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RESEARCH NOTES

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BIOLOGICAL EFFICIENCY OF SPAT COLLECTION DEVICES PLACED ON OYSTER SEED AREAS IN MARYLAND

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Spatfall, when oyster larvae fall from the water column to attach themselves to some compatible medium where they will reside to grow their shells, occurs in its season in estuaries all over the world. In the Chesapeake Bay, the Maryland Department of Natural Resources plants oyster shells on the bottom in areas known to produce good quantities of spat. The attached spat are then moved to growing areas. However, spatfall in the Chesapeake has declined by over 90 percent from levels in the previous decade.

In other estuaries, spat are farmed on manmade collectors suspended in the water column or placed on the bottom to gather spat. In this project, various types of collectors and collector substrates were tested in the Chesapeake Bay for their ability to attract spat and provide a suitable growing environment for the oyster seeds, then compared by cost to other methods of acquiring seed: the current shell-planting program, hatchery-produced spat, and seed for sale from more productive spatfall areas. If cost-effective, aquaculture techniques might be used to shore up declining oyster harvests in the once bountiful estuary.

--The Editors

INTRODUCTION

Placing man-made collectors on the bottom, or on a floating raft, is a widely used technique for collecting seed oysters in estuaries around the world. Numerous books, technical reports and public information bulletins document substantial evidence that spat collection devices are effective. In the U.S., the West Coast oyster industry relies in part on man-made collectors to gather seed oysters from natural set.

The Maryland management agency for the Chesapeake Bay currently relies on loose shell planted on the Bay's bottom to collect natural spatfall. Seed oysters are then moved to growing areas. In 1964 when this practice was introduced, spatfall was high and consistent in all areas of the Bay. In the past decade, however, spatfall has declined by 90 to 95%, challenging the cost effectiveness of this procedure. Using hatchery technology to obtain a predictable level of seed oysters might replenish Maryland's oyster harvests, but capital investment, labor and energy-intensive technology costs are too high, say critics, for Maryland to justify rearing seed oysters in hatcheries.

This field demonstration research effort was conducted to determine the technical and economic efficiency of using spat collection devices to obtain seed oysters from Maryland waters. The results were then compared with costs for the Maryland shell-planting program, hatchery-reared oysters, and other sources of spat.

METHODOLOGY

Various collection devices were tested at four sites on the Maryland portion of Chesapeake Bay and at a site on Chincoteague Bay, locations where some of the largest spatfalls in the last five years have occurred. Most of the sites have been used as seed areas by the state's management agency. Because of storms, the Chesapeake Bay has been described by many authors as unsuitable for suspended oyster culture. Therefore, the sites chosen were located in protected areas in the river systems.

The Maryland management agency presently uses both dredge fossil shell and green shell collected from shucking houses to collect seed oysters. In experimental studies, the agency has used chicken wire mesh bags filled with shell and suspended from rafts and buoys to collect spat. In this experiment chicken wire and Vexar polyethylene mesh bags were filled with shell and with tire chips from a waste recycling center to form the first type of collector used. Shallow trays lined with fine-mesh Vexar and filled with slag, a solid byproduct of steel manufacture, formed a second type. Wooden collectors of oak and pine were driven into the bottom or nailed into the frame of a raft. The project also planned to test a recently developed French collector, a series of interlocking polyethylene frames coated with concrete, but these are not yet available in the U.S. because of patent problems. Layers of vinyl-coated wire trays, coated again with one of two types of cement or with tile grout, were substituted. Some of the concrete-coated trays received a third coat of ground oyster shell to increase surface area and acceptance of the substrate by oyster larvae.

While the various types of collectors were assembled, time-motion studies were conducted and material costs documented.

All collectors were conditioned for one month in flowing sea water in the Horn Point Environmental Laboratory's oyster raceway. Then the collectors were cleaned. During the first three days of July, 1979, collectors of each type were placed on the bottom and suspended from styrofoam rafts in equal numbers at each of the five locations. They were left in place through the end of August, 1979.

Tests to determine the relative acceptance of the various collector substrates by oyster larvae were conducted in the laboratory. Each type of substrate was added to vinyl-coated trays of the same dimensions as the concrete-coated wire collectors. These replications were placed in aerated, filtered water tanks to which setting stage oyster larvae were added.

During the study, spatfall at each site was monitored on cement board "butter plates" on a weekly and monthly basis. The Maryland Department of Natural Resources also monitored spatfall by this technique at 60 other locations throughout the Chesapeake and Chincoteague Bays.

RESULTS

No spatfall was observed on the butter plates in Chincoteague Bay, even at locations that produced 2000 to 3000 spat per bushel of shell in 1978. At the end of the 1979 biological season, a Sea Grant-supported Bay-wide cruise to examine oyster bars for recruitment and mortality found levels of spatfall at 5 to 35 spat per bushel of shell on the bottoms adjacent to the study sites. No spat were found at the St. Mary's River site. The 1979 Bay-wide survey found spat set poor throughout the Bay relative to other years.

All surfaces of the collectors at the Chincoteague site were covered in one month with tube worms, bryozoans and barnacles. Each location had a different group of fouling organisms, but the heaviest growth was from bryozoans, molgula, filamentous diatoms and barnacles. Suspended sediment from the water column was deposited on the surfaces of the collectors and trapped by the fouling community. Earlier experiments at the Horn Point Environmental Laboratory have demonstrated that a thin layer of sediment kills newly attached spat. Closely packed substrate--oyster shell and slag--collected the greatest quantities of sediment. Shell bags weighing 35 pounds increased to 80 pounds with acquired sediment. Wood collectors doubled in weight. Concrete-coated wire collectors accumulated less sediment because spaces between the wires allowed sediment to fall through, but doubled in weight to 10 or 11 pounds. Only slag and tire chips remained relatively impervious to biofouling.

Table 1 summarizes the mean numbers of spat collected at each site. Although the number of spat to set on a bushel of loose shell on the bottom was greater in most cases, the concrete-coated wire collector--which has less surface area--proved a close competitor. At Broad Creek the concrete collector actually attracted twice as many spat as did a loose bushel of shell on the bottom at the same location. Green shell appeared to collect more spat than dredged shell. Tire chips, slag, oak and pine proved very poor substrates for spatfall.

Table 1. Summary of spat set density on collecting devices placed at 5 different sites.

Collector	Mean Number of Spat $\bar{X}$	Rank	Broad Creek	Little Choptank	St. Mary's	Deal Island	Chincoteague
Green shell							
Wire	3.9	2	5.6	10.7	2.0	0.8	0.3
Vexar	3.3	3	8.1	4.6	1.3	2.5	0
Dredged shell							
Wire	3.0	4	7.4	5.5	0.3	1.7	0
Vexar	2.9	5	4.5	6.2	1.3	2.0	0.3
Tire chip							
Wire	0.8	6	1.5	2.4	0	0.1	0
Vexar	0.7	7	1.1	1.9	0	0.4	0
Slag	0.6	8	0.1	2.0	0.3	0.8	0
Pine wood	0.1	9	0.3	0	0	0	0.3
Oak wood	0	10	0	0	0	0	0
Concrete collector	8.4	1	13.0	22.3	0.3	6.4	0
Natural shell, bottom	12.1*	1*	6.5	24.0	0	18.0	-

* Data are for one Maryland bushel of shell, a greater surface area and volume than collectors.

Detailed comparisons of bottom collectors versus suspended collectors showed very little difference in the number of spat collected. This observation could have been strongly influenced by the poor natural spatfall in Maryland during 1979. Working in the Chesapeake, Engle (1955), Butter (1955) and Shaw (1966) demonstrated that suspended bags of oyster shell or concrete plates collected more spat than the same materials placed on the bottom. Even though these investigators worked during periods of high spatfall--1955 to 1966--the spat set they observed produced less than 1000 spat per bushel of shell.

A large number of suspended collectors were lost during the three-month study period. One thunderstorm in July produced 20-knot winds and destroyed 50% of the suspended collectors. These were replaced only to have tropical storm David destroy 60 to 70% of the collectors in a two-day period, confirming what other authors have observed about the Chesapeake's suitability for suspended collection devices.

In the laboratory tests of collector substrates, concrete-coated wire collectors sprinkled with oyster shell chips were used most by setting larvae (Table 2). Concrete not coated with chips and loose shell showed nearly equal collection ability. The results of one test in Table 2 suggest that dredged shell is more attractive to spat than green shell, but this result was not consistent with the results shown in Table 1 where green shell appears to be more attractive. This test and the results from Table 1 confirmed the superiority of concrete collectors coated with shell chips. In the laboratory experiment, spat growth on the densely populated shell-coated collectors was equal to that on the less densely covered loose shell or concrete surfaces.

Table 2. Spat set on collectors placed into the same tank with hatchery-reared larvae. 21 August 1979. Measured 20 October 1979.

Collector	Mean no. Spat/ 116.14 sq. cm. tank space	Mean Spat Size (mm)	Spat Size Range (mm)	Collector Surface Area (cm^2)
Green shells	361	26.3	8-42	4000+
Dredged shells	505	28.1	12-44	5000+
Tire chips	65	28.9	20-41	2624
Slag	8	13.2	7-20	5000+
Pine wood	0	--	--	4181
Oak wood	0	--	--	4181
Concrete Collector:				
Portland I + Chips	1236	27.8	13-36	1000+
Portland II + Chips	2052	28.8	11-42	1000+
Grout + chips	1100	28.1	15-39	1000+
Portland I	600	28.4	18-44	712.5
Portland II	156	24.4	18-33	712.5
Grout	193	23.4	18-38	712.5
Masonite plate	14*	31.2	18-41	208

* = 1 - 10.2 cm plate

Table 3 shows the labor and material costs for preparing the collectors and placing them on the bottom or suspending them from rafts. The cost of the rafts doubled the cost of suspended collectors over bottom collectors. The last two columns in Table 3 show estimates of the cost per 1000 spat if a natural spatfall equal to 500 spat per bushel of loose shell had occurred. This level of spat settlement is rare in Chesapeake Bay; it has occurred only five times in 40 years of recorded data. Using data from Table 2, at this theoretical level of spatfall on the collectors, four wire shell bags would have been needed to collect 1000 spat, but only one concrete-coated wire collector would have provided enough substrate to produce 1000 spat. Data in Table 3 does not include the cost of harvesting and moving the seed oysters to a planting location.

Table 3. Cost components of spat collection devices and theoretical cost of oyster seed production by the devices.

	Material Cost	Substrate Cost	Labor Cost to Construct	Labor to Fill	Labor to Place	Transport Cost	Total Cost on Bay Bottom	Suspended System	Rope Cost	Raft Cost	Total Cost Suspended	Suspended Spat Cost per 1,000	Bottom Spat Cost per 1,000
Wire bag w/	0.34	-	.35	-	.60	.10	(1.39)	.50	.07	1.12	(3.08)		
Dredged shell		.08		.14			1.61				3.30	13.20	6.44
Green shell		.38		.14			1.91				3.60	14.40	7.64
Tire chip		.04		.20			1.63				3.32	13.28	6.52
Slag		.04		.07			1.50				3.19	12.76	6.00
Vexar bag w/	0.16	-	.07	-	.60	.10	(0.93)	.50	.07	1.12	(2.62)		
Dredged shell		.08		.20			1.21				2.90	11.60	4.84
Green shell		.38		.20			1.51				3.20	12.80	6.04
Tire chip		.04		.25			1.22				2.91	11.64	4.88
Slag		.04		.07			1.04				2.73	10.92	4.16
Wood	1.98	-	1.50	-	.60	.10	4.18	.50	.07	1.12	5.87	5.87	4.18
Wire collector w/	1.58	-	.45	-	.60	.10	(2.73)	.50	.07	1.12	(4.42)		
Concrete		.08					2.81				4.50	4.50	2.81
w/shell chip		.10		-			2.83				4.52	4.52	2.83
Grout		.12		-			2.85				4.54	4.54	2.85
w/shell ship		.14		-			2.87				4.56	4.56	2.87

Data in Table 4 provides a comparison of the cost of spat produced by the HPEL hatchery, other commercial hatcheries, natural seed sources, and the current Maryland management program. The most cost-effective system to collect spat from the natural environment remains the Maryland State Shell Planting Program at $.32 to $2.00 per 1000 spat. Spat from the James River is purchased at $3.00 per 1000. HPEL-reared spat cost from $1.40 to $4.70 per 1000.

Table 4. Comparative costs for obtaining seed oysters in Maryland.

Source	Year	Spat Cost per 1000
Hatchery:		
University of Maryland	1978	1.40- 4.70
Maryland	1976	7.50
California	1978	14.00
Natural; bottom:		
James River, Virginia	1977	3.00
Maryland shell-plants	1976	0.32- 2.00
Maryland shell bags	1979	6.44- 7.64
Concrete collector	1979	2.81- 2.87
Natural; suspended:		
Maryland shell bags	1979	12.76-14.40
Concrete collector	1979	4.50- 4.56

DISCUSSION

The foremost concerns of the Maryland oyster industry are economic. If new oyster farming devices or hatchery technology are to be introduced, the industry will want to know how much the products of the new technology will cost. How much capital investment is needed? What are the financial risks? To remain competitive, any aquaculture technique must produce seed oysters at very nearly the cost of seed available from other sources.

This field experiment helped to document the expedience and cost of various types of spat collectors, and measured these costs against other methods for acquiring seed oysters--the Maryland shell-planting program, seed for sale from other areas and hatchery-reared spat.

For each of the collectors tested, the results showed:

- Tire chips and slag, the only collectors not subject to biofouling, are poor collector substrates, as are pine and oak.

- Shell bags are moderately good collectors of spat, but they also collect sediment and fouling organisms. Their weight, which increases from 35 to 80 pounds with sedimentation, makes them difficult and expensive to handle. Labor costs for filling the bags with shell bring the total price to $6.44 to $7.64 per 1000 spat. In other parts of the world where similar devices are used successfully, labor costs are less.

- Suspended collectors do not exceed bottom collectors for attracting spat, contrary to earlier reports; but given the low spatfall during the test period, these results may be inconclusive. Paying for the rafts to suspend them on doubles their cost. Moreover, as noted by other authors, suspended collectors appear to be unsuitable for use in the Chesapeake Bay where many are lost or destroyed by storms.

- Concrete-coated wire collectors are easy to handle at only 5 pounds. They collect only small amounts of sediment, increasing their weight to 10 or 11 pounds. They collect more spat on less surface area than does loose shell. Placed on the bottom, they cost $2.81 to $2.87 per 1000 spat produced, undercutting the price of James River spat.

- Concrete-coated collectors coated with ground shell are the most efficient collectors, attracting from two to four times as many spat on one-fourth the surface area as does loose shell. Spat growth is good even at this high density.

The Maryland State Shell Planting Program is still the most cost-effective means of collecting spat. But any of the successful and cost-effective aquaculture techniques described rely on natural spatfall, and spatfall has dropped to a low level in the Chesapeake Bay in recent years. The cost of hatchery-produced spat at the University of Maryland hatchery is higher than costs documented for loose shell planting and concrete bottom collectors, but at slightly higher production costs, only hatchery technology can produce predictable yields of seed oysters.

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