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Sex Reversal in Ostrea virginica

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The work done on sex reversal in Ostrea virginica during the summer of 1933 was a continuation of that started in 1930. It was mainly designed to find out whether the change of sex is affected by the proximity of oysters of the opposite sex.

Sex ratios in oysters of known age.

In 1929 the Totten bed was planted with spat and since 1930 samples of oysters have been examined each year. In 1930 only 19% of the oysters contained sexual products but since that time practically all the oysters have spawned each year although a few (recorded as "?") were in such a condition when examined that the sex could not be determined. The findings are summarized in the following table.

Table I. Sex ratios in 1929 spat on Totten bed.

Year	Total number examined	Percentage of each sex			
		♂	♀	♀	?
1930	167	17	2	0	81
1931	500	62	25	1	12
1932	157	43	54	4	1
1933	115	33	65	0	2

Consideration of this table shows plainly that the sex ration has been changing and the proportion of females to males has been steadily increasing. This is in accordance with previous studies of sex ratios on natural beds.

In 1930 a number of spat settled on the 1929 oysters on Totten bed. Some of these 1930 oysters were examined in 1932 and it was found that there were very few females in proportion to the males.

In 1933 some more of these oysters were examined and it appeared that there was much higher proportion of females than in 1932. The

Table II. Sex ratios in 1930 spat on Totten bed.

<u>Year</u>	<u>Total number examined</u>	<u>Sex</u>	<u>Percentage of each sex</u>
1932	63	♂♂	86
		♀♀	5
		Hermaphrodite	1
		?	8
1933	86	♂♂	62
		♀♀	37
		Hermaphrodite	1

results for the two years are summarized in Table II. They seem to show that, although the swing towards the female sex was extraordinarily retarded up to 1932, the factor producing this effect was not strong enough to do so permanently. In 1932 it was suggested that this factor might be the close proximity of older females, especially as growth seemed to be proceeding at a normal rate. This indicated that it was not poor nutrition due to overcrowding which retarded the change. The satisfactory growth continued in 1933 for the 1930 spat examined had attained an average length of 8.4 cm. as compared with an average length of 8.7 cm. reached by the 1929 spat in 1932. According to these records, then, it would seem that the proximity of older females might be the factor which retarded but did not inhibit the general change in the 1930 population from male to female. These suppositions are not altogether supported, however, by the other work and will be referred to again later.

Changes in oysters of known sex.

Since 1930 the sex has been determined in some oysters each year by boring a small hole in the shell of each and extracting some of the contents of the gonad with a pipette. Those so treated in 1930 and 1931 were not kept under very good conditions and the

mortality was very heavy but during the summers of 1932 and 1933 all such marked oysters were kept suspended from the wharf in wire baskets and the very low mortality and the good growth made by the oysters showed that they were quite healthy. But they were apparently not being kept under normal conditions even so. This will be more fully discussed after the results have been presented.

Of the oysters marked in 1930 only one was still alive in 1933. This oyster had never changed its sex but was female every year.

The sex of the oysters marked in 1931 that remained in 1933 is recorded for each of the three years in the following table.

Table III. Change of sex in oysters marked in 1931.

<u>Number</u>	<u>Sex from year to year</u>
5	♀ every year.
15	♂ every year.
5	♀ to ♀ to ♂.
3	♂ to ♀ to ♂.
2	♀ to ♂ to ♂.

It is worth noting that no oysters changed from male to female from 1932 to 1933 while eight changed from female to male.

In 1932 the sex was determined in about 250 oysters. Some of these were placed in wire baskets with the sexes separated. These separated oysters came from three different beds, - Cooper bed being farther down the river than the other two. Previous records of sex ratios have indicated that change in the female direction proceeds more slowly on this bed than farther up the river. The records are as follows:

Table IV. Changes in oysters male in 1932.

<u>Bed</u>	<u>No. of oysters in 1932</u>	<u>Numbers of oysters in 1933.</u>			
		<u>Dead</u>	<u>Female</u>	<u>Male</u>	<u>?</u>
Cooper (1930 spat)	111	4	21	85	1.
Shipyard point (1930 spat)	7	0	3	4	0
Totten (chiefly 1929 spat)	26	0	9	17	0

Table V. Changes in oysters female in 1932.

<u>Bed</u>	<u>Number in 1932</u>	<u>Numbers of oysters in 1933.</u>		
		<u>Dead</u>	<u>Male.</u>	<u>Female.</u>
Cooper (1930 spat)	45	1	37	7
Shipyard point (1930 spat)	12	3	8	1
Totten (mostly 1929)	21	1	16	4

It can be seen that the mortality amongst the oysters recorded in these last two tables was very low. It may be added that the oysters appeared to be healthy and making good growth. There is no appreciable difference in behaviour of oysters from the different beds.

A few oysters were examined in 1932 that were in pairs. Most of them were 2+ (spawned in 1930) although a few were 3+. These groups were all kept together over winter in one wire basket. The results are summarized as follows.

Table VI. Groups made in 1932.

<u>Nature of groups</u>	<u>Number of groups.</u>	<u>Remarks.</u>
Both males	7	One oyster changed to ♀ No change in the rest.
Both females	1	No change
One male, one female	4	One oyster changed from female to male. No change in the rest.

Lastly, some of the single oysters examined in 1932 were embedded in blocks of cement in such a way that the valves could open freely for feeding. The oysters were arranged in pairs with

the mouths of the shells together, and a male and a female in each pair.

Table VII. Oysters embedded in cement blocks.

<u>Age in 1932</u>	<u>Sex and No. in 1932.</u>	<u>Sex in 1933.</u>
All 2+	21 males 21 females	13 males, 7 females 1 ? 14 " 4 " 2 dead 1?
pp 3+. ♂♂ 2+	7 ♂ 7 ♀	3 males 4 females 4 males 2 females 1 dead.
oo 3+. oo 2+	7 ♂ 7 ♀	3 males 4 females 6 males 1 female

The purpose of this experiment was to test the idea that the close proximity of females inhibits the males from changing towards female, but it cannot be said that the results support the theory. There is some tendency observable for females to turn male rather than for males to turn female but it is not as strong a tendency as amongst most of the other oysters recorded above.

Discussion.

Altogether the results of these experiments are rather puzzling. It has been pointed out that on the oyster beds there is a constant change in sex ratio with more and more females in proportion to the males as the oysters get older. Even in the cases recorded above, where the spat settling on the Totten bed in 1930 went through this change much more slowly than usual, still the change was only retarded and there was the same general tendency as on the other beds. On the other hand there has been a strong tendency among the marked oysters for more to change from female to male than the other way. For the first two years, when there was a very heavy mortality among the marked oysters, it was thought that this female to male tendency might be caused by poor living conditions. But after these living conditions were improved and the

oysters were apparently quite healthy the same tendency was still found. Now when the 1930 spat settling on the Totten bed showed an extraordinarily high proportion of males in 1932 it was suggested that the change from male to female had been retarded by the proximity of older females. It was in an attempt to test this idea that some of the oysters were embedded in pairs in concrete, but the oysters on the blocks behaved more or less in the same way as did those in natural groups and those kept in baskets with the sexes separated. And yet all these oysters kept in captivity seem to behave quite differently from those on the beds where a much higher proportion of males must change to females each year than females to males. Now the factor of crowding was dismissed because the oysters in baskets seemed to be quite healthy, but it may be the controlling factor after all. Certainly the oysters in baskets are much more crowded together than those on the oyster beds. It might be that the oysters in the baskets are sufficiently crowded to upset the normal sex change but not sufficiently to interfere with growth. Possibly the close proximity of other oysters, irrespective of sex, will tend to produce a swing in the male direction. It may be pointed out that the 1930 spat, which were obviously retarded in their sex change up to 1932, would have been steadily growing so that the mouths of the oysters would tend to separate and the effect of very close proximity be somewhat overcome.

To test this theory of crowding being a controlling factor some marked oysters are being kept until the breeding season of 1934 suspended individually at a distance from one another, and will be compared with controls kept in baskets.