

Evaluation of Elevated Rack Height to Control Biofouling on an Intertidal Oyster Farm: Efficacy and Economics

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Relevance

Mud worms are recognized as important pest on shellfish farms worldwide. This project, conducted on the east coast of the U.S. in the southern Delaware Bay, New Jersey sought to establish a strategy to control two mud worm species – *Polydora cornuta* and *Polydora websteri* on an intertidal oyster farm employing rack and bag oyster culture methods.

Core questions

1. Can I reduce biofouling, and the cost of mitigating biofouling, by using higher racks?
2. What are the production economic costs and or benefits that might be associated with employing higher racks?

Research approach

During the study oyster production and cost data was collected for oysters grown at each rack height (15", 20" and 30") in an experimental field trials. This information along with past business records for the rack and bag farm operation was used to develop an economic cost model. The economic assessment included a producer-level enterprise cost of production budget for a typical "rack-and-bag" oyster operation using standard height (15") racks. This served as a baseline for comparing the costs and benefits of changing to one of the other rack heights evaluated in the trial.

Findings

- Rack height had a significant effect on growth during the course of the experiment with higher rates of growth occurring with decreasing rack heights (more time out of water = less growth).. Extrapolating growth rates to yield market size oysters an addition 2 and 8 weeks of growing time was needed for oyster grown at 20" and 30" relative to the lower 15" rack height (Fig1).
- Oyster mortality was higher at a 15" (21%) rack height than at 20", and 30", which remained at or below 5% through the 12-week field trial (Fig 2)
- Biofouling associated with *P. cornuta* (mud worms) significantly increased with decreasing rack height resulting in increases in time (labor) spent washing (Figs 3 and 4) .
- *P. websteri* prevalence and coverage increased with decreasing rack height (Tab 1).
- Oyster condition, shell strength, shell height, shell width, and shell depth did not significantly differ among rack heights (Tab1).

The numbers (\$\$\$)

- A producer-level enterprise cost of production budget was developed for a rack and bag oyster farm (Tab 2).
- Higher costs and lower growth rates associated with higher rack heights were offset by significant increases in survival, thus increasing overall profits (Tab 3, Tab 4, Tab 5).
- Sensitivity analysis shows that methods to reduce biofouling dramatically shift profit margins.
- Even small improvements in survival can greatly improve profitability. Conversely, even small reductions in survival could lead to serious cash flow problems (Tab 6).
- In this instance gross revenues increased for 20" and 30" racks by \$61,794 and \$55,708, respectively; representing a significant profit increase for a small farm (<500,000 oysters in annual production) (Tab 6).

Learn more about this work

Reach out to lisa@sweetamalia.com. Visit our report at <https://northeast.sare.org/> Farmer Grant Project FNE23-038.

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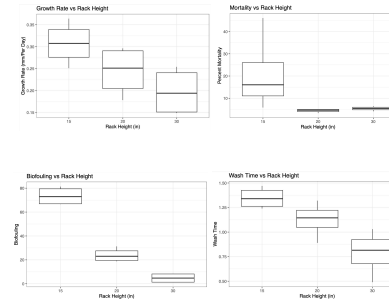


Table 2. Intertidal rack-and-bag enterprise budget

Item	# Units	Unit	Cost Per Unit (\$)	Total Cost In Year 1 (\$)	Total Cost In Year 2 (\$)	Total Cost (\$)	Cost Per Oyster (\$)	Percent Of Total
Variable Costs								
Zero Oysters (Seed)	400,000	Seed Oyster	\$0.01	\$4,000.00	\$0	\$4,000.00	\$0.01	2%
General Labor	1,000	\$ Per Hour	\$17.00	\$17,000.00	\$17,000.00	\$34,000.00	\$0.21	31%
Equipment	1,000	\$ Per Hour	\$17.00	\$17,000.00	\$17,000.00	\$34,000.00	\$0.21	31%
Supervisory Labor	1,000	\$ Per Hour	\$17.00	\$17,000.00	\$17,000.00	\$34,000.00	\$0.21	31%
Employment Tax	% of Labor Costs		7.65%	\$1,309.50	\$1,309.50	\$2,619.00	\$0.02	4%
Workers Comp	% of Labor Costs		5.00%	\$850.00	\$850.00	\$1,700.00	\$0.01	2%
Fuel	\$ Per Year		\$100.00	\$100.00	\$100.00	\$200.00	\$0.00	0%
Other Supplies (e.g., boats, etc.)	% of above Labor		0.80%	\$136.00	\$136.00	\$272.00	\$0.00	0%
Overhead	2.0%	Of above Costs		\$880.00	\$880.00	\$1,760.00	\$0.01	3%
Total Variable Costs				\$58,080.00	\$58,080.00	\$116,160.00	\$0.40	67%
Fixed Costs								
Insurance (Business Liability)	1	Year	\$1,000	\$1,000.00	\$1,000.00	\$2,000.00	\$0.01	1%
Lease Fees	1	Year	\$11.00	\$11.00	\$11.00	\$22.00	\$0.00	0%
Permit & License Fees			\$75.00	\$75.00	\$75.00	\$150.00	\$0.01	1%
Repairs (General, Major & Minor)	2%		\$1,440.00	\$1,440.00	\$1,440.00	\$2,880.00	\$0.02	2%
Slip Fee (Dock Rental)	NA		\$0	\$0	\$0	\$0.00	\$0.00	0%
Labor Payments	NA		\$0	\$0	\$0	\$0.00	\$0.00	0%
Depreciation			\$100.00	\$100.00	\$100.00	\$200.00	\$0.00	0%
Total Fixed Costs				\$1,626.00	\$1,626.00	\$3,252.00	\$0.02	3%
Total Production Costs (Variable + Fixed)				\$59,706.00	\$59,706.00	\$119,412.00	\$0.42	70%
Production Costs (Variable + Fixed)								
Post-Harvest Facility (Rent, Inc. Utilities)				\$12,000.00	\$12,000.00	\$24,000.00	\$0.04	6%
Post-Harvest Labor	1,000	\$ Per Hour	\$17.00	\$17,000.00	\$17,000.00	\$34,000.00	\$0.21	31%
Employment Tax	% of Labor Costs		7.65%	\$1,309.50	\$1,309.50	\$2,619.00	\$0.02	4%
Workers Comp	% of Labor Costs		5.00%	\$850.00	\$850.00	\$1,700.00	\$0.01	2%
Retain Containers	1,000	Bag & Taps	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	0%
Trucking (Inc. Fuel)			\$5,417.00	\$5,417.00	\$5,417.00	\$10,834.00	\$0.03	3%
Trucking (Vehicle Insurance)			\$1,000.00	\$1,000.00	\$1,000.00	\$2,000.00	\$0.01	1%
Marketing Expenses			\$2,100.00	\$2,100.00	\$2,100.00	\$4,200.00	\$0.01	1%
Total Post-Harvest Costs				\$30,676.50	\$30,676.50	\$61,353.00	\$0.20	28%
Gross Total Costs				\$90,382.50	\$90,382.50	\$180,765.00	\$0.72	100%
Income (Before Taxes) - Retail Market								
Price Per Oyster				\$0.25	\$0.25	\$0.25	\$0.25	
# Market Oysters				240,000	240,000	240,000	240,000	
Total Revenue				\$60,000.00	\$60,000.00	\$60,000.00	\$0.25	

Table 3. General labor costs by rack height

Time to grow-out (months)	Rack Height		
	Std 15"	20"	30"
25	26.5	28	
Set-up, Break-down, etc.			
1st season general labor (hours)	1,392	1,392	1,392
2nd season general labor (hours)	1,624	1,624	1,624
1st season general labor cost @ \$17/hr (\$)	\$23,664	\$23,664	\$23,664
2nd season general labor cost @ \$17/hr (\$)	\$27,608	\$27,608	\$27,608
Washing			
Wash-time / rack (minutes)	2,021	1,888	1,181
Season 1 # washes	11	12	11
Season 2 # washes	23	23	26
Season 1 washing labor (hours)	111	101	77
Season 2 washing labor (hours)	232	258	354
Season 1 washing labor cost @ \$17/hr (\$)	\$1,887	\$1,717	\$1,309
Season 2 washing labor cost @ \$17/hr (\$)	\$3,944	\$4,398	\$6,018
Total General Labor			
Total season 1 labor (hours)	1,503	1,493	1,469
Total season 2 labor (hours)	1,855	1,876	2,010
Total General Labor (hours)	3,358	3,369	3,479
Season 1 labor cost (\$)	\$25,551	\$25,381	\$24,973
Season 2 labor cost (\$)	\$31,552	\$31,892	\$34,170
Total General Labor Cost (\$)	\$57,103	\$57,273	\$59,143

Table 1. Means and standard deviation of measured parameters of oysters grown at 15", 20", and 30" rack heights

Item	15"			20"			30"		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	SD
Growth rate (mm/week)	0.307	0.048	0.344	0.057	0.197	0.038			
Mortality (%)	21	17.617	4.375	0.809	10.640	59.590	8.205		
Shell width (mm)	62.200	6.334	65.712	6.533	68.270	6.216			
Shell depth (mm)	21.258	2.569	26.932	3.641	21.593	2.696			
Biofouling coverage (%)	73.425	7.719	24.025	5.880	4.796	4.630			
Right valve mud closure coverage (%)	18.5	6.638	6.717	11.180	6.875	9.975			
Left valve mud closure coverage (%)	19.5	10.114	6.614	6.261	5.512	6.766			
Condition	2.777	0.767	0.777	0.608	2.815	0.709			
Dry weight (g)	1.504	0.070	0.694	0.833	1.711	0.601			
Condition	2.777	0.767	0.777	0.608	2.815	0.709			
Dry weight (g)	1.504	0.070	0.694	0.833	1.711	0.601			
Strength N	644.96	171.641	161.271	212.425	640.227	187.500			
Strength standardized (N/g)	42.212	13.219	41.688	14.568	48.633	12.873			
Pea cost (proportion)	0.1	0.303	0.049	0.160	0.070	0.298			
Mean Score (Z-score)	2.277	2.048	3.25	1.783	0.642	1.608			

Table 4. Mortality by rack height

Item	Rack Height		
	Std 15"	20"	30"
1st season mortality (%)	15.00%	15.00%	15.00%
2nd season mortality (%)	21.00%	4.38%	5.33%
# Market Oysters	240,000	225,130	321,900

Table 5. Price and yield effects on income (standard 15" racks)

Avg Price Received per Oyster (\$)	Survival (Yr 2%) / Annual Production (Q Oysters)				
	65%	72%	79%	86%	93%
\$0.90	221,000	244,800	268,600	292,400	316,200
\$0.85	212,052	233,472	254,892	276,312	297,732
\$0.80	203,104	224,096	244,512	265,936	287,352
\$0.75	194,156	214,720	235,136	256,560	277,976
\$0.70	185,208	205,344	225,760	247,184	268,600
\$0.65	176,260	195,968	216,384	237,808	259,224
\$0.60	167,312	186,600	207,008	228,432	249,848
\$0.55	158,364	177,232	197,632	219,056	240,472
\$0.50	149,416	167,856	188,256	209,680	231,100
\$0.45	140,468	158,480	178,880	200,304	221,724
\$0.40	131,520	149,104	169,504	190,928	212,348
\$0.35	122,572	139,728	160,128	181,552	202,972
\$0.30	113,624	130,352	150,752	172,176	193,600
\$0.25	104,676	120,976	141,376	162,800	184,224
\$0.20	95,728	111,600	132,000	153,424	174,848
\$0.15	86,780	102,224	122,624	144,048	165,472
\$0.10	77,832	92,848	113,248	134,672	156,100
\$0.05	68,884	83,472	103,872	125,300	146,724
\$0.00	59,936	74,096	94,496	115,924	137,348

The table illustrates how net income is highly sensitive to changes in oyster mortality. For example, holding price constant at \$1.10 but increasing survival by 7% (to 86%) yields additional income of approximately \$26,000.

Table 6. Partial budget – itemized costs and benefits of heightened racks

Item	Rack Height	
	20" rack	30" rack
Additional Costs		
General Labor	\$170	\$2,040
Employment Tax	\$13	\$156
Workers Comp	\$9	\$105
Fuel	\$13	\$50
Overhead	\$5	\$54
Depreciation	\$150	\$450
Repairs	\$18	\$54
Misc. Supplies	\$10	\$20
Retail Containers	\$2	\$2
Total Added Costs	\$390	\$2,922
Reduced Revenue		
	\$0	\$0
Reduced Costs		
	\$0	\$0
Additional Revenue		
Increased Yield	\$62,183	\$58,630
Change in Net Income	\$61,793	\$55,708