Importance of Local Environment in Oyster Growth

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Cultivation of the oyster, *Crassostrea virginica*, Gmelin, has always been dependent to some degree on the transplanting of young oysters from so-called seed areas to growing grounds. In recent decades, however, the planter has had to go progressively farther afield for his source of seed and the scarcity of seed oysters in many producing areas is a problem of increasing concern. The transportation costs involved in these operations make it imperative that the imported stock survive and grow at better than average rates. Oysters are readily transplanted many thousands of miles from the area in which they set, but stocks from some areas have been found to grow better than others. It has been shown too, as in the case of the eastern oyster transplanted to the Pacific coast, that oysters, while growing well in a new environment may fail to reproduce normally. For these and other reasons, it has become desirable, if not imperative, that the biologist study growth and mortality rates in as many different imported stocks as possible so that the best of these may be recommended to the commercial planter.

Stocks of oysters from the Pensacola area, where there is an abundant set, have been sent to several different geographical regions to develop information on this problem. In cooperation with Mr. Francis Beaven of the Chesapeake Biological Laboratory at Solomons Island, Maryland, reciprocal plantings of native oysters have been made. This paper summarizes observations on Chesapeake Bay oysters in Florida and compares their growth with that of Florida native stock.*

The Pensacola laboratory received a supply of Chesapeake oysters in December, 1950, when they were about six months old. The edges of the oysters were broken smooth in shipment, and there was an initial mortality of 10 per cent. The oysters were separated from the natural cultch, cleaned and placed in wire trays having fifty individual compartments. Identical trays containing Pensacola spat of the same approximate age were prepared and duplicate sets of trays were placed at each of two locations, designated as East and West stations. The trays hung three feet below mean low water and were about four feet above a barren sand bottom. Length, dorso-ventral width and the weight of each oyster were recorded at regular intervals for the next 18 months, i.e., until the oysters were two years old. Water temperature and salinity levels were recorded continuously at the West station, intermittently at the East station.

During the 18 months of observation there was a total mortality in all trays of 51 per cent. The drill, *Thais*, caused 32 per cent of this mortality, the remainder (19 per cent) was due to unknown agents. This amount of mortality, 19 per cent, is expected under our experimental conditions at Pensacola, over a period of 18 months. The mortality rates in the Chesapeake group were the same as in the local oysters although more of the local oysters

* I am indebted to John R. Wiggins and John S. MacGregor, former Fishery Aids at this laboratory, for some of the measurements reported here.

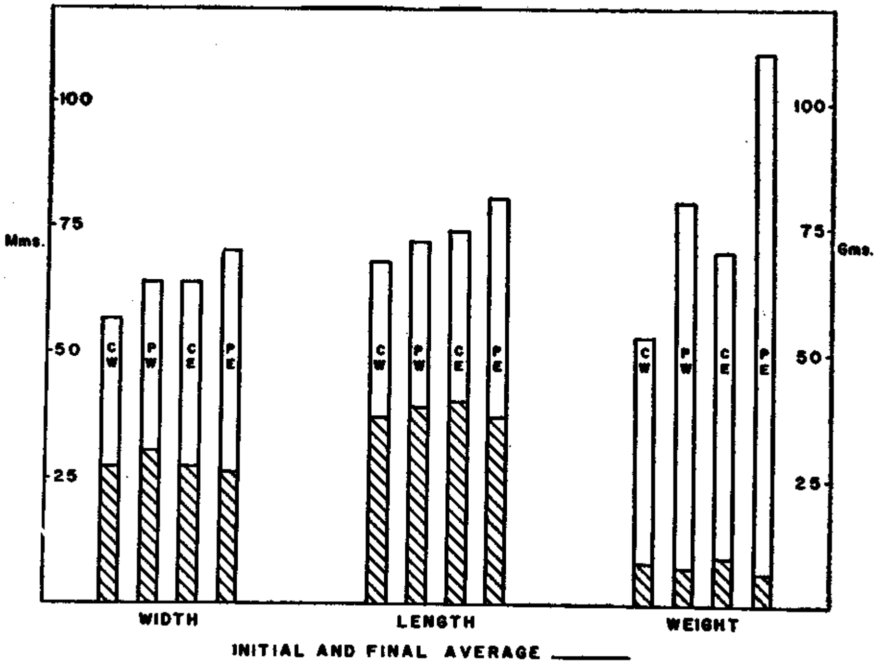

FIGURE 1. Average measurements of four groups of oysters at Pensacola, Florida in January 1951and July 1952. Chesapeake and Pensacola oysters grown at West stations are indicated by CW and PW; the same stocks grown at East station are indicated by CE and PE respectively.

were lost because of drill damage in one tray which fell to the bottom. There was no consistent difference in mortality rates at the two stations or during particular seasons of the year.

During the first few months of observation the Chesapeake oysters grew especially well, and faster than the local controls. This was perhaps due to the stimulus of being moved to a new environment. This rapid growth was, of course, at a time when the oysters would have been hibernating had they remained in their original environment. At the close of the experiment, some oysters in both stocks were over three and one-half inches long but there were also many only two and one-half inches long. All oysters were well shaped, with smooth rounded shells, as a result of the routine cleanings they received. All were infested to some extent with boring sponge and it is probable that some contained the boring clam, *Martesia.* At least 15 per cent of the Chesapeake oysters were sponge infested on arrival and presumably this condition had no material effect on the final results.

TABLE 1

CHESAPEAKE AND PENSACOLA OYSTERS AT PENSACOLA, FLORIDA, 1951-1952

	Jan.	Mar.	May	July	Sept.	Nov.	Jan.	Mar.	May	July
Chesapeake-East										
Length, mms.	40	46	52	55	58	60	66	72	74	74
Width, mms.	27	35	42	43	43	45	52	61	65	64
Weight, gms.	9	12	19	28	33	40	48	58	66	70
'G'	10	19	42	66	82	108	165	255	318	332
Mortality				4	2		4			6
Chesapeake-West										
Length, mms.	37	42	47	49	52	54	59	65	67	68
Width, mms.	27	34	38	38	39	40	47	54	58	57
Weight, gms.	8	10	16	22	26	31	37	45	51	53
'G'	8	14	29	41	53	67	103	158	198	205
Mortality			2	2			10	4		2
Pensacola-East										
Length, mms.	37	43	49	55	62	66	71	78	81	81
Width, mms.	26	32	40	43	46	48	56	67	71	70
Weight, gms.	6	8	15	28	43	55	69	86	99	110
'G'	6	11	29	66	123	174	274	449	569	624
Mortality		2		4	6		6		8	4
Pensacola-West										
Length, mms.	39	44	48	51	53	56	62	67	71	72
Width, mms.	30	36	39	41	42	43	51	60	65	64
Weight, gms.	7	10	20	27	33	39	50	62	70	80
'G'	8	16	37	57	74	94	158	249	323	369
Mortality		2	2							2

Average data recorded on first day of month for four groups of oysters at two stations.

The oysters showed great individual variability in the amount and timing of growth increases, as is to be expected, but the distribution of size frequencies was normal both initially and at the close of the experiment. On a commercial basis, the performance of the entire population is of more interest than that of the extreme individual. For this reason the data are presented as that of group averages and all measurements are rounded to the nearest whole number. Data are based only on oysters surviving beyond the end of the experimental period. Of the 400 original oysters, 16 were damaged or lost, 112 killed by drills, 86 died and 188 survived. Table 1 is a summary of the pertinent data.

Figure 1 illustrates the average size of the four groups of oysters at the start and close of the experimental period. Pensacola oysters at the east and west stations are designated PE and PW, Chesapeake oysters as CE and CW respectively. Initial differences in the average measurements of the four groups were quite small and are without significance. After 18 months the four groups were clearly differentiated in size and especially in regard to weight. PE oysters were consistently the longest, widest and heaviest. The CW group was the smallest in these respects, while CE and PW occupied intermediate positions.

These data on length, width and weight may be combined arbitrarily into a single factor representing growth in the several dimensions simultaneously.

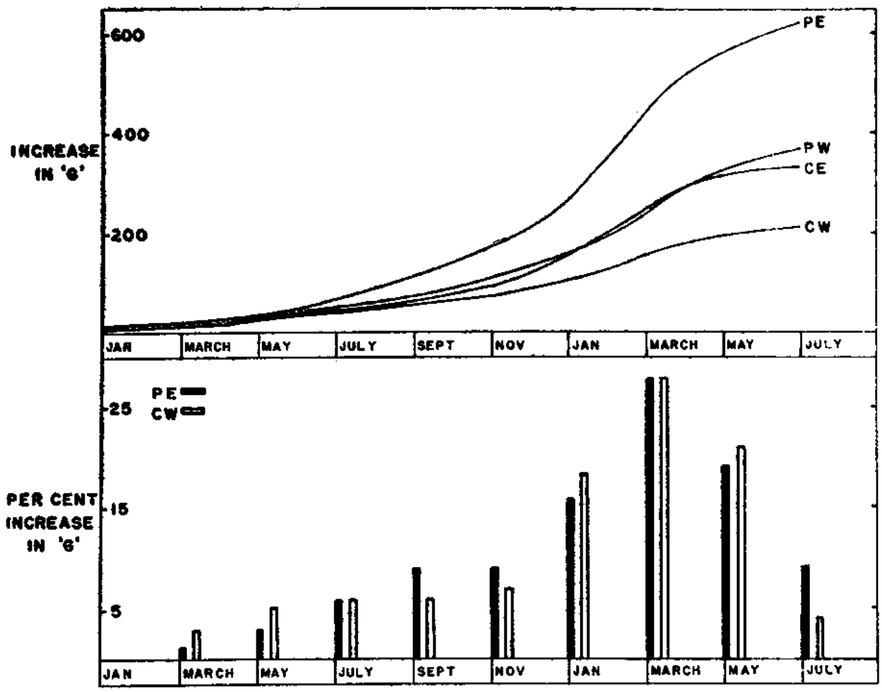

FIGURE 2. Bimonthly increases in calculated 'G' factor in four groups of oysters, where 'G' is product of length, width and weight divided by 1000. Percentage increase in 'G' when total 'G' for 18 months is considered to be 100. Pensacola East oysters, PE, attained largest average size; Chesapeake West oysters, CW, attained smallest average size.

This factor, which is termed 'G', is the product of length, width and weight, divided, for convenience, by 1000. In this study, the 'G' factor ranged from six in the young oysters to over 600 in the PE group, at 18 months. In Figure 2, the upper graph shows increases at bi-monthly intervals of the calculated 'G' factor for the four groups of oysters. These curves indicate clearly the distinctive nature of the growth increases in the different trays of oysters. During the first six months there were no sharp differences in average data, although the pattern of growth was clearly established. From this time until the end of the following year differences between the groups became accentuated. The uniformity of the several growth patterns was such that monthly gains in any three groups could have been predicted by the performance of the fourth group. This uniformity indicates that the factors controlling growth in the different groups were permanent features of the internal or external environment and not seasonal in nature.

These data may be presented in another way, to consider the total 'G' for the 18 months to be 100 and then indicate the per cent increases in 'G' at regular intervals. Such data are shown in the lower graph of Figure 2 for the fastest and slowest growing groups, PE and CW. It is important to note here that percentage increases in these groups are very similar, sometimes identical, at each time interval throughout the experimental period. Data for groups PW and CE, although not shown, possess the same pattern. Up until the last observation, increases in any one period for all four groups of oysters do not vary by more than four per cent of the total. It is justified to conclude then, without regard to actual growth in grams and millimeters, that all four groups grew at nearly identical rates in terms of their capacity to grow. This implies, further, that the rate of metabolic activity in each group was influenced to a similar degree by the environment. This is an expected conclusion, considering that temperature levels paralleled each other at the two stations. It is believed that this means that temperature, and probably salinity also, can be eliminated as decisive factors in producing the different growth patterns.

Despite similarities in rates of growth, the four groups of oysters attained quite different final sizes. This may be shown most clearly by tabulating the final 'G' factor for each group:

PE — 624	CE — 332
PW — 369	CW — 205

If the group with the lowest rating is reduced to unity, relative growth may be represented approximately as follows:

PE — 3X	CE — 1.5X
PW — 1.5X	CW — X

The data on any one of the measurements, such as length, width or weight could be treated in the same manner, but when this is done the distinctions between the four groups become less obvious.

This tabulation makes certain relationships apparent. Oysters at the East station did at least half as well again as the same stocks at the West station; the Pensacola oysters at each station grew at least half again as well as the Chesapeake oysters. The PW and CE oysters grew approximately as well as each other; the PE oysters grew three times as well as the CW group.

It must be concluded from these facts that not only is the environment at the two stations fundamentally different, but also, that local oysters grow far better than Chesapeake oysters in this area.

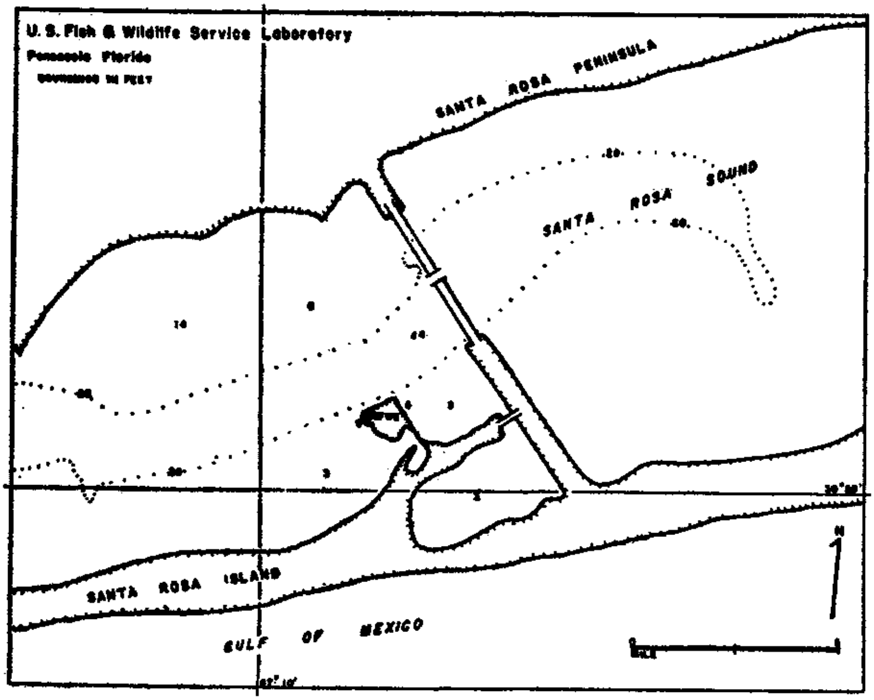

FIGURE 3. Location of laboratory island, USFWS, near Pensacola Florida. East and West stations are located at 6 and 9 foot soundings shown on either side of laboratory island and are 1000 feet apart.

The location of the two stations should assist us in interpreting these results but instead presents an additional problem. The diagram in Figure 3 shows the locations of the stations at the 6 and 9 foot sounding on either side of the laboratory island. The stations are not more than 1000 feet apart; they are exposed apparently to the same water currents; temperature and salinity levels parrallel each other. So far as can be determined without extensive chemical analyses, the two stations are similar, except that at one the morning sun is dominant and at the other the afternoon sun. Nevertheless, differences between samples of the same stock of local oysters placed at the two stations were greater in some instances than the differences between local oysters and oysters transplanted here from Chesapeake Bay, over 700 miles away.

It is fortunate that these plantings were made reciprocally at the two stations. Suppose that an investigator had made test plantings of a similar nature, but not using as many samples. Since a thousand feet between plantings is not ordinarily considered of importance, any one of the following combinations of plantings might have been made:

a. PE and CW
b. PE and CE
c. PW and CE

In these three selected combinations, the following conclusions would have been inevitable:

a. Pensacola oysters grow three times as well as Chesapeake oysters,
b. Pensacola oysters grow twice as well as Chesapeake oysters, or
c. Pensacola oysters and Chesapeake oysters grow equally well.

Unfortunately, such anomalous conclusions are much more than a theoretical possibility in an incompletely controlled test planting.

It would be desirable to go on from this point and describe the environmental factors which differentiate the east and west stations, but the data necessary to interpret this situation are not available. Of greater importance is the fact that it is not certain what data are necessary to interpret this situation. Until the superiority of one location a thousand feet from another can be accounted for it is not possible to interpret or predict the results of moving oysters up and down the coast—except on a trial and error basis.

From the little data available, there appears to be no logical explanation for the different results obtained at these two stations. The apparent continuity of water currents between the two areas would seem to preclude the existence of local concentrations of some water-borne factor. The absence of natural populations of oysters, or concentrations of other sedentary organisms, eliminates from consideration the possible effects of population densities. These conditions, combined with the similarity in the physical arrangement of the test oysters at the two stations, leaves little basis for profitable speculation on what factors are involved.

When the reasons for the poor growth of the Chesapeake oysters as compared to the local stock at the same station are examined it is equally difficult to arrive at any satisfactory conclusions. Mr. Beaven states that Pensacola oysters transplanted to Chesapeake Bay grow at slower rates than the native oysters. Thus it appears that each of these stocks of oysters does best in its own environment. This is certainly not due to an inherent adaptation to a warmer or colder climate. The slow growth pattern of the Chesapeake oysters was well established here before the water became any warmer than it is customarily in Chesapeake Bay. Nor can it be assumed that these oysters in the six months prior to transplanting became so accustomed to the local food supply that they were unable to adjust completely to the food in the new environment. The seasonal variation in the variety of plankters at either one location is probably as great as the differences in the plankton between Chesapeake Bay and Pensacola. There are numerous instances of transplants growing much better when their environment had been changed radically. No explanation is offered at this time for the observed differences in these groups of oysters.

It seems desirable that biologists make special efforts to examine in all possible detail the factors which interact to make a particular environment more or less suitable for oysters. A concerted attack on this problem may be far more productive than the wide-ranging surveys of oyster producing areas which have occupied so much of the investigators' time in the past. It is hoped that considerable effort can be devoted to a comprehensive study of the situation described here. The stations are convenient to the laboratory, and the fact that the essential differences must not be seasonal or sporadic, but exist throughout the year, makes this situation especially promising for an intensive investigation.