This technical paper explains the equations, outlines examples, and shows the derivations for Rudner (2020). Create an Efficient Oyster-Sorting Schedule, *East Coast Shellfish Growers Association Newsletter*, October 2020 (Issue 4), pages 7,10,11. Available online at https://ecsga.org/wp-content/uploads/2020/09/ECSGA_NL_v4-20.pdf.

Developing an efficient oyster sorting schedule

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Having a schedule to direct when to haul and sort can result in clear expectations, minimized touches, and improved overall efficiency. Mathematics is used in this note to help develop schedules based on the expected volumes of fresh oysters given various combinations of planted shell height and time. With the presented equations one could, for example, identify when 4 liters of 15mm seed would become 10 liters of larger oysters and need to be hauled. One could similarly determine the volume of 25mm seed to put in trays today so that the volume in four months would be 32 liters.

The equations, developed by algebraically combining 1) a volume-to-shell height model and 2) a local growth model relating shell height-to-time, are easy to apply and can greatly facilitate overall farm planning. Look-up tables are appended to this article and a free Excel® spreadsheet is available.

Volume as a function of shell height

Chip Terry and the Oyster Tracker Team provide the needed data for the first part of modeling volume in an elegant graph in the August 2018 issue of the *ECSGA Newsletter*. They presented the number of bags needed to hold 1 million oysters at different shell heights. The needed number of bags grows exponentially as the oyster size increases. One million .3” oysters fit in 114 bags and require 9,467 bags when they reach market size (3” or 76mm) – an 83-fold increase!

Converting inches to mm and expressing (bags) x (liters per bag) for one million oysters as (liters per oyster), the Terry and Team data can be expressed as

Shell height (mm)	7.62	15.24	25.4	38.1	50.8	76.2	88.9
liters/oyster	.000144	.000580	.002154	.006342	.013542	.028401	.056868

This volume data was then modelled with the power function:

$$v = .0000009\, x^{2.4237}$$ where v is the volume in liters/oyster and x is the shell height

The relationship between observed and predicted values is exceptional, with the proportion of explained variance, R^2, equal to .996. The observed and predicted values are shown in Figure 1.

As validation, the volume equation was applied to data found in a PowerPoint presentation of Dale Leavitt (http://shellfish.ifas.ufl.edu/wp-content/uploads/Oyster-Growout-Systems-and-Methods-used-in-NE-US.pdf). Right after his "Jiffy Pop Syndrome[1]" slide showing the rapid growth of small seed, Leavitt presents the number of oysters with biomasses of 1.5 and 2 gallons at various sizes. That data was converted to liters per oyster and the above equation was then applied. Here the R^2 for the new observed and predicted values is .9995. Again, nearly perfect! The equation fits exceptionally well across multiple datasets.

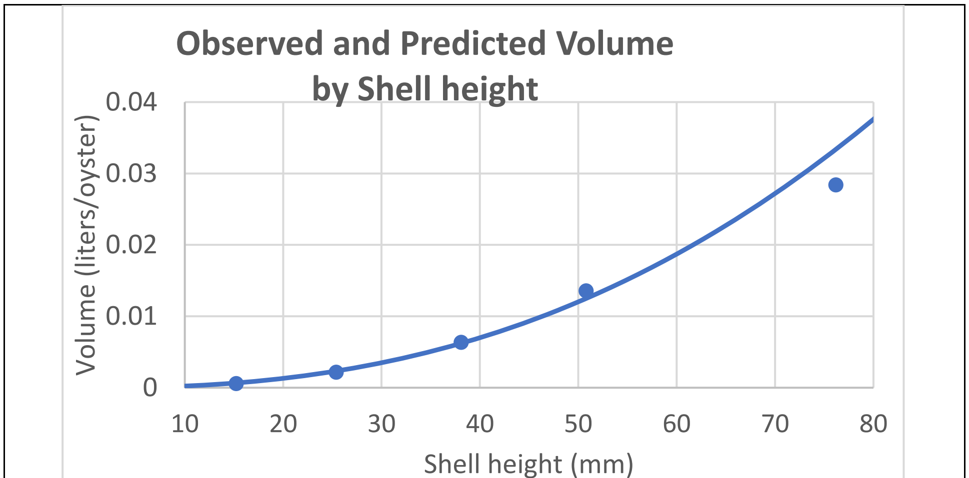

Figure 1. Observed and predicted volume of a single oyster in liters as a function of shell height in millimeters. Larger oysters have a larger volume, but the relationship is non-linear.

Shell height as a function of time

A model for predicting size as a function of time for a given farm is the second input to the mathematics. There is a large body of literature using the non-linear von Bertalanffy growth model, $l_t = l_{inf}(1 - e^{-kt})$. That model captures the rapid growth for tiny seed and fits averaged yearly data well. It does not, however, take into consideration any of the known correlates with growth that vary over time such as water temperature, available food, and water flow. Further, the von Bertalanffy curves are very linear in the region of interest – 16mm to 76mm. A simple user-derived linear model of the form

[1] The Jiffy Pop Syndrome, first outlined by Bob Rheault, is actually an understatement. Popcorn only increases 40- to 50-fold.

$x = ct + d$ where x is again shell height, t is time, c is the average monthly shell height growth, and d is the shell size when seed is placed on the farm

is just as realistic (and as unrealistic) as the more complicated von Bertalanffy models and, more importantly, is easy to develop to reflect local data based on experience. If 16mm seed take thirty months to grow to 76mm, then the growth model is $x = (76-16)/30\ t + 16 = 2t + 16$.

Derived equations

The volume equation and the growth model were combined algebraically to yield the following useful functions. The derivations are in the Appendix. The examples here are based on c = 2mm per month growth.

1. **In how many more months will the volume of oysters increase M-fold?**

$$t' = \frac{1}{c}\, x\, (M^{.4126} - 1)$$

For example, how long will it take for 10 liters of 20mm oysters to increase 2-fold to become 20 liters? ½ * 20 * ($2^{.4126}$ - 1) = 3.3 months

2. **What will the average shell height of today's oysters be when their volume increases M-fold?**

$$x' = x * M^{.4126}$$

For example, what will the shell height of 20 mm oysters be when their volume increases 2-fold? 20 * $2^{.4126}$ = 26.6mm

3. **What will the volume multiplier of today's oysters be in t' months?**

$$M = \left(\frac{ct'}{x} + 1\right)^{2.4237}$$

For example, what will the multiplier for today's 20mm oysters be in four months?
$M = \left(\frac{2*4}{20} + 1\right)^{2.4237}$ = 2.26

Thus, 10 liters of 20mm oysters will be 10 * 2.26 = 22.6 liters in four months and one needs to plant 30/2.26 = 13.31L of 20mm oysters to yield 30 liters in four months.

Equation 3 is the Oyster Girl equation for the oyster Jiffy Pop Syndrome. It models the volume of oysters as a function of time, growth rate, and planted seed size and is illustrated in Figure 2. Smaller seed grows more quickly, and their volume increases faster, than larger seed.

Again, these are models and the values represent averages. Growth will be accelerated in the summer, there will be a great deal of variation within any single batch of seed, and biofouling will remain an important consideration. Nevertheless, the equations can be a powerful tool that can greatly facilitate farm planning.

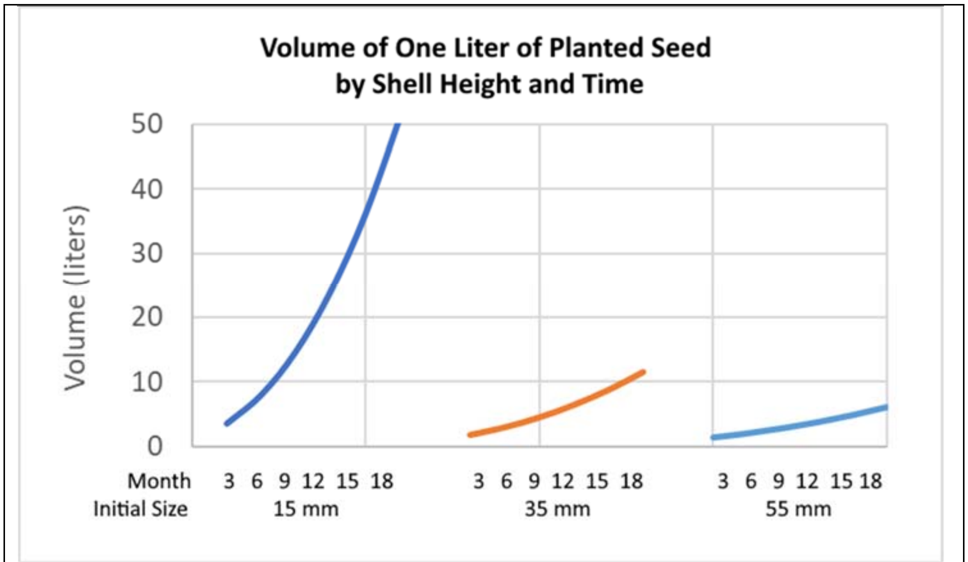

Figure 2. The volume multiplier as a function of initial shell size and time. Smaller seed grows more quickly, and their volume increase is greater than that of larger seed.

Examples

Assume that

1) it takes eighteen months on the farm for my oysters to reach market size (triploids in floats),
2) I never want more than 10L of biomass (which is 307 market size oysters weighing 15 pounds) in a single bag, and
3) seed is placed on the farm when they are 15mm.

Then the growth model is $x = (76\text{-}15)/18\ t + 15 = 3.39\ t + 15$. Shell height increases an average of $c = 3.39$ mm per month.

If one plants 5 liters of biomass in a bag and hauls every time the volume doubles, then they will need to haul and sort their bags 6 times. Table 1 shows the schedule. Five liters of 15mm seed are placed in bags. In 1.5 months, they will have doubled in volume and have a shell height of 20 mm. They are hauled and sorted and five liters of the 20mm seed are placed in bags. In 2.0 more months those 20mm oysters will have doubled in volume and have a shell height of 27 mm. The process continues until the final set of 63mm oysters. While frequent sorting makes for more homogenous oysters, 6 times will require an excessive amount of labor.

Table 1. Schedule based on volume doubling.

Plant size (mm)	Plant Volume (L)	Plant quantity (n)	Time (months)	Cumulative Time (months)	Multiplier	Sort Volume (L)	Sort size (mm)
15	5.0	7,839	1.5	1.5	2.0	10	20
20	5.0	3,919	2.0	3.4	2.0	10	27
27	5.0	1,960	2.6	6.0	2.0	10	35
35	5.0	980	3.5	9.5	2.0	10	47
47	5.0	490	4.6	14.1	2.0	10	63
63	6.3	307	3.9	18.0	1.6	10	76

If, instead, one plants 2.5 liters of seed each time and lets that grow to 10 liters, then only 3 hauls and sorts are needed. The initial batch of 15mm is left in their bags for 3.4 months when they will be 27mm. The 27mm seed is planted for 6.1 months. That grows to 47mm., and then 307 47mm seed are planted and harvested 8.6 months later. This is less frequent work, but it does require twice the number of bags for a given number of oysters.

Table 2. Schedule based on volume quadrupling.

Plant size (mm)	Plant Volume (L)	Plant quantity (n)	Time (months)	Cumulative Time (months)	Multiplier	Sort Volume (L)	Sort size (mm)
15	2.5	3,919	3.4	3.4	4.0	10	27
27	2.5	980	6.1	9.5	4.0	10	47
47	3.1	307	8.6	18	3.2	10	76

Oyster growth does not have to completely dictate the schedule. One could pick a schedule and then determine volume of seed to put in each bag. Suppose one starts with 15 mm seed in April and wants to work a set of bags in August and then April of the next year. Then one should plant 2.1 liters in April. Those 15mm seed will grow to a length of 29mm and a volume of 10 liters by August. At that time, the 29mm seed will need to be hauled and sorted and 2.0 liters of 29mm seed placed into bags. Then in April of the next year, 4.7L which is 307 56mm-oysters, would be prepared for their final set.

Table 3. Planting volume based on desired haul times

Plant size (mm)	Plant Volume (L)	Plant quantity (n)	Time (months)	Cumulative Time (months)	Multiplier	Sort Volume (L)	Sort size (mm)
15	2.1	3,293	4	4	4.76	10	29
29	2.0	653	8	12	5.04	10	56
56	4.7	307	6	18	2.13	10	76

Look-up Tables

Rather than applying the formulas directly, it is extremely easy to use a look-up table derived from the equations.

The following table shows the expected volume by time-in-the-water and planted shell height for an 18-month grow-out period. This grow-out period might be expected for triploids grown in bags placed in floating cages. Detailed tables for different grow-out periods are included in the appendix.

Expected Volume (vol) and Shell Height (SH) Through Time
With Initial Volume of 1 Liter of Oysters of Various Sizes
(18-month 10mm to 76mm grow-out period)

		Initial planted shell height											
Months in water before hauling		10	15	20	25	30	35	40	45	50	55	60	65
1	vol	2.1	1.7	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.1
	SH	(14)	(19)	(24)	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)
2	vol	3.8	2.6	2.1	1.9	1.7	1.6	1.5	1.4	1.4	1.4	1.3	1.3
	SH	(17)	(22)	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)
3	vol	6.0	3.8	2.9	2.4	2.1	1.9	1.8	1.7	1.6	1.6	1.5	1.5
	SH	(21)	(26)	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)
4	vol	8.9	5.2	3.8	3.1	2.6	2.3	2.1	2.0	1.9	1.8	1.7	1.6
	SH	(25)	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)
5	vol	12.5	6.9	4.8	3.8	3.2	2.8	2.5	2.3	2.1	2.0	1.9	1.8
	SH	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)	(83)
6	vol	16.8	8.9	6.0	4.6	3.8	3.3	2.9	2.6	2.4	2.3	2.1	2.0
	SH	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)	(87)
7	vol	21.8	11.2	7.4	5.5	4.5	3.8	3.3	3.0	2.7	2.5	2.4	2.2
	SH	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)	(81)	(86)	(91)
8	vol	27.6	13.8	8.9	6.6	5.2	4.4	3.8	3.4	3.1	2.8	2.6	2.5
	SH	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)	(84)	(89)	(94)
9	vol	34.3	16.8	10.6	7.7	6.0	5.0	4.3	3.8	3.4	3.1	2.9	2.7
	SH	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)	(83)	(88)	(93)	(98)
10	vol	41.8	20.0	12.5	8.9	6.9	5.7	4.8	4.2	3.8	3.4	3.2	3.0
	SH	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)	(87)	(92)	(97)	(102)
11	vol	50.2	23.7	14.5	10.3	7.9	6.4	5.4	4.7	4.2	3.8	3.5	3.2
	SH	(50)	(55)	(60)	(65)	(70)	(75)	(80)	(85)	(90)	(95)	(100)	(105)
12	vol	59.6	27.6	16.8	11.7	8.9	7.2	6.0	5.2	4.6	4.2	3.8	3.5
	SH	(54)	(59)	(64)	(69)	(74)	(79)	(84)	(89)	(94)	(99)	(104)	(109)

As an example, suppose we plant 10mm seed and expect to haul in four months. How much seed should we put in each bag now and how much of the larger seed should we place in each bag after the first haul?

We see from the table that in four months 10mm seed can be expected to have an 8.9-fold increase in volume. What volume of 10mm seed should be planted? If we want no more than 12 liters in each bag four months from now, then no more than 12/8.9 = 1.4 liters of 10mm seed should be planted in each bag. That seed will grow to an average shell height of 25mm in four months.

We can plan for our now 25mm seed. One liter of 25mm seed will have a volume of 4.6 liters in six months. Thus, we should plant less than 12/4.6 = 2.6 liters of 25mm seed. That seed will grow to an average of about 47mm in six months.

We can then use the 45mm column to plan for our 47mm seed. One liter of 45mm seed will grow to 67mm and have a volume of 2.6 liters in six months. In nine months, that same seed will grow to 78mm and have a volume of 3.8 liters. Therefore, if one wants to haul and sort when a bag has 12 liters of biomass, they should either put 12/2.6 = 4.6 liters of 47mm seed in a bag and plan to haul in six months or 12/3.8 = 3.2 liters and plan to haul in nine months.

While the above examples are applied to bags, the principles and equations are equally applicable to Hexcyl®, floating cages and cages on the bottom. Again, these are averages. A great deal of variation can be expected with each batch and growth period.

Contact me at VolCalc2 [at] OysterGirl.us for a free Excel® spreadsheet that allows you to vary the size of seed first planted, grow-out time, and maximum volume you want in your bags or cages. The spreadsheet will tell you how long to leave seed before hauling and how much the seed will grow over time. It will also generate a detailed look-up table specific to your site.

Lawrence Rudner is a retired psychometrician/statistician and aspiring oyster farmer.

Appendix

Derivation of elapsed time for volume to increase M-fold - equation 1:

$v = .0000009\, x^{2.4237}$; volume given shell length

$x = \left(\frac{v}{.0000009}\right)^{\frac{1}{2.4237}} = \left(\frac{v}{.0000009}\right)^{.4126}$; shell length given volume

$x = c\,t + d$; shell length given time

$t_0 = \frac{1}{c}(x-d) = \frac{1}{c}\left(\left(\frac{v}{.0000009}\right)^{.4126} - d\right)$; initial time (age) seed planted

$t_1 = \frac{1}{c}\left(\left(\frac{(M\,v)}{.0000009}\right)^{\frac{1}{2.4237}} - d\right)$; time (age) volume has increased M-fold

$t' = t_1 - t_0 = \frac{1}{c}\left(\left(\frac{(Mv)}{.0000009}\right)^{.4126} - d\right) - \left(\frac{1}{c}(x-d)\right)$; elapsed time for M-fold increase

$t' = \frac{1}{c}\left(M^{.4126}\left(\frac{v}{.0000009}\right)^{.4126} - d - x + d\right)$

$t' = \frac{1}{c}(M^{.4126}x - x) = \frac{1}{c}\, x\,(M^{.4126} - 1)$

Derivation of shell length after volume increased M-fold - equation 2:

$x' = \left(\frac{(Mv)}{.0000009}\right)^{.4126}$; shell length after M-fold increase

$x' = M^{.4126}\left(\frac{v}{.0000009}\right)^{.4126} = x\,M^{.4126}$

Derivation of volume multiplier after *t'* months – equation 3

$t' = \frac{1}{c}\, x\,(M^{.4126} - 1)$; equation 1

$M^{.4126} - 1 = \frac{ct'}{x}$

$M = \left(\frac{ct'}{x} + 1\right)^{2.4237}$; multiplier after t' months

Expected Volume (vol) and Shell Height (SH) Through Time With Initial Volume of 1 Liter of Oysters of Various Sizes (30-month 10mm to 76mm grow-out period)

		Initial planted shell height											
Months in water before hauling		10	15	20	25	30	35	40	45	50	55	60	65
1	vol	1.6	1.4	1.3	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
	SH	(12)	(17)	(22)	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)
2	vol	2.4	1.9	1.6	1.5	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2
	SH	(14)	(19)	(24)	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)
3	vol	3.4	2.4	2.0	1.8	1.6	1.5	1.4	1.4	1.4	1.3	1.3	1.3
	SH	(17)	(22)	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)
4	vol	4.6	3.1	2.4	2.1	1.9	1.7	1.6	1.5	1.5	1.4	1.4	1.4
	SH	(19)	(24)	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)
5	vol	6.0	3.8	2.9	2.4	2.1	1.9	1.8	1.7	1.6	1.6	1.5	1.5
	SH	(21)	(26)	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)
6	vol	7.7	4.6	3.4	2.8	2.4	2.2	2.0	1.9	1.8	1.7	1.6	1.6
	SH	(23)	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)
7	vol	9.6	5.5	4.0	3.2	2.7	2.4	2.2	2.0	1.9	1.8	1.7	1.7
	SH	(25)	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)
8	vol	11.7	6.6	4.6	3.6	3.1	2.7	2.4	2.2	2.1	2.0	1.9	1.8
	SH	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)	(83)
9	vol	14.1	7.7	5.3	4.1	3.4	3.0	2.7	2.4	2.2	2.1	2.0	1.9
	SH	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)	(85)
10	vol	16.8	8.9	6.0	4.6	3.8	3.3	2.9	2.6	2.4	2.3	2.1	2.0
	SH	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)	(87)
11	vol	19.7	10.3	6.8	5.2	4.2	3.6	3.1	2.8	2.6	2.4	2.3	2.2
	SH	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)	(84)	(89)
12	vol	22.9	11.7	7.7	5.7	4.6	3.9	3.4	3.1	2.8	2.6	2.4	2.3
	SH	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)	(81)	(86)	(91)

Expected Volume (vol) and Shell Height (SH) Through Time With Initial Volume of 1 Liter of Oysters of Various Sizes (36-month 10mm to 76mm grow-out period)

Months in water before hauling		Initial planted shell height: 10	15	20	25	30	35	40	45	50	55	60	65
1	vol	1.5	1.3	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	SH	(12)	(17)	(22)	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)
2	vol	2.1	1.7	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.1
	SH	(14)	(19)	(24)	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)
3	vol	2.9	2.1	1.8	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.2
	SH	(16)	(21)	(26)	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)
4	vol	3.8	2.6	2.1	1.9	1.7	1.6	1.5	1.4	1.4	1.4	1.3	1.3
	SH	(17)	(22)	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)
5	vol	4.8	3.2	2.5	2.1	1.9	1.8	1.6	1.6	1.5	1.5	1.4	1.4
	SH	(19)	(24)	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)
6	vol	6.0	3.8	2.9	2.4	2.1	1.9	1.8	1.7	1.6	1.6	1.5	1.5
	SH	(21)	(26)	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)
7	vol	7.4	4.5	3.3	2.7	2.4	2.1	2.0	1.8	1.7	1.7	1.6	1.5
	SH	(23)	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)
8	vol	8.9	5.2	3.8	3.1	2.6	2.3	2.1	2.0	1.9	1.8	1.7	1.6
	SH	(25)	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)
9	vol	10.6	6.0	4.3	3.4	2.9	2.6	2.3	2.1	2.0	1.9	1.8	1.7
	SH	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)
10	vol	12.5	6.9	4.8	3.8	3.2	2.8	2.5	2.3	2.1	2.0	1.9	1.8
	SH	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)	(83)
11	vol	14.5	7.9	5.4	4.2	3.5	3.0	2.7	2.5	2.3	2.1	2.0	1.9
	SH	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)	(85)
12	vol	16.8	8.9	6.0	4.6	3.8	3.3	2.9	2.6	2.4	2.3	2.1	2.0
	SH	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)	(87)

Expected Volume (vol) and Shell Height (SH) Through Time With Initial Volume of 1 Liter of Oysters of Various Sizes (18-month 15mm to 76mm grow-out period)

Months in water before hauling		Initial planted shell height										
		15	20	25	30	35	40	45	50	55	60	65
1	vol	1.6	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1
	SH	(18)	(23)	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)
2	vol	2.5	2.0	1.8	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3
	SH	(22)	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)
3	vol	3.5	2.7	2.3	2.0	1.9	1.7	1.6	1.6	1.5	1.5	1.4
	SH	(25)	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)
4	vol	4.8	3.5	2.9	2.5	2.2	2.0	1.9	1.8	1.7	1.6	1.6
	SH	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)
5	vol	6.2	4.4	3.5	3.0	2.6	2.4	2.2	2.0	1.9	1.8	1.8
	SH	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)
6	vol	8.0	5.5	4.2	3.5	3.0	2.7	2.5	2.3	2.1	2.0	1.9
	SH	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)	(85)
7	vol	10.0	6.7	5.0	4.1	3.5	3.1	2.8	2.6	2.4	2.2	2.1
	SH	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)	(84)	(89)
8	vol	12.2	8.0	5.9	4.8	4.0	3.5	3.1	2.9	2.6	2.5	2.3
	SH	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)	(87)	(92)
9	vol	14.7	9.4	6.9	5.5	4.6	3.9	3.5	3.2	2.9	2.7	2.5
	SH	(46)	(51)	(56)	(61)	(66)	(71)	(76)	(81)	(86)	(91)	(96)
10	vol	17.5	11.0	8.0	6.2	5.2	4.4	3.9	3.5	3.2	3.0	2.8
	SH	(49)	(54)	(59)	(64)	(69)	(74)	(79)	(84)	(89)	(94)	(99)
11	vol	20.6	12.8	9.1	7.1	5.8	4.9	4.3	3.9	3.5	3.2	3.0
	SH	(52)	(57)	(62)	(67)	(72)	(77)	(82)	(87)	(92)	(97)	(102)
12	vol	24.0	14.7	10.4	8.0	6.5	5.5	4.8	4.2	3.8	3.5	3.2
	SH	(56)	(61)	(66)	(71)	(76)	(81)	(86)	(91)	(96)	(101)	(106)

Expected Volume (vol) and Shell Height (SH) Through Time With Initial Volume of 1 Liter of Oysters of Various Sizes (30-month 15mm to 76mm grow-out period)

Months in water before hauling		Initial planted shell height										
		15	20	25	30	35	40	45	50	55	60	65
1	vol	1.4	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	SH	(17)	(22)	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)
2	vol	1.8	1.6	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2
	SH	(19)	(24)	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)
3	vol	2.3	1.9	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.2
	SH	(21)	(26)	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)
4	vol	2.9	2.3	2.0	1.8	1.7	1.6	1.5	1.4	1.4	1.4	1.3
	SH	(23)	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)
5	vol	3.5	2.7	2.3	2.0	1.9	1.7	1.6	1.6	1.5	1.5	1.4
	SH	(25)	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)
6	vol	4.2	3.2	2.6	2.3	2.1	1.9	1.8	1.7	1.6	1.6	1.5
	SH	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)
7	vol	5.0	3.7	3.0	2.6	2.3	2.1	1.9	1.8	1.7	1.7	1.6
	SH	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)
8	vol	5.9	4.2	3.4	2.9	2.5	2.3	2.1	2.0	1.9	1.8	1.7
	SH	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)	(81)
9	vol	6.9	4.8	3.8	3.2	2.8	2.5	2.3	2.1	2.0	1.9	1.8
	SH	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)	(83)
10	vol	8.0	5.5	4.2	3.5	3.0	2.7	2.5	2.3	2.1	2.0	1.9
	SH	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)	(85)
11	vol	9.1	6.2	4.7	3.9	3.3	2.9	2.7	2.5	2.3	2.2	2.0
	SH	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)	(87)
12	vol	10.4	6.9	5.2	4.2	3.6	3.2	2.9	2.6	2.4	2.3	2.2
	SH	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)	(84)	(89)

Expected Volume (vol) and Shell Height (SH) Through Time With Initial Volume of 1 Liter of Oysters of Various Sizes (18-month 25mm to 76mm grow-out period)

Months in water before hauling		Initial planted shell height 25	30	35	40	45	50	55	60	65
1	vol	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1
	SH	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)
2	vol	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.2
	SH	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)
3	vol	2.0	1.8	1.7	1.6	1.5	1.5	1.4	1.4	1.3
	SH	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)
4	vol	2.5	2.2	2.0	1.8	1.7	1.6	1.6	1.5	1.5
	SH	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)
5	vol	3.0	2.6	2.3	2.1	1.9	1.8	1.7	1.7	1.6
	SH	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)
6	vol	3.5	3.0	2.6	2.4	2.2	2.0	1.9	1.8	1.8
	SH	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)
7	vol	4.1	3.4	3.0	2.7	2.4	2.2	2.1	2.0	1.9
	SH	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)	(85)
8	vol	4.8	3.9	3.4	3.0	2.7	2.5	2.3	2.2	2.1
	SH	(48)	(53)	(58)	(63)	(68)	(73)	(78)	(83)	(88)
9	vol	5.5	4.4	3.8	3.3	3.0	2.7	2.5	2.4	2.2
	SH	(51)	(56)	(61)	(66)	(71)	(76)	(81)	(86)	(91)
10	vol	6.3	5.0	4.2	3.7	3.3	3.0	2.7	2.6	2.4
	SH	(53)	(58)	(63)	(68)	(73)	(78)	(83)	(88)	(93)
11	vol	7.1	5.6	4.7	4.0	3.6	3.2	3.0	2.8	2.6
	SH	(56)	(61)	(66)	(71)	(76)	(81)	(86)	(91)	(96)
12	vol	8.0	6.3	5.2	4.4	3.9	3.5	3.2	3.0	2.8
	SH	(59)	(64)	(69)	(74)	(79)	(84)	(89)	(94)	(99)

Expected Volume (vol) and Shell Height (SH) Through Time With Initial Volume of 1 Liter of Oysters of Various Sizes (30-month 25mm to 76mm grow-out period)

Months in water before hauling		Initial planted shell height 25	30	35	40	45	50	55	60	65
1	vol	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	SH	(27)	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)
2	vol	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1
	SH	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)
3	vol	1.6	1.5	1.4	1.3	1.3	1.3	1.2	1.2	1.2
	SH	(30)	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)
4	vol	1.8	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3
	SH	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)
5	vol	2.0	1.8	1.7	1.6	1.5	1.5	1.4	1.4	1.3
	SH	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)
6	vol	2.3	2.0	1.9	1.7	1.6	1.6	1.5	1.5	1.4
	SH	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)
7	vol	2.6	2.2	2.0	1.9	1.8	1.7	1.6	1.6	1.5
	SH	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)
8	vol	2.9	2.5	2.2	2.0	1.9	1.8	1.7	1.6	1.6
	SH	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)
9	vol	3.2	2.7	2.4	2.2	2.0	1.9	1.8	1.7	1.7
	SH	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)
10	vol	3.5	3.0	2.6	2.4	2.2	2.0	1.9	1.8	1.8
	SH	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)
11	vol	3.9	3.2	2.8	2.5	2.3	2.2	2.0	1.9	1.8
	SH	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)	(84)
12	vol	4.2	3.5	3.0	2.7	2.5	2.3	2.1	2.0	1.9
	SH	(45)	(50)	(55)	(60)	(65)	(70)	(75)	(80)	(85)

Expected Volume (vol) and Shell Height (SH) Through Time With Initial Volume of 1 Liter of Oysters of Various Sizes (36-month 25mm to 76mm grow-out period)

		Initial planted shell height								
Months in water before hauling		25	30	35	40	45	50	55	60	65
1	vol	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
	SH	(26)	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)
2	vol	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1
	SH	(28)	(33)	(38)	(43)	(48)	(53)	(58)	(63)	(68)
3	vol	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2
	SH	(29)	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)
4	vol	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.2
	SH	(31)	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)
5	vol	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.3	1.3
	SH	(32)	(37)	(42)	(47)	(52)	(57)	(62)	(67)	(72)
6	vol	2.0	1.8	1.7	1.6	1.5	1.5	1.4	1.4	1.3
	SH	(34)	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)
7	vol	2.2	2.0	1.8	1.7	1.6	1.6	1.5	1.4	1.4
	SH	(35)	(40)	(45)	(50)	(55)	(60)	(65)	(70)	(75)
8	vol	2.5	2.2	2.0	1.8	1.7	1.6	1.6	1.5	1.5
	SH	(36)	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)
9	vol	2.7	2.4	2.1	2.0	1.8	1.7	1.7	1.6	1.5
	SH	(38)	(43)	(48)	(53)	(58)	(63)	(68)	(73)	(78)
10	vol	3.0	2.6	2.3	2.1	1.9	1.8	1.7	1.7	1.6
	SH	(39)	(44)	(49)	(54)	(59)	(64)	(69)	(74)	(79)
11	vol	3.2	2.8	2.4	2.2	2.1	1.9	1.8	1.7	1.7
	SH	(41)	(46)	(51)	(56)	(61)	(66)	(71)	(76)	(81)
12	vol	3.5	3.0	2.6	2.4	2.2	2.0	1.9	1.8	1.8
	SH	(42)	(47)	(52)	(57)	(62)	(67)	(72)	(77)	(82)