

PROGRESS REPORT
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INVESTIGATIONS ON OYSTERS
CRASSOSTREA VIRGINICA (GMELIN)
PLANTED AT BROAD LAKE, BELLEVUE,
TRINITY BAY,
NEWFOUNDLAND.

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DEPARTMENT OF BIOLOGY,
MEMORIAL UNIVERSITY OF NEWFOUNDLAND.

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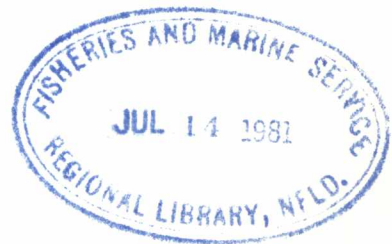
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Progress report #43

Report No. 2

Investigations on Oysters

Crassostrea virginica (Gmelin)

Planted at Broad Lake, Bellevue, Trinity Bay



By

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and

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January 1967

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INTRODUCTION

This report represents a continuation of studies commenced in 1965 on Prince Edward Island oysters, Crassostrea virginica, introduced into Broad Lake, Bellevue, Newfoundland, in May of 1965.

Precise details concerning quantities, age composition and specific locations of the various plantings may be found in the previous report (Aldrich 1965).

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Miss P. Bradbrook of the Department of Biology, Memorial University was extremely helpful in the preparation of the manuscript.

Special thanks are due to Dr. F. A. Aldrich of the Department of Biology, Memorial University, for his invaluable guidance and encouragement.

MATERIALS AND METHODS

The two surface trays (one of adults and one of seed) which had been purposely submerged in the previous autumn were re-floated on May 4th, 1966. The two bottom trays (one of adults and one of seed) were left in position. All four trays were located in Area A, exactly as in the previous summer.

Upon completion of the 1966 seasonal analysis, the trays were once again submerged for the winter on October 31st, 1966.

Checks of all trays and all four free plants were conducted at approximately monthly intervals as follows:

- a) May 16-20.
- b) June 15-20.
- c) July 16-17.
- d) August 13-14.
- e) September 17-19.

At each check counts and measurements (length and width) were made on all tray oysters. Particular note was made of the monthly mortality of tray oysters. Length and width measurements were made to the nearest millimeter with a simple measuring box containing an inset ruler. Recent shell growth and incidence of fouling organisms were also noted. During each check, boxes, gapers and blanks were removed from the tray. None of the tray oysters were sacrificed for internal analysis during the course of this study.

Samples were obtained from each of the free plants by tonging from a boat. The lengths and widths of these oysters were recorded as well as the incidence of fouling organisms. The animals were then opened and checked for:

- a) water content
- b) internal parasites
- c) gonad development
- d) presence or absence of crystalline style
- e) condition rating (Butler index) Aldrich (1965)
- f) presence or absence of mud within shell

Surface temperatures (to the nearest 0.1°C.) and surface and bottom salinities were recorded frequently at area A. Monthly surface temperatures were recorded at each of the free plant sites. Temperature and salinity data obtained during the course of this study are included in Appendix 1 of this report.

The statistical analysis of the data was carried out by the author at Memorial University.

RESULTS

The total monthly counts of living and dead seed and adult oysters held in both surface and bottom trays are presented in Tables 1 and 2. The percent mortality is given as a percentage of the total living and dead oysters counted in each tray and also as a percentage based on the total number of oysters present initially (i. e. May 1965). The latter computation was undertaken to permit the tabulation of percent survival data for the tray populations.

For the purposes of this study, gapers (intact valves that are unable to close but contain a variable quantity of meat) were counted with boxes and blanks as dead oysters.

Increments of tray mortality for both seed and adult oysters expressed as a percentage based on the May 1965 (original population) base and cumulative increments of mortality are presented in Table 3.

Figure 4 represents a tabulation of the percent of tray populations surviving at each check during the two seasons. The percentages are based on the original May 1965 populations which are represented in the tables as 100%.

Mean lengths expressed in centimeters of both tray and free plant oysters are presented in Table 5; while mean widths in centimeters of tray and free plant oysters are tabulated in Table 6.

Monthly percent increments derived from the length and width data for both trays and free plants are presented in Tables 7 and 8. The increments are expressed both as percent growth since the previous check (percentages based on lengths and widths at previous check and indicated /1, /2, /3) and percent growth since the May 1966 check (percentages based on lengths and widths at May 1966 check and indicated /0).

The data on percent occurrence of crystalline style in both seed and adult free plant oysters at each sampling is presented in Table 9. No data on crystalline style occurrence was obtained for tray oysters.

The mean conditions of the free plant seed and adult oysters throughout the summer are tabulated in Table 10. The combined monthly condition values for all three sites for seed and adult oysters are also presented.

The condition values are based on the Butler oyster condition scale which was developed by Dr. P. A. Butler of the U. S. Fish and Wildlife Service.

The scale is organized as follows:

1. Poor. More than 75% translucent.
2. Poor. Less than 75% translucent, but more than 25% translucent.
3. Fair. Digestive gland visible, less than 25% translucent.

4. Fair. Transition between 3 and 5.
5. Fair. Digestive gland not visible, less than 25% translucent.
6. Fair. Transition between 5 and 7.
7. Good. Digestive gland not visible, tissues opaque.
8. Good. Transition between 7 and 9.
9. Good. Digestive gland not visible, tissues more opaque.
10. Good. Entire animal cream colored and opaque.

The percent of the free plant monthly population samples showing some degree of gonad development are presented in Table 11.

Data on percent occurrence of epifauna on tray and planted oysters at each check is presented in Tables 12, 13, 14, 15, and 16.

At the check made on August 13, 1966, the tray of surface seed ~~was~~ found to have broken loose from its moorings and drifted across Broad Lake. It was found on the same day beached on a sand bar in the vicinity of free plant Site 2, apparently below high tide level. It was impossible to determine exactly how long the tray was out of position, but since the last check had been made on August 4th, the maximum possible period was 9 days.

Field data collected during the course of this study is being held by Dr. F. A. Aldrich, Department of Biology, Memorial University.

Table 1. Mortality of adult oysters held in trays.

<u>SURFACE TRAY</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Total oysters	187	89	78	79	79
Total living	91	80	77	79	78
Total dead	96	9	1	0	1
% mortality	51.3%	10.1%	1.3%	0.0%	0.4%
% mortality (on May 1965 base)	37.6%	3.5%	0.4%	0.0%	0.4%

<u>BOTTOM TRAY</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Total oysters	438	220	195	195	192
Total living	213	201	195	190	187
Total dead	225	19	0	5	5
% mortality	51.4%	8.63%	0.0%	2.6%	2.6%
% mortality (on May 1965 base)	45.3%	3.8%	0.0	1.0%	1.0%

Table 2. Mortality of seed oysters held in trays.

<u>SURFACE TRAY</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Total oysters	507	483	475	476	473
Total living	504	476	475	474	472
Total dead	3	7	0	2	1
% mortality	0.6%	1.4%	0.0%	0.4%	0.2%
% mortality (on May 1965 base)	0.6%	1.5%	0.0%	0.4%	0.2%

<u>BOTTOM TRAY</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Total oysters	468	475	460	459	459
Total living	460	463	459	458	457
Total dead	8	12	1	1	2
% mortality	1.7%	2.5%	0.2%	0.2%	0.4%
% mortality (on May 1965 base)	1.6%	2.4%	0.2%	0.2%	0.4%

Table 3. Increments of tray mortality.

ADULTS

<u>Surface tray</u>	<u>Aug. 65</u>	<u>May 66</u>	<u>June 66</u>	<u>July 66</u>	<u>Aug. 66</u>	<u>Sept. 66</u>
% mortality*	27.8%	37.6%	3.5%	0.4%	0.0%	0.4%
cumulative	27.8%	65.4%	68.9%	69.3%	69.3%	69.7%
<u>Bottom tray</u>						
% mortality*	16.7%	45.3%	3.8%	0.0%	1.0%	1.0%
cumulative	16.7%	62.0%	65.8%	65.8%	66.8%	67.8%

SEED

<u>Surface tray</u>	<u>Aug. 65</u>	<u>May 66</u>	<u>June 66</u>	<u>July 66</u>	<u>Aug. 66</u>	<u>Sept. 66</u>
% mortality*	2.1%	0.6%	1.5%	0.0%	0.4%	0.2%
cumulative	2.1%	2.7%	4.2%	4.2%	4.6%	4.8%
<u>Bottom tray</u>						
% mortality*	1.8%	1.6%	2.4%	0.2%	0.2%	0.4%
cumulative	1.8%	3.4%	5.8%	6.0%	6.2%	6.6%

*% mortality based on May 1965 base.

Table 4. Survival of tray oysters over two seasons.

SURFACE SEED

	<u>1965</u>				<u>1966</u>				
	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
% mortality	0.0%	1.3%	1.8%	2.1%	2.7%	4.2%	4.2%	4.6%	4.8%
% survival	100.0%	98.7%	98.3%	97.9%	97.3%	95.8%	95.8%	95.4%	95.2%

BOTTOM SEED

	<u>1965</u>				<u>1966</u>				
	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
% mortality	0.0%	1.6%	1.8%	1.8%	3.4%	5.8%	6.0%	6.2%	6.6%
% survival	100.0%	98.4%	98.2%	98.2%	96.6%	94.2%	94.0%	93.8%	93.4%

SURFACE ADULTS

	<u>1965</u>				<u>1966</u>				
	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
% mortality	0.0%	11.4%	16.1%	27.8%	65.4%	68.9%	69.3%	69.3%	69.7%
% survival	100.0%	88.6%	83.9%	72.2%	34.6%	31.1%	30.7%	30.7%	30.3%

BOTTOM ADULTS

	<u>1965</u>				<u>1966</u>				
	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
% mortality	0.0%	9.9%	12.1%	16.7%	62.0%	65.8%	65.8%	66.8%	67.8%
% survival	100.0%	90.1%	87.9%	83.3%	38.0%	34.2%	34.2%	33.2%	32.2%

Table 5. Mean lengths tray and free plants.

<u>SEED</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Top tray	6.545	6.595	7.039	7.330	7.411
Bottom tray	6.415	6.406	6.508	6.640	6.636
Plant No. 1	6.64	6.12	6.04	6.21	6.63
Plant No. 2	-	-	7.41	7.67	7.14
Plant No. 3	7.19	6.32	6.60	6.21	6.69

<u>ADULT</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Top tray	11.129	11.355	11.536	11.616	11.582
Bottom tray	10.841	10.607	10.646	10.832	10.706
Plant No. 1	11.90	10.83	12.12	11.61	11.12
Plant No. 2	12.14	12.58	12.08	11.69	12.84
Plant No. 4	-	11.16	11.64	10.72	12.68

Table 6. Mean widths tray and free plants.

<u>SEED</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Top tray	4.530	4.520	4.888	5.020	5.016
Bottom tray	4.504	4.488	4.539	4.640	4.614
Plant No. 1	4.45	3.98	3.87	3.92	4.20
Plant No. 2	-	-	4.73	4.52	4.79
Plant No. 3	4.41	4.23	4.07	3.75	4.14

<u>ADULTS</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Top tray	3.911	4.119	4.245	4.289	4.338
Bottom tray	4.163	4.087	4.061	4.144	4.143
Plant No. 1	4.56	4.23	4.12	4.08	3.97
Plant No. 2	4.02	4.54	4.49	4.42	4.33
Plant No. 4	-	3.97	4.31	3.99	4.22

Table 7. Percent increment in mean length of seed and adult oysters from free plantings and in trays, Broad Lake.

SEED OYSTERS	JUNE	JULY	AUGUST	SEPTEMBER
Top tray	+2.29%/0	+6.73%/1 +7.54%/0	+ 4.13%/2 +11.99%/0	+1.10%/3 +13.23%/0
Bottom tray	-0.14%/0	+1.59%/1 +1.44%/0	+2.02%/2 +3.50%/0	-0.06%/3 +3.44%/0
Position 1	-7.83%/0	-1.30%/1 -9.03%/0	+2.81%/2 -6.47%/0	+6.76%/3 -0.15%/0
Position 2			+3.50%/2	-6.91%/3 -3.64%/2
Position 3	-12.10%/0	+4.43%/1 -8.20%/0	-5.90%/2 -13.60%/0	+7.72%/3 -6.95%/0
ADULT OYSTERS	JUNE	JULY	AUGUST	SEPTEMBER
Top tray	+2.03%/0	+1.59%/1 +3.65%/0	+0.69%/2 +4.37%/0	-0.29%/3 +4.07%/0
Bottom tray	-2.15%/0	+0.36%/1 -1.79%/0	+1.74%/2 -0.08%/0	-1.16%/3 -1.24%/0
Position 1	-8.99%/0	+11.91%/1 +1.84%/0	-4.20%/2 -2.43%/0	-4.22%/3 -6.55%/0
Position 2	+3.62%/0	-3.97%/1 -0.49%/0	-3.22%/2 -3.70%/0	+9.83%/3 +5.76%/0
Position 3		-4.30%/1	-7.90%/2 -12.54%/1	+18.28%/3 + 5.01%/1

Table 8. Percent increment in mean width of seed and adult oysters from free plantings and in trays, Broad Lake.

SEED OYSTERS	JUNE	JULY	AUGUST	SEPTEMBER
Top tray	-0.22%/0	+8.14%/1 +7.90%/0	+2.70%/2 +10.81%/0	-0.07%/3 +10.72%/0
Bottom tray	-0.35%/0	+1.13%/1 +0.77%/0	+2.22%/2 +3.01%/0	-0.56%/3 +2.44%/0
Position 1	-12.33%/0	-2.76%/1 -14.75%/0	+1.29%/2 -13.65%/0	-7.14%/3 -19.82%/0
Position 2			-4.43%/2	+5.97%/3 +1.26%/2
Position 3	-4.08%/0	-3.78%/1 -7.70%/0	-7.86%/2 -14.96%/0	-10.40%/3 -23.80%/0
ADULT OYSTERS	JUNE	JULY	AUGUST	SEPTEMBER
Top tray	+5.31%/0	+3.05%/1 +8.54%/0	+1.03%/2 +9.66%/0	+1.14%/3 +10.91%/0
Bottom tray	-1.82%/0	-0.63%/1 -2.45%/0	+2.04%/2 -0.45%/0	-0.02%/3 -0.48%/0
Position 1	-7.23%/0	-2.60%/1 -9.64%/0	-0.97%/2 -10.52%/0	-2.69%/3 -12.93%/0
Position 2	+12.93%/0	-1.10%/1 +11.69%/0	-1.55%/2 +9.95%/0	-2.03%/3 +7.71%/0
Position 3		+8.56%/1	-7.42%/2 +0.50%/1	+5.76%/3 +6.29%/1

Table 9. Percent occurrence of crystalline style.

<u>SEED</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Plant No. 1	0.0%	50.0%	100.0%	69.2%	80.0%
Plant No. 2	n.d.	n.d.	86.7%	77.8%	90.9%
Plant No. 3	0.0%	70.0%	80.0%	100.0%	90.0%

<u>ADULT</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Plant No. 1	0.0%	22.2%	70.0%	70.0%	62.5%
Plant No. 2	20.0%	58.3%	80.0%	90.0%	80.0%
Plant No. 4	n.d.	63.2%	57.1%	55.6%	50.0%

Table 10. Butler condition index.

<u>SEED</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Plant No. 1	4.300	3.900	2.750	3.154	4.000
Plant No. 2	n.d.	n.d.	4.333	4.889	4.636
Plant No. 3	3.300	4.000	2.533	2.727	2.300
All	3.800	3.950	3.205	3.590	3.645

<u>ADULTS</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Plant No. 1	3.100	3.111	2.100	2.400	2.188
Plant No. 2	2.300	3.417	3.150	3.700	2.900
Plant No. 4	n.d.	2.684	2.286	2.222	2.571
All	2.700	3.071	2.512	2.774	2.553

Table 11. Percent population showing gonad development.

<u>SEED</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Plant No. 1	0.0%	0.0%	0.0%	0.0%	0.0%
Plant No. 2	n.d.	n.d.	87.0%	78.0%	9.0%
Plant No. 3	0.0%	0.0%	0.0%	0.0%	0.0%

<u>ADULTS</u>	<u>MAY</u>	<u>JUNE</u>	<u>JULY</u>	<u>AUGUST</u>	<u>SEPTEMBER</u>
Plant No. 1	0.0%	0.0%	0.0%	10.0%	0.0%
Plant No. 2	0.0%	0.0%	35.0%	70.0%	7.0%
Plant No. 4	n.d.	0.0%	0.0%	5.0%	7.0%

Table 12. Percent occurrence of epifauna on trays and planted oysters.

MAY 1966

	<u>SEED</u>					<u>ADULTS</u>				
	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P3</u>	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P4</u>
Littorina	-	-	30.0	n.d.	30.0	-	-	30.0	20.0	n.d.
Mytilus	-	-	30.0	n.d.	80.0	-	-	60.0	40.0	n.d.
Barnacles	-	-	--	n.d.	-	100.0	-	50.0	50.0	n.d.
Bryozoans	-	-	-	n.d.	-	--	-	30.0	30.0	n.d.
Limpets	-	-	80.0	n.d.	10.0	-	-	80.0	100.0	n.d.
Polychaetes	-	-	-	n.d.	-	-	-	-	-	n.d.
Hydroids	-	-	-	n.d.	-	-	-	-	-	n.d.
Drilled	-	-	-	n.d.	-	-	-	-	-	n.d.
Gastropods	-	-	-	n.d.	-	-	-	-	-	n.d.
Anemones	-	-	-	n.d.	-	-	-	-	-	n.d.
Lepidonotus	-	-	-	n.d.	-	-	-	-	-	n.d.
Polydora	n.d.	n.d.	60.0	n.d.	100.0	n.d.	n.d.	100.0	100.0	n.d.
Sponges	-	-	-	n.d.	-	-	-	-	-	n.d.

n.d. = no data.

Table 13. Percent occurrence of epifauna on trays and planted oysters.

	<u>JUNE 1966</u>									
	<u>SEED</u>					ADULTS				
	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P3</u>	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P4</u>
Littorina	0.4	9.9	8.5	n.d.	13.3	-	25.9	9.4	8.3	63.2
Mytilus	86.3	33.6	6.4	n.d.	15.0	90.0	51.2	46.9	50.0	-
Barnacles	2.7	-	2.1	n.d.	-	73.0	22.4	84.4	58.3	100.0
Bryozoans	-	0.8	-	n.d.	-	59.6	16.9	7.3	-	15.8
Limpets	0.2	0.8	36.2	n.d.	53.3	-	2.0	65.6	83.3	5.3
Polychaetes	-	0.2	-	n.d.	-	-	0.5	-	-	-
Hydroids	--	-	-	n.d.	-	-	-	-	-	-
Drilled	-	-	-	n.d.	-	-	-	3.1	-	-
Gastropods	-	-	-	n.d.	-	-	-	9.4	-	-
Anemones	-	-	-	n.d.	-	-	-	-	-	-
Lepidonotus	-	0.8	-	n.d.	-	-	4.0	-	-	5.3
Polydora	n.d.	n.d.	-	n.d.	60.0	n.d.	n.d.	-	75.0	84.2
Sponges	-	-	-	n.d.	-	-	-	-	-	-
Pelecypods	-	0.2	-	n.d.	-	-	8.0	-	-	-

n.d. = no data.

Table 14. Percent occurrence of epifauna on trays and planted oysters.

	<u>JULY 1966</u>									
	SEED					<u>ADULTS</u>				
	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P3</u>	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P4</u>
Littorina	0.6	-	-	13.3	-	-	12.8	-	5.0	23.8
Mytilus	98.5	14.8	33.3	-	6.7	94.9	49.2	40.0	-	14.3
Barnacles	-	-	-	-	-	53.8	16.9	50.0	30.0	61.9
Bryozoans	-	-	-	-	-	25.6	14.9	5.0	-	14.3
Limpets	-	-	58.3	53.3	33.3	-	-	65.0	70.0	38.1
Polychaetes	-	0.4	-	-	-	-	-	-	-	-
Hydroids	-	-	-	-	-	-	-	-	-	-
Drilled	-	-	-	-	-	-	-	-	-	-
Gastropods	-	-	-	-	-	-	-	-	-	-
Anemones	-	-	-	-	-	-	-	-	-	-
Lepidonotus	-	-	-	-	-	-	-	-	-	-
Polydora	n.d.	n.d.	41.7	26.7	40.0	n.d.	n.d.	-	70.0	90.5
Sponges	-	-	-	-	-	-	-	-	-	-

n.d. = no data.

Table 15. Percent occurrence of epifauna on trays and planted oysters.

AUGUST 1966

	<u>SEED</u>					<u>ADULTS</u>				
	Top	Btm	P1	P2	P3	Top	Btm	P1	P2	P4
Littorina	0.2	17.4	-	-	-	-	29.2	20.0	-	44.4
Mytilus	91.2	70.6	23.1	11.1	9.1	98.7	71.8	20.0	10.0	-
Barnacles	-	-	-	-	-	74.7	15.9	60.0	30.0	11.1
Bryozoans	-	-	-	-	-	44.3	9.2	10.0	10.0	22.2
Limpets	-	1.1	23.1	88.9	18.2	-	10.8	20.0	80.0	50.0
Polychaetes	-	-	-	-	-	-	0.5	-	-	-
Hydroids	-	-	-	-	-	3.8	-	-	-	-
Drilled	-	-	-	-	-	-	-	-	-	-
Gastropods	-	-	-	-	-	-	0.5	-	-	-
Anemones	-	-	-	-	-	-	-	-	-	-
Lepidonotus	-	2.2	15.4	-	18.2	-	4.6	10.0	10.0	11.1
Polydora	n.d.	n.d.	23.1	55.6	72.7	n.d.	n.d.	80.0	90.0	100.0
Sponges	-	-	-	-	-	-	-	-	-	-
Pelecypods	-	-	-	-	-	1.3	0.5	-	-	-

n.d. = no data.

Table 16. Percent occurrence of epifauna on trays and planted oysters.

	<u>SEPTEMBER 1966</u>									
	<u>SEED</u>					<u>ADULTS</u>				
	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P3</u>	<u>Top</u>	<u>Btm</u>	<u>P1</u>	<u>P2</u>	<u>P4</u>
Littorina	-	18.1	-	36.4	18.9	-	28.1	6.3	-	28.6
Mytilus	98.7	81.7	11.8	-	2.7	97.5	94.8	50.0	-	28.6
Barnacles	-	-	-	-	-	70.9	16.7	56.3	10.0	28.6
Bryozoans	1.3	-	-	-	-	19.0	9.4	-	-	14.2
Limpets	0.2	3.1	82.4	100.0	89.2	-	13.0	81.3	100.0	57.1
Polychaetes	-	-	-	-	-	-	0.5	-	-	-
Hydroids	0.6	-	-	-	-	3.8	-	-	-	-
Drilled	-	-	-	-	-	-	-	-	-	-
Gastropods	-	-	-	-	-	-	-	-	-	-
Anemones	16.3	-	-	-	-	41.8	-	-	-	-
Lepidonotus	3.0	2.8	-	9.1	2.7	10.1	8.3	12.5	40.0	7.1
Polydora	n.d.	n.d.	69.0	72.7	100.0	n.d.	n.d.	81.3	90.0	100.0
Sponges	-	13.5	-	-	-	-	-	-	-	-
Pelecypods	-	0.2	-	-	-	-	-	-	-	7.1

n.d. = no data

DISCUSSION

MORTALITY

Mortality studies were restricted to the oyster populations maintained in trays at Broad Lake. Estimates of mortalities of populations on natural bottoms would have required more extensive and refined sampling techniques than those employed in this study. Results of other workers suggest that the mortality experienced by oysters held in trays is somewhat lower than that occurring in oysters planted on the natural bottom. Hewatt and Andrews (1954) observed an annual mortality of tray oysters that ranged from 17% to 29%. McHugh and Andrews (1954) reported a 37% annual mortality in oysters planted on natural bottoms, while the data of Owen (1953) suggests a 42.3% annual mortality for free plants. These differences in mortality are generally assumed to be due to a combination of predation and smothering, factors which have a somewhat limited influence on tray oysters. Thus it would seem reasonable to assume (although no data is available from the present study to support this hypothesis) that the mortality experienced by oysters planted on the natural bottom in Broad Lake was somewhat greater than that observed in the tray populations.

The adult oysters in both the top and bottom trays suffered an extremely high mortality during their first winter (Sept. 1965-May 1966) in Broad Lake. (Figs. 1 and 2). Little difference was observed between the adults in the surface and bottom trays; the mortalities being 51.3% and 51.4 % respectively.

In contrast, the mortalities experienced by the seed oysters during the winter (Sept. 1965-May 1966) were almost insignificant; being 1.4% and 2.5% for the surface and the bottom trays respectively.

The highest mortalities observed for both seed and adults (excluding adult overwinter mortality) during the 1966 season occurred during the late May-early June period. The mortality was extremely low through July, August and early September for both the seed and adults.

During the 1966 season the bottom trays tended to show a slightly higher mortality than the surface trays. This is at variance with the observations made during the 1965 season when the reverse was found to be the case. This difference can probably be attributed to the abnormal mortality experienced during the first season which tended to obscure the results somewhat.

The mortality experienced during the 1966 summer season was considerably lower than that noted in the previous summer. This was particularly true in the case of the adult oysters. It would appear that the tray populations have now reached a stabilized mortality rate (Figs. 3 and 4).

The seed oysters showed an unusually low mortality over the two seasons, with 95.2% of the surface tray oysters and 93.4% of the bottom tray oysters surviving to the end of the second year (Table 4). Only 30.3 % of the surface tray adults and 32.2 % of the bottom tray adults survived to the end of the second season.

The greater mortality of both the surface and bottom seed oysters during the summer months than during the winter months agrees with the observations of Aldrich (1957) on tray oysters in the York River, Virginia, where the peak mortality occurred from June to November. The annual mortality in trays of various age classes observed in the York River studies ranged from 15% to 75%. Hewatt and Andrews (1954) in a study conducted at Gloucester Point noted an annual mortality in trays from 17-29%. In the light of these studies, the 4.8% and 6.6% observed over two seasons for the surface and bottom trays of seed, respectively, at Bellevue, appear unusually low.

As already noted both surface and bottom adults suffered unusually high mortality over the first season. In his study of the York River oysters, Aldrich (1957) felt that the observed high mortality could be attributed to a combination of predation by a number of species and infection by Dermocystidium marinum, with the latter probably being the most important.

In the Bellevue work no checks were made for Dermocystidium, and no significant occurrence of predator organisms was noted in the trays. In view of the remarkable difference in mortality between the seed and adult oysters and the apparent stabilization of the adult mortality rate during the second season, it seems likely that the high mortality experienced by the adults is attributable either to the inability of the transplanted adults to adapt to the new environment or to physiological damage suffered during the transportation to the new site. In contrast, the seed oysters appear to have adapted extremely well.

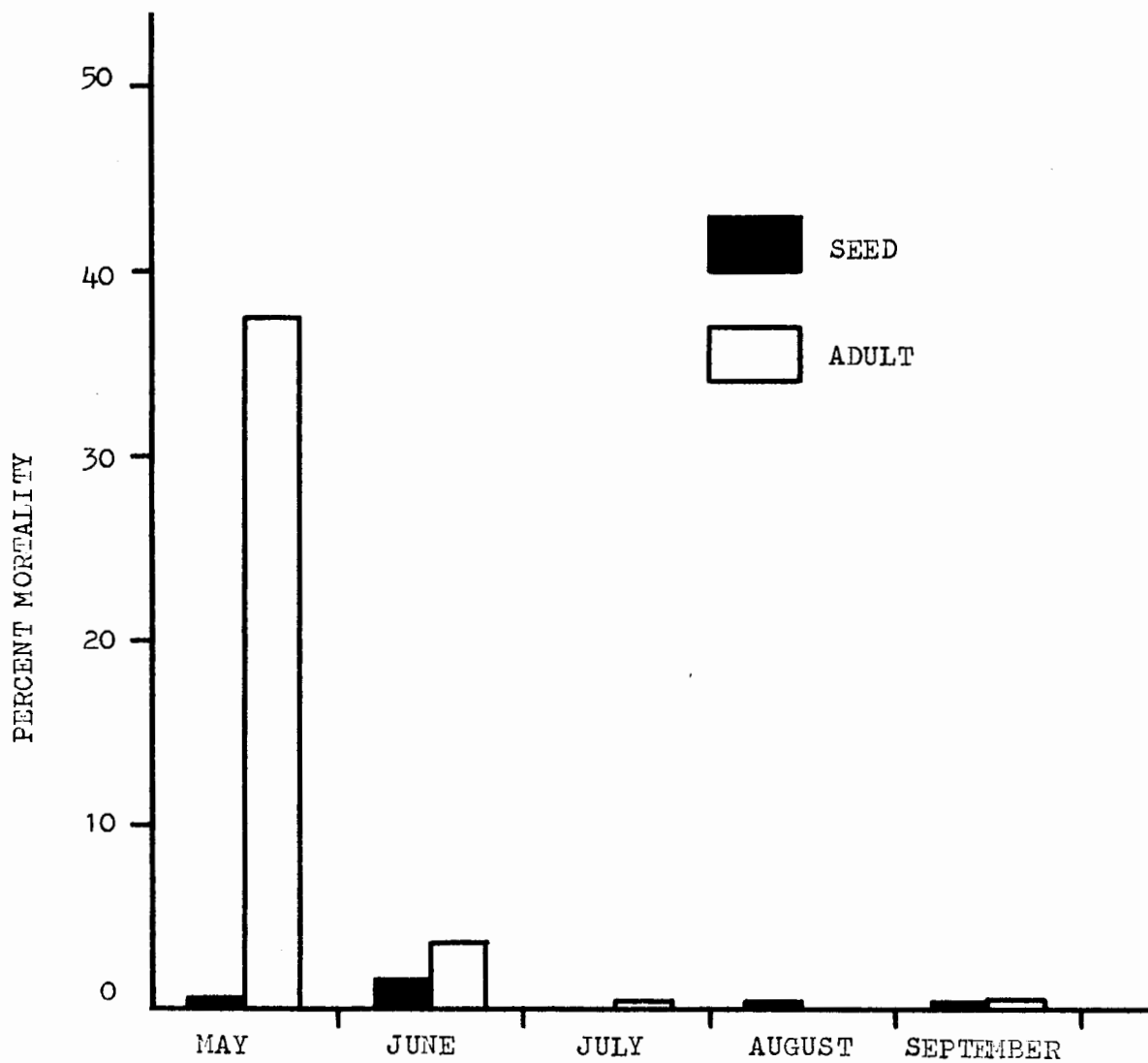


Fig. 1. Mortality of seed and adult oysters in surface trays; May to September 1966. (Percentages calculated with reference to May 1965 population).

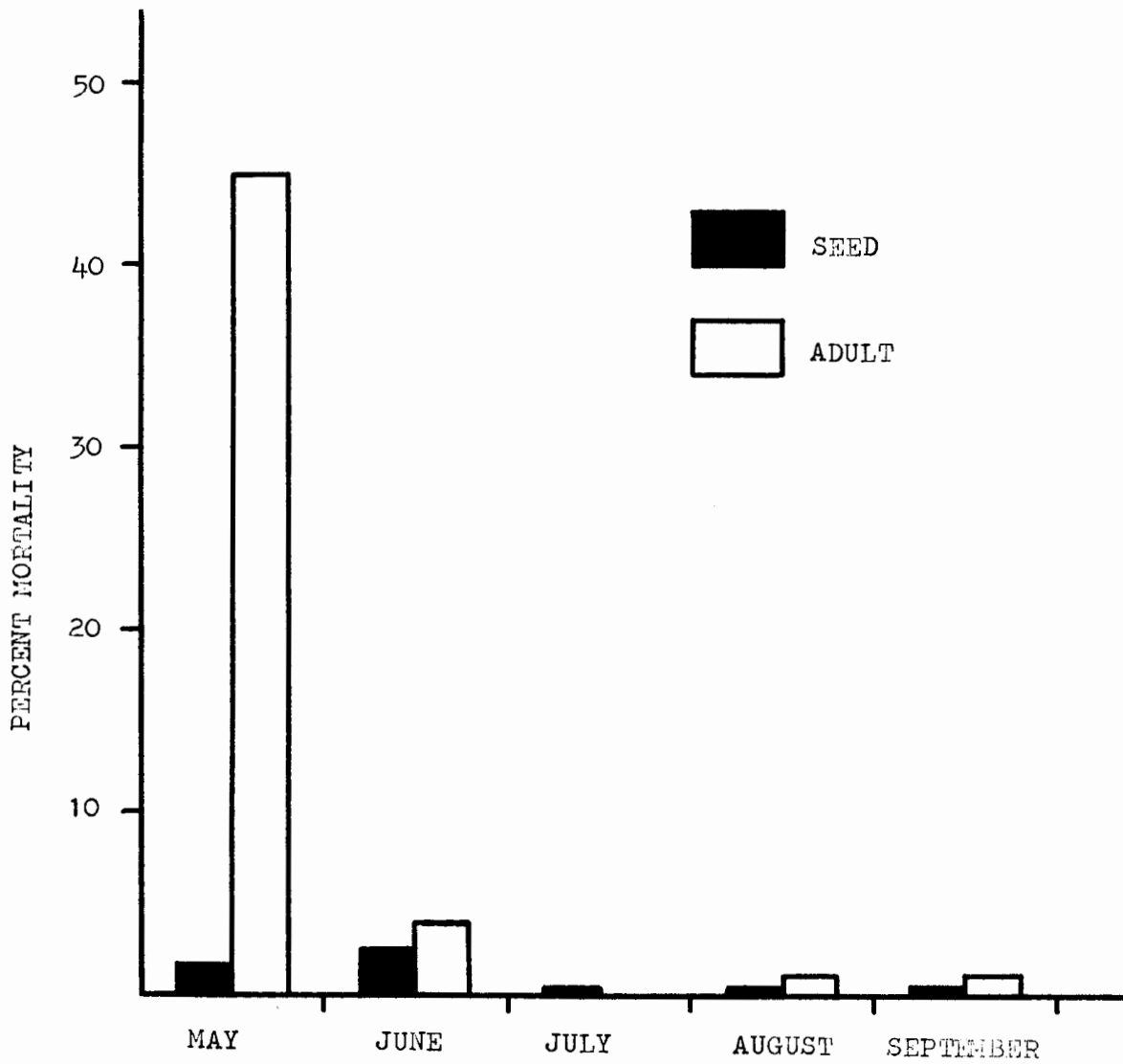


Fig. 2. Mortality of seed and adult oysters in bottom trays; May to September 1966. (Percentages calculated with reference to May 1965 population).

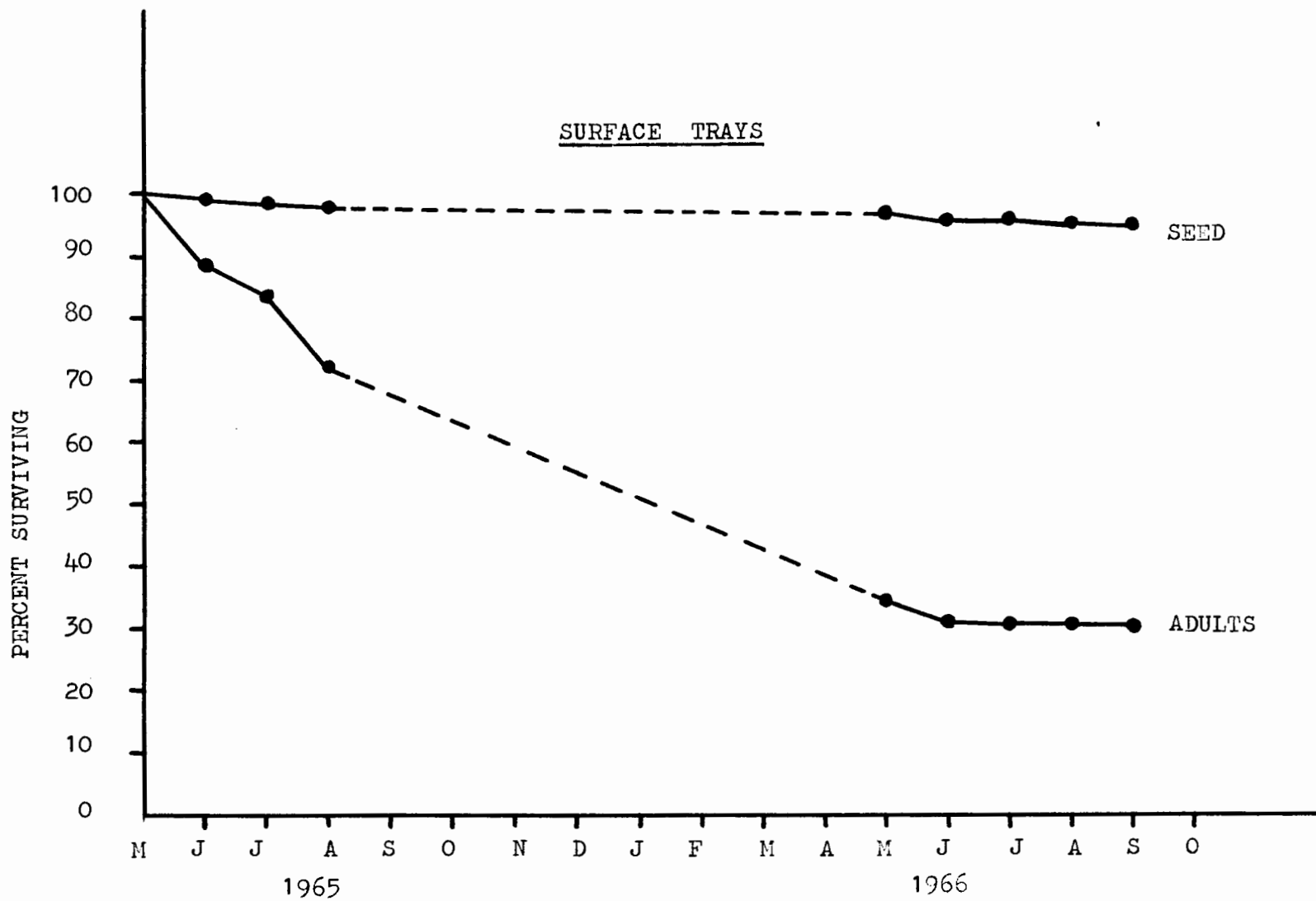


Fig. 3. Percent survival; seed and adults, surface trays.

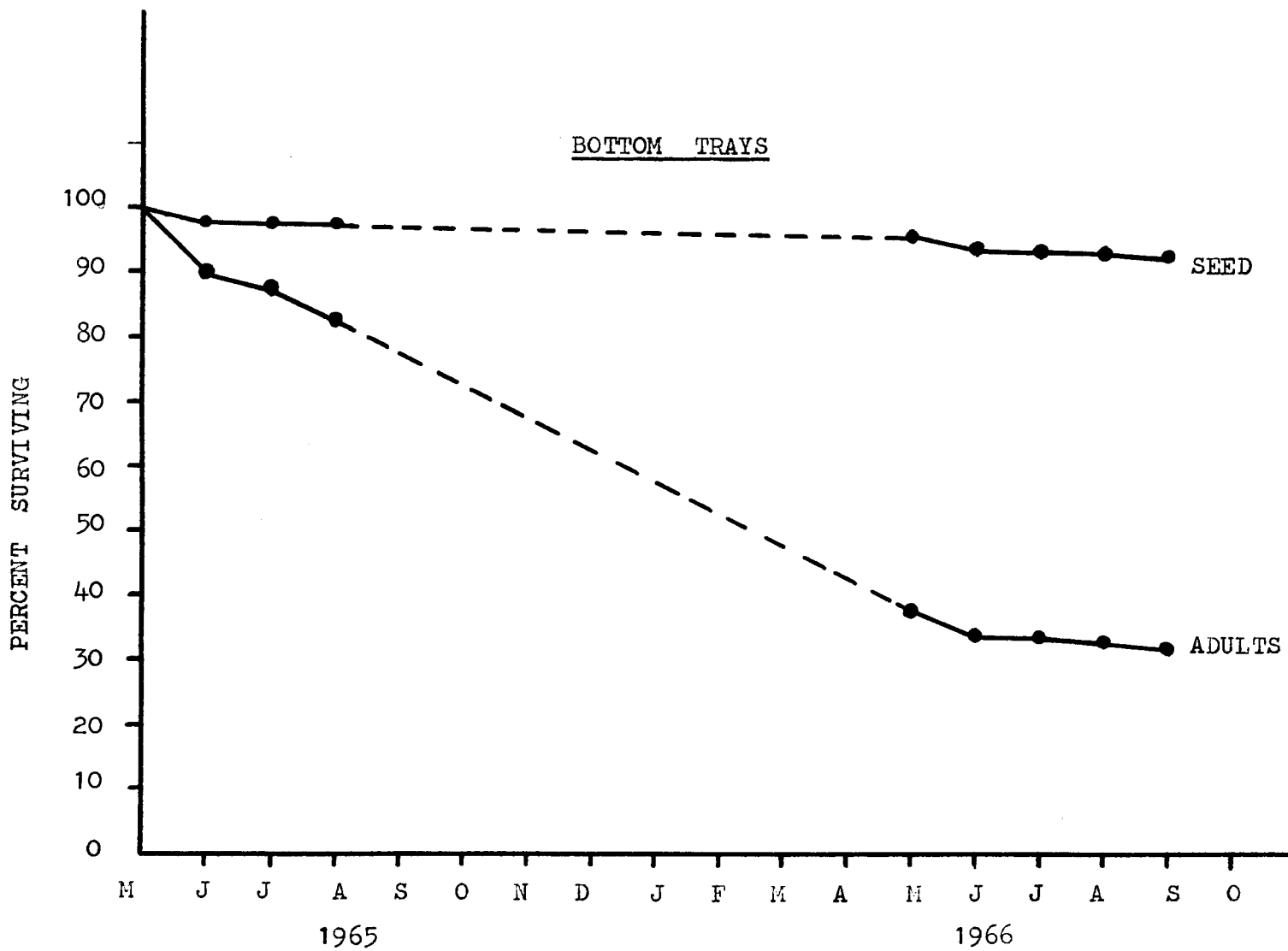


Fig. 4. Percent survival; seed and adults, bottom trays.

GROWTH

Length and width measurements of the oysters were made to the nearest millimeter by means of a simple right angled measuring board containing an inset ruler. The details of the various dimensions and the reasons for not attempting greater accuracy in readings are outlined by Aldrich (1965).

Seed oysters in trays

Seed in both the surface and bottom trays showed an initial period of slow growth, no growth or even an actual decrease in size. During late June and early July, growth in both length and width was relatively rapid, and this active growth was maintained into the middle of August. Very little or no growth occurred after the middle of August. A study of the temperature characteristics of Broad Lake (Fig. 21) seem to indicate that active growth only occurred when the water temperature rose above approximately 15 degrees C. This appears to agree well with the statement of Medcof (1961) that although some growth occurs at temperatures in excess of 10 degrees C. maximal growth only occurs when the temperature rises above 15 degrees C. Fig. 21 indicates that the growing season of oysters in Broad Lake extends from mid July to approximately late August, or about two months as a maximum. This growing season is considerably shorter than that observed by Loosanoff and Nomejko (1949) for Milford Harbour, Conn., where growth occurs for approximately seven months of the year. Medcof (1961) reports a growth period extending from mid May to mid-September (approximately four months) for Maritime oysters.

The growth of seed in the surface tray was considerably better

than seed in the bottom tray as can be seen by reference to Fig. 9 and Table 7. Surface seed increased 13.23% in length and 10.72% in width over the 1966 season while the bottom seed increased only 3.44% in length and 2.44% in width over the same period.

The surface seed oysters increased by 0.866 cm. in length and 0.486 cm. in width over the season, while seed in the bottom tray increased 0.221 cm. in length and 0.110 cm. in mean width. These length and width increases are considerably less than those observed by Aldrich (1957) for seed oysters in trays at Back Creek, Chesapeake Bay, where the length increased by 2.2 cm. and the width by 1.7 cm. over the course of a season. The smaller growth increments observed in Newfoundland waters are undoubtedly due to a combination of slower growth resulting from lower water temperatures and a growing season of very short duration.

Adult Oysters in Trays

Figures 10 and 12 indicate a considerable fluctuation in the observed growth rates of adult oysters held in trays during the 1965 season. This variability can probably be attributed to the high mortality experienced during the first year. The high mortality also accounts for the major part of the considerable decrease in mean size over the winter, although some actual shrinkage of the individual oysters could have also occurred (Aldrich 1957).

Growth in both surface and bottom trays was more consistent during the 1966 season, probably as a result of the stabilized mortality rate.

The oysters in the surface tray once again showed considerably better growth in both length and width than the oysters in the bottom tray. In fact, the bottom tray oysters showed an overall decline in length and width of 1.24% and 0.48% respectively. The surface tray oysters showed an overall length and width increase of 4.07% and 10.91% respectively. The greater increase in width seems unusual.

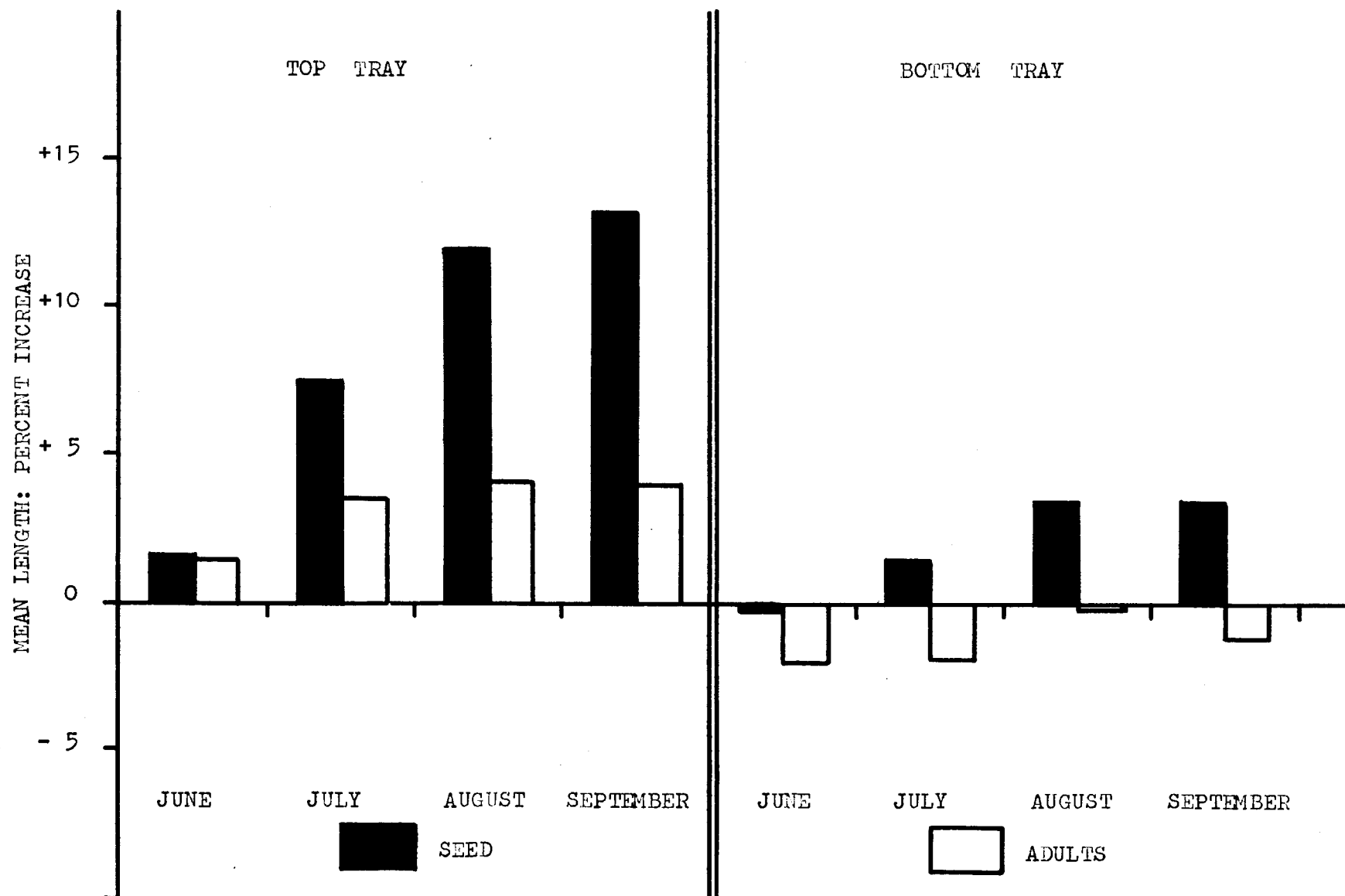
The surface adults appeared to start growth earlier in the season than the surface seed. Like the seed, the adults underwent a period of maximal growth during the middle of the summer and then a cessation of growth in late August.

The bottom tray adults showed an initial decline in both length and width in early summer followed by a slow growth during the summer and a decline in late August.

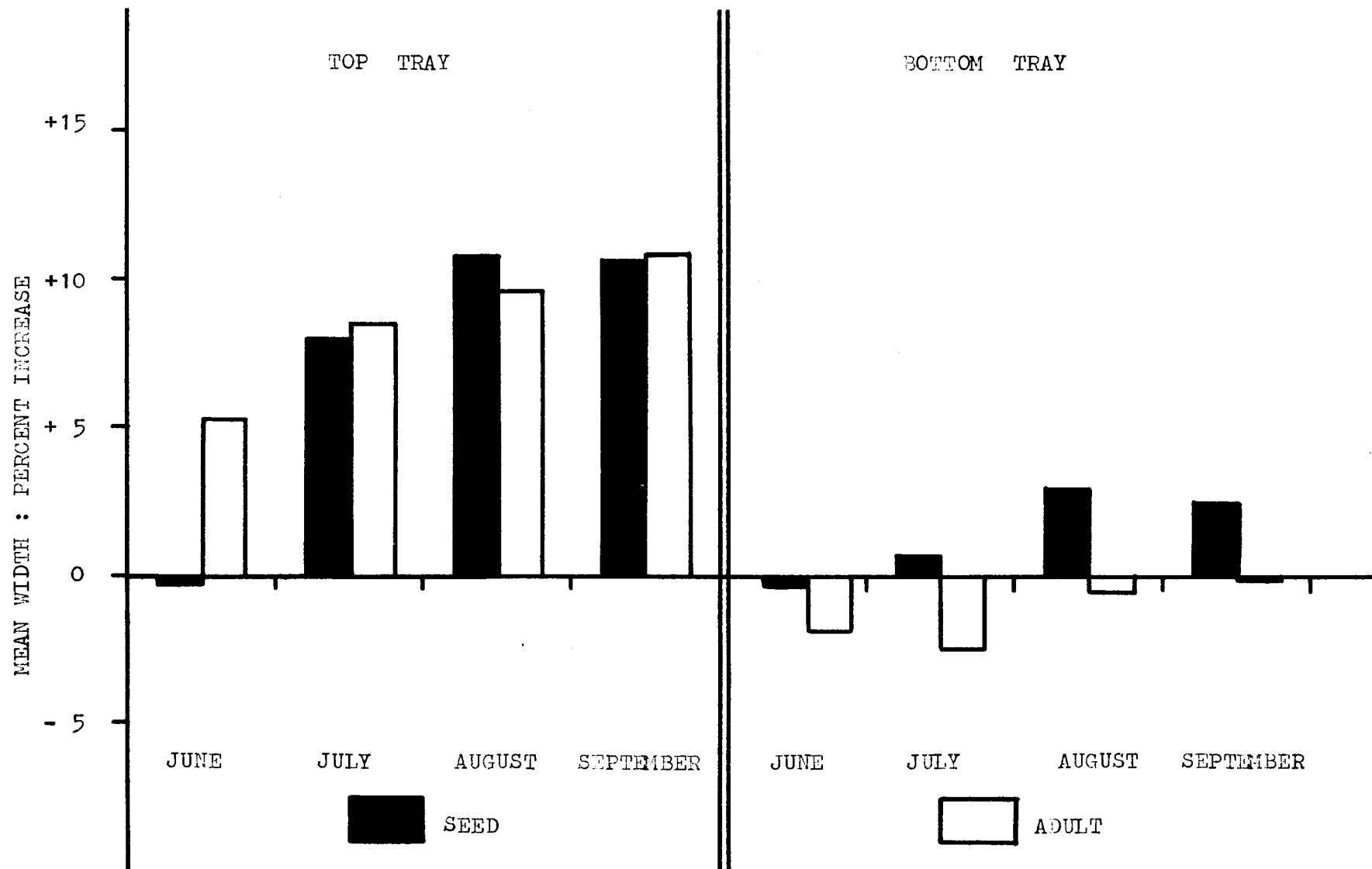
The total amount of new shell produced by both seed and adults in trays over the 1966 season may be summarized as follows:

	<u>Length</u>	<u>Width</u>
surface seed	+0.866 cm.	+0.486 cm.
bottom seed	+0.221 cm.	+0.110 cm.
surface adults	+0.453 cm.	+0.427 cm.
bottom adults	-0.135 cm.	-0.020 cm.

The data would seem to suggest (Tables 7 and 8) that the oysters held in trays grew somewhat better than those planted on natural bottoms. This would tend to confirm the findings of Aldrich (1965) during the previous season.



Figs. 5 and 6. Growth in length of seed and adult oysters held in trays, May to September 1966. (Percentages calculated with reference to May 1966 lengths.)



Figs. 7 and 8. Growth in width of seed and adult oysters held in trays; May to September 1966. (Percentages calculated with reference to May 1966 widths.)

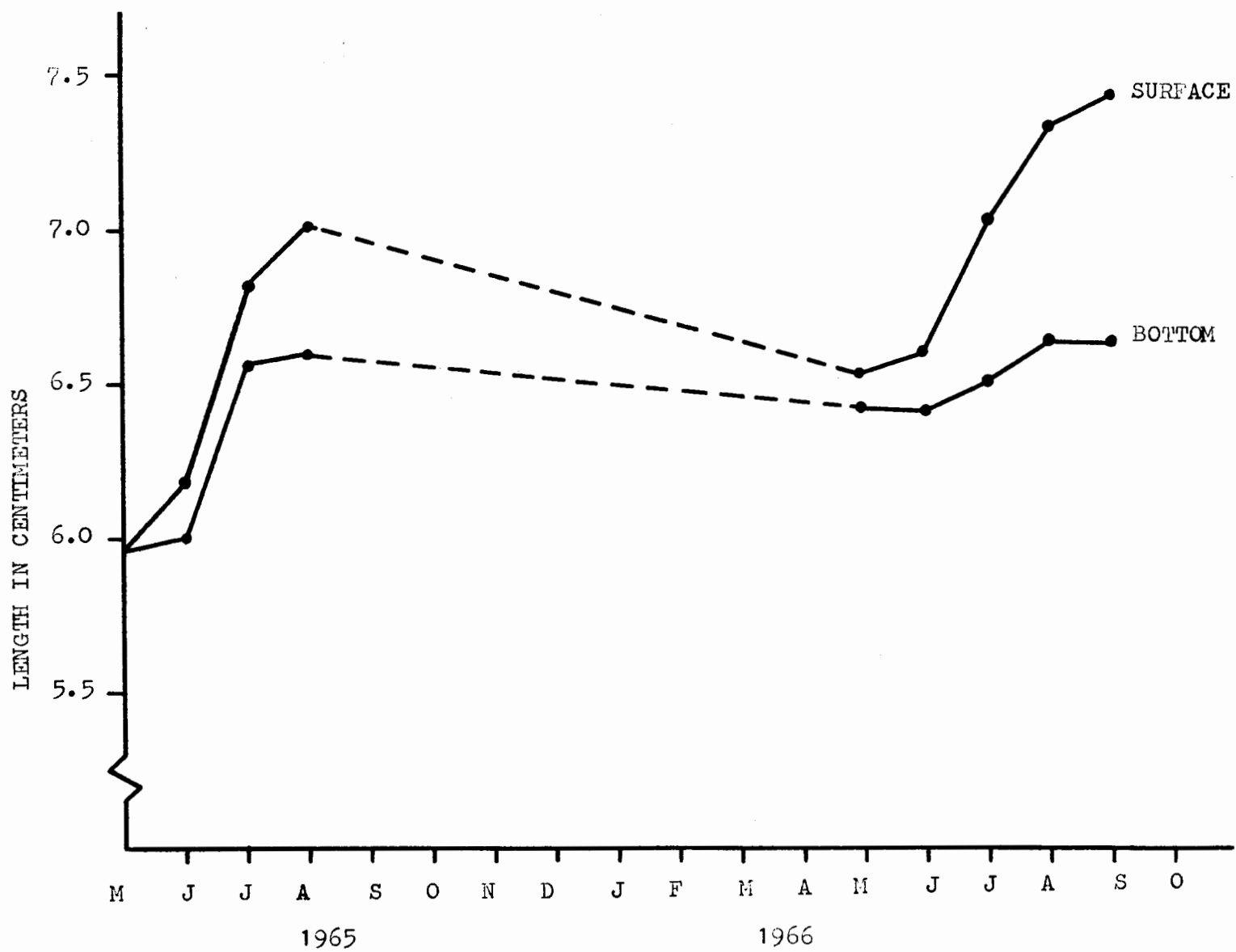


Fig. 9. Length increase of seeds in trays over two seasons.

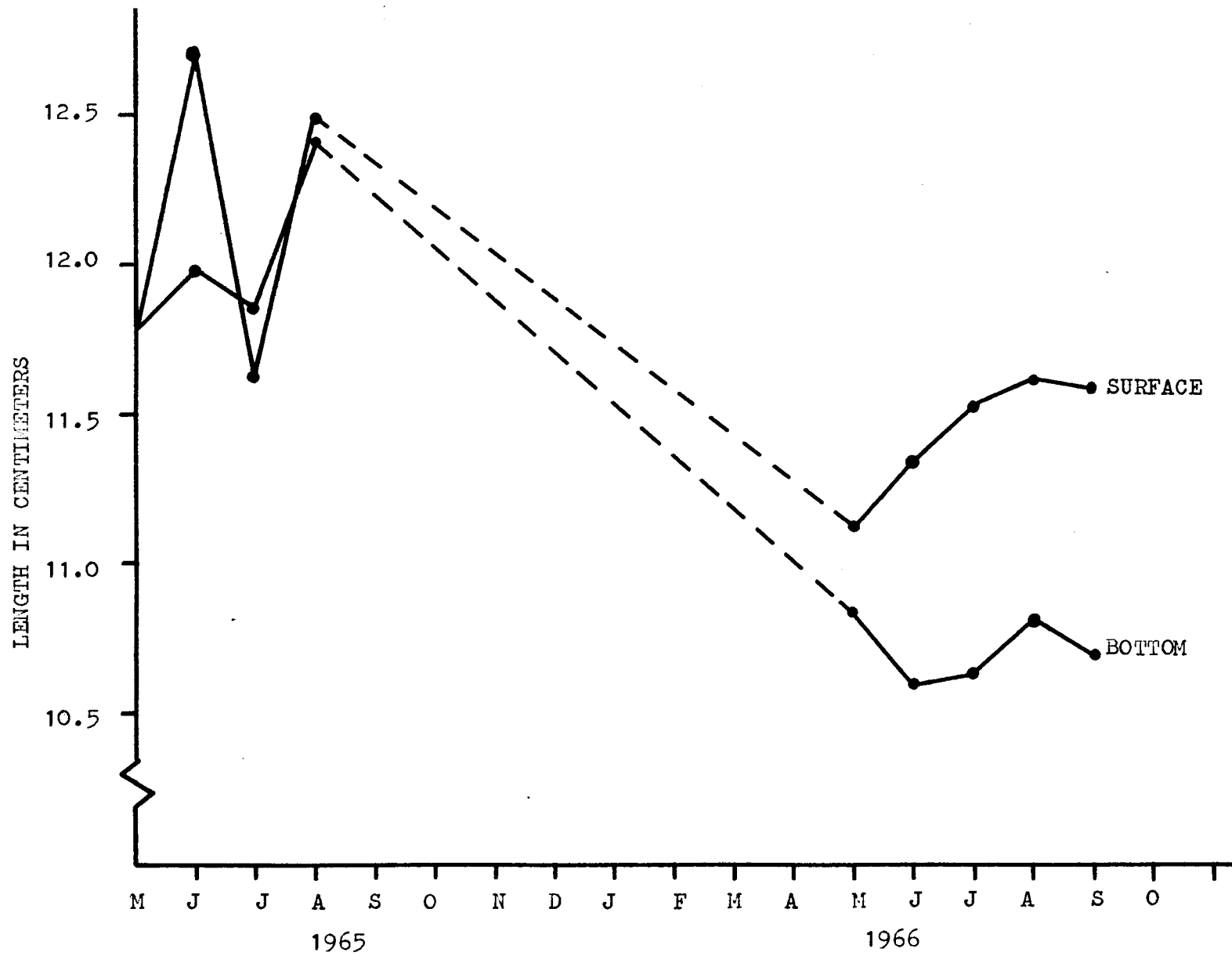


Fig. 10. Length increase of adults in trays over two seasons.

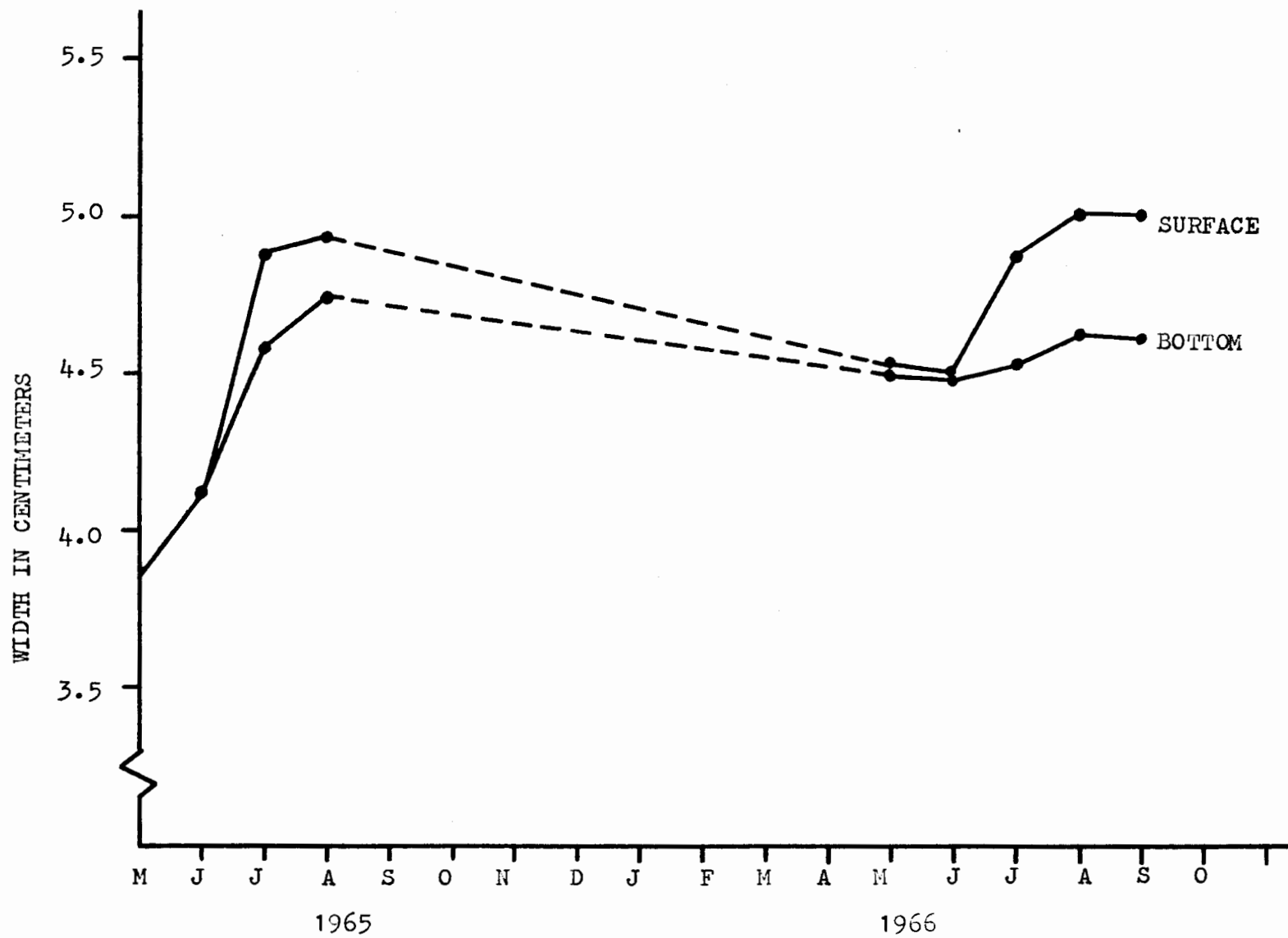


Fig. 11. Width increase of seed in trays over two seasons.

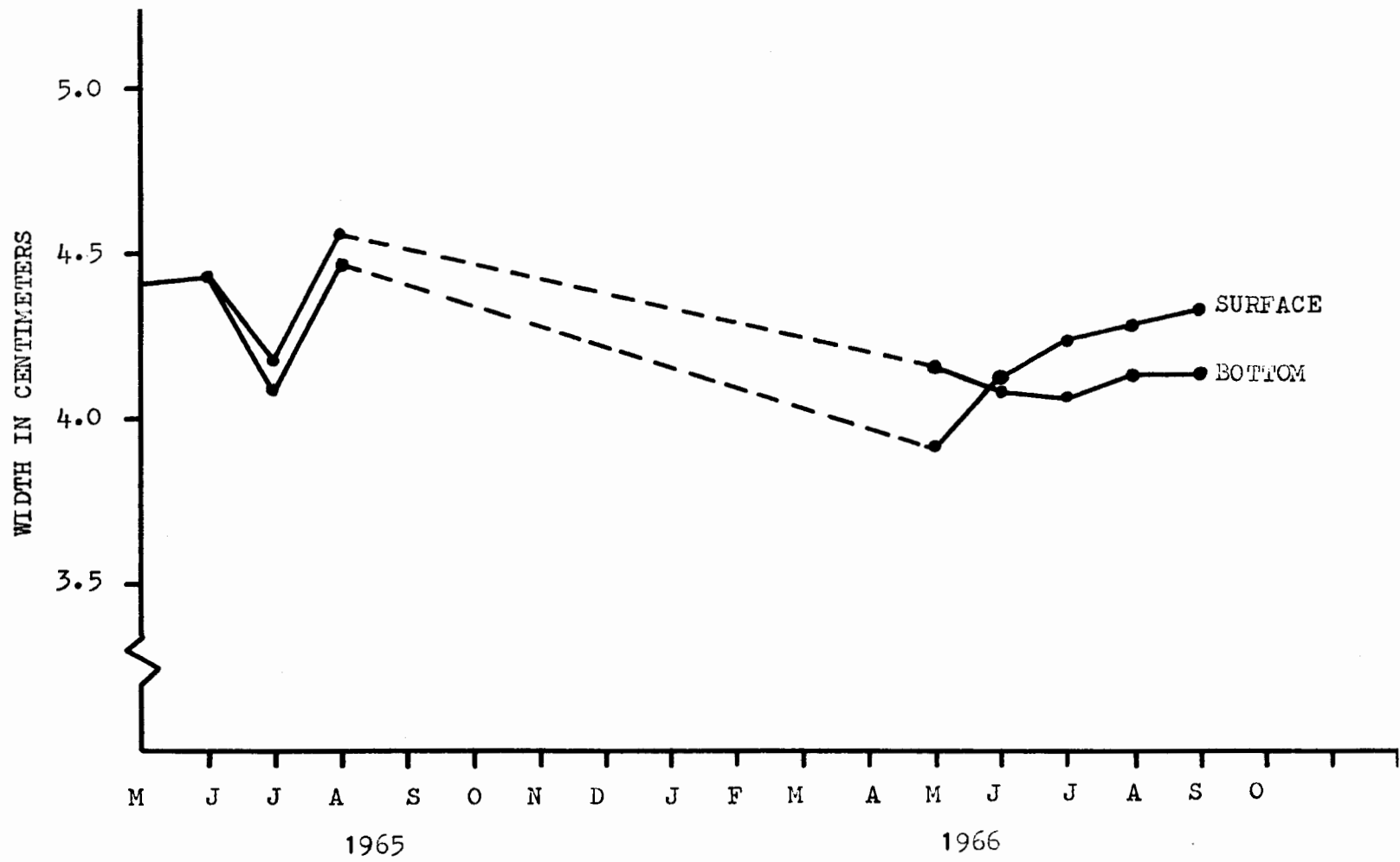


FIG. 12. Width increase of adults in trays over two seasons.

Condition

Estimates of the condition of samples of oysters from the free plant sites were made monthly during the 1966 season. None of the tray oysters were sacrificed during the course of the study, consequently condition ratings for the tray populations are not available.

The estimates of condition were based on the Butler scale which provides a qualitative estimate of the market condition of the oysters. For a discussion of the relationship between the Butler scale and the glycogen content of the oysters, the previous report (Aldrich 1965) should be consulted.

In contrast to the previous season's results, the seed oysters had a considerably higher condition rating than the adults throughout the season at all locations.

The maximum observed condition rating during the season for both seed and adults occurred at Position 2 in August, when the values 4.889 and 3.700 were observed respectively. This result is rather interesting in view of the fact that during the 1965 season the highest mean condition rating for the adult oysters and the lowest mean condition rating for the seed oysters were observed at Site 2 in August. The condition rating of the adults this year at Site 2 was somewhat lower than last year, while the seed oysters demonstrated a significant increase in condition rating.

The general trend appeared to be a gradual decline in condition rating from the initial May level, followed in some cases by an increase in condition rating in August and September.

Mitchell (1917) reported a depletion in glycogen in warm weather, while Gunter (1942, 1955) suggested that oysters become fat in the fall and winter when the temperature drops. Galtsoff (1947) found that in York River oysters the most glycogen was found in November and December, and the least amount was present in August. He suggested a depletion of glycogen during spawning to account for these results.

The oysters at Position 2 appear to be a notable exception to the general trend in that they appear to show an increase in the condition index during the summer followed by a decline in the late summer.

The overall indications (Table 10) are that the adults had a lower condition rating during the 1966 season than during the previous year, while the seed showed a somewhat improved condition. This finding again emphasizes the fact that the seed oysters appear to be able to adapt to the new conditions much better than the adult oysters.

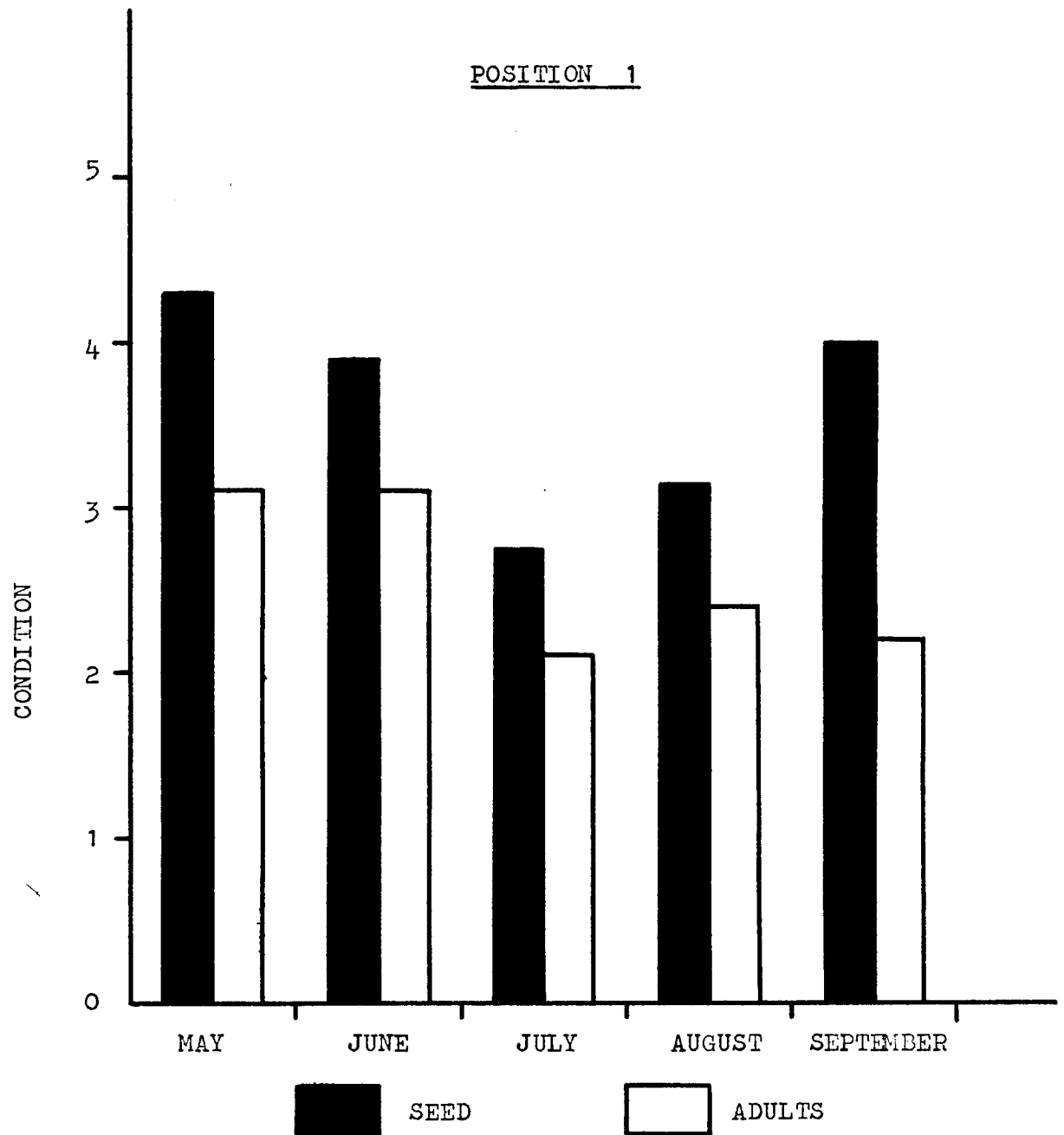


Fig. 13. Butler condition index; free plant position 1.

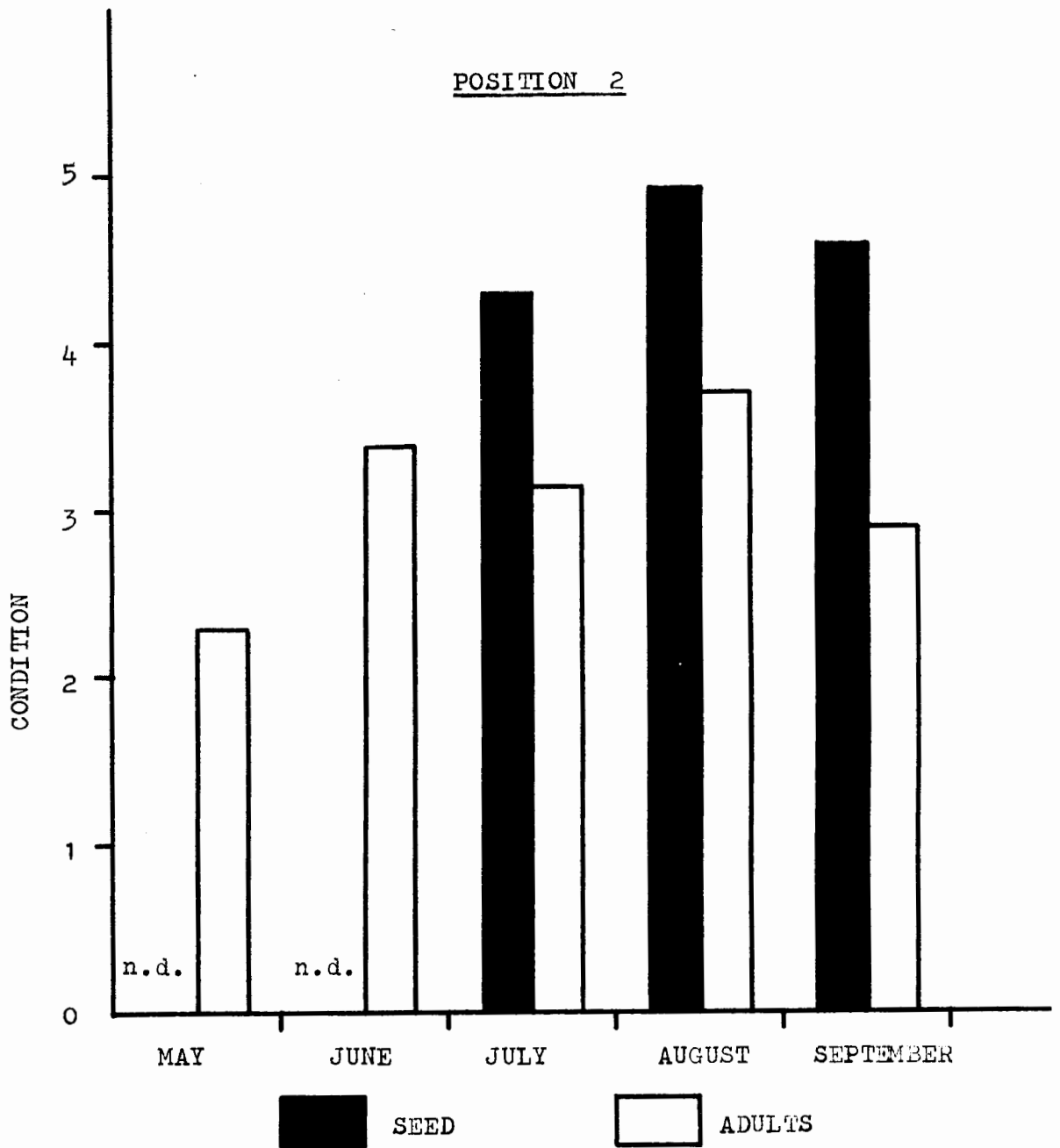


Fig. 14. Butler condition index; free plant position 2.

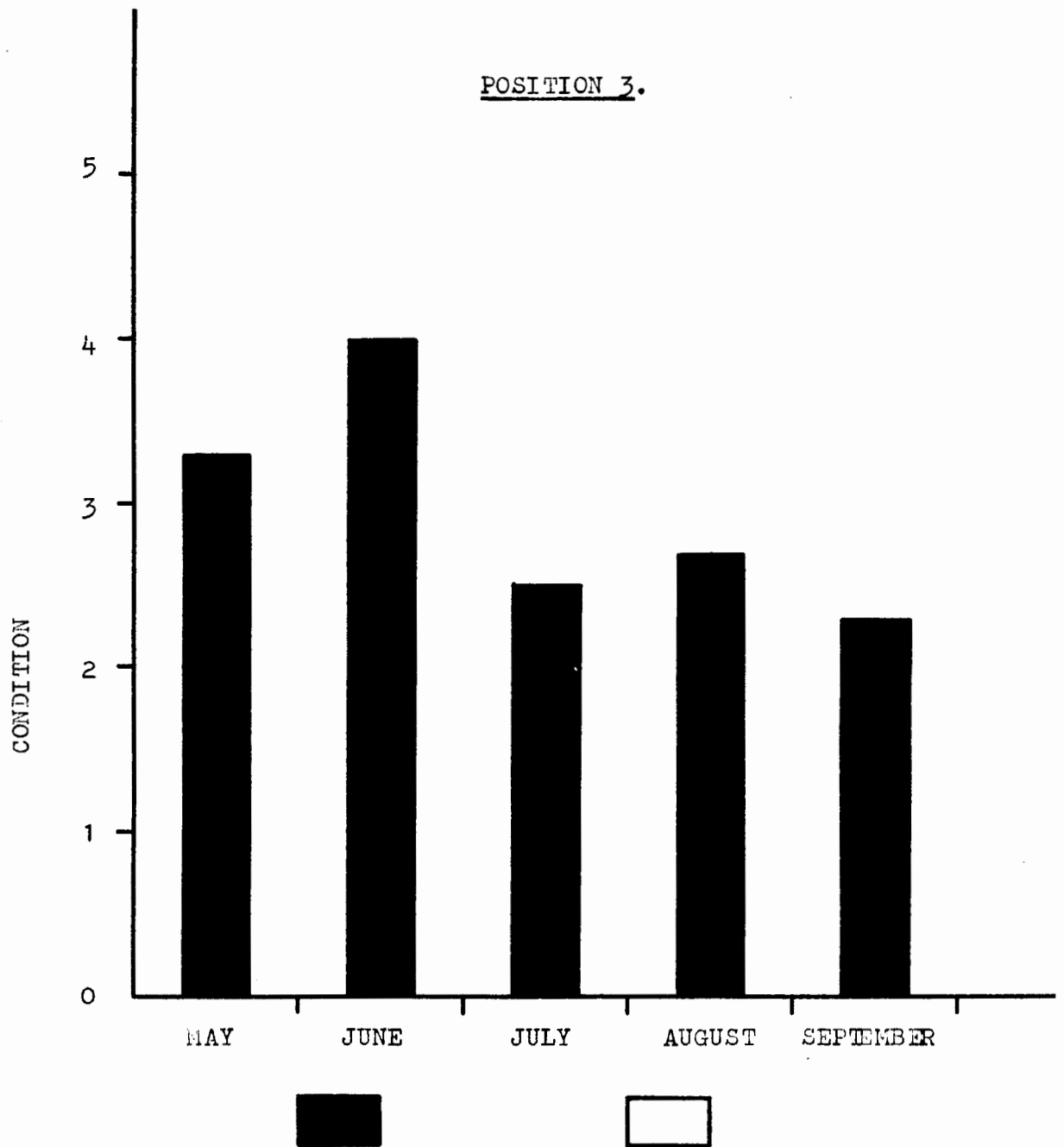


Fig. 15. Butler condition index; free plant position 3.

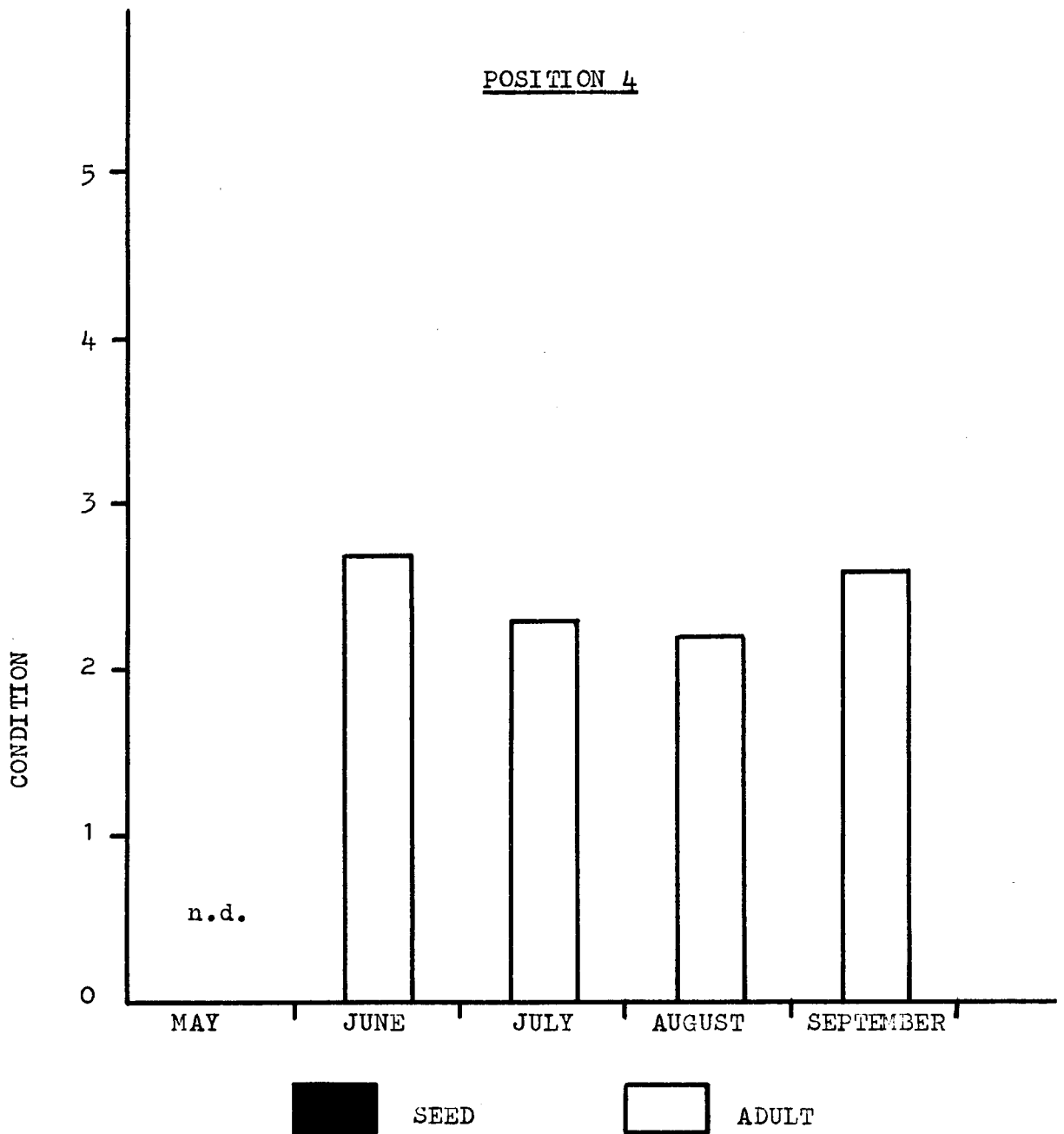


Fig. 16. Butler condition index; free plant position 4.

Crystalline style:

For a discussion of the general morphology and function of the crystalline style the previous report (Aldrich 1965) should be consulted.

As in the previous season, the free plant oysters showed a fairly high incidence of crystalline style throughout the summer months. Once again, the seed showed a somewhat higher incidence of crystalline style than the adults (Figs. 17, 18, 19, 20).

There appeared to be a gradual increase in incidence over the course of the summer, with a maximum occurrence in August.

GONAD DEVELOPMENT

No gonad development was observed during the 1965 season. During 1966 a fairly high percentage of both seed and adult oysters at free plant Position 2 showed varying degrees of gonad development during the months of July and August. The gonad layer never attained any great thickness and presumably did not reach full spawning size. Needler (1932) states that in P.E.I. spawning of oysters is not induced until the water temperature rises above 68 degrees F., (20 C.). This minimal temperature did not appear to be reached at Broad Lake even during the warmest months of the summer.

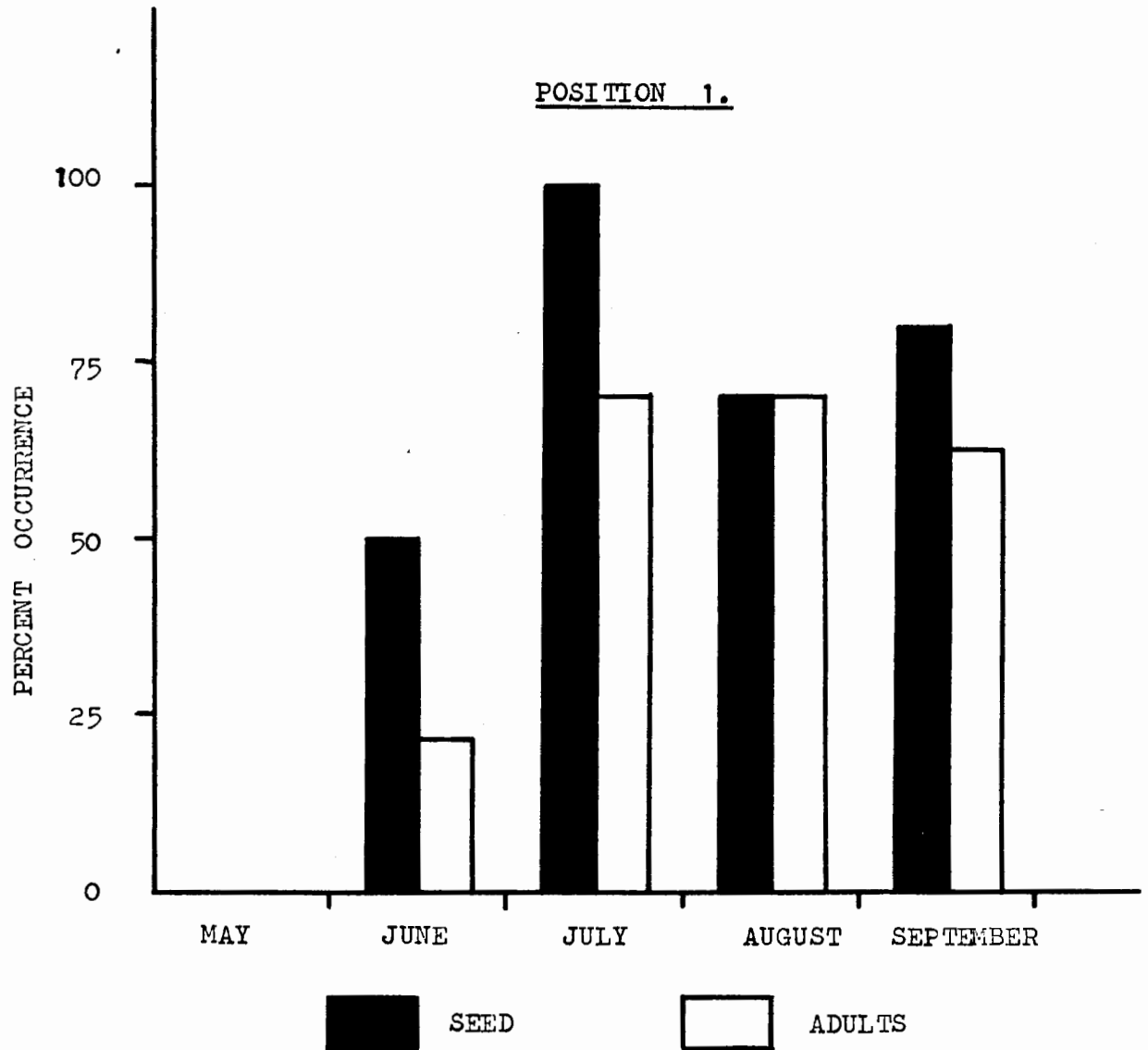


Fig.17. Percent occurrence crystalline style; free plant position 1.

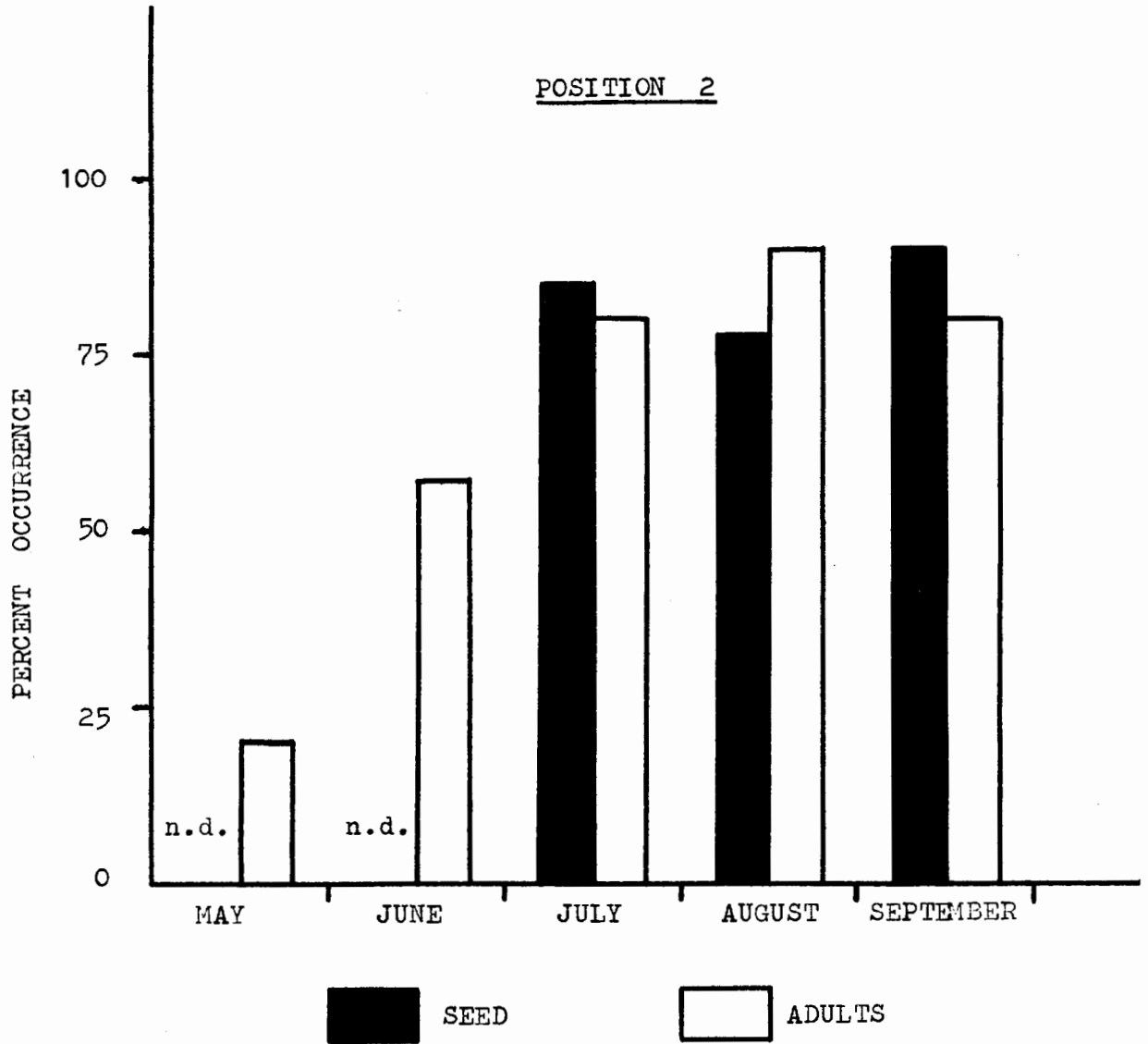


Fig.18. Percent occurrence crystalline style; free plant position 2.

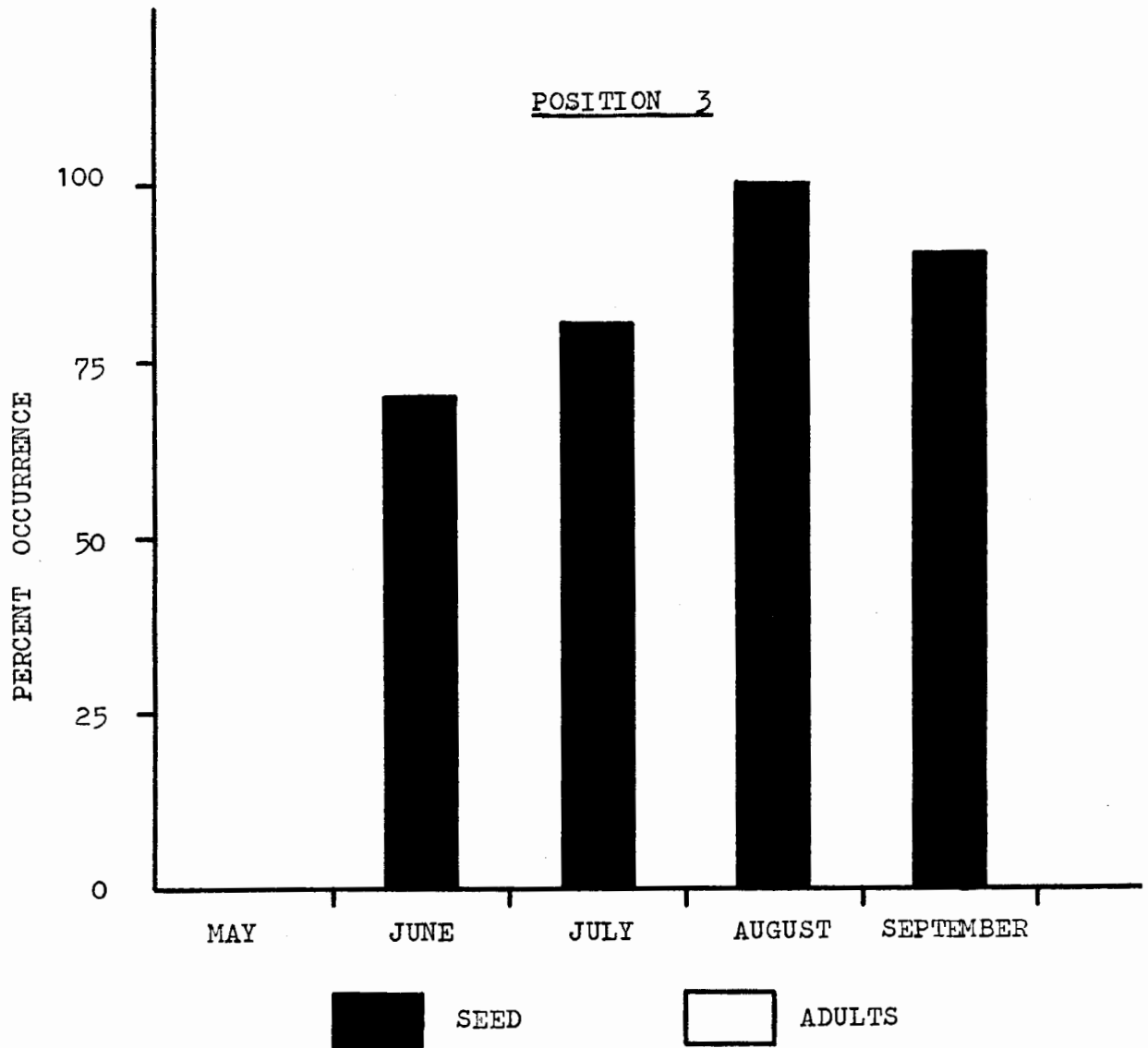


Fig.19. Percent occurrence crystalline style; free plant position 3.

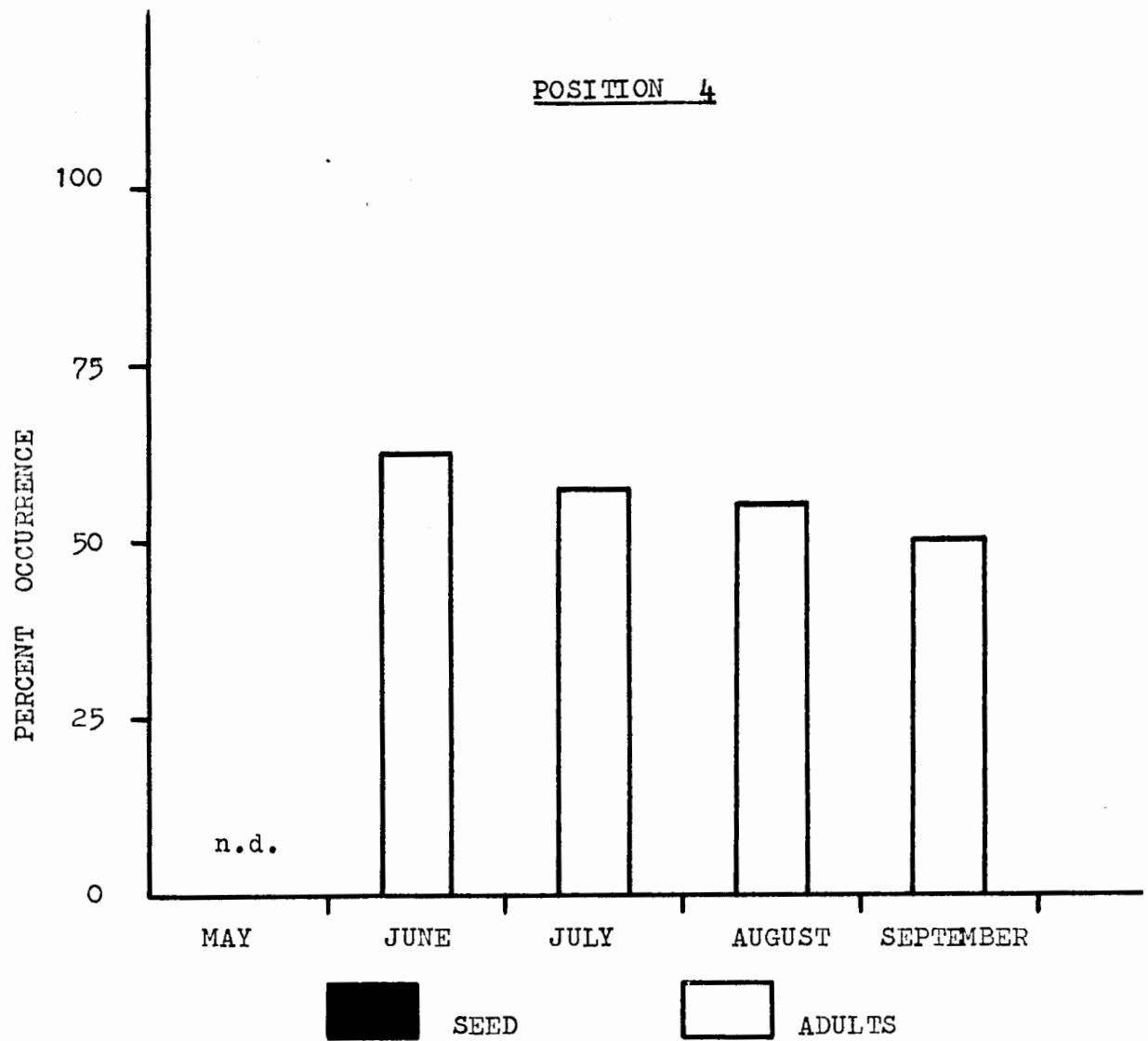


Fig. 20. Percent occurrence crystalline style; free plant position 4.

EPIFAUNA

Littorina: Aldrich (1965) reported that 3 species of *Littorina* occur commonly in Broad Lake: *Littorina littorea*, *L. obtusata* and *L. saxatilis*. No effort was made during the course of this study to differentiate between the three types.

A very low incidence of *Littorina* was found on the surface tray oysters throughout the season. Oysters in the bottom trays were found to have an initial low incidence followed by a gradual increase in numbers as the summer progressed.

The highest incidence of *Littorina* in the free plant oysters was found at Position 4. Only moderate incidence was recorded at Sites 1 and 3, while Site 2 showed a low incidence throughout most of the summer.

The only adverse effect that *Littorina* might conceivably have on the oyster populations would be in respect to competition for food and space. However, indications are that the abundance of *Littorina* at Bellevue is not sufficient to pose any serious threat to the oysters.

Limpets: The limpet *Acmea testudinalis* is fairly common in Broad Lake. Few limpets were found in the trays during the greater part of the summer, though there did appear to be some slight increase in numbers in August and September in the bottom trays. Limpets were fairly abundant in all the bottom plant samples, with highest incidence occurring at Position 2 throughout the season. It seems unlikely that the limpet populations offer any significant competition to the oysters.

Mytilus: The Blue Mussel, Mytilus edulis, is extremely common in Broad Lake, particularly in areas of muddy bottom.

The tray oysters were found to be completely free of mussels at the May check. Heavy settling of mussels occurred during the late May-early June period and at the time of the mid-June check about 90% of the surface tray oysters had seed mussels attached. The incidence on the bottom tray oysters was considerably less (seed 33.6% and adults 51.2% in June). The incidence of mussels on surface tray oysters remained very high for the remainder of the season. Further settling of mussels during August resulted in the incidence on the bottom trays almost equalling that in the surface trays by the end of the season.

Mytilus was present in fairly large numbers at all of the free plant sites except Site 2.

In view of the fact that Mytilus competes with the oysters for bottom space and also draws heavily on the same food source (Medcof 1961), the large population of mussels in Broad Lake would appear to be the oyster's most serious competitor. Medcof is of the opinion that it is impossible to grow oysters successfully in areas where mussels are abundant.

Barnacles: The barnacle Balanus balanoides is fairly common in Broad Lake. The results of this year's study are very similar to those obtained the previous summer in that only a light incidence of barnacles was noted on seed oysters and a rather heavy incidence on adult oysters. In the case of the tray oysters, the

surface tray adults had about three times as many barnacles attached as those in the bottom tray.

Galtsoff (1964) states that "barnacles have no adverse effect on adult oysters". The only serious threat offered to oysters by barnacles appears to be with respect to utilization of space that would otherwise be available for settling oyster spat.

Bryozoans: As in the case of the barnacles, the bryozoans appear to have been largely restricted to the adult oysters, with the adults in the surface tray showing heavier infestation than those in the bottom tray. The only adverse effect of the bryozoans occurs in respect to the newly settled oyster spat that might be smothered by the encrusting growth.

Hydroids: There appeared to be no significant occurrence of hydroids except in the surface trays towards the end of the season. In no instance were they found to occur on more than about 4% of the oysters. Their chief detrimental effect would appear to be the smothering of newly settled oyster spat.

Drills: Only one or two drilled adult shells were observed during the course of the study. A number of drilled mussel shells were also found suggesting that perhaps the mussel population is bearing the brunt of the drill attack and thus protecting the oyster population to a certain extent.

Several live Thais sp. were observed in the samples during the course of the season. There has been no evidence to suggest that Thais, at the moment, is a serious threat to the oyster population.

Anemones: No anemones were noted through the greater part of the summer. At the September check, a fairly heavy infestation was found to have occurred in the surface trays of both adults and seeds (being 41.8% and 16.3% respectively). The apparent preference of the anemones for adult oysters is undoubtedly due to the fact that the seed population was considerably larger than the adult population, thus distorting the final percentage calculations.

At present the anemones do not appear to be sufficiently abundant to have any adverse effect on the oyster population.

Lepidonotus: This polychaete was found in only small numbers throughout most of the year, with the greatest abundance occurring in August and September. There are no indications that these organisms have any significant effect on the oyster populations.

Polydora: For an excellent discussion on the morphology and general ecology of Polydora see Galtsoff (1964).

There was a consistently high incidence of Polydora blisters in the samples from all of the free plant sites, with the adults showing heavier infestation than the seed oysters. The principal effect of the infestation appears to be a lowering of the market condition of the oysters because of the mud-filled blisters on the inner surface of the valves. Galtsoff (1964) states that Polydora causes "no visible injuries" to the meat. Some disagreement exists as to whether infestation by Polydora results in a decline in the condition of the oyster meat. (Loosanof and

Engle 1942, Galtsoff 1964, Lunz 1940, 1941).

Cliona: The boring sponge, Cliona sp., was reported (Aldrich 1965) in a number of oysters examined at the time of initial planting in May 1965.

No sponges were noted during the greater part of the 1966 season, though a light infestation did occur on seed oysters in the bottom tray during late August, early September. Thus it would appear that if Cliona was introduced into Broad Lake with the oysters, it has managed to adapt to the conditions there and could represent a potential threat to the Bellevue oyster population, although Galtsoff (1964) states that all oyster beds are infested to a varying extent by boring sponges.

Starfish: A number of different species of sea stars were noted in Broad Lake. In most instances they tended to remain in relatively deep water away from the oyster beds. No starfish were observed feeding on oysters during the course of the study, but a number of sea stars that were tonged from the bottom were found to be actively engaged in opening Mytilus. Thus, although there is presumably some predation on the oysters by the sea stars, the Mytilus population probably represents the principal food source for these predators at the moment.

Conclusions

The mortality of the adult oysters in Broad Lake was extremely high, with only about 30% of the populations remaining at the end of two seasons.

Seed mortality, on the other hand, was extremely low; about 95% of the tray populations surviving to the end of the second season.

The peak mortality during the 1966 summer season for both seed and adult oysters occurred in early June.

Growth in both length and width was slow but consistent. The greater part of the growth occurred during the two month period when Broad Lake water temperature exceeded 15 degrees C. (July and August).

The adult oysters appear to be growing extremely slowly.

On the whole, the growth of Bellevue oysters is considerably limited because of the relatively low water temperatures and the extremely short growing season.

The seed oysters were, in general, in better condition than the adult oysters at all sites. With respect to the Butler scale both the seed and adult oysters would be considered in **fair** condition.

The incidence of crystalline style was fairly high throughout the greater part of the summer, with the seed having a somewhat higher incidence than the adults.

Varying degrees of gonad development occurred in both seed and adults at Position 2 in July and August. However, the development did not appear to be sufficiently great for spawning to occur. The minimal spawning temperature of 20 degrees C. was not attained in Broad Lake during the course of this study. As the minimal spawning temperature is based on the mean spawning response of the population it is conceivable that there are animals in the population that deviate sufficiently from the mean to be able to spawn at the somewhat lower temperatures of Broad Lake. It would be of considerable benefit to the oyster introduction program if such animals could be isolated and spawned under controlled conditions with a view to raising the progeny and thus building up a stock of oysters capable of low temperature spawning.

There is no evidence of excessive predation on the oyster population by either sea stars or oyster drills, although both these groups do represent a potential threat.

Mussels appear to present the most severe competition for the oyster populations, with respect to both food supply and bottom space.

The boring sponge, *Cliona*, is present in Broad Lake. It is impossible to say whether it was present prior to the introduction of oysters or was actually introduced along with the oysters. At present, the infestation appears to be relatively

light. However, it is possible that Cliona may in the future represent a considerable threat to oyster populations in Broad Lake.

Polydora infestation was extremely high in both adult and seed oysters. These polychaetes probably represent no threat to the survival and growth of the oysters, but they will certainly influence the market condition.

In summary, the seed oysters have adapted extremely well to conditions at Broad Lake, as indicated by low mortality, reasonable growth, high incidence of crystalline style, fair condition and some evidence of gonad ~~de~~velopment.

The adult population has, on the other hand, suffered unusually high mortality, a rather poor growth record, a somewhat lower condition index than the seed, and a somewhat lower incidence of crystalline style than the seed.

APPENDIX

Physical Characteristics

Broad Lake, Bellevue

I. Temperature

II. Salinity

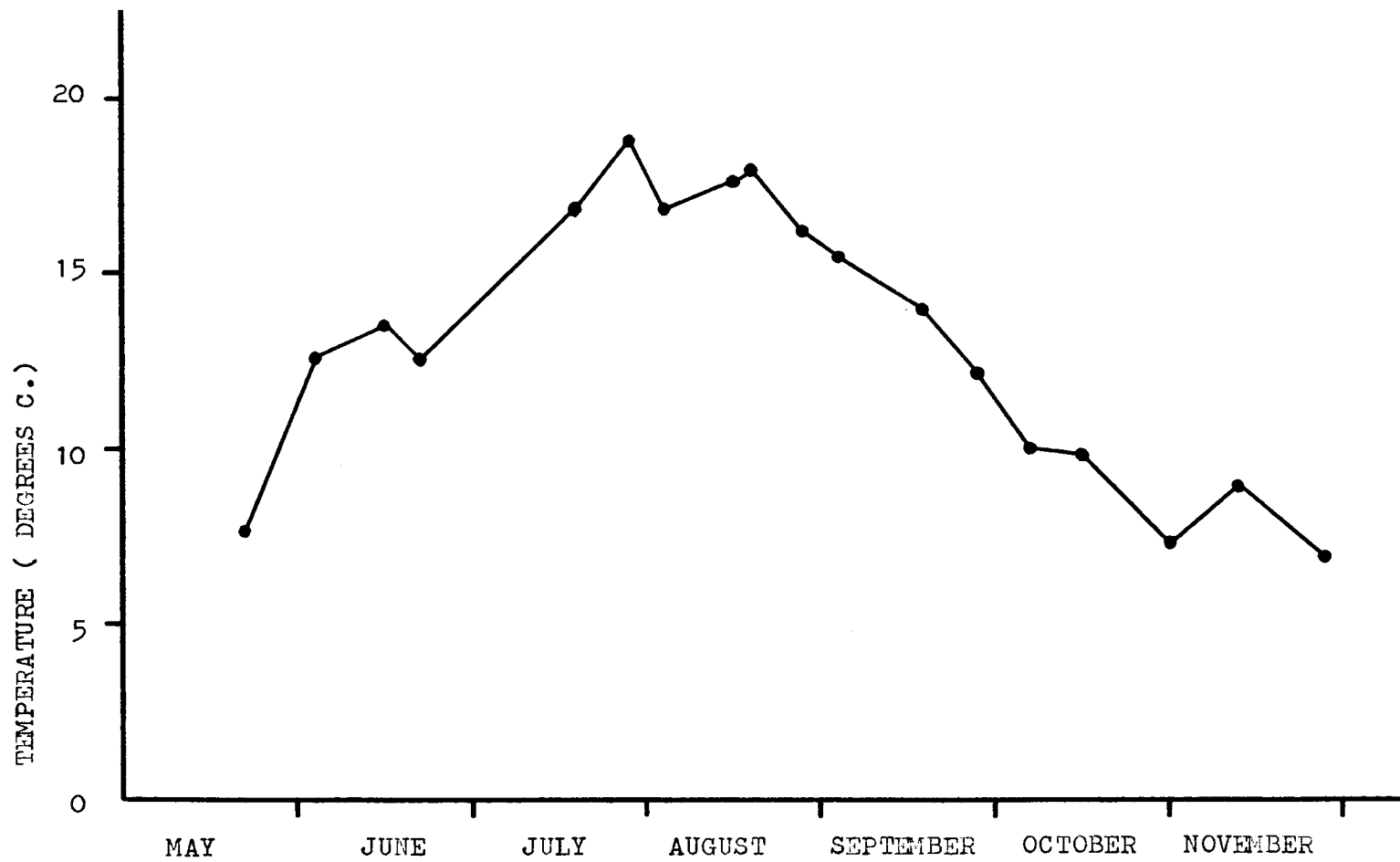


Fig. 21. Surface water temperatures Area "A" Broad Lake, Bellevue.

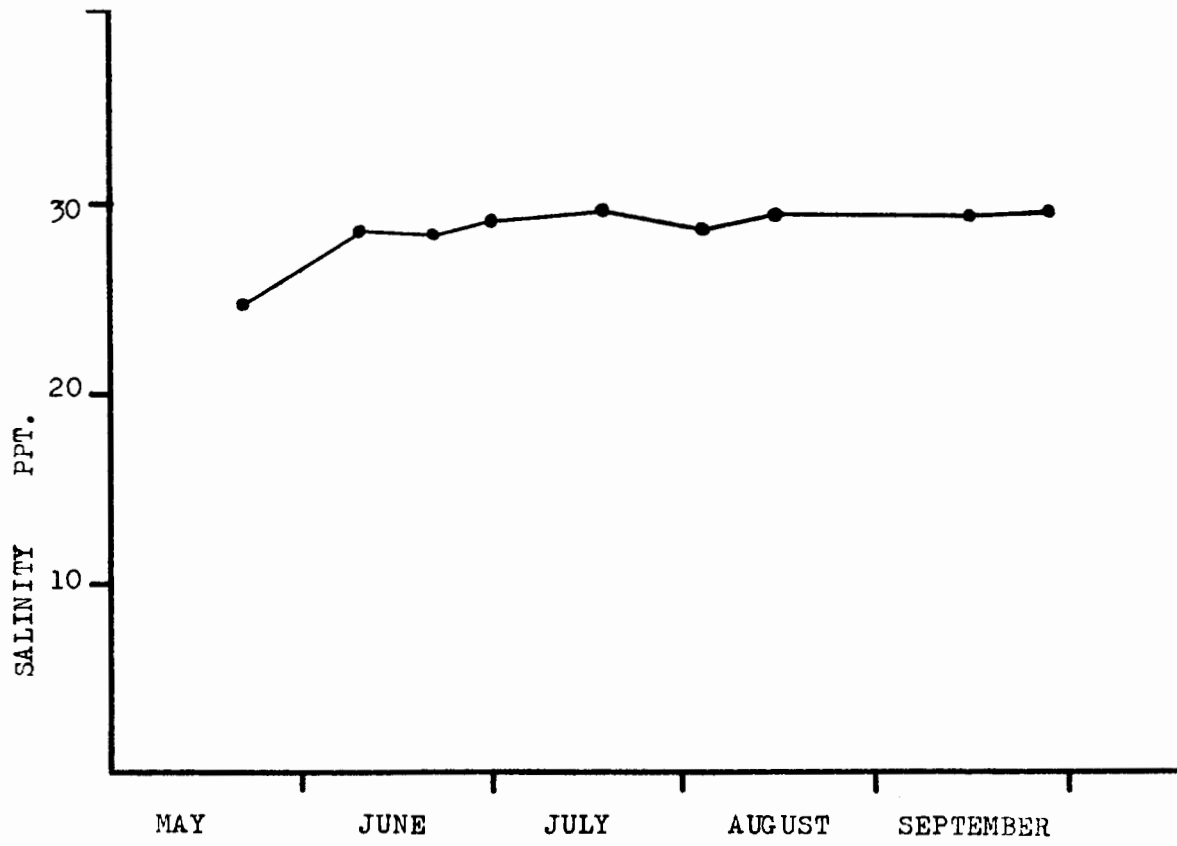


Fig. 22. Surface water salinity Area "A" Broad Lake, Bellevue.

LITERATURE CITED

- Aldrich, F.A., 1957. Statistical studies of oysters and associated organisms. Acad. Nat. Sci. Phila. 209 pp. (Restricted circulation)
- Aldrich, F.A., 1957. Study of oysters held in trays. Acad. Nat. Sci. Phila. 63 pp. (Restricted circulation)
- Aldrich, F.A., 1965. Investigations on oysters planted at Broad Lake, Bellevue, Trinity Bay. Memorial University of Newfoundland Publication. (Restricted circulation)
- Galtsoff, P.S., W.A. Chipman Jr., J.B. Engle & H.N. Calderwood, 1947. Ecological and physiological studies on the effects of sulfate pulp mill wastes on oysters in the York River, Va. U.S. Fish & Wildlife Service, Fish Bull. 51: 59-186 (Fisheries Bulletin No. 43).
- Galtsoff, P.S., 1964. The American Oyster. U.S. Fish & Wildlife Service. Fish. Bull. 64: 397-456.
- Gunter, G., 1942. Seasonal condition of Texas oysters. Proc. and Trans. Texas Acad. Sci. 25: 89-93.
- Gunter, G., 1955. Mortality of oysters and abundance of certain associates as related to salinity. Ecology, 36 (4): 601-605.
- Hewatt, W.J. & J.D. Andrews, 1954. Oyster mortality studies in Virginia. I. Mortalities of oysters in trays at Gloucester Point, York River. Texas Jour. Sci. 6 (2): 121-133.

- Loosanof, V.L. and C.A. Nomejko, 1949. Growth of oysters O. virginica, during different months. Biol. Bull. 97 (1): 82-94.
- McHugh, J.L. & J.D. Andrews, 1954. Computation of oyster yields in Virginia. Va. Fish. Lab. Spec. Sei. Rept. No. 7.
- Medcof, J.C., 1961. Oyster farming in the maritimes. Jour. Fish. Res. Board of Canada. Bulletin 131: 1-158.
- Mitchell, P.H., 1917. Nutrition of oysters: glycogen formation and storage. Bull. U.S. Bur. Fish. (1915-1916) 35: 151-161.
- Needler, A.W.H., 1932. Oyster farming on the Atlantic Coast of Canada. Department of Fisheries Publication.
- Owen, H.M., 1957. Etiological studies on oyster mortality. II. Polydora websteri Hartman. Bull. Mar. Sci. Gulf and Carib. 7 (1): 35-46.

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