OBSERVATIONS AND EXPERIMENTS ON THE GROWTH OF OYSTERS.

By O. C. Glaser.

INTRODUCTION.

One can hardly fail to be impressed with the great diversity in the shape of oysters on the natural beds. Normal disk-shaped and oval individuals lie side by side with those of irregular and even grotesque form, while here and there in vertical clusters are narrow shells of extreme length. These narrow and elongated shells, which in some places predominate to the almost entire exclusion of all other shapes, are important agents in the formation of reefs, marshes, and islands.

The elongated condition of these oysters has been attributed to various causes. According to one view, the complete exposure to the air at every low tide accounts for it, but this explanation is entirely inadequate. Not only is it difficult to understand how such exposure could bring about the great increase in length which these oysters have experienced without corresponding growth in width, but it completely fails to account for the fact that equally elongated individuals are found on beds that are always below watermark and can not receive any periodic exposure to the air.

According to another view, this shape of the oysters is due to the fact that they are half buried in mud, because, in order to escape suffocation, they elongate into the clearer strata of water above them. This explanation is apparently more credible than the first, but it has still greater difficulties to overcome. If the presence of mud were the factor determining the elongation of oysters it would be difficult to find any that are not elongated, and it would be useless to look for well-shaped oysters in many places from which we gather large and choice specimens for the market. It would also be useless to look for elongated forms on the reefs where they are now most abundant, because these reefs are almost entirely composed of shells and calcareous sand. That there is nothing in the general environment which effects the elongation of oysters is shown further by the fact that perfectly normal individuals grow on the elongated ones.

A third view attributes the elongated condition to crowding. Ryder, in his Contribution to the Life History of the Oyster, says that the natural tendency of oysters to grow upward accounts for the fact that they become crowded, and crowding makes them narrow and elongated. "In all the natural banks which I have had the pleasure of examining in the Chesapeake, the individual oysters assume an approximately vertical position. The assumption of this position seems perfectly natural. With the large end downward and the free edges of the valves directed upward the animals are in an excellent position to feed, while the outside vertical surfaces of the valves are well adapted to afford places of attachment for the spat. The habit of growing in the erect position, where the banks are prolific and undisturbed, causes the individuals to be very much crowded together, so that they do not have a chance to expand and grow into their normal shape. From this cause—overcrowding—the shells of the individual oysters become very narrow and greatly elongated. The peculiar forms which result are known to oystermen as 'raccoon oysters' or 'cat's tongues.'" Verrill, in his Vineyard Sound report, points out that old specimens in crowded beds often grow to be more than a foot long and, perhaps, only 2 inches wide. Professor Brooks, in his well-known book on the oyster, also thinks that the elongated forms are due to crowding: "The oysters are crowded together so closely that they can not lie flat, but grow vertically upward side by side. They are long and narrow, are fastened together in clusters, and are known as 'coon oysters.'" Dr. Caswell Grave, in his article on the oyster reefs of North Carolina (1901), believes that the oysters composing the clusters on the reefs are long and narrow on account of their crowded condition, and Dr. H. F. Moore, of the United States Fish Commission, in a personal communication, commits himself to the view "that the elongation of the oyster, tending to the raccoon type, is either due to crowding on the beds or to the attempt of the oyster to keep the lips of its shell above the surface of the soft bottom."

These opinions, with the exception of that of Moore, who thinks that the presence of mud may also be one of the reasons for the elongation, agree as to the cause of the shape of the oysters. Ryder thinks that the crowding is due to the natural tendency of oysters to grow upward. I have not been able to observe this natural tendency, and I believe with Professor Brooks that the crowding brings about the upward growth, and not the upward growth the crowding.

OBSERVATIONS.

Young oysters are frequently found covering shells, rocks, and other suitable material so completely that nothing can be seen of the objects to which they are attached. In such collections it is easy to see that the proximity of the oysters to one another causes the thin growing margins of their shells to fuse and become folded upward. As they grow without any corresponding increase in the surface on which they have settled, those portions of the shells which have been made, after all the available surface has been used, become more and more raised, until finally the oysters are placed at a sharp angle to their original position. If growth continues they will finally be perpendicular to the surface of attachment.

Very frequently new spat settles on the shells which have been elevated, and if this new layer is sufficiently dense the shells again become crowded, misshaped, and elevated. If there were no irregularities in the shells to which they are attached they would ultimately stand at right angles to them. The first layer, however, presents so many openings and corners into which shells of the second layer may squeeze that these, instead of growing out at a sharp angle, usually are densely packed into the available crevices. In this way clusters are formed in which one may often count from five to seven generations. The oysters in these collections are nearly all misshaped or unduly elongated, and all such are oppressed on one or more sides by neighbors. Often the direction of growth is suddenly changed by a sharp angle and the edges of the shells follow even the minute indentations and irregularities of their neighbors. It seems clear from such clusters that the elongated and irregular shapes of the oysters are due to the fact that there is not room enough for them to expand and grow to the width which they might have attained had they been isolated or comparatively free.

One of the first facts to be noticed during a study of localities where elongated oysters grow is that normal adults occur frequently in the little bays and indentations of marshes, but are rare on the points, which are tipped with regions composed almost entirely of the elongated forms growing actively under an environment similar to that of the reef oysters. The oysters that grow in the marsh bays and inlets are surrounded by great quantities of mud, which is in part produced by decaying vegetable and other organic matter derived from the marsh itself, but probably is collected chiefly by the mass of green vegetation which acts as a sieve through which the water passes at high tide, parting with much of the matter that it holds in suspension. The mud thus collected accumulates, especially in the little bays and inlets, and after a heavy rain may rise several inches and smother a good many oysters which were on the surface of the old shore line. Sometimes the accumulation is very sudden and great. In making these observations on one occasion it was necessary to revisit, after some days, a certain little bay, and there I found a perfectly smooth and even muddy shore line, knee deep under which were the oysters I had come to examine.

From this it seems probable that the presence of mud, while it sacrifices many oysters, is good for those which survive, because they are freed from the crowding of neighbors. I suspect that the advantage of dragging a dredge over young beds not yet ready to yield a harvest, lies not only in the fact that in this way the clusters are forcibly separated, but that many young oysters, which would have grown to maturity and then crowded one another, are turned under and killed by the mud, giving their more fortunate neighbors a better opportunity for normal and regular growth.

The excessive crowding to which the oysters growing in clusters are subject has been held by Professors Brooks and Verrill to account for the fact that such collections, often numbering as many as 100, are frequently composed entirely of empty shells. The work of Doctor Grave on the conditions under which oysters feed lends strong support to the opinion that crowding may bring about the death of entire clusters, because it is almost certain that the individuals composing them are poorly fed, and therefore probably not so resistant as oysters growing alone or in less densely crowded communities. Doctor Grave has shown that under normal and favorable conditions a Newport River oyster takes one hour to strain 333 c. c. of water, and that it can obtain sufficient nutriment in from two to six hours. The thickest clusters of marsh and reef oysters are found where they are covered only during the last hour of flood tide, during slack water, and during the first hour of ebb tide, and in this brief period they must get their food. Thus the maximum time which many of these oysters have for feeding is little more than the minimum time during which their more fortunately situated relatives can procure all they need. The supply of food, shortened in this way by a disadvantageous position, is in all probability still further diminished as a direct result of the crowding. The density with which the elongated oysters are packed makes it almost certain that the water containing their food passes through more than one set of gills, and the amount that each individual can extract will depend on the number of times that the water has already been strained. Only the first oyster securing a given quantity of water has the opportunity of extracting from it all the diatoms that it contains.

While there seem to be good reasons for believing that the ill-nutrition and the crowding of oysters, caused by their location, may account for the fact that so many of them die, there is another possibility which must be taken into consideration in explaining the large numbers of clusters of empty shells. It is no rare occurrence for many of the animals inhabiting the sand flats to be killed at low tide by the great heat of the midsummer sun. There can be little doubt that the oysters also suffer during these periods of too high temperature, and it is very probable that many of them, whether underfed or not, succumb. In the winter, also, exposure to too low a temperature may freeze them to death. These unfavorable temperatures surely occur with sufficient frequency to account in part for the great quantities of empty shells.

EXPERIMENTS.

I. *To ascertain whether normal oysters can be converted into elongated ones by pressure.*

Thirty round, well-shaped young oysters were removed from cultch taken from the experimental bed in Newport River. These oysters were fastened by means of Portland cement to slabs of slate and the cement was so piled up around them that each oyster was subject to pressure on two of its edges, the margin opposite the hinge being free. After the cement had hardened, the slabs were put in the water near the laboratory and left undisturbed for one month. At the end of this time they were removed and the oysters examined.

None had died, indicating that the abnormal conditions under which they had been placed were not unfavorable to life. None had grown in width, but all were longer than at the beginning. Some had the scolloped anterior edges characteristic of elongated oysters, and due probably to the fact that the laterally oppressed mantles, instead of spreading out flat and evenly, are thrown into folds. These results indicate that mechanical pressure may be an important factor in determining the shape of the shell.

II. *To ascertain whether elongated oysters liberated from an oppressive environment will change in shape.*

Thirty-five elongated and narrow young oysters were removed from their crowded condition, cleaned, and carefully measured. Their length was taken from the tip of the umbo of the upper valve to the middle of the anterior edge, and their width at a point on the same valve halfway between the two extremities of the first measurement. They were then placed in a cage made of galvanized iron wire, and this was suspended horizontally in the water under the laboratory wharf, where an especially strong tidal current prevails. After thirty, and again after forty-eight, days the above measurements were taken in the same way and compared with the initial figures. The results are given in the table following.

TABLE I.

August 2, 1902, initial measurement.			September 2, 1902, after thirty days.			September 18, 1902, after forty-eight days.		
Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.
Cm.	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*
4.2	2.1	50	2.9	2.1	72	4.9	3.7	76
6.6	3.0	45	2.7	2.1	78	5.7	2.6	46
3.7	1.9	51	4.6	3.1	67	4.2	2.1	50
5.0	2.1	42	5.8	3.0	52	4.0	2.3	58
4.0	1.5	38	2.4	2.2	92	3.7	2.6	70
4.0	2.3	58	3.3	2.0	61	6.0	3.0	50
3.5	1.9	54	3.6	2.5	69	5.4	3.3	62
5.9	2.6	44	4.0	2.2	55	3.8	2.0	53
3.4	1.9	56	4.1	2.4	59	4.9	2.9	57
3.6	2.5	69	4.1	2.1	51	3.2	2.8	88
3.8	1.9	50	3.6	2.0	56	5.0	3.3	66
4.2	1.8	43	3.0	2.0	67	4.1	2.5	61
3.6	1.9	53	5.1	2.5	49	5.2	2.8	54
2.2	1.2	55	4.2	2.5	60	7.1	3.6	51
3.0	1.7	57	5.0	3.0	60	3.4	2.9	85
2.5	1.1	44	3.9	2.9	74	2.9	2.9	100
2.6	1.9	73	3.7	2.4	65	4.2	3.1	74
3.2	1.2	38	3.8	3.0	79	4.6	2.8	61
4.0	2.1	53	3.5	2.3	65	4.5	3.0	67
3.8	1.8	55	3.1	1.9	61	4.5	3.0	67
3.2	1.8	56	3.5	1.9	54	4.0	3.0	75
4.2	2.2	52	4.3	2.8	65	3.4	2.4	71
3.0	1.4	47	3.8	2.3	61	4.3	3.5	81
3.1	1.4	45	5.0	2.9	58	4.2	2.4	57
2.0	.9	45	4.0	2.8	70	5.6	4.0	71
2.7	1.1	40	4.8	3.3	64	6.4	3.1	48
1.7	.9	53	4.1	3.1	76	5.4	4.0	74
2.8	1.9	68	4.6	2.3	50	4.2	3.3	79
2.4	1.5	63	3.6	2.2	61	3.6	2.2	61
2.5	1.4	56	6.7	3.1	46	4.3	2.9	67
2.6	1.8	69	3.6	2.3	64	4.0	2.7	68
2.9	1.5	52	6.2	3.1	50	4.1	2.7	66
3.8	2.1	55	3.0	2.0	67	4.2	2.5	60
2.3	1.2	52	(a)	(a)		(a)	(a)	
1.6	1.3	81	(a)	(a)		(a)	(a)	
Average ratio, 53.			Average ratio, 62.			Average ratio, 66.		

a Dead.

NOTE.—In taking the measurements and in calculating the percentage ratios of width to length decimals under 0.05 were neglected and 0.05 and over were counted as .1.

From this table it is evident that at the beginning of the experiment, August 2, 1902, the width of this lot of oysters was only 53 per cent of the length, whereas on September 2 it was 62 per cent, an increase of 9 per cent; on September 18 it was 66 per cent, an increase over the original ratio of 13 per cent. This marked change, easily noticeable without measurements, was very surprising because it took place in forty-eight days after the liberation of the oysters from their original oppressive environment.

To compare these oysters with the normally shaped ones from the experimental bed in Newport River, thirty young oysters from this locality were measured in the same way:

TABLE II.

Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.
Cm.	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*
3.1	2.9	94	3.3	3.3	100
5.0	3.5	70	4.6	3.6	78
2.3	1.8	78	4.8	3.5	73
2.9	3.0	103	5.4	3.5	67
4.8	3.0	63	3.6	2.8	78
4.9	3.7	76	2.8	2.6	93
5.4	3.3	61	5.0	2.9	58
5.0	4.2	84	3.5	2.5	71
4.1	3.0	76	5.6	3.9	70
5.0	3.6	72	3.7	3.3	89
5.7	4.3	75	4.8	3.7	77
4.2	3.6	86	4.0	3.6	90
5.7	4.0	70	3.5	2.8	80
5.5	3.8	69	2.5	3.0	120
4.0	3.1	78	2.4	2.0	83

Average ratio of width to length 79 per cent.

These measurements show that in some cases a young oyster is actually wider than it is long, and the occurrence of such makes the ratio of width to length very high. For the present lot it was 79 per cent.

The oysters used in Experiment II were, according to their size, of about the same age as the normal spat, and the two groups can therefore be compared. At the beginning the width of the experiment oysters was only 53 per cent of their length, or 26 per cent less than the similar relation in the normal spat. On September 2 it was 62 per cent, or 17 per cent below normal, and on September 18 it was 66 per cent, or 13 per cent below normal, showing a steady approximation to the condition found in oysters which have never been subject to crowding.

This comparison between the normal spat and the young elongated forms suggested a similar one between adults of normal shape and elongated oysters of about the same size and approximately the same age. The length and width of these were measured by the method employed with the younger oysters.

TABLE III.

Normal adults.			Elongated oysters.		
Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.
Cm.	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*
10.7	6.2	57	10.0	3.2	32
8.8	4.8	55	7.8	4.0	50
8.7	4.3	49	9.4	3.9	41
8.5	4.6	54	8.4	3.3	39
9.0	6.0	67	7.4	3.0	41
8.9	5.4	61	7.8	3.2	41
9.9	5.3	54	8.6	3.5	41
9.4	4.6	49	8.0	3.8	48
7.3	4.5	62	7.6	2.8	37
8.9	5.7	64	6.5	2.7	42
7.5	4.1	55	7.6	3.7	49
8.2	4.6	56	6.0	2.6	43
8.8	4.0	45	8.9	3.5	39
8.3	5.2	63	6.8	3.5	51
6.5	4.4	68	7.3	3.7	51
6.6	3.4	52	7.7	2.9	34
7.7	4.4	57	8.0	2.9	36
9.0	4.8	53	8.7	3.9	45
6.7	4.5	67	6.3	2.7	43
9.5	3.7	39	6.3	2.5	40
9.2	4.0	43	6.4	3.0	47
7.2	4.7	65	7.6	2.6	34
8.4	4.5	54	6.5	2.7	42
8.7	4.9	56	7.7	2.1	27
7.7	4.3	56	8.1	2.3	28
8.8	4.8	55	7.0	3.4	49
10.0	5.2	52	6.5	2.9	44
6.2	4.0	64	7.6	3.1	41
8.1	4.8	59	8.3	3.8	46
8.0	4.3	54	6.3	2.4	38
Average ratio, 56.			Average ratio, 41.		

These measurements illustrate very strikingly that oysters normally grow longer than they do wide, so that a large, well-shaped adult oyster may, in the relation between its width and its length, give a figure far below the one expressing the same relation in younger stages.

At first glance it might possibly be thought that the adult "normal" oysters were not normal at all, because their width was only 56 per cent of their length, being 13 per cent lower than the ratio between the width and length of the young spat referred to in Table II. This, however, is by no means the case, because the relation between width and length varies with the age. An old "normal" oyster is not a "good" oyster; thus the interesting fact is brought to light that a condition which normally occurs only in oysters of extreme old age may be induced in young ones by crowding. As far as the relations between width and length are concerned, therefore, young elongated oysters are in a state of premature old age. Verrill long ago pointed out that great increase in length without corresponding growth in width is the natural order of things. "Nearly all the oyster shells composing the ancient Indian shell heaps along our coast are of this much elongated kind. Nowadays the oysters seldom have a chance to grow to such a good old age as to take on this form, though such are occasionally met with in deeper water." Such mounds as Professor Verrill mentions occur at Marshallsburg, N. C., and there this kind of oyster shell is extremely abundant. The same type of shell, commonly known as the "razor blade," is also found, sometimes with the animal still alive, on the shores of the Newport River marshes.

III.—*To ascertain whether the recuperative power of elongated oysters varies with their age.*

Experiment II clearly demonstrates the fact that oysters grown under oppressive conditions are capable of changing in shape and assuming ultimately a form normal for their age. It is desirable, however, to know how late in life an oyster is still able to take advantage of new opportunities, and for this purpose the following experiment was made:

Ninety oysters were liberated from the most oppressive surroundings and were divided roughly, according to length, into three lots—(A) containing all sizes up to and slightly over an inch, (B) sizes between 1 and 2 inches, and (C) all measuring 3 inches or more in length. These three lots were measured, as in experiment II, and then placed in separate galvanized iron wire cages which were suspended horizontally under the wharf, as in the former experiment. They were placed in the water on September 5, 1902, and removed on November 5. The measurements were as follows:

TABLE IV.

SEPTEMBER 5, 1902.

A			B			C		
Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.
Cm.	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*
4.7	2.1	45	5.4	3.0	56	10.0	3.2	32
3.6	2.0	56	4.6	1.9	41	7.8	4.0	50
4.6	1.9	41	5.7	1.6	28	9.4	3.9	41
2.6	1.3	50	5.6	2.5	45	8.4	3.3	39
4.8	2.2	46	5.5	1.9	35	7.4	3.0	41
2.3	1.5	65	5.4	2.5	46	7.8	3.2	41
3.7	1.9	51	5.0	2.0	40	8.6	3.5	41
3.0	1.4	47	5.5	2.1	38	8.0	3.8	48
3.9	2.2	56	5.8	2.7	48	7.6	2.8	37
2.7	1.2	44	5.4	3.1	57	6.5	2.7	42
3.9	2.2	56	4.7	2.9	62	7.6	3.7	49
2.1	1.1	53	7.0	2.5	36	6.0	2.6	43
3.3	1.3	39	5.3	1.7	32	8.9	3.5	39
4.1	1.8	44	4.6	2.1	46	6.8	3.5	51
2.9	1.2	41	4.8	2.0	42	7.3	3.7	51
3.5	1.5	43	5.5	2.4	44	7.7	2.6	34
4.3	2.2	51	4.8	2.2	46	8.0	2.9	36
3.3	2.1	64	5.3	2.7	51	8.7	3.9	45
3.8	1.9	50	5.4	2.3	43	6.3	2.7	43
3.0	1.8	60	5.2	2.4	46	6.3	2.5	40
3.1	1.4	45	5.0	2.3	46	6.4	3.0	47
4.8	2.0	42	4.6	2.7	59	7.6	2.6	34
2.2	1.0	45	5.1	1.8	35	6.5	2.7	42
3.8	1.9	50	4.8	2.0	42	7.7	2.1	27
2.1	1.4	67	6.2	2.6	42	8.1	2.3	28
3.7	1.6	43	5.2	1.7	33	7.0	3.4	49
3.7	1.7	46	5.6	2.1	38	6.5	2.9	44
4.3	2.1	49	5.4	2.5	46	7.6	3.1	41
3.0	1.3	43	5.5	2.6	47	8.3	3.8	46
3.0	1.6	53	5.0	2.2	44	6.3	2.4	38
Average ratio, 50.			Average ratio, 44.			Average ratio, 41.		

NOVEMBER 5, 1902.

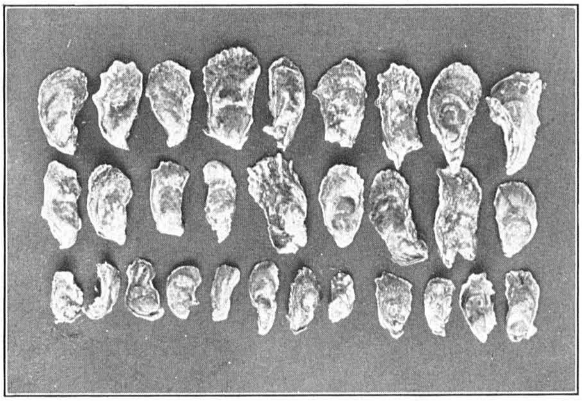
A			B			C		
Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.	Length.	Width.	Ratio of width to length.
Cm.	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*	*Cm.*	*Cm.*	*Per cent.*
4.2	2.8	67	5.8	3.3	57	6.9	3.2	46
4.6	3.5	76	6.6	3.9	59	9.0	3.8	42
4.0	2.8	70	4.4	2.7	61	6.7	3.7	55
4.5	2.9	64	7.1	3.6	51	7.4	3.8	51
3.6	2.8	78	6.2	3.0	48	7.6	3.6	47
4.5	2.9	67	5.9	3.5	59	8.6	4.3	50
4.3	2.5	58	6.0	3.4	57	8.6	4.3	50
3.1	2.3	74	5.8	2.9	50	8.3	3.8	46
4.8	3.1	65	5.5	2.5	45	8.2	4.0	49
3.1	2.3	74	6.2	3.1	50	6.6	3.3	50
5.5	2.9	53	6.0	3.3	55	7.3	3.6	49
4.2	2.7	64	5.5	2.7	49	7.6	3.2	42
5.7	3.3	58	6.3	3.4	54	7.3	3.9	53
4.3	3.0	70	5.8	3.8	66	7.9	3.4	43
4.1	2.5	61	5.8	2.7	47	9.5	4.2	44
3.0	2.5	83	5.4	2.9	54	7.9	3.3	42
3.1	2.5	81	7.1	3.3	46	8.1	3.1	38
5.6	3.3	59	5.9	3.1	53	7.7	4.0	52
3.3	2.2	67	5.8	2.9	50	7.9	4.3	54
5.0	3.3	66	5.1	3.4	67	8.3	2.9	35
4.0	2.7	68	6.3	3.3	52	6.6	2.9	44
5.8	3.7	64	6.1	3.7	61	7.4	4.0	54
4.5	3.1	69	5.7	3.0	53	6.3	3.2	51
4.8	2.7	55	(a)	(a)		6.4	3.4	53
3.7	2.4	65	(a)	(a)		(a)	(a)	
4.6	3.4	74	(a)	(a)		(a)	(a)	
3.9	2.4	62	(a)	(a)		(a)	(a)	
4.6	2.6	57	(a)	(a)		(a)	(a)	
(a)	(a)		(a)	(a)		(a)	(a)	
(a)	(a)		(a)	(a)		(a)	(a)	
Average ratio, 68.			Average ratio, 54.			Average ratio, 47.		

a Dead.

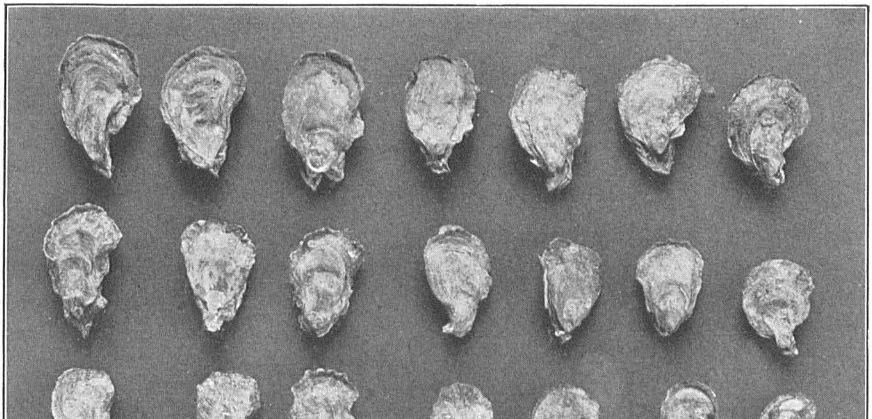
The oysters in lot A were of the same age as those used in experiment II, and a comparison of the measurements of the two groups fully corroborates the earlier results. The final measurements of lot A were made two months after the oysters had been liberated, and show more strikingly than the former experiment that elongated oysters are capable of approaching a normal shape with surprising rapidity. Two photographs were taken of this particular lot (plate x), and these illustrate as forcibly as the figures the great change that took place.

A comparison of the initial and final measurements of lots A, B, and C also shows that the recuperative power varies with age. On September 5 the ratio of width to length was 50 per cent in lot A, 44 per cent in lot B, and 41 per cent in lot C, whereas on November 5 the same lots presented respectively a percentage of width to length of 68, 54, and 47 per cent. Thus in all an improvement in the relation between width and length took place, lot A increasing 18 per cent, lot B 10 per cent, and lot C 6 per cent. This gradation is just what would be expected from the fact that oysters approaching old age normally grow longer than they do wide.

Of the oysters used in this experiment lots A and C, on account of



LOT A (EXPERIMENT III) AT BEGINNING OF EXPERIMENT, SEPTEMBER 5, 1902. (THREE-TENTHS NATURAL SIZE.)



LOT A (EXPERIMENT III) AT END OF EXPERIMENT, NOVEMBER 5, 1902. (THREE-TENTHS NATURAL SIZE.)

their original size, can be compared with the spat and normal oysters of Tables II and III. Such a comparison of the percentage ratios in the three tables shows that at the beginning lot A was 29 per cent below normal and lot C 15 per cent below normal, whereas after 60 days of improved surroundings lot A was only 11 per cent below normal and lot C 9 per cent below normal, demonstrating that the recuperative power of lot A was exactly three times that of lot C.

Without attaching too much weight to the results, it is interesting to note in what time these two lots A and C would have reached the normal states for their respective ages, if the rates of growth had continued what they were during the sixty days of the experiment. In lot A, in sixty days, the relation between the width and the length changed from 50 to 68 per cent, an average daily change of three-tenths per cent. According to Table II the normal condition is 79 per cent, from which it follows that at the rate of three-tenths per cent change per day, it would have taken this lot of oysters ninety-seven days (probably less, because at the age then attained the normal would be less than 79 per cent) to make up the discrepancy between 50 and 79 per cent. In lot C, on the other hand, the relation between the width and the length changed in sixty days from 41 to 47 per cent, a daily change of one-tenth per cent. According to Table III, the normal for this age is 56 per cent, from which it follows that at the rate of change of one-tenth per cent per day, lot C would have taken one hundred and fifty days to attain a normal condition. The recuperative power of the younger oysters is so much greater than that of the older ones, that in spite of the fact that they are much further below normal, they are nevertheless capable of realizing this condition in much less time.

The young oysters, besides having the advantage over the older ones of possessing greater recuperative power, seem also to possess greater resistance to the ill effects almost certainly attendant on a sudden change of environment. Not enough cases have been noted, of course, to establish this fact with a great degree of certainty, but a glance at Table IV will show that the mortality in lots B and C respectively was 23 and 20 per cent while it was only 7 per cent in lot A.

CONCLUSIONS.

The elongated condition which many oysters exhibit before they have attained old age is due to crowding. A great increase in length without an apparently proportionate increase in width represents the normal growth of an oyster, and the so-called "razor blades," much narrower than many of the elongated marsh and reef oysters, exhibit this condition, not because they have grown under unfavorable conditions, but because they are old. The elongated oysters which have been considered in this paper are young, and their shape is abnormal.

Because they have the same forms and proportions of much older normal oysters they may be said to be in a state of premature old age.

The crowded condition of these prematurely old oysters makes it impossible for them to expand and grow to a width normal for their age. They have the power to expand, however, when removed from this crowded condition, and this expansion takes place so rapidly that for the periods during which they were under observation they grew more in width than in length.* This is exactly what happens in very young oysters that have settled where they have abundant room. Under such favorable conditions the growth in width, for a period at least, is equal to the growth in length, and at times the former measurement may even exceed the latter. After this period in early youth the growth in width steadily decreases until the oyster reaches old age. Under unfavorable crowded conditions the growth in width is inhibited immediately after the period during which it is equal to or greater than the growth in length. If the hindrance is removed, a growth in width exceeding the growth in length nevertheless takes place. It seems as though the shell made up the loss which is the result of the crowding.

If we were to represent the normal growth in length and width by two curves, the width curve would, in the beginning, rise to the same or to a greater height than the length curve, but as the shell grew older the width curve would descend and the length curve rise until the original condition was reversed. In the elongated oysters, the width curve would have an early rise corresponding to the rise in the normal width curve, then a sudden fall, and, after isolation, another rise which would not be found in the normal curve. After this second rise the width curve would descend and correspond, in all probability, to the normal width curve for corresponding ages. The length curve of the elongated oysters would probably correspond stage for stage with the normal length curve, because the elongated oysters owe their condition, not to excessive length, but to excessive narrowness.

The recuperative power of oysters that have lived under oppressive conditions varies with their age. Young individuals recover much more rapidly than old ones, though these too improve to a marked degree. The latter, however, seem less able to adapt themselves to a sudden and violent change of environment, and the mortality among them is much greater than among younger ones.

These facts have a decided economic bearing. The experience of oystermen, in Northern waters especially, has shown that oysters can be transplanted with great profit. At present millions of young spat settle on the shells fringing the marshes and reefs, and there, under unfavorable conditions, grow into the elongated forms which have no market value. In this paper evidence is brought forward which shows that these oysters, when separated from the oppressive conditions under which they have grown, are able to recover and assume normal shapes.

The advantages which this class of seed offers to planters are its cheapness and the fact that the oysters are older and larger than those ordinarily used for planting. The most promising size is between 1 and 2 inches in length. After separation the oysters should not be left where they became crowded, but should be transplanted to properly located natural or artificial beds. There they will have favorable conditions of food, and in addition will be free from the danger of again becoming crowded, as the number of spat that settles on shells in wisely chosen localities is very much less than that which settles and continues to exist on the shells of the marshes and reefs.

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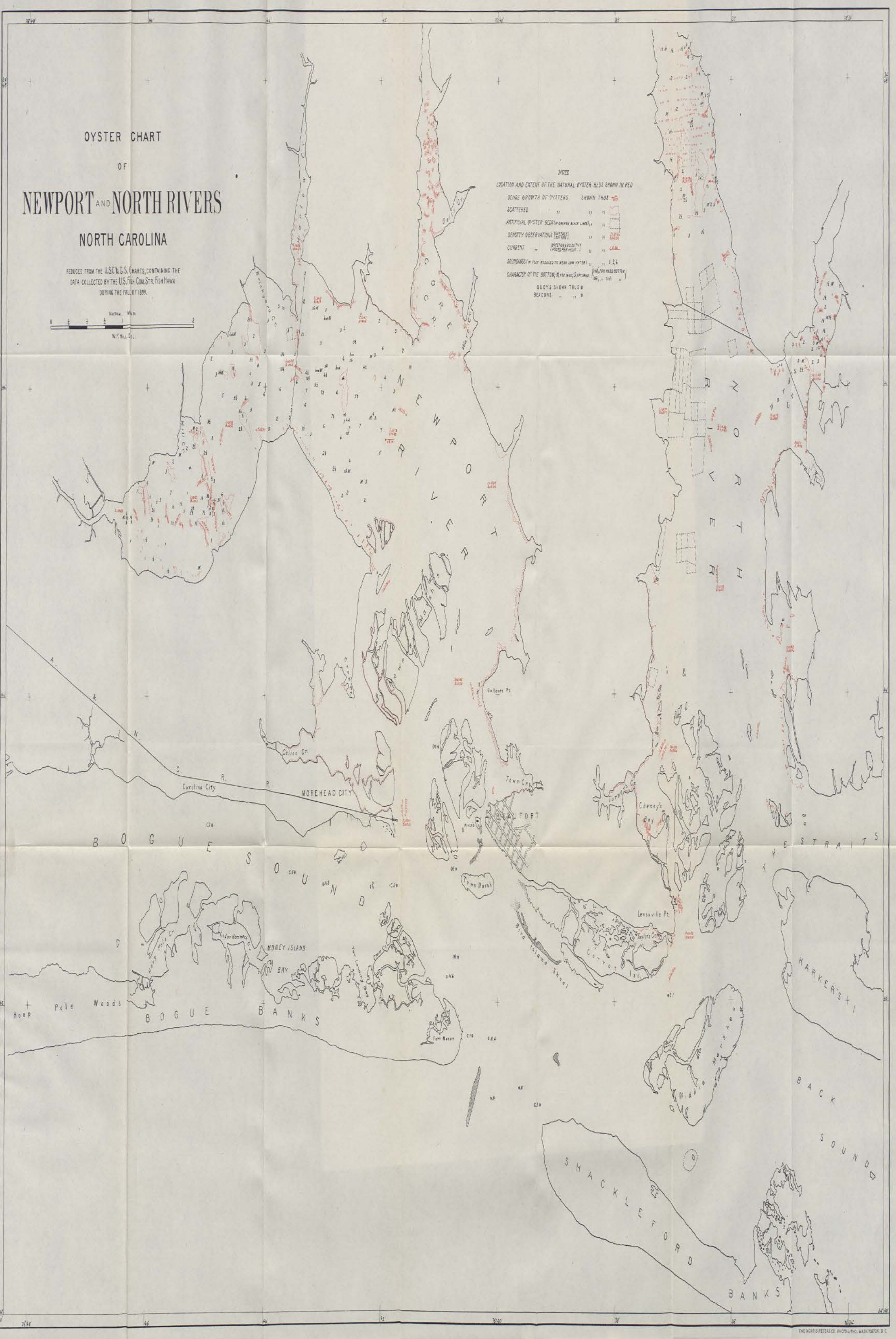

OYSTER CHART
OF
NEWPORT AND NORTH RIVERS
NORTH CAROLINA
REDUCED FROM THE U.S.C.& G.S. CHARTS, CONTAINING THE DATA COLLECTED BY THE U.S. FISH COM. STR. FISH HAWK DURING THE FALL OF 1899.
NAUTICAL MILES
0 1 2
W.F. HILL DEL.
NOTE
LOCATION AND EXTENT OF THE NATURAL OYSTER BEDS SHOWN IN RED
DENSE GROWTH OF OYSTERS SHOWN THUS
SCATTERED " " "
ARTIFICIAL OYSTER BEDS (IN BROKEN BLACK LINES) " "
DENSITY OBSERVATIONS (SURFACE) (BOTTOM) " "
CURRENT " (DIRECTION & VELOCITY) (MILES PER HOUR) " "
SOUNDINGS (IN FEET REDUCED TO MEAN LOW WATER) " " 1, 2, 6
CHARACTER OF THE BOTTOM; M, FOR MUD; S, FOR SAND.
BUOYS SHOWN THUS
BEACONS " "
NEWPORT RIVER
NORTH RIVER
CORE CR.
Calico Cr.
Gallants Pt.
Carolina City
MOREHEAD CITY
BEAUFORT
Town Cr.
Town Marsh
Cheney's Bay
Lenoxville Pt.
Taylor's Cr.
Carrot Isd.
Bird Island Shoal
THE STRAITS
HARKER'S I.
BACK SOUND
SHACKLEFORD BANKS
BOGUE SOUND
MONEY ISLAND BAY
BOGUE BANKS
Hoop Pole Woods
Fort Macon
A. & N. C. R. R.
THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON, D.C.