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DRS. Andrews and Hewatt have been holding oysters in trays suspended from the Virginia Fisheries Laboratory pier at Gloucester Point, Virginia, for the past four years. The preliminary objective has been to study mortality rates, but other information has been gathered from time to time, particularly on the growth rate. During the course of these investigations we have been impressed by the yields that have been obtained, for it has not been uncommon to realize three bushels of market-sized oysters for each original bushel of seed placed in the trays.

Reduced to the simplest terms, the yield of market oysters from planted seed is determined by the interaction of growth and mortality. This has been pointed out by Hopkins and Menzel (1952), who have outlined methods by which planters can determine growth and mortality rates from which they can calculate the net yield. Owen (1953) has described the relationship between growth, mortality, and yield at given locations in Louisiana waters, using figures obtained from experimental plants of seed. Thus, our work is not original in the sense that it represents a new approach. It is original, however, to the extent that it concerns the Chesapeake Bay region, and that it utilizes the methods of computation applied to fish populations by Ricker (1945, 1948) and others.

Hewatt and Andrews (1954) have presented extensive data on oyster mortalities in trays at Gloucester Point, Virginia, and information on oyster growth is accumulating. Both items of information are available in some detail, for mortality records were made daily in summer and at intervals of 10 days to two weeks in winter, and growth measurements have been made at intervals of two weeks to one month.

Oystermen usually report that planted grounds in Chesapeake Bay yield about one bushel of market oysters for each bushel of seed planted. The crop is harvested two to four years after planting, depending on the characteristics of the particular piece of ground, usually determined through past experience or by occasional sampling, and based on the size of the oysters.

It is relatively simple to calculate the mortality that occurs between planting and harvesting. A bushel of seed oysters from Wreck Shoal in the James River may contain as many as 3,000 oysters of various sizes. If he counts a sample of seed, the planter will ignore the small spat, for he knows that these tiny oysters will not survive the planting operations, or if they do, will fall prey to oyster drills and other enemies shortly after, and hence cannot contribute to the harvest. The planter, therefore, will conclude that the viable seed in each bushel number perhaps 1,000 or 1,200 at the most. The market oysters that he harvests in an average period of three years will run about 300 to each bushel. Therefore, when the yield is 1:1, about 900 of the original 1,200 oysters, or 75 per cent of the number planted, will have been lost. The true mortality, based on all the oysters in the original planting, is of the order of 90 per cent, but the lower figure is more realistic from the oysterman's point of view.

On first thought, it might seem that a mortality of 75 per cent in three years is equivalent to a death rate of 25 per cent per year. Percentages cannot be summed or divided so simply, however, and actually the annual rate is considerably higher. It can be demonstrated simply that an annual death rate of 37 per cent will produce a total mortality of 75 per cent in three years, by applying this annual rate to a group of 100 oysters, as follows:

Original number	=	100	
Subtract 37 per cent		37	
Survivors	=	63	(End of first year)
Subtract 37 per cent		23	
Survivors	=	40	(End of second year)
Subtract 37 per cent		15	
Survivors	=	25	(End of third year)

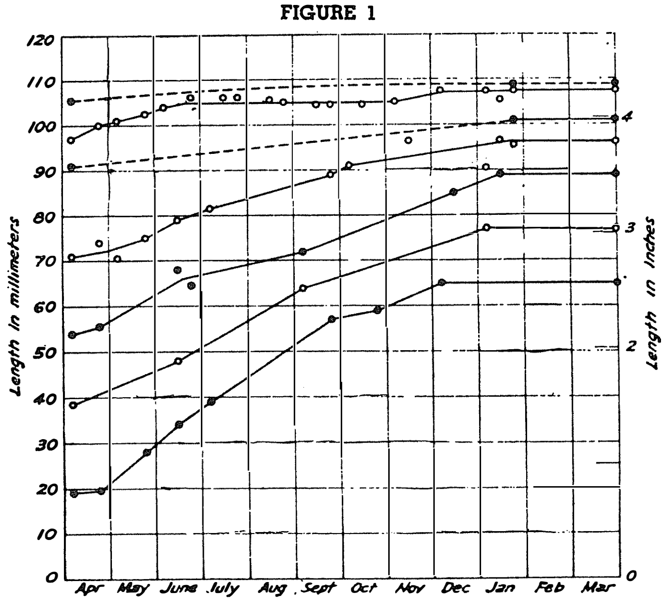
Total survival rate = 25 per cent
Total mortality rate = 75 per cent

Mathematically, the conversion of short period observations on mortality or growth rates to annual rates is somewhat complicated. Fortunately, these calculations have been made and recorded systematically in tables (Ricker, 1948) from which mortality rates on a percentage basis can be converted to instantaneous rates, which can be summed directly.

The Rate of Growth in Length

Growth rates were measured on oysters held in trays at the Virginia Fisheries Laboratory pier. The most extensive data were available on the rate of growth in length, hence length was used in setting up the basic growth curves (Fig. 1). The curves in Figure 1 were obtained by grouping data

FIGURE 1



Average growth rates of oysters in trays at Gloucester Point, Virginia. The data were grouped into broad categories based on the average length in April, which marks approximately the beginning of the year's growth. The points on which the successive curves were based are indicated alternately as black and open circles, for ease in recognition.

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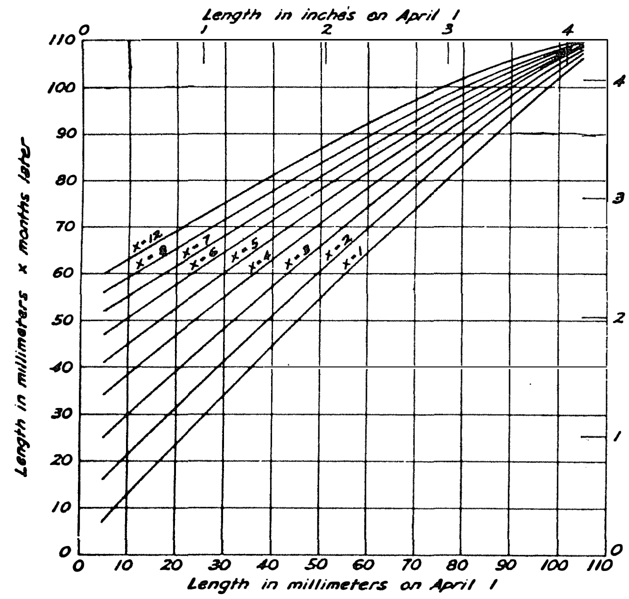
from various trays of oysters according to their average length at the beginning of April, the approximate time at which the year's growth commences. The decision to group was dictated by two considerations, namely, that the data were not sufficient to permit grouping according to specific lengths, and that the averaging process is much more practical from the oysterman's point of view.

From the curves in Figure 1, the lengths at the end of each month were recorded. Figure 2 was then constructed, after the method described by Walford (1946), by which the

FIGURE 2



Growth curves for oysters held in trays at Gloucester Point, Virginia, transformed according to the method of Walford (1946).

lengths at a particular date are plotted against the lengths a given time interval later, in this case at intervals of one month. Smooth lines were drawn through each set of points. By reading off lengths from these curves, or by interpolating between them, the growth in length of oysters in trays at Gloucester Point, starting with any given original size, can be reconstructed easily.

The Rate of Growth in Weight

The available data on growth in weight at Gloucester Point, though less extensive than the length records, are adequate to construct a graph of the length-weight relationship. Plotted on logarithmic coordinates the resulting points assume a linear relationship, which can be represented by a line fitted by the method of least squares, as in Figure 3. Weights corresponding to the lengths read off Figure 2 were plotted as in Figure 4, which represents the best available average estimate of the growth in weight of Wreck Shoal seed transferred to trays at Gloucester Point. The lower curve in this figure illustrates the growth rate of the small oysters (mostly less than one inch in length) that do not survive planting operations in Chesapeake Bay. The upper curve represents the growth of the larger seed oysters (those recognized as seed by the planters).

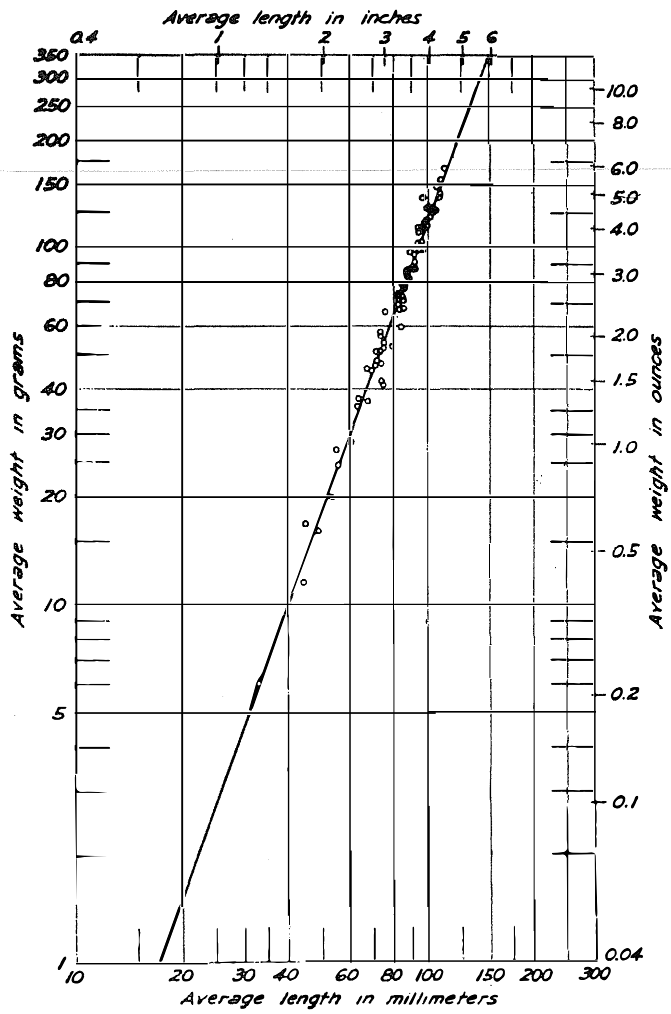
The Instantaneous Rate of Growth

The instantaneous growth rate can be computed from the following expression (Ricker, 1945):

$$e^k = 1 + b$$

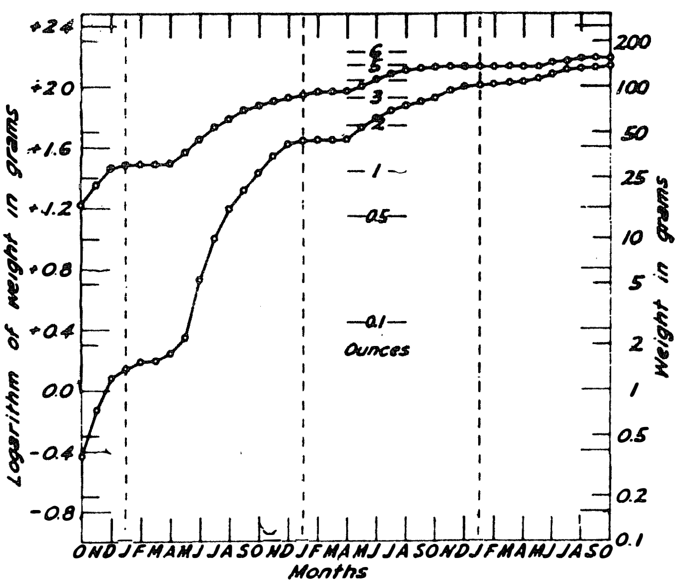
where e = 2.7183, the base of the natural logarithms, k = the instantaneous ~~mortality~~ Growth rate, and b = the fraction by which the surviving oysters have increased in weight during the period in question.

FIGURE 3



The relationship between length and weight in oysters held in trays at Gloucester Point, Virginia.

FIGURE 4



Seasonal patterns of growth in weight of oysters held in trays at Gloucester Point. The lower curve represents the growth of the current-year spat in seed oysters from Wreck Shoal in the James River, which do not survive when transplanted to Chesapeake Bay. The upper curve represents the thick-shelled larger oysters in Wreck Shoal seed, that are recognized as seed by the planters.

For the present purpose, however, the computations can be presented more simply by the method outlined by Ricker and Foerster (1948), as illustrated in Table 1. The instantaneous growth rates k were computed by dividing the values in the previous column by 0.4343, the logarithm of e.

TABLE 1

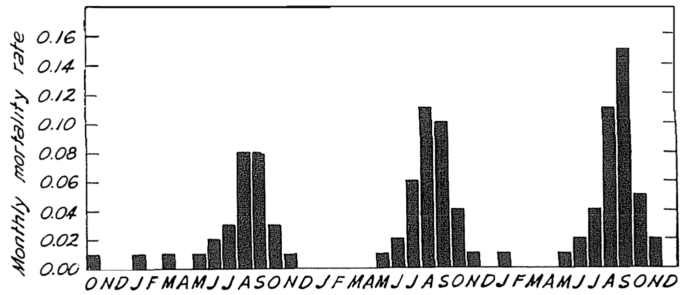
Computation of seasonal growth rates for Wreck Shoal seed oysters transferred to trays at Gloucester Point. The lengths are inserted for reference, and are not used in the computations.

Beginning of month	Current Year Spat				One year of age or older			
	Length in mm.	Log_{10} weight in gms.	Difference	k	Length in mm.	Log_{10} weight in gms.	Difference	k
Oct.	12	—0.43			48	1.22		
			0.30	0.69			0.13	0.30
Nov.	15	—0.13			54	1.35		
			0.21	0.48			0.11	0.25
Dec.	18	+0.08			59	1.46		
			0.06	0.14			0.03	0.07
Jan.	19	0.14			60	1.49		
			0.05	0.12			0.00	0.00
Feb.	20	0.19			60	1.49		
			0.00	0.00			0.00	0.00
Mar.	20	0.19			60	1.49		
			0.05	0.12			0.00	0.00
Apr.	21	0.24			60	1.49		
			0.11	0.25			0.08	0.18
May	23	0.35			64	1.57		
			0.38	0.88			0.08	0.18
June	32	0.73			69	1.65		
			0.27	0.62			0.08	0.18
July	40	1.00			74	1.73		
			0.19	0.44			0.05	0.12
Aug.	47	1.19			78	1.78		
			0.13	0.30			0.06	0.14
Sept.	53	1.32			81	1.84		
			0.11	0.25			0.03	0.07
Oct.	58	1.43			84	1.87		
			0.11	0.25			0.03	0.07
Nov.	63	1.54			86	1.90		
			0.08	0.18			0.03	0.07
Dec.	67	1.62			89	1.93		
			0.02	0.05			0.01	0.02
Jan.	68	1.64			90	1.94		
			0.01	0.02			0.03	0.07
Feb.	69	1.65			91	1.97		
			0.00	0.00			0.00	0.00
Mar.	70	1.65			92	1.97		
			0.00	0.00			0.00	0.00
Apr.	70	1.65			92	1.97		
			0.08	0.18			0.03	0.07
May	74	1.73			94	2.00		
			0.06	0.14			0.05	0.12
June	78	1.79			97	2.05		
			0.05	0.12			0.03	0.07
July	82	1.84			100	2.08		
			0.03	0.07			0.03	0.07
Aug.	86	1.87			102	2.11		
			0.03	0.07			0.01	0.02
Sept.	88	1.90			103	2.12		
			0.03	0.07			0.01	0.02
Oct.	90	1.93			104	2.13		
			0.04	0.09			0.00	0.00
Nov.	92	1.97			105	2.13		
			0.03	0.07			0.00	0.00
Dec.	94	2.00			105	2.13		
			0.01	0.02			0.00	0.00
Jan.	95	2.01			106	2.13		
			0.01	0.02			0.00	0.00
Feb.	95	2.02			106	2.13		
			0.01	0.02			0.00	0.00
Mar.	96	2.03			106	2.13		
			0.01	0.02			0.00	0.00
Apr.	96	2.04			106	2.13		
			0.01	0.02			0.00	0.00
May	98	2.05			106	2.13		
			0.03	0.07			0.03	0.07
June	101	2.08			107	2.16		
			0.03	0.07			0.01	0.02
July	103	2.11			108	2.17		
			0.01	0.02			0.02	0.05
Aug.	105	2.12			109	2.19		
			0.01	0.02			0.00	0.00
Sept.	106	2.13			109	2.19		
			0.01	0.02			0.00	0.00
Oct.	106	2.14			110	2.19		
			0.01	0.02			0.00	0.00
Nov.	106	2.15			110	2.19		
			0.01	0.02			0.00	0.00
Dec.	107	2.16			110	2.19		

The Mortality Rate

As demonstrated by Hewatt and Andrews (1954), the mortality of oysters in trays at Gloucester Point is concentrated for the most part in the summer months (July to October inclusive). From the original data on which their report was based, the monthly mortality rates have been computed, that is, the percentage of the oysters alive at the beginning of each month that died during that month (Fig. 5).

FIGURE 5



The monthly pattern of mortality of oysters held in trays at Gloucester Point, commencing with the larger oysters in Wreck Shoal seed, and following through three successive summers. Compiled from the original data on which the paper of Hewatt and Andrews (1954) was based.

The Instantaneous Rate of Mortality

The instantaneous mortality rate can be computed, as was the instantaneous growth rate, from a similar formula (Ricker, 1945):

$$e^{-q} = 1 - a$$

where e = 2.7183, q = the instantaneous natural mortality rate in trays at Gloucester Point, and a = the fraction of the original number of oysters that died during the period under consideration (usually a signifies the annual rate).

Here again it is simpler to use Ricker's (1948) table to read off the corresponding values directly, according to the value of a. The instantaneous rates listed in Tables 2 and 3 were obtained by this method. (See Pages 29 and 31)

Computation of Yields

The instantaneous rates of growth and mortality were combined, as in Tables 2 and 3, to calculate the net increase in total mass of oysters (k - q). The corresponding changes in biomass (total volume of oysters) were read from column 12 (if positive) or from column 2 (if negative) in Ricker's (1948) appendix table. Assigning the arbitrary value 100 to the original volume of oysters planted, the relative biomass at the end of each month was computed. The absolute volume of oysters in 100 bushels of seed was then calculated, and this value was substituted for the original arbitrary value of 100. The subsequent absolute biomass at the end of each month after planting was derived by simple proportion.

Table 2 presents these computations as applied to the current-year spat in 100 bushels of Wreck Shoal seed. The increase in biomass is very large, reaching 168 times the original volume at the end of 33 months, when this group reached its greatest computed yield. The original volume of these oysters is relatively small, however, being only one-half bushel for each 100 bushels of seed. Consequently, this tremendous increase in biomass produces a maximum of only 84 bushels of market oysters for each 100 bushels of seed. It must be pointed out that these figures are only approximations, for the original estimate of 0.5 bushels in each 100 bushels of seed was derived from the average length of these oysters. It is probable that this represents an overestimate rather than a low figure, thus the maximum volume may be too high. Nevertheless, this group of small seed oysters probably contributes significantly to the higher yields obtained by planters in the upper estuaries, where drills are not a problem.

In Table 3 the same computations are applied to the group of larger oysters in Wreck Shoal seed, recognized as useful seed by the planters. Here, although the maximum volume, reached in 22 months, is only about 5 times that of the original planting, the oysters when planted make up about half the entire volume of seed. Thus, a yield of about 2.5 bushels is possible from the larger oysters in each original bushel of seed.

Another consideration must be introduced in combining these two sets of figures to derive the total yield. At planting, few, if any, of the oysters are of market size, and our growth studies have shown that some of the survivors may

TABLE 2

Computation of relative biomass, and absolute biomass per original bushel of seed oysters, for the current-year spat in Wreck Shoal seed.

Beginning of month	k	q	k-q	Change in Biomass	Biomass	Absolute biomass per 100 bu. of seed
Oct.					100	0.5
	0.69	0.01	0.68	+0.97		
Nov.					197	1.0
	0.48	0.00	0.48	+0.61		
Dec.					317	1.6
	0.14	0.00	0.14	+0.15		
Jan.					365	1.8
	0.12	0.01	0.11	+0.12		
Feb.					409	2.0
	0.00	0.00	0.00	0.00		
Mar.					409	2.0
	0.12	0.01	0.11	+0.12		
Apr.					457	2.3
	0.25	0.00	0.25	+0.28		
May					585	2.9
	0.88	0.01	0.87	+1.39		
June					1,398	7.0
	0.62	0.02	0.60	+0.82		
July					2,544	12.7
	0.44	0.03	0.41	+0.51		
Aug.					3,841	19.2
	0.30	0.08	0.22	+0.25		
Sept.					4,801	24.0
	0.25	0.08	0.17	+0.18		
Oct.					5,665	28.3
	0.25	0.03	0.22	+0.25		
Nov.					7,081	35.4
	0.18	0.01	0.17	+0.18		
Dec.					8,356	41.8
	0.05	0.00	0.05	+0.05		
Jan.					8,774	43.9
	0.02	0.00	0.02	+0.02		
Feb.					8,948	44.7
	0.00	0.00	0.00	0.00		
Mar.					8,948	44.7
	0.00	0.00	0.00	0.00		
April					8,948	44.7
	0.18	0.00	0.18	+0.19		
May					10,648	53.2
	0.14	0.01	0.13	+0.14		
June					12,139	60.7
	0.12	0.02	0.10	+0.10		
July					13,353	66.8
	0.07	0.06	0.01	+0.01		
Aug.					13,486	67.4
	0.07	0.12	—0.05	—0.05		
Sept.					12,812	64.1
	0.07	0.10	—0.03	—0.03		
Oct.					12,428	62.1
	0.09	0.04	0.05	+0.05		
Nov.					13,049	65.2
	0.07	0.01	0.06	+0.06		
Dec.					13,832	69.2
	0.02	0.00	0.02	+0.02		
Jan.					14,109	70.5
	0.02	0.01	0.01	+0.01		
Feb.					14,250	71.2
	0.02	0.00	0.02	+0.02		
Mar.					14,535	72.7
	0.02	0.00	0.02	+0.02		
Apr.					14,826	74.1
	0.02	0.00	0.02	+0.02		
May					15,122	75.6
	0.07	0.01	0.06	+0.06		
June					16,029	80.1
	0.07	0.02	0.05	+0.05		
July					16,830	84.2
	0.02	0.04	—0.02	—0.02		
Aug.					16,493	82.5
	0.02	0.12	—0.10	—0.10		
Sept.					14,844	74.2
	0.02	0.16	—0.14	—0.13		
Oct.					12,914	64.6
	0.02	0.05	—0.03	—0.03		
Nov.					12,526	62.6
	0.02	0.02	0.00	0.00		
Dec.					12,526	62.6
		0.00				

never reach the arbitrary length of three inches or over that we have used to designate market oysters. Allowance has been made for the size factor in computing the yields in Table 4. It will be noted that two maxima in the yield of market-sized oysters are reached, the first, of about 2.8 bushels for one, in 22 months after planting, and the second, of about 2.9 bushels for one, in 34 months. The slightly larger value for the second maximum probably is not significant, and the greater total volume of oysters in existence at 22 months (see column 4) would almost certainly contain significant numbers smaller than 3 inches worth shucking so as to boost the computed yield.

Applications to Oyster Planting

The yields discussed above are illustrated graphically in Figure 6. Obviously, it is not wise to apply results obtained from tray culture directly to practical oystering problems, at least without attempting to determine how these rates of growth and mortality compare with those on planted grounds.

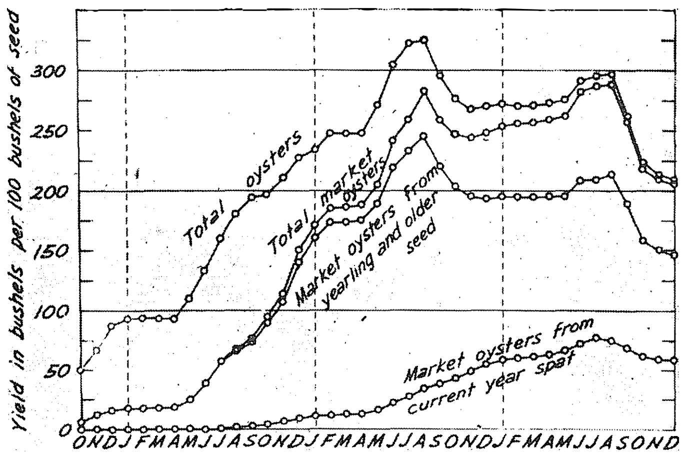
Considering first the growth rate, it is fairly certain that the seasonal variations observed in trays are similar in order of time, if not in magnitude, to growth on planted ground. It can be assumed also, that because the trays are exposed

TABLE 3

Computation of relative biomass, and absolute biomass per original bushel of seed oysters, for the yearling and older oysters in Wreck Shoal seed.

Beginning of month	k	q	k-q	Change in Biomass	Biomass	Absolute biomass per 100 bu. of seed
Oct.					100	50
	0.30	0.01	+0.29	+0.34		
Nov.					134	67
	0.25	0.00	+0.25	+0.28		
Dec.					172	86
	0.07	0.00	+0.07	+0.07		
Jan.					184	92
	0.00	0.01	—0.01	—0.01		
Feb.					182	91
	0.00	0.00	0.00	0.00		
Mar.					182	91
	0.00	0.01	—0.01	—0.01		
Apr.					180	90
	0.18	0.00	+0.18	+0.19		
May					214	107
	0.18	0.01	+0.17	+0.18		
June					252	126
	0.18	0.02	+0.16	+0.17		
July					295	148
	0.12	0.03	+0.09	+0.09		
Aug.					322	161
	0.14	0.08	+0.06	+0.06		
Sept.					341	170
	0.07	0.08	—0.01	—0.01		
Oct.					338	169
	0.07	0.03	+0.04	+0.04		
Nov.					352	176
	0.07	0.01	+0.06	+0.06		
Dec.					373	186
	0.02	0.00	+0.02	+0.02		
Jan.					380	190
	0.07	0.00	+0.07	+0.07		
Feb.					407	204
	0.00	0.00	0.00	0.00		
Mar.					407	204
	0.00	0.00	0.00	0.00		
Apr.					407	204
	0.07	0.00	+0.07	+0.07		
May					435	218
	0.12	0.01	+0.11	+0.12		
June					487	244
	0.07	0.02	+0.05	+0.05		
July					511	256
	0.07	0.06	+0.01	+0.01		
Aug.					516	258
	0.02	0.12	—0.10	—0.10		
Sept.					464	232
	0.02	0.10	—0.08	—0.08		
Oct.					427	214
	0.00	0.05	—0.05	—0.05		
Nov.					406	203
	0.00	0.01	—0.01	—0.01		
Dec.					402	201
	0.00	0.00	0.00	0.00		
Jan.					402	201
	0.00	0.01	—0.01	—0.01		
Feb.					398	199
	0.00	0.00	0.00	0.00		
Mar.					398	199
	0.00	0.00	0.00	0.00		
Apr.					398	199
	0.00	0.00	0.00	0.00		
May					398	199
	0.07	0.01	+0.06	+0.06		
June					422	211
	0.02	0.02	0.00	0.00		
July					422	211
	0.05	0.04	+0.01	+0.01		
Aug.					426	213
	0.00	0.12	—0.12	—0.11		
Sept.					375	188
	0.00	0.16	—0.16	—0.15		
Oct.					315	158
	0.00	0.05	—0.05	—0.05		
Nov.					299	150
	0.00	0.02	—0.02	—0.02		
Dec.					293	146

FIGURE 6



The yield, in bushels of live oysters, in successive months after planting in trays at Gloucester Point, Virginia, from Wreck Shoal seed. The upper curve represents all oysters, including the current-year spat. It must be noted that the original yield at planting is only about one-half the actual bulk of the seed, because each bushel of seed oysters contains about half a bushel of shell, to which the oysters are attached, and fouling organisms. The three lower curves represent respectively the yield of oysters larger than three inches in length from the entire volume of seed, from the larger seed oysters, and from the current-year spat.

to a more effective circulation of water, and because there is relatively less silt to be rejected, oysters in trays will grow faster than those on the bottom. This appears to be supported by the available data, and we hope to obtain better data soon.

The seasonal pattern of mortality rates in trays at Gloucester Point appears to bear a close relationship to the seasonal cycle of water temperature (Hewatt and Andrews, 1954). Therefore, for the sources of mortality to which tray oysters are subject, it would not appear unreasonable to assume that a similar mortality pattern would apply on planted bottom, with respect to time though not necessarily in magnitude. Oysters on the bottom, however, are subject to death from other important causes, the depredations of drills or screwborers being perhaps the principal factor. Unpublished observations of oyster drill activity in the vicinity of Gloucester Point show that the activity of these predators is closely associated with the temperature cycle, and these observations can reasonably be extended to cover the activities of other predators, all of which are cold-blooded and thus quite sensitive to temperature variations. Thus it seems safe to assume that the average seasonal pattern of mortality on the bottom is similar to the pattern observed in trays.

Hewatt and Andrews (1954) report annual mortalities of about 25 per cent for oysters in trays at Gloucester Point, but the calculations made earlier in the present paper suggest that the annual mortality on the bottom is of the order of 37 per cent. The annual mortality rate associated with bottom factors, therefore, is about 16 per cent. This suggests that the fungus *Dermocystidium marinum* is a more serious source of mortality than the oyster drill, at least insofar as the larger seed oysters are concerned.

There seems to be good reason to believe that growth and mortality on planted bottom differ from the same rates in trays chiefly in magnitude rather than in seasonal pattern. Thus, curves showing the yield on planted ground at various levels of growth and mortality can be constructed by adjusting by appropriate factors the rates determined from tray culture. Such a series of curves, based on a growth rate three-quarters as great as the rate in trays, is illustrated in Figure 7. It is worth noting that the maximum yield, unless mortality is exceptionally low, is reached about a year and a half after planting. If these oysters were not harvested until fall, a mere three or four months after the maximum yield was reached, the yield would have fallen considerably, and although the spring growth of the following year would cause the yield to increase again, it would never apparently reach the former level.

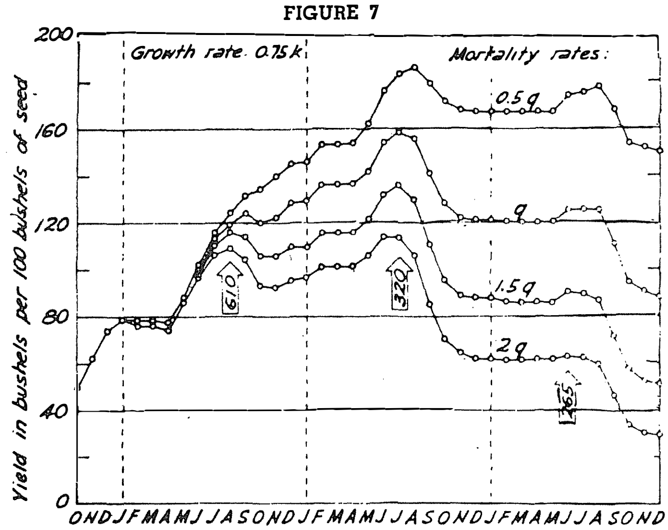
Families of curves, based on various rates of growth and mortality, can be constructed readily. The oysterman can determine the rates characteristic of his grounds by methods described by Hopkins and Menzel (1952), and by selecting the appropriate curve, can determine when to harvest for the greatest yield in bushels of oysters.

TABLE 4

Total biomass resulting from the planting of 100 bushels of Wreck Shoal seed in trays at Gloucester Point.

Beginning of month	Absolute biomass per 100 bu. of seed			Percent market oysters per 100 bu. of seed		Bushels of market oysters per 100 bu. of seed
	Spat	Young	Total	Spat	Young	
Oct.	0.5	50	50	0	12	0 + 6 = 6
Nov.	1.0	67	68	0	18	0 + 12 = 12
Dec.	1.6	86	88	0	19	0 + 16 = 16
Jan.	1.8	92	94	0	20	0 + 18 = 18
Feb.	2.0	91	93	0	20	0 + 18 = 18
Mar.	2.0	91	93	0	20	0 + 18 = 18
Apr.	2.3	90	92	0	20	0 + 18 = 18
May	2.9	107	110	1	23	0 + 25 = 25
June	7.0	126	133	3	31	0 + 39 = 39
July	12.7	147.5	160	5	38	1 + 56 = 57
Aug.	19.2	161	180	8	41	2 + 66 = 68
Sept.	24.0	170.5	194	14	43	3 + 73 = 76
Oct.	28.3	169	197	19	53	5 + 90 = 95
Nov.	35.4	176	211	21	61	7 + 107 = 114
Dec.	41.8	186.5	228	25	75	10 + 140 = 150
Jan.	43.9	190	234	26	84	11 + 160 = 171
Feb.	44.7	203.5	248	27	85	12 + 173 = 185
Mar.	44.7	203.5	248	28	85	13 + 173 = 186
Apr.	44.7	203.5	248	29	86	13 + 175 = 188
May	53.2	217.5	271	31	87	16 + 189 = 205
June	60.7	243.5	304	36	90	22 + 219 = 241
July	66.8	255.5	322	40	91	27 + 232 = 259
Aug.	67.4	258	325	55	95	37 + 245 = 282
Sept.	64.1	232	296	60	95	38 + 220 = 258
Oct.	62.1	213.5	276	70	95	43 + 203 = 246
Nov.	65.2	203	268	75	96	49 + 195 = 244
Dec.	69.2	201	270	80	96	55 + 193 = 248
Jan.	70.5	201	272	83	97	58 + 195 = 253
Feb.	71.2	199	270	84	98	60 + 195 = 255
Mar.	72.7	199	272	84	98	61 + 195 = 256
Apr.	74.1	199	273	86	98	64 + 195 = 259
May	75.6	199	275	87	98	66 + 195 = 261
June	80.1	211	291	90	99	72 + 209 = 281
July	84.2	211	295	91	99	77 + 209 = 286
Aug.	82.5	213	296	91	100	75 + 213 = 288
Sept.	74.2	188	262	93	100	69 + 188 = 257
Oct.	64.6	158	223	95	100	61 + 158 = 219
Nov.	62.6	150	213	95	100	59 + 150 = 209
Dec.	62.6	146	209	95	100	59 + 146 = 205

FIGURE 7



Hypothetical yield curves, based on a growth rate three-quarters as rapid (0.75k) as the rate in trays at Gloucester Point, Virginia, and at mortality rates equal to one-half, one, one and one-half, and two times (0.5q, q, 1.5q, and 2q) the rate in trays. The figures within the arrows represent the numbers of oysters per bushel.

It would be of little benefit to the planter if he were to harvest his oysters at the point of maximum yield, only to find that the size was too small for economical shucking. The oysterman's criterion of size is the count per bushel, and it is useful to know how the relationship between the average length, or average weight of oysters, and the bushel count. By actual measure of oysters of various sizes, grown in trays at Gloucester Point, we have found that the relationships between both length and weight with yield, can be expressed as straight lines on logarithmic coordinates, as with the length-weight relationship in Figure 4. Furthermore, the relationship of weight to yield can be expressed roughly by an even simpler expression:

$$n = \frac{(3 \times 10^4)}{w}$$

where n is the number of oysters per bushel, and w is the average weight of oysters in grams.

In Figure 7 the counts per bushel at the points of inflection are given as numbers within arrows at the appropriate positions.

Is Further Investigation Necessary?

Several factors important to the oysterman have been ignored in the preceding sections. Perhaps the most important is the question: "Are the oysters in prime condition at the time of maximum yield, and is the shucking ratio high?" The planter is perhaps better able than the biologist to answer this question.

The producer will also be interested in the demand and the price, for he may find it necessary often to hold his crop past the point of maximum yield whether he wishes to or not. Some practical considerations such as the labor supply, will tend to force him to spread his operations over as many months as possible; others, such as the necessity to obtain high yields, favor a concentration of effort. Technological developments that would eliminate such conflicting pressures, such as the discovery of mechanical shucking methods and the development of quick freezing processes, seem to offer the best hope for solution of these problems.

Much more accurate information is necessary on the growth and mortality rates characteristic of planted bottom. It is hoped to get this information in two ways, by examining representative samples from planted grounds in various areas of the Bay and estuaries, and by experimental plantings of marked oysters. We hope also that some planters will be stimulated by these findings to examine our figures carefully. If our argument appears reasonable, we would urge them to experiment by harvesting at various time intervals. It goes without saying that for maximum results, such experimentation should be planned carefully and should be accompanied by careful and systematic recording. The Virginia Fisheries Laboratory will be willing and anxious to cooperate in such experiments.

LITERATURE CITED

HEWATT, WILLIS G. and JAY D. ANDREWS 1954.
Oyster mortality studies in Virginia. I. Mortalities of oysters in trays at Gloucester Point, York River.
Texas Jour. Sci., 6 (2), June 1954: 121-133.

HOPKINS, SEWELL H. and R. WINSTON MENZEL 1952.
How to decide best time to harvest oyster crops.
Atlantic Fisherman, 33 (9), Oct. 1952: 15, 36-37.

OWEN, H. MALCOLM 1953.
Growth and mortality of oysters in Louisiana.
Bull. Marine Sci. Gulf and Caribbean, 3 (1), June 1953: 44-54.

RICKER, WILLIAM E. 1945.
A method of estimating minimum size limits for obtaining the maximum yield.
Copeia, 1945 (2), June 30, 1945: 84-94.

RICKER, WILLIAM E. 1948.
Methods of estimating vital statistics of fish populations.
Indiana Univ. Publ., Science Ser., 15, Bloomington, Indiana, v + 101 pp.

RICKER, WILLIAM E. and R. E. FOERSTER 1948.
Computation of fish production.
Bull. Bingham Ocean. Coll., 11 (4), May 1948: 173-211.

WALFORD, LIONEL A. 1946.
A new graphic method of describing the growth of animals.
Biol. Bull., 90 (2), April 1946: 141-147.