyster Kings; C) 30 Bottom Rigs; and D) 10 Circle C Reefs. *(See Appendix 2: Fabricated Units Utilized in Study)* Simultaneously, a "Nursery Phase" was undertaken where 40,000 oyster seed were to be grown to one-inch (25mm) average size, the point that each system exhibits common characteristics. As a result of problems with seed die-off, the plan was modified to use two different sizes; 30,000-32,000 one-inch seed and 10,000-12,000 3/8-1/2 seed. Each system was then to be loaded with approximately 10,000 seed each and put out in long-line rigs at a Horn Harbor lease, permitted by VMRC for oyster floats. *(See Appendix 3: Oyster Seed Grow-out in Study)*

Grow-out Phase

The "Grow-out Phase" commenced with placement of the oyster seed in the water. Four "control samples" with fifty carefully selected 24-26mm oysters were put in 18"x 18" seed sleeves with ½ x ½ mesh and placed with each of the four grow-out systems. Measurements were taken and recorded and all systems were checked at two-week intervals, and major maintenance was performed quarterly or as needed. System comparison observation data was compiled on growth/survival rates, system convenience and durability, predator and fouling rates/types and maintenance time/costs. In addition, harvest/ mortality figures were compiled as well as fabrication time and costs.

The Grow-out Phase was initially scheduled to end with a final fall harvest of the oysters carried over the summer of 2002 (December 2002) and a final report prepared in the first quarter of 2003. However, a late start and seed complications necessitated an extension through the spring harvest of 2003. The second batch of seed obtained was spawned in spring 2001 and did not finish its two-year growing cycle until spring 2003. Final harvest tallies were completed in May 2003.

Results, Conclusions and Recommendations

The Study evaluates each of the systems in major comparison areas including: 1) Production Costs; 2) Maintenance Time and Cost; and 3) Harvest, Growth and Survival Rates. *(See Appendix 4: Oyster System Comparisons)* Some of the data collected, while significant to the experiment protocols, does not provide enough distinction to differentiate between systems. The study augments this data with key observations and considerations. It contains non-measurable information that was important to the development of results, conclusions and recommendations. This information may be critical to one system, but not significant for another. The following is a summary of project results, conclusions and recommendations.

Production Costs

The four grow-out systems were each fabricated in sufficient quantity to grow ten thousand oysters. Both the Taylor Float and Circle C Rig have a capacity of one thousand oysters each and both require the utilization of bags as a principal component (the Taylor can be used without bags but ease in handling strongly argues for the use of bags to facilitate handling). The Oyster King and Bottom Rig require three cages to grow one thousand oysters, therefore the data has been adjusted to reflect this requirement. While they do not utilize bags or sleeves for handling larger seed, they can be adapted to grow any size seed by placing the smaller seed in bags and inserting the bag in the cage. Care should be taken when examining the data to distinguish these differences as material costs, set-up costs and maintenance costs change significantly.

The major material components of the systems differ in that three utilize PVC pipe and one does not, while three use PVC coated wire and another does not. While one requires ADPI bags, the others do not require them, yet all could utilize them. All have a constant in that they each require physical labor to construct and set up, however, this component can change significantly if bags are used. For example the Bottom Rig that is already the most economical, will enjoy almost a 50% material cost reduction if bags are not required.

Also, while the Oyster King only reduces material cost by 15%, when set up time (also harvest and maintenance costs) is included and this savings compounded over the life of the equipment the Oyster King will prove to be much more economical than the Circle C Rig requiring high set up and harvest costs which cannot be reduced without changing the way it is used (Note: this cost can be improved substantially by eliminating the cross-stress harness' and relying on cable ties). The Taylor Float is a good medium cost alternative in that it enjoys moderate set up time and will prove competitive over its useful life (Note: by making the Taylor 10' instead of 8' capacity allows an additional bag and performance is not negatively impacted). No system clearly distinguishes itself based solely upon production costs. *(See Appendix 5: Production Costs)*

Maintenance Time and Cost

The above discussion has already alluded to cost distinctions with regard to labor costs associated with day-to-day usage. These major cost components are: 1) set up cost which is the time involved putting seed in the respective systems and placing those systems in a long line; 2) breakdown cost, or the time to bring a system from long line to dock, empty oysters and break down for cleaning; 3) cleaning cost which is the time to pressure wash and debarnacle the bags, cages and floats; and 4) reinstallation cost which is simply setup costs once the growing process has begun. It is important to emphasize that these are reoccurring costs that repeat with frequent regularity, as opposed to the one time labor charge associated with fabrication. Careful consideration should be given to which system involves a minimum of routine labor.

With the exception of the Circle C Rig which is labor intensive and rated inferior in this category, the remaining systems are comparable with regard to the numbers, each involving about the same amount of time if bags are not used in the Oyster King or Bottom Rig. This is most of the time as bags are redundant when oysters are slightly larger than one inch. The tables all calculate costs for the Oyster King and Bottom Rig using bags so that there is no chance of understating their costs but the following reductions can be taken when bags are not used: setup 7 minutes; harvest 7 minutes; break down 3 minutes; cleaning 8 minutes; and reinstallation 7 minutes. After one adjusts the cost figures for these reductions it becomes clear that unit costs are all very close. This number would not be reduced on the Taylor Float by eliminating bags, as it would suffer increased costs in other areas that would offset the savings.

During the life of the project no systems failed or required major repairs. However, an effort was made based on experience and fabrication cost to derive a comparative factor that took into account the probability of a system failure coupled with likely repair cost (severity). Three ratings, Superior, Neutral, and Inferior were assigned the respective systems with the Bottom Rig easily outstripping the other systems because of the absence of a float that is the main source of problems. Care should be taken when gluing the PVC floats as these joints have a high incidence of failing and repair is costly. The Oyster King is distinguished from the Taylor and Circle C in that no structural stress is placed upon the float as it merely provides buoyancy and relies on the wire cage for structural support. One might also consider filling the PVC pipes with Styrofoam peanuts during fabrication to minimize water infiltration in the event of a leak.

Convenience and Durability

A great deal has already been alluded to with respect to convenience and durability. It has already been pointed out that bags should be an integral part of the Taylor Float configuration based mainly on the contention that the time involved to remove loose oysters from it would clearly offset any savings from not handling the bags. The bag allows the significant ease of access in loading and unloading and clearly distinguishes the Taylor as superior to other systems in this respect. The open top allows items to be added or removed easily which is very convenient; however, it does also make theft much easier than the other systems. It is also quite durable when the float is left in the water and only the bags worked. It should be pointed out that many simply flip the float upside down to allow the sun to dry any fouling and perform maintenance only when the barnacles get real bad.

The Oyster King and Bottom Rig also rate superior with regard to handling convenience as their compact size makes them reasonable to handle even when loaded with oysters. Additionally, their portability allows easy movement if relaying is necessary or they need to be put back in the water temporarily due to unforeseen circumstances. They are unrivaled when loading and unloading oysters, as their bungee cord and hook are simply undone and the contents poured in or out. Even bags just slide in or out of the cage. The inferior rating of the Circle C Rig in the accessibility and mobility categories relates to the rig's cross stress harness design. The harnesses prevent any rearranging or individual movement of bags, making it impossible to access the contents of one of its bags without breaking down the whole unit. The design also drove up labor cots related to set up, maintenance and harvest.

The issue of durability has already been discussed to some extent. The PVC floats of the Taylor Float and the Circle C Rig are both relied upon for structural support. This puts stress on the joints and can cause failure that is expensive and troublesome. In addition, they are very heavy and bulky when loaded and efforts to move them can cause joint failure. The Oyster King relies on an internal float that is compact and protected. It is not used for structural support and has been relatively trouble free after eight years. The Bottom Rig uses no float and is fairly durable except that there is structural weakness at the door opening where the foot joins the cage. It is important that a 2" lip extends into the door opening and that it be well stapled.

Predators and Fouling

Fouling is a very important element to oyster aquaculture in that it can affect flow rates, oxygen levels and competition for growing space. The best defense is a good maintenance schedule and adequate spacing of oysters as crowded cages inhibit growth and shell shape. Providing adequate space will help the oysters overcome heavier fouling when maintenance cannot be performed. The experiment called for the observation of fouling types and rates, however it also provided for quarterly maintenance that obviated the ability to observe fouling rates of any critical degree. In addition, a brine dip was added to major maintenance to combat predators and it seemed to also slow the rate of fouling. This may have been due to allowing the rigs to dry in the sun after dipping rather than the dip. Appendix 6 identifies the types of fouling present in the respective systems as well as observations as to whether they presented any adverse threat as well as whether remediation (maintenance) could be provided. Little critical comparative data was yielded in this section except for the fact that there are some observable differences in type and rate of predators and fouling between bottom and surface rigs.

There were numerous predators and associated creatures that thrived around the oyster rigs. A list of the types, the threats they pose, and need for remediation is provided in Appendix 6. For the most part the cages and bags protect the oysters from their major predators and these were listed in a no impact category. The two major exceptions that I encountered were Blue Crabs, which can be devastating, and Polydora worms, which will either kill the oyster or make it unusable. A brine dip was added to the maintenance protocols and had a very beneficial impact as it reduced many of the potential predators or competitors as well as reducing fouling. The crabs could be eliminated with routine maintenance and in some instances stabbed with a screwdriver without breaking the system down. The Taylor Float is rated superior with regard to combating predators in that the bag could easily be removed from the float and placed directly in the brine dip. Additionally, it was easy to see crabs in the bags and eliminate them. The Oyster King is also rated superior in this regard in that it too could be placed directly in the brine dip. This observation closely mirrors the discussion and factors regarding ease of handling. While the Circle C rig was rated superior in predator resistance it was rated neutral in the fouling category. The recommended maintenance method to reduce fouling, flipping the rig upside down for a day and allowing the reversal to combat the fouling was found to be extremely difficult to do and yielded very limited results. *(See Appendix 6: Fouling and Predators and Appendix 7: Fouling in Units)*

Harvest, Growth and Survival Rates

This aspect of the experiment produced the most unanticipated results, and did not comport with expectations. Prior to this study, a much superior growth performance was expected from the Circle C Rig than was anticipated from the Bottom Rig. The data shows that this did not happen. Rather, the Circle C Rig seemed to be adversely effected by slight temperature variances on the surface, while the Bottom Rig was a steady performer. There did seem to be a lag in slowdown caused by the onset of colder temperatures possibly due to warmer water on the bottom. Also growth in the Bottom Rig was slower to commence with the spring warm up which again could be tracking water temperatures. The Oyster King and Taylor Float performed almost identically. The appended graph *(See Appendix 8: Oyster Growth Comparison)* and data chart *(Appendix 9: Oyster Growth Comparison Data)* show little that would substantially distinguish one system from another. The growth results may have been significantly impacted by the mild winter and higher than normal water temperatures.

The end of the experiment was postponed approximately one quarter so that spring harvest totals could be recorded and added to earlier figures. This was because of a problem with seed at the project's inception. A shortfall due to a die off had to be covered with seed spawned in the spring of 2001 while the original seed was from the fall of 2000. Consequently the ending date for the experiment was pushed back so that the younger seed could go through a full growth cycle. This was possibly a bonus as the harvest records and mortality rates are a little more telling than the growth averages. Probably the most important observation is that there were significantly more oysters harvested from the Bottom Rig. Additionally the percentage of oysters reaching harvest size was noticeably higher and the percentage of oysters dying was lower. While the reason for this is uncertain, it does distinguish the Bottom Rig from the other systems in this regard.

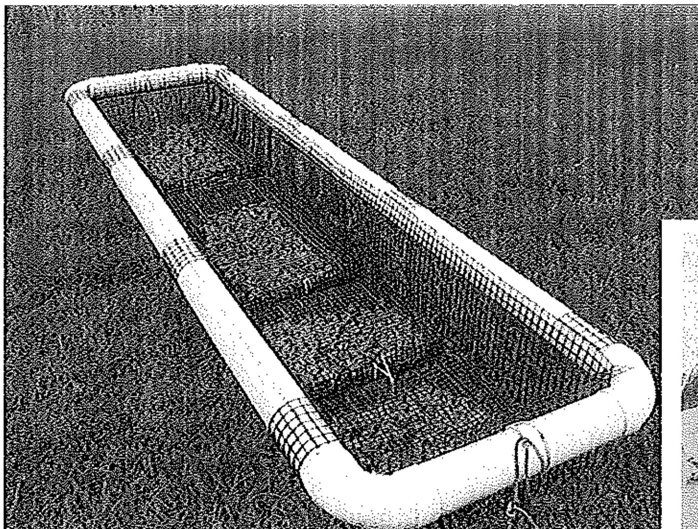
Summary

The most valuable aspect of this experiment is that it will highlight key considerations that should enable one to work through the process for a particular set of parameters and reach a better-informed decision. A great deal of information was gleaned from these observations, some of it expected, some not. The system that was expected to do the best was the worst, the one expected to lag did not, and the "tried and true" proved why it is so. The data derived from a particular category often proved of little value in distinguishing a hierarchy between systems but that did not diminish its informational importance as a factor to be weighed in confluence with the others in the overall review process. A great deal was learned from the experiment that will improve the oyster aquaculture process and production rates.

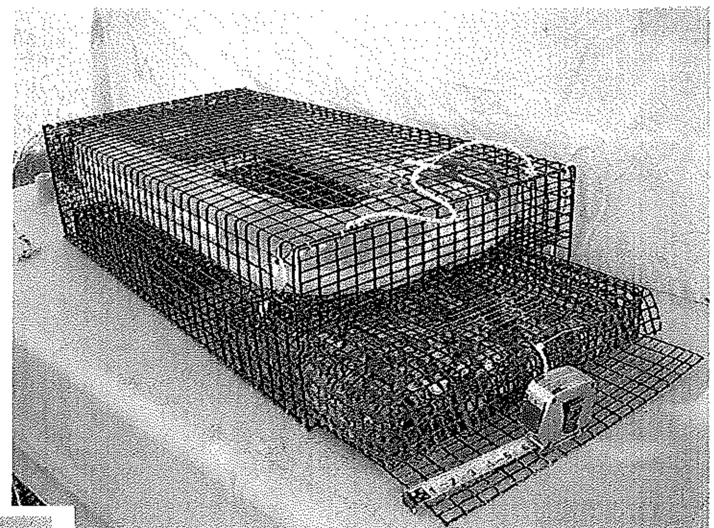
The single most important consideration is that a combination of equipment is probably the best approach. In a perfect world, seed should by fast grown in upwellers, and then moved to a level in the water column that was best suited to conditions at that particular time. Surface rigs seem to gain an advantage in spring as water temperatures are rising. They suffer a drop off in performance as water temperatures get hot. Larger oysters should be moved to bottom rigs in the summer months to take advantage of the slower onset of warm water and hence reduce mortality rates. These changes could be effectuated in conjunction with major maintenance that would avoid any extra handling expense. While not included in the experiment, the use of a "rack and bag" system should be carefully examined, as they can be very effective and economical if conditions are right. Finally, life cycle costs that are decreased by the elimination of repetitive costs associated with day-to-day maintenance and operation are a much more important determinant of economy than the one time cost of acquisition or fabrication of equipment.

A myriad of factors must be considered in the decision process many of which were not within the parameters of this experiment. Site conditions such as bottom type, water flow and shelter along with location (neighbor objections to interrupted views can be fatal) will be critical for any equipment review and could wind up as the key factor in the decision process. Also legal issues such as permitting and access need to be examined as well as security (these issues were prime movers leading to the Bottom Rig's design). The scale of production and investment is critical as this equipment is largely contemplated for smaller less capital intense operations. There are many things that could be mentioned but space does not permit full discussion of my observations. There is a great deal of useful information in the appended material that should be reviewed. Sincere thanks goes to the Virginia Fishery Resource Grant Program for making the effort to improve the body of knowledge and resources available to this vital industry.

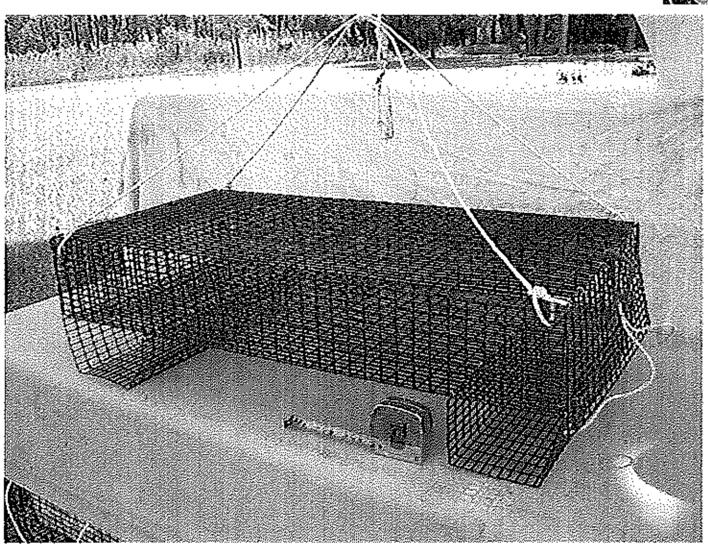
Appendix 1: Grow-out Systems Utilized in Study



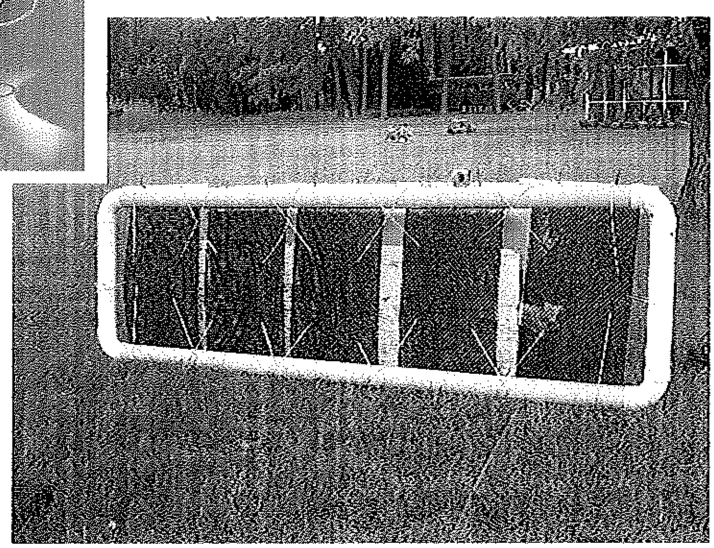
Taylor Float



Oyster King

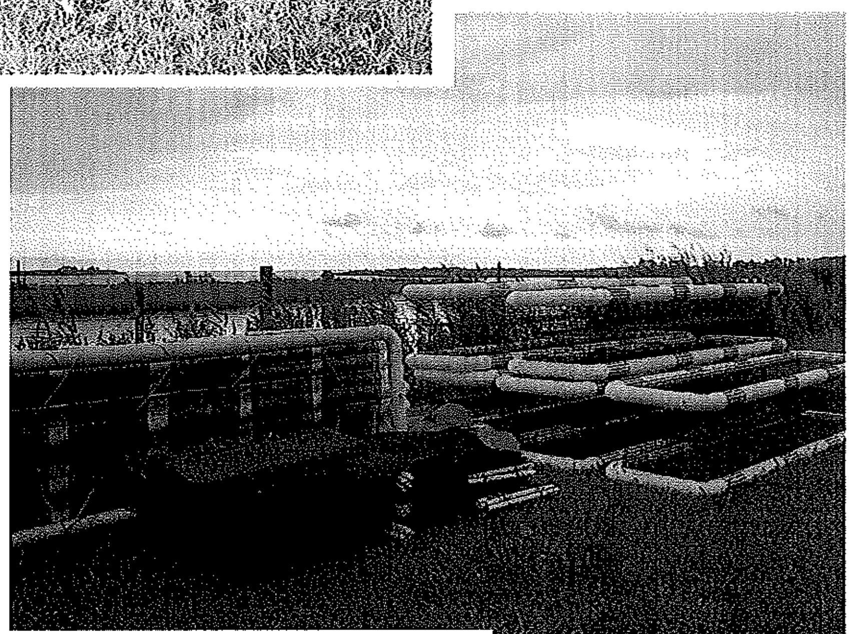


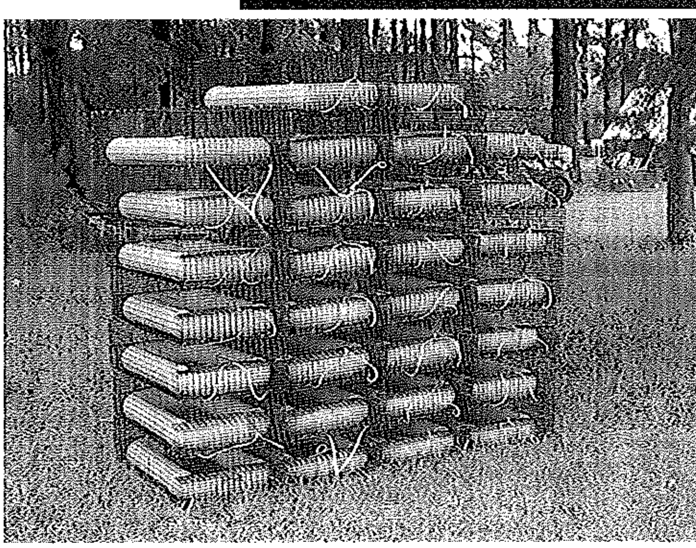
Oyster King Bottom Rig



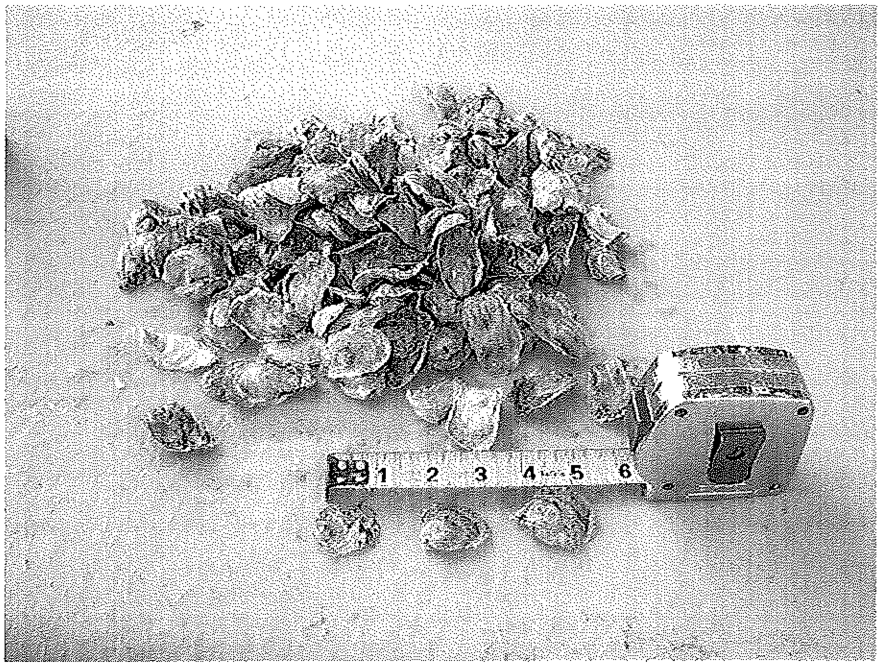
Circle C Floating Oyster Reef

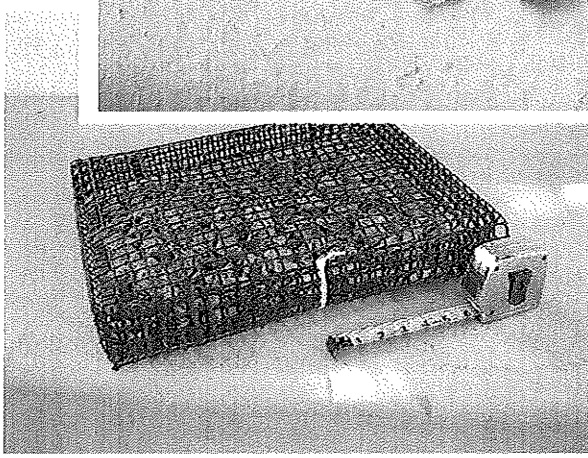
Appendix 2: Fabricated Units Utilized in Study

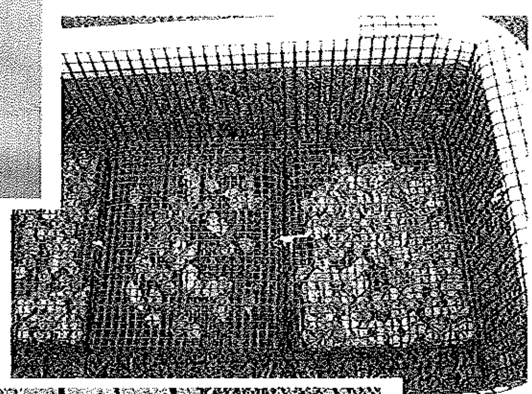




Appendix 3: Oyster Seed Grow-out in Study







Appendix 4: Oyster System Comparisions

Points of Comparison	Oyster King	Bottom Rig	Taylor Float	Circle C Reef
Production & Fabrication Costs				
Note: Adjust Oyster King/Bottom Rig due to 1/3 capacity				
A. Material Costs (subtract $5 bag cost for OK and BR)	32.84	17.83	61.48	55.51
B. Labor Costs	14.96	8.51	21.08	13.61
C. Set Up Costs (set up time x labor rate)	5.11	6.81	6.81	20.41
Note: reduce costs by 50% when seed is large for Oyster King and Bottom Rig systems				
Subtotal:	52.91	33.15	89.37	89.53
D. Cost Adjustment (3x)	105.82	66.31	n/a	n/a
F. Total Cost per unit (capacity for 1000 oysters)	158.73	83.56	89.37	89.53
System Convenience & Durability				
Note: see costs reductions in text for savings when larger seed is used in Oyster King & Bottom Rig				
A. Set Up Time (time to install 1000 oysters in water)	15min.	20min.	20min.	50min.
B. Accessibility (ease of adding or removing oysters)	S	S	S	I
C.Mobility (Ability to move system after set up)	S	S	N	I
D. Harvest Time (move rig from water to culling table)	21min.	18min.	11min.	45min.
Maintenance Costs				
Note: see costs reductions in text for savings when larger seed is used in Oyster King & Bottom Rig				
A. Breakdown Costs (time to break unit down to clean)	7.14	6.12	3.74	15.31
B. Cleaning Costs (pressure wash time for 1000 oysters)	30.61	15.31	22.11	17.01
C. Reinstallation Costs (set up & reinstall in water)	15.31	18.39	6.81	20.41
D. Total Maintenance Costs (A+B+C)	53.06	39.82	32.66	52.73
E. Repair Costs (probability of problem x severity)	N	S	I	I
Growth & Survival Rates				
A. Growth Rate See Graph				
B. Harvest Totals (number of oysters harvested)	5907	7134	6296	6331
C. Percentage of oysters reaching harvest size	58.51%	66.89%	61.22%	61.52%
D. Mortality (number of dying)	3138	2586	3044	3256
E. Percentage of oysters dying	31.08%	24.25	29.60%	31.64%
Predator & Fouling Types/Rates				
A. Predators (resistance & susceptibility)	N	I	I	S
B. Fouling (resistance & susceptibility)	N	N	N	N

SYMBOL KEY (reflect rating where no numbers exist)

Symbols reflect comparison of systems with each other.
SUPERIOR "S"
NEUTRAL "N"
INFERIOR "I"

Appendix 5: Production Costs

	Oyster King	Bottom Rig	Taylor Float	Circle C Reef
Components:				
wire	$12.06	$9.68	$21.12	$0.00
staples	$0.43	$0.57	$0.92	$0.00
elbows	$8.36	$0.00	$8.36	$8.36
glue & primer	$0.81	$0.00	$0.81	$0.81
PVC pipe	$3.99	$0.00	$13.74	$14.25
line	$0.15	$1.44	$0.64	$2.20
hooks	$2.03	$1.14	$0.89	$4.89
bags	$5.00	$5.00	$15.00	$25.00
Materials:	**$32.83**	**$17.83**	**$61.48**	**$55.51**
(Subtract bag cost on Oyster King and Bottom Rig when seed is large)				
Labor:				
Manufacturing time x rate @.34min.	$14.96	$8.50	$21.08	$13.60
Set up time x rate @ .34min.	$5.10	$6.80	$6.80	$20.40
Subtotal:	**$52.89**	**$33.13**	**$89.36**	**$89.51**
Adjust for cost per 1000 (x3) (Labor for set up reduces 50% on Oyster King & Bottom Rig w/ large)	158.67	83.49	n/c	n/c
Total Unit Cost (per 1000 seed)	158.67	83.49	89.36	89.51

Appendix 6: Fouling and Predators

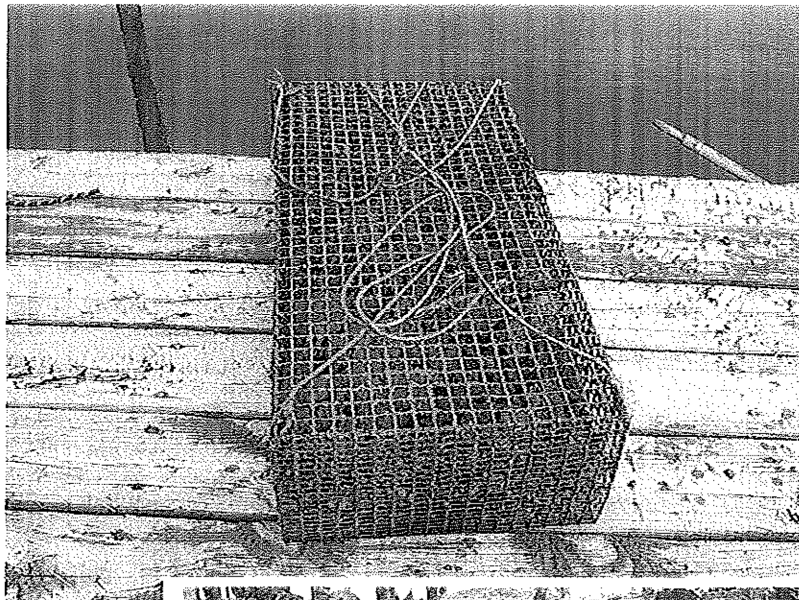
FOULING TYPE	OYSTER KING	BOTTOM RIG	TAYLOR FLOAT	CIRCLE C REEF
Algae (algae/sediment/psuedofeces)	P, H, R, RP	P, H, R, RP	P, H, R, RP	P, H, R, RP
Bryzoan (scurf/growth)	P, H, R, RP	P, M, R, RP	P, H, R, RP	P, H, R, RP
Teromorpha (waterline grass growth)	P, H, R, RP	X	P, H, NR	P, H, R, RP
Ulva (sheetgrass growth)	P, H, R, RP	X	P, H, R, RP	P, L, NR
Sponge	P, L, R, RP	P, M, R, RP	P, L, R, RP	P, L, R, RP
Sea Squirts	P, L, R, RP	P, H, R, RP	P, L, R, RP	P, L, R, RP
Anemone	P, L, RP	P, L, RP	P, L, RP	P, L, RP
Coral (tracklike growth that hardens)	X	P, M, RNP	X	X
Barnacles	P, H, R, RP	P, H, R, RP	P, H, R, RP	P, H, R, RP
Eelgrass (accumulation/other debris)	P, M, R, RP	X	P, M, R, RP	P, M, R, RP

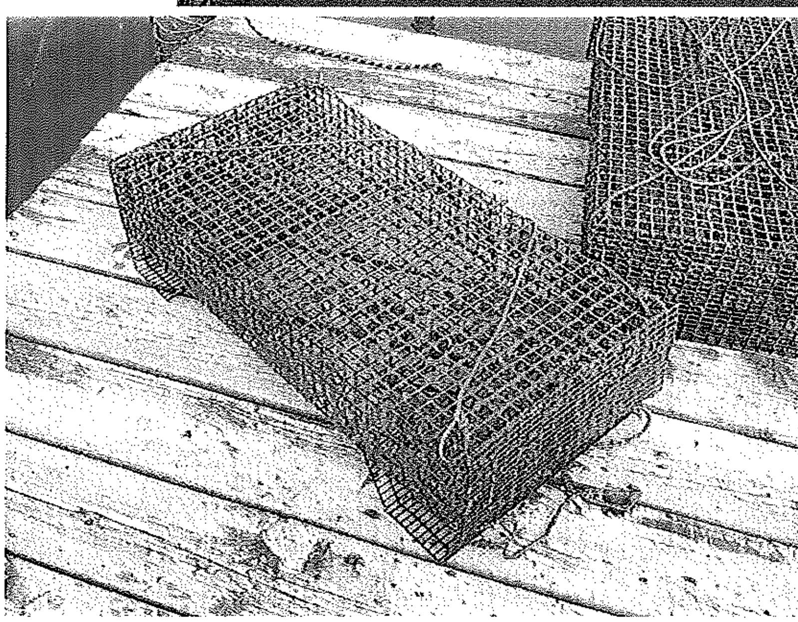
PREDATORS (associated lifeforms)				
Blue Crabs	P,L, R, RP	P,L, R, RP	P,L, R, RP	P,L, R, RP
Mud Crabs	P, M, NR	P, H, NR	P, M, NR	P, M, NR
Mussels	P,L ,NR	P,L ,NR	P,L ,NR	P,L ,NR
Amphipod	P, H, B, NR	P, M, B, NR	P, H, B, NR	P, H, B, NR
Grass Schrimp	P, H, B, NR	X	P, H, B, NR	P, H, B, NR
Pistol Schrimp	P, L, B, NR	P, L, B, NR	P, L, B, NR	P, L, B, NR
Periwikle Snails	P, L, B, NR	X	P, L, B, NR	P, L, B, NR
Polydura	P, M, R, RP	P, M, R, RP	P, M, R, RP	P, M, R, RP
Clam Worm	P, M, NR	P, M, NR	P, M, NR	P, M, NR
Footfungus	P, L, R, NRP	P, L, R, NRP	P, L, R, NRP	P, L, R, NRP
Stylocus (flatworm)	X	X	X	X
Blennies (shell dwelling fish)	P, H, B, NR	P, L, B, NR	P, H, B, NR	P, H, B, NR
Toadfish	P, L, NR	P, M, NR	P, L, NR	X
Sucker Fish	P, M, NR	P, L, NR	P, M, NR	P, M, NR
Round head fish	P, H, NR	P, L, NR	P, H, NR	P, L, NR
Oyster Drills	X	X	X	X
Starfish	X	X	X	X
Stingrays	P, M, NR	P, M, NR	P, M, NR	P, M, NR
Whelks	X	X	X	X
Hermit Crabs	X	X	X	X
Otters	P, M, NR	P, M, NR	P, M, NR	P, M, NR
Raccoons	P, M, NR	P, M, NR	P, M, NR	P, M, NR
Humans	P, L, NRP	P, L, NRP	P, L, NRP	P, L, NRP

SYMBOL KEY (See Note Below)

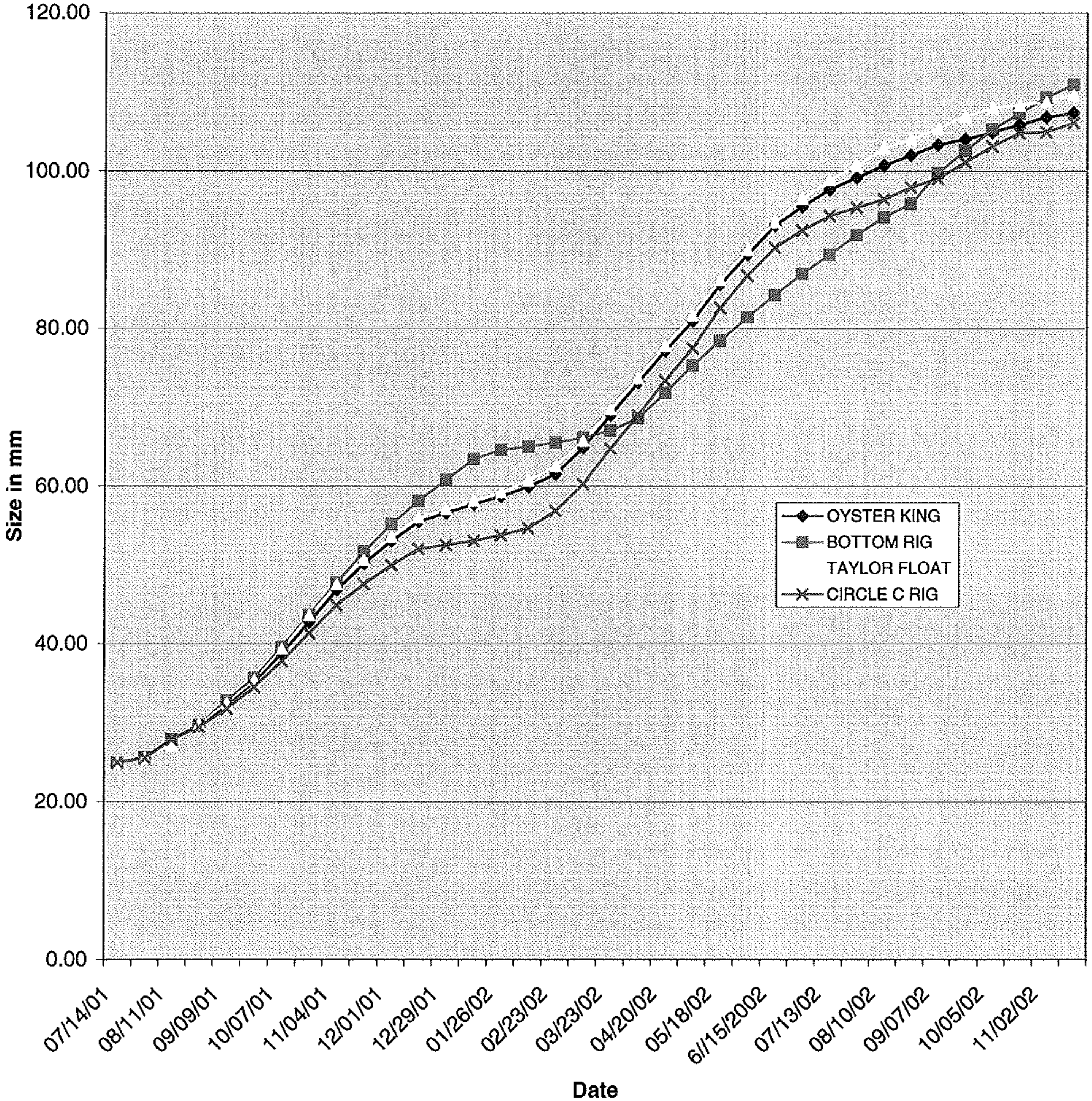
P = Present
NP = Not Present
L = Light Presence
M = Medium Presence
H = Heavy Presence
NR =No Remediation Necessary
R = Remediation Necessary
RP = Remedition Performed
NRP = No Remediation Practicable
B = Benificial
X = No Impact

Appendix 7: Fouling





Appendix 8: Oyster Growth Comparision



Appendix 9: Oyster Growth Comparison Data

Date:	07/14/01	07/28/01	08/11/01	08/26/01	09/09/01	09/22/01	10/07/01	10/20/01	11/04/01	11/17/01
OYSTER KING	25.00	25.6	27.91	29.71	32.3	35.18	38.81	42.74	46.86	50.21
BOTTOM RIG	25.00	25.79	28.01	29.84	32.91	35.75	39.64	43.71	47.82	51.75
TAYLOR FLOAT	25.00	25.58	27.27	29.82	32.53	35.43	39.38	43.61	47.53	50.63
CIRCLE C REEF	25.00	25.52	27.88	29.48	31.81	34.52	37.83	41.35	44.9	47.6

Date:	12/01/01	12/15/01	12/29/01	1/13/02	01/26/02	02/09/02	02/23/02	03/09/02	03/23/02	04/07/02
OYSTER KING	53.05	55.49	56.61	57.72	58.7	59.93	61.56	64.91	69.05	73.14
BOTTOM RIG	55.22	58.18	60.83	63.48	64.66	65.07	65.61	66.2	67.11	68.7
TAYLOR FLOAT	53.6	56.04	57.09	58.14	59.18	60.7	62.55	65.76	69.78	73.68
CIRCLE C REEF	49.98	52.05	52.56	53.07	53.8	54.68	56.88	60.29	64.78	69.02

Date:	04/20/02	05/05/02	05/18/02	06/01/02	6//15/2002	6/302002	07/13/02	07/27/02	08/10/02	08/24/02
OYSTER KING	77.16	80.97	85.59	89.43	93.19	95.59	97.73	99.23	100.73	102.05
BOTTOM RIG	71.9	75.35	78.49	81.48	84.27	87	89.45	92.02	94.32	96
TAYLOR FLOAT	77.78	81.63	86.15	90.05	93.6	96.52	98.9	100.7	102.91	103.97
CIRCLE C REEF	73.4	77.5	82.6	86.75	90.35	92.58	94.42	95.47	96.47	98

Date:	09/07/02	09/21/02	10/05/02	10/19/02	11/02/02	11/16/02
OYSTER KING	103.34	104.06	104.94	105.87	106.8	107.37
BOTTOM RIG	99.87	102.68	105.34	107.36	109.38	110.95
TAYLOR FLOAT	105.34	106.88	107.91	108.34	108.77	109.62
CIRCLE C REEF	99.06	101.15	103.15	104.83	104.91	106.08