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Sex Reversal in *Ostrea virginica*

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A. Berkeley Needler. Report for 1930.

In 1880 W. K. Brooks published a paper on the development of the American oyster. He did not have time or opportunity to go into the matter very deeply, but on the strength of such evidence as he could collect he gave it as his opinion that the sexes were quite distinct and that no change of sex took place during the life-time of the oyster. This opinion has never been seriously contradicted and is still quoted but recently it has been suggested that some change does take place. The writer has been endeavouring to prove the truth of this assertion.

This year (1930) the investigation began in June. The weather being very warm the temperature of the water was unusually high for the time of year and it was possible to distinguish the sex of nearly all the oysters. Two oyster beds in particular were considered and specimens taken for examination every few days throughout the spawning season. These oysters had been planted there the previous summer. In addition two other collections were made on other beds in the neighborhood. All work was done in Bideford river, Malpeque bay. In the case of each oyster the length, width, age, sex and degree of spawning or any symptoms of disease were noted. Although this examination was carried on in full detail until near the end of September none are considered in the following account after July 25th. In other words only oysters taken at the height of the spawning season are reviewed, for reasons that will appear later. In each case the sex was determined by squeezing out some of the contents of the gonad and examining them with a microscope, and the age was estimated by counting the rings on the shell. In

the following tables of the age "2+" would be in the third summer of their lives, those marked "3+" would be in the fourth summer etc. These tables, then, summarize the number of oysters of each age and of each sex taken throughout the spawning season on each of the beds examined. Those oysters in which the sex could not be determined are noted in the column headed "?".

Table 1. Station 2001. Paugh's bed. Oysters taken June 21 to July 19.

Age	♂♂	♀♀	?	Total
1+	7	0	6	13
2+	48	4	4	56
3+	70	37	3	110
4+	25	25	1	51
5+	5	12	0	17
6+	0	2	0	2
7+	1	0	0	1
8+	0	0	0	0
11+	1	0	0	1
Total	157	80	14	251

Table 2. Station 2002. Pulpit bed. Oysters taken June 20 to July 25.

Age	♂♂	♀♀	Herm.	?	Total
1+	8	0	0	5	13
2+	48	5	2	1	56
3+	64	41	1	6	112
4+	26	34	0	1	61
5+	6	5	0	1	12
6+	0	2	0	0	2
7+	0	3	0	0	3
8+	0	1	0	0	1
Total	152	91	3	14	257

Table 3. Grant's bed. Oysters taken July 8.

Age	♂♂	♀♀	?	Total
1+	7	0	4	11
2+	38	9	2	49
3+	16	15	1	32
4+	2	2	0	4
5+	1	1	0	2
6+	0	2	0	2
Total	64	29	7	100

Table 4. Bed by Shipyard point. Oysters taken June 30.

Age	♂♂	♀♀	?	Total
5+	2	1	0	3
6+	5	1	0	6
7+	0	5	0	5
8+	0	4	0	4
9+	1	3	0	4
Total	8	14	0	22

The oysters taken at Shipyard point were somewhat selected with a view to getting larger specimens than ordinarily were to be found on the beds at stations 2001 and 2002. Here no oysters were taken less than 5+ and it may be seen that a fair proportion of the younger ones are males, although there is the same tendency as in the other beds for the older specimens to be female. We shall further consider this later. Meantime a review of the first three tables will show that there are very few females in their second or third summers (1+ and 2+), about half as many females as males in the fourth summer (3+), approximately the same number of each sex in thefifth summer (4+), and from that age on there are more females than males. It can also be seen that there were very few oysters in which the sex could not be determined--much too few to account for the large numbers of females of 3+ and the high proportions of females in later years. This strongly suggests that on these beds a number of the males have undergone a change of sex at the end of the third summer and some when a year or two older. Then in Table 2 a note is made of three definitely hermaphrodite oysters, two 2+ and one 3+. These oysters contained sperms and ova, both quite ripe. Self-fertilization was successfully carried out in the laboratory with one of these oysters and two have been preserved for histological examination during the winter. These oysters were at the ages

when one would expect, on the strength of the above records to find a change of sex taking place. However, only three such oysters were found and, as far as the writer is aware, there is no such previous record. It seems probable, then, that the change to the female usually begins only after the spawning season is over for the year and all the sperms discharged. With regard to the oysters at Shipyard point and the fact that the change of sex has apparently taken place at a much more advanced age we may suggest that in some way the conditions were not right for a change to take place earlier. This retarded change under certain conditions has been recorded in other animals.

In Bideford river there were two beds where oyster spat had been planted in the autumn of 1929. Here, then, it was possible to obtain oysters known to be in their second summer (1+), and a number from each bed were examined and the condition of the gonads noted.

The findings are summarized in the following tables:

Table 5. Totten bed. Oysters taken June 25 and July 4.

Age	♂♂	♀♀	?	Total
1+	27	3	132	162

Table 6. Wharf bed. Oysters taken July 3 and 30, and August 16.

Age	♂♂	♀♀	?	Total
1+	25	1	131	157

Now it can be seen that on one bed 18% and on the other 15% of the young oysters contained sexual products and would almost certainly spawn in their second summer, or when just one year old. It also appears that of all these sexually mature oysters

52 were male and 4 were female. Evidently a few oysters are female from the beginning.

As another method of attacking the problem it was decided to keep a number of oysters of known sex for a year or two to see whether any change took place. A few oysters were induced to spawn in shallow pans but this method of determining the sex proved too slow so about 100 oysters were drilled and a little of the contents of the gonad extracted with a pipette. About 85% of the oysters successfully survived the operation and cemented over the hole. A few subsequently died and a great many were lost during a storm early in November. Only 16 oysters remained to be kept through the winter, but it is hoped that these will show something next year. In any case the method has been worked out and can easily be tried again.

On the strength of the findings this summer it appears to be a legitimate assumption that about half the males undergo a change to the female sex by the end of the third summer when the sperms have been all spawned out and that some of the males go through this change at a greater age. A few of the oysters contain eggs in the second summer--probably as soon as they are sexually mature--and a few males are found at an advanced age. Whether these last have returned to the male sex after a time in the female or whether they have never changed there is no way of telling. Thoroughly to check these assumptions it will be necessary in future years to cut sections of oysters at all stages and at all times of year and to keep oysters of known sex for long periods, observing the sexual condition at intervals.