

MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 331

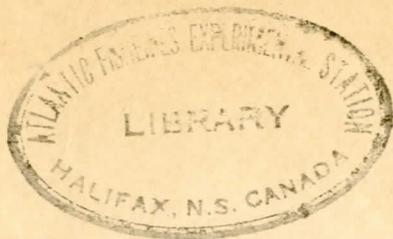
REPORT ON 1942 INVESTIGATIONS

(Principally oysters, with small note on Irish moss)

by

J. C. Medcof.

59017



FISHERIES RESEARCH BOARD OF CANADA

MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 331

Title

REPORT ON 1942 INVESTIGATIONS

(Principally oysters, with small note on Irish moss)

Author

J. C. Medcof

REPORT ON

1942 INVESTIGATIONS

(Principally oysters, with small note on Irish moss)

by

J. C. Medcof.

TABLE OF CONTENTS

	Introduction	1
I.	Effect of relaying at different seasons on the condition of oysters	2
II.	Comparison of "Condition Factor" and Index of Condition"	6(a)
III.	The Needler-Clark growth experiment of 1935	9
IV.	Growth and growing conditions of oysters in 1942	25
V(a).	Specific Gravity of oyster meats and shell liquor	39
V(b).	Shell proportions of oysters	40
VI.	Seasonal changes in shell characters	43
VII.	Shell characters of Gillis cove "brush" oysters	45
VIII.	Effect of storage on shell characters	46
IX.	Effect of temperature on condition and on shell growth	50(a)
X(a).	The effect of storage on the flavour of oysters	50(c)
X(b).	Self-purification of sewage-contaminated oysters	51
XI.	Oyster investigations in the Shippigan district of New Brunswick	58
XII.	Preliminary report on the distribution of Irish moss on the gulf coast of New Brunswick	98
XIII.	References	101

INTRODUCTION

The 1942 field work began on April 30 when the writer left St. Andrews and went to the P. E. I. Biological Station where several branches of investigation were carried on. There were two main studies at Ellerslie, one on growth and growing conditions of oysters, the other on the effect of relaying on the fatness of oysters. At Summerside, from August 24 to September 11, and from September 24 to October 2, a study of self-purification of sewage-contaminated oysters was made in co-operation with Mr. A. G. Campbell of the Department of Pensions and National Health. Visits were made to Shippegan, N. B., May 13-18, June 18-25, August 4-19 and October 21-26, to study the oyster situation in that district and to assist prospective lessees in finding suitable areas for cultivation of oysters. A small amount of work was done with Irish moss - chiefly in northern New Brunswick.

The return to the Atlantic Biological Station was made on November 17 where the year's collection of data was analyzed. In this work the writer is indebted to Miss Molly McIntosh and Miss Fae Hallet for much assistance. They also aided the writer in completing an analysis begun several years ago by Dr. A. W. H. Needler of data collected chiefly by Miss A. E. Clark in 1935 during an experiment designed by Dr. Needler to study growth of oysters.

The facilities of the biological station were used during the winter to study the influence of temperature on condition and on shell growth and the effect of storage on the shell characters of oysters.

I.

EFFECT OF RELAYING AT DIFFERENT SEASONS ON THE CONDITION OF OYSTERS

The 1941 experiment in relaying oysters (Medcof 1941) was repeated this year with certain modifications. The up-river bed chosen was the "Sand bed" which was not quite so far up-stream and better stocked with oysters than the Ellis cove bed which was used last year. Both UU and DU stocks were laid on this area in close proximity to one another. In this new area there were no rank growths of algae such as were encountered in Ellis cove and at the warehouse in 1941.

At each relay the index of condition was determined for samples taken from each of the lots transferred up to that time. This increased the amount of work enormously and laboratory and field assistance was required most of the time the tests were being run.

Besides the changes in the design of the experiment the water temperatures in 1942 were very different from those in 1941. The oysters in the fall of 1942 were the fattest they have ever been during the four years the writer has studied fatness. The results are presented in tables I and II in the same form as those for 1941.

Conclusions from the data applying to UU and DD stocks

1. In undisturbed stocks down-river oysters are nearly always fatter than the up-river but the difference this year was less than in 1941 and in this respect 1942 is less typical than 1941.
2. There was much less individual variation in down-river than in up-river oysters.

3. With few exceptions fishing and planting of oysters back on their own native beds improved the fatness regardless of the season at which they were handled.

4. The earlier in the season handling was done the fatter the oysters tend to be at the close of the season.

5. Oysters that are transferred late in the season may improve in fatness even after the temperature falls below 15° but in other lots they became poorer below 15°

6. In other respects the above data support conclusions from earlier studies on the effect of water temperature on fatness of oysters.

7. The Cooper bed oysters were fatter this year than in any other of the four years in which fatness studies have been carried on.

8. There is no evidence that there is a particular season or seasons during which relaying should be avoided because of any directly harmful affects on fatness.

9. It is an advantage however to make all UD relays sometime before fall fattening begins. This makes for a fatter oyster at the close of the season.

Conclusions from data applying to UD and DU stocks

10. The DU stocks fattened about as well as the UU's and better than the undisturbed D's and U's but not so well as the UD's.

11. The fattest oysters met with were UD's relaid early in the season before fall fattening commenced.

12. Regardless of season it always improves fatness to make UD transfers.

13. The oysters transferred late showed some improvement even after the water temperature fell below 15°.

Table I. Showing the index of condition of samples from each of the lots on various dates.

Date	UU Lot Number							
	1	2	3	4	5	6	7	8
May 8	97							
May 20	103	112						
June 9	109	113	103					
June 26	66	93	88	82				
July 20	95	87	87	82	71			
Sept. 1	110	113	133	118	113	95		
Oct. 11	130	115	115	121	101	105	100	
Nov. 7	120	125	118	118	117	113	110	96

Date	UD Lot Number							
	1	2	3	4	5	6	7	8
May 8	97							
May 20	111	112						
June 9	129	121	103					
June 26	114	111	99	82				
July 21	98	97	92	87	71			
Sept. 4	131	158	128	136	117	95		
Oct. 11	135	142	135	141	141	118	100	
Nov. 10	115	136	121	131	130	119	117	96

Table II. Showing the index of condition of samples from each of the lots on various dates.

Date	DD Lot Number							
	1	2	3	4	5	6	7	8
May 7	114							
May 20	113	101						
June 8	107	119	107					
June 26	110	108	107	86				
July 21	97	95	107	97	90			
Sept. 2	111	126	126	133	121	108		
Oct. 16	125	127	127	125	133	113	117	
Nov. 10	118	105	117	124	123	122	133	126

Date	DU Lot Number							
	1	2	3	4	5	6	7	8
May 7	114							
May 20	119	101						
June 8	111	106	107					
June 26	103	81	100	82				
July 20	93	86	83	96	90			
Sept. 1	122	102	127	120	113	108		
Oct. 7	119	103	115	120	119	121	117	
Nov. 6	113	110	112	117	121	123	119	126

II

COMPARISON OF "CONDITION FACTOR" AND "INDEX OF CONDITION"

Quale (1940) has described a "Condition Factor"[#] for oysters and presented a limited number of data relating to it without stating what species of oyster they apply to. He suggests that with refinements this condition factor might be useful to investigators. Essentially his condition factor was calculated by dividing the volume of shucked drained (10 minutes) meats by the volume of the space between the valves, (Shell capacity).

In order to compare this value with the "index of condition" used by the present writer during the past several years, samples of 20 to 24 oysters of "choice grade" were taken on the same dates and from the same areas as those used in the transfer experiment. The condition factors worked out for these according to Quale's method appear in table III. For sake of comparison the indices of condition determined for the samples of oysters taken in connection with the transfer experiment are presented with the condition factors.

The average value of the condition factor for Cooper bed oysters taken throughout the season was 0.49. This is higher than that given by Quayle for whatever species of west-coast oyster he was working with.

The condition factor shows a decline during the spawning season but this is less remarkable than that of the index of condition. Besides this, the condition factor shows erratic fluctuations which the writer is unable to explain.

This is essentially the same as that introduced by Grave (1912) and used by J. Nelson (1915) and T. C. Nelson (1929) in their condition studies.

Table III. Summary of observations on special samples of oysters from the Cooper bed.

	666						
	May 11	May 25	June 11	July 23	Sept. 3	Oct. 15	Nov. 10
Condition Factor	0.52	0.54	0.51	0.46	0.58	0.56	0.53
Index of Condition	114	101	107	90	108	117	126
Specific Gravity of Meats	1.08	1.05	1.07	1.05	1.06	1.08	1.09
Specific Gravity of Liquor	1.04	1.02	1.02	1.02	1.03	1.02	1.03
Mean Length of Oyster in mm.	81	73	86	80	81	92	92
Mean Thickness 65 mm. from the hinge	10.6	11.6	12.0	9.3	10.6	15.0	15.5
<u>M. Thickness</u> . 100	13	16	14	12	13	16	17
<u>M. Length</u>							

From a comparison of the values of the index and the factor, on corresponding dates the average relationship may be expressed as follows:

$$\text{Condition Factor} = \text{Index of Condition} \times 0.0049$$

In reviewing this matter it is of interest to refer to Herdman's discussion (1923 p.319) of the reasons why wet weight is a poor index to the condition of a marine animal. He showed how sea water replaces losses of organic matter in tissues during starvation. While the amount of sea water in a tissue has little effect on its dry weight it does influence its live weight tremendously. Dry weights are therefore preferable to wet in any study of condition. In other words, the Index of Condition should be a more reliable value than the Condition factor in studying fatness of oysters. This conclusion is borne out for O. virginica by the observations reported in table III.

III

THE NEEDLER-CLARK GROWTH EXPERIMENT OF 1935

Introduction

In 1935 an experiment designed by Dr. A. W. H. Needler for the study of growth of young oysters was carried out at the P. E. I. Biological Station. The data were gathered chiefly by Miss A. E. Clark and were partly analyzed by Dr. Needler but have never been presented in report form. They constitute the most comprehensive series of observations on linear growth that has been compiled at the station previous to 1942 and are unique in that they combine volume, weight and length measurements of the animals studied.

During the winter of 1943 Dr. Needler turned over a summary of the data to the writer for further analysis. The original data which were not available included between 3,000 and 4,000 length measurements and close to 100 each of weight and volume measurements. Some assistance in the analytical work was given by Miss MacIntosh and Miss Hallet. The results of this important experiment are presented in this report before those of the 1942 experiment because they illustrate the phases of the growth cycle very clearly. The 1942 results show how environmental factors modify the processes. Had the 1935 results been available in this form a year ago the design of the 1942 experiment would have been different.

Procedure

Dr. Needler has supplied the detailed information as to the manner in which the experiment was conducted. Four lots of 45 spat of the 1934 set were chosen from each of two size classes

that ranged about 1.7 and 3.7 cm. A lot of large and a lot of small was placed in each of four rearing cages. These latter were constructed of $\frac{1}{4}$ " mesh galvanized wire cloth measuring approximately 24" x 12" x 6". Each was provided with five horizontal shelves spaced at intervals of about 4" and running crosswise the long axis of the cage. The samples of large and small spat were kept separate throughout the experiment.

The oysters were planted in the cages, 15 to the square foot (approximately) of shelf space. This density is not considered high enough to make crowding a growth-limiting factor.

On May 21 and 22 the cages were set out as follows:

- #13758 Just off the bottom on the Wharf bed suspended from a stake in 5 feet of water at a low tide.
- #14136 Just below the surface at the boat mooring which at that time was in the channel of Smelt creek northeast of the back door of the biological station suspended from a tripod.
- #14135 Just off the bottom at the same place as #14136, suspended from a tripod in 10' of water.
- #14132 Suspended from a tripod in middle of Claude Williams' creek just off the bottom. At low tide the top of the cage was barely covered with water.

At fortnightly intervals the cages were brought to the laboratory. Before measurement the oysters were cleaned in water with a soft brush and allowed to drain. Length measurements were made with a vernier caliper to the nearest 0.1 cm. The volume of each lot of 45 spat was estimated to the nearest

c.c. by immersion in a graduate. Weights of the lots were measured to the nearest gm, using a balance accurate to the nearest gm. The number of oysters in the lots was counted at each observation.

Results.

The data gathered permit the calculation of the mean length, weight and volume for the oysters of each lot on each of the eleven observation dates. The necessary data were not available to calculate standard errors for any of the means listed in the tables. The only indication of the degree of scattering is the length range which is listed in the tables together with the number of oysters measured in each lot. The data are summarized in tables IV to VII.

Discussion of Results

A. General Characteristics of Growth

The experiment did not begin early enough or continue late enough to illustrate the features of initiation and completion of growth.

When lengths, weights and volumes are plotted against time (fig. 1) they show some interesting relationships but when growth is expressed as a percentage increase per day and plotted against time (fig. 2) the results are more revealing. Figure 2 shows:

1. In May when the observations began the growth rate was already high and increasing.
2. It continued to rise until it reached a spring maximum late in June or early in July.
3. Following this there was a mid-summer depression in late July and early August. This phase was more conspicuous among the "large" stocks than the "small".

Table IV. Summary of data on oysters in cage #13758 at wharf bed 1935

A Small Stock

Date	No. oysters measured.	Length range cm.	Mean length cm.	% increase per day in length	Mean weight gms.	% increase per day in mean weight	Mean vol. c.c.	% increase per day in vol.
May 22	45	1.4-2.2	1.71		0.64		----	
June 6	39	1.5-2.5	2.03	1.1	0.86	2.0	----	
June 20	38	1.4-3.0	2.13	0.3	1.18	2.3	0.74	
July 5	38	2.1-3.3	2.71	1.6	1.91	3.2	1.13	2.6
July 19	38	2.2-3.7	2.94	0.56	2.86	2.8	1.66	2.7
Aug. 2	38	2.3-4.0	3.11	0.79	4.08	2.5	2.79	3.6
Aug. 16	38	2.4-4.4	3.45	0.61	6.00	2.7	3.68	1.9
Aug. 30	37	2.6-4.7	3.67	0.45	8.12	2.1	5.45	1.4
Sept. 13	38	2.7-4.8	3.75	0.16	9.08	0.80	5.37	0
Sept. 27	37	2.8-4.7	3.75	0	9.49	0.31	5.87	0.6
Oct. 11	37	2.6-4.7	3.83	0.16	9.97	0.35	5.78	0

Table IV (Continued.)

B Large Stock

Date	No. of ysters meas- ured	Length range cm.	Mean length cm.	% incr- ease per day in length	Mean weight gms.	% incr- ease per day in mean weight	Mean vol. c.c.	% incr- crease per day in vol.
May 22	45	2.9-4.3	3.60		4.17		----	
June 6	36	2.9-4.5	3.83	0.40	5.64	2.0	----	
June 20	35	3.1-4.6	3.94	0.20	6.11	0.80	3.69	
July 5	34	3.6-5.5	4.38	0.70	7.75	1.6	4.44	1.8
July 19	34	3.9-5.6	4.58	0.32	9.37	1.4	5.44	1.5
Aug. 2	34	3.6-5.4	4.76	0.28	12.9	2.2	7.59	2.4
Aug. 16	34	3.8-6.2	5.00	0.35	16.6	1.8	10.0	1.9
Aug. 30	34	3.9-6.3	5.14	0.20	19.8	1.3	11.0	0.7
Sept. 13	34	4.0-6.3	5.31	0.11	21.9	0.95	12.0	0.6
Sept. 27	34	4.0-6.1	5.22	0.12	22.6	0	12.3	0.2
Oct. 11	34	4.0-6.2	5.26	0	23.4	0.49	12.6	0.2
Total Increase			1.66 cm. = 46%		19.2 gm. = 460%			

Table V. Summary of data on oysters in cage #14136 held near the surface at the boat mooring.

A Small stock

Date	No. oysters measured	Length range cm.	Mean length cm.	% increase in length per day	Mean weight gms.	% increase in weight per day	Mean vol. c.c.	% increase per day in volume
May 21	30	1.5-2.7	1.87		0.80		----	
				0.3		1.5		
May 31	28	1.2-3.0	1.92	1.3	0.93	3.8	----	
June 14	29	1.7-3.0	2.30	1.5	1.62	4.1	1.04	3.3
June 28	29	2.1-3.3	2.79	1.3	2.91	3.5	1.66	3.8
July 13	29	2.4-4.1	3.41	0.40	4.98	3.5	2.97	3.6
July 27	29	2.2-4.7	3.61	0.50	8.19	2.8	5.00	2.7
Aug. 10	29	2.3-5.0	3.88	0.70	12.2	1.3	7.28	0.14
Aug. 26	28	2.3-5.6	4.35	0.40	15.1	1.6	7.50	1.0
Sept. 7	28	2.3-6.0	4.57	0.22	18.2	1.3	8.46	2.6
Sept. 21	27	3.5-6.0	4.71	0.15	21.8	0.6	12.1	0.7
Oct. 5	27	3.5-6.1	4.82		23.9		13.5	
Total Increase			2.95 cm. = 158%		23.1 gm. = 2900%			

Table V. Continued.

		B Large Stock						
Date	No. oysters measured	Length range cm.	Mean length cm.	% increase per day in length	Mean weight gms.	% increase per day in weight	Mean Vol. c.c.	% increase per day in volume.
May 21	45	2.9-4.4	3.76		4.11		----	
May 31	40	3.0-4.8	3.83	0.43	5.43	2.7	----	
June 14	40	2.6-5.4	4.13	0.54	6.83	1.6	4.25	
June 28	40	3.4-5.4	4.43	0.49	9.75	2.5	6.15	2.6
July 13	39	4.3-6.6	5.13	0.98	13.2	2.0	8.10	1.8
July 27	39	4.3-6.5	5.32	0.26	18.4	2.4	11.7	2.9
Aug. 10	39	4.6-6.9	5.38	0.08	24.6	2.1	14.6	1.6
Aug. 26	38	4.6-7.1	5.72	0.38	29.0	1.0	16.3	0.69
Sept. 7	38	4.9-7.7	5.92	0.29	33.5	1.2	18.7	1.1
Sept. 21	38	5.0-7.6	6.02	0.12	34.6	0.27	0	0.87
Oct. 5	38	5.0-7.6	6.06	0.04	40.0	1.0	21.1	0.55
Total Increase			2.39 cm. = 65%		35.9 gms. = 870%		22.9	

Table 6. Summary of data on oysters in cage #14135 near bottom at boat mooring 1935.

A Small stock

Date	No. oysters measured	Length range cm.	Mean length cm.	% increase per day in length	Mean weight gms.	% increase per day in weight	Mean vol. c.c.	% increase per day in volume.
May 21	46	1.3-2.2	1.70		0.62		----	
May 31	42	1.4-2.5	1.78	0.46	0.68	0.92	----	
June 14	37	1.5-3.2	2.22	1.6	1.32	4.6	0.92	
June 28	37	1.6-3.2	2.51	0.89	2.35	4.0	1.43	3.1
July 13	37	2.0-4.0	3.25	1.7	4.41	4.1	2.38	3.3
July 27	37	2.5-4.3	3.54	0.61	7.84	4.0	4.56	4.5
Aug. 10	37	2.8-4.7	3.85	0.60	11.5	2.7	6.62	2.7
Aug. 24	37	3.0-5.0	4.23	0.68	14.6	1.7	8.35	1.7
Sept. 7	37	3.0-5.3	4.50	0.44	18.1	1.5	10.5	1.6
Sept. 21	37	3.2-5.4	4.61	0.17	19.3	0.46	12.2	1.1
Oct. 5	37	3.3-5.8	4.77	0.23	23.6	1.3	13.2	0.64
Total Increase			3.1 cm. =182%		23.0 gms =3800%			

Table VI. Continued

B Large Stock

Date	No. eyes measured	Length range cm.	Mean length cm.	% increase per day in length	Mean weight gms.	% increase per day in weight	Mean vol. c.c.	% increase per day in volume
May 21	45	2.9-4.5	3.70		4.14		----	
May 31	40	3.2-4.7	3.89	0.50	5.10	2.1	----	
June 14	40	3.4-5.3	4.26	0.65	7.10	2.4	4.45	
June 28	39	3.0-5.5	4.49	0.38	9.64	2.2	5.95	2.1
July 13	39	3.3-6.3	5.20	0.98	14.7	2.8	8.54	2.4
July 27	39	3.0-6.8	5.33	0.18	19.8	2.1	12.6	2.8
Aug. 10	38	4.5-6.9	5.63	0.39	26.5	2.1	15.9	1.7
Aug. 24	38	4.4-7.5	5.92	0.36	31.9	1.3	18.8	1.2
Sept. 7	38	4.3-7.2	5.95	0.04	36.0	0.86	20.3	0.8
Sept. 21	37	4.7-6.8	6.00	0.06	39.5	0.66	22.5	0.7
Oct. 5	37	4.6-7.0	6.15	0.16	41.6	0.34	23.9	0.4
Total Increase			2.45 cm. =66%		37.5 gm. =910%			

Table VII. Summary of data on oysters in cage #14132 in Claude Williams' creek, 1935.

A Small Stock

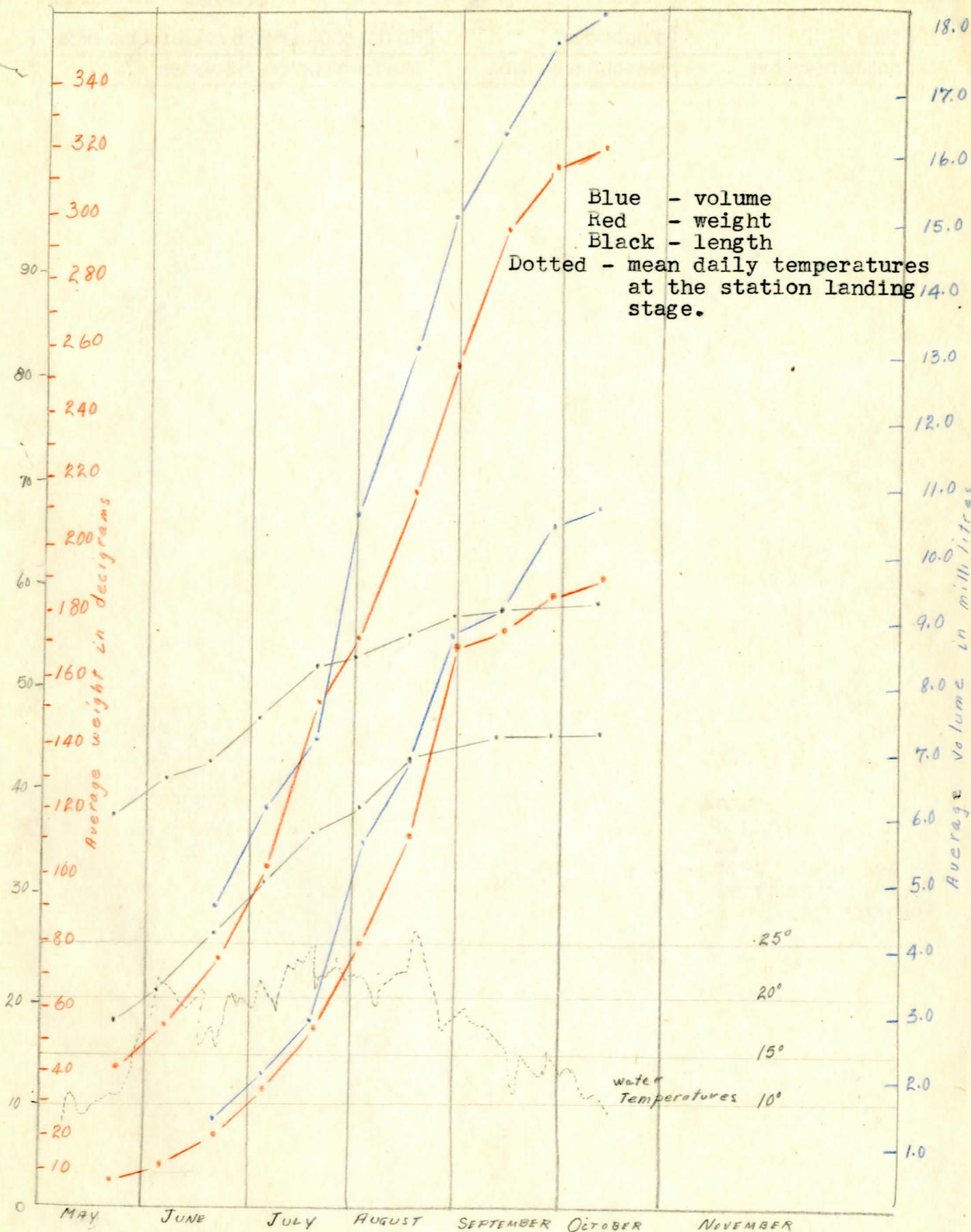
Date	No. oysters measured	Length range cm.	Mean length cm.	% increase per day in length	Mean weight gm.	% increase per day in weight	Mean vol. c.c.	% increase per day in volume
May 22	45	1.4-2.2	1.80	1.2	0.76	2.8	----	
June 6	36	1.5-3.1	2.41	1.5	1.17	4.1	----	
June 20	35	2.0-3.3	2.65	1.1	2.11	3.4	1.31	3.0
July 5	34	2.3-3.8	3.14	1.0	3.54	2.9	2.06	2.3
July 19	34	2.5-4.7	3.61	0.44	5.37	2.8	2.85	1.5
Aug. 2	34	2.7-5.0	3.84	0.89	7.97	2.4	5.53	1.4
Aug. 16	34	3.2-5.6	4.35	0.14	11.2	3.0	6.76	1.9
Aug. 30	34	3.5-5.7	4.43	0.18	17.1	0.2	8.76	0.26
Sept. 13	34	3.5-5.6	4.45	0.08	17.6	0.4	9.12	0.95
Sept. 27	34	3.5-5.8	4.59	0.00	18.7	0.2	10.4	0.20
Oct. 11	34	3.6-5.8	4.59		19.2		10.7	
Total Increase			2.79 gm.		18.4 gm.			
			= 155%		= 2430%			

Table VII. Continued

B Large Stock

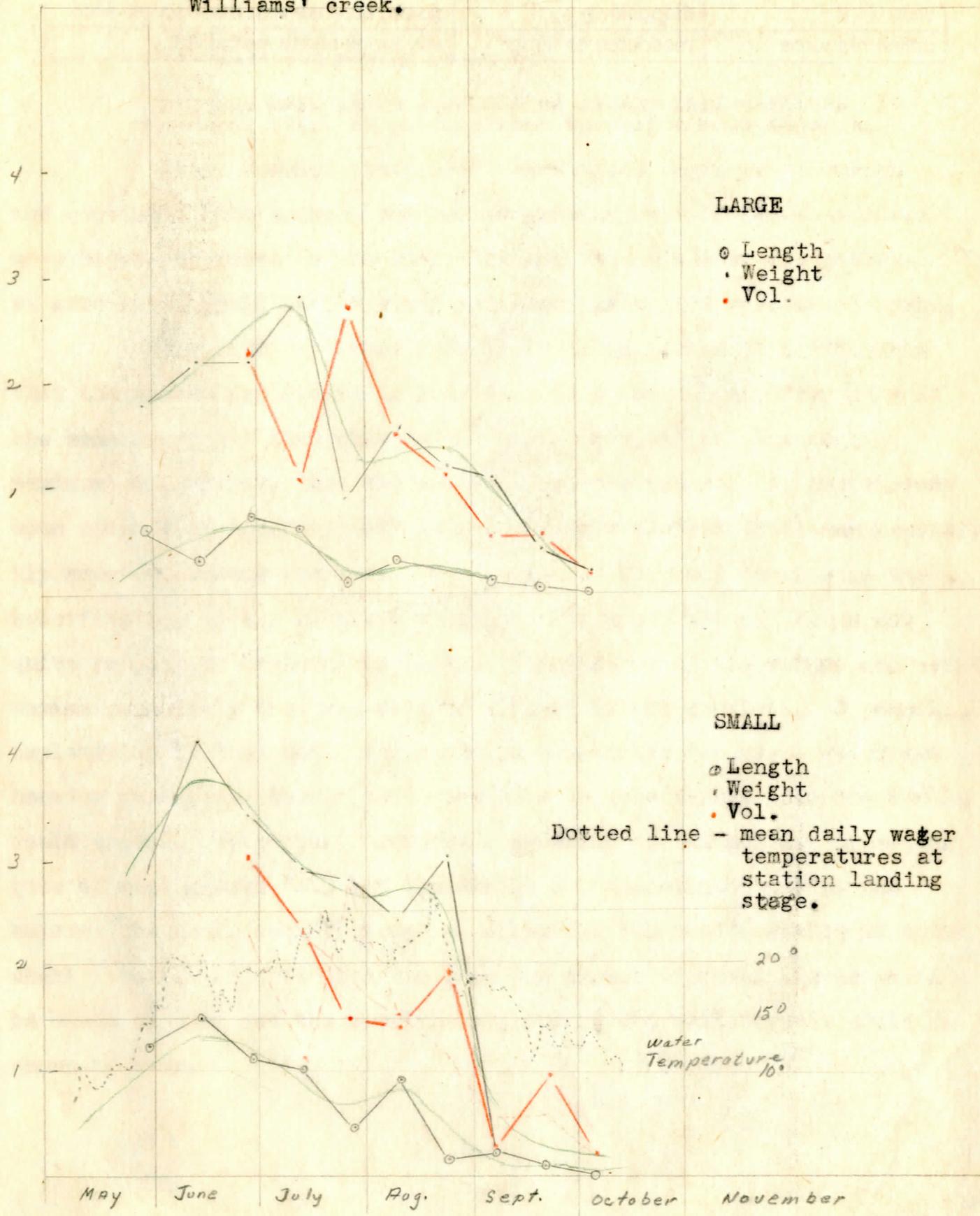
Date	No-oy- oysters measured	Length range cm.	Mean length cm.	% incr- ease per day in length	Mean weight gms.	% incr- ease per day in weight	Mean vol. c.c.	% incr- crease per day in volume
May 22	45	3.0-4.5	3.77		4.17		----	
June 6	43	3.5-5.0	4.11	0.6	5.44	1.8	----	
June 20	43	3.5-5.1	4.31	0.3	7.44	2.2	4.53	
July 5	42	3.7-6.0	4.79	0.7	10.3	2.2	6.07	2.3
July 19	42	3.7-6.7	5.21	0.6	15.3	2.8	7.10	1.1
Aug. 2	41	3.6-6.4	5.30	0.1	17.3	0.9	10.5	2.7
Aug. 16	41	3.6-6.9	5.52	0.3	21.7	1.6	13.0	1.5
Aug. 30	41	3.6-6.8	5.70	0.2	25.6	1.2	15.1	1.1
Sept. 13	41	3.5-7.0	5.79	0.1	29.8	1.1	16.3	0.55
Sept. 27	40	4.5-7.0	5.83	0.05	31.7	0.4	17.7	0.56
Oct. 11	40	4.5-7.0	5.84	0.01	32.3	0.2	18.2	0.20
Total Increase			2.07 cm. =55%		28.1 gm. =675%			

Figure 1. Showing mean length, weight and volume of "large and "small" oysters in cage #14132 in Claude Williams' creek.



1935

Figure 2. Showing the rates of growth in length, weight and volume for large and small stocks in cage #14132 in Claude Williams' creek.



1935

4. This was followed by a summer maximum in middle or late August. This peak is a less pronounced feature than the spring maximum.
5. The last phase represented is the fall decline. It was still in process when the experiment stopped.

It is assumed that, had observations begun early enough and continued late enough, the curves showing rate of increase would have begun and ended on the zero line and that a winter depression at zero level would be the sixth and last phase in the seasonal cycle.

Figure 2 and other data included in tables IV to VII show that the maxima for growth in length, weight and volume occur at nearly the same times but that they do not coincide exactly. The length maximum comes first, then the weight, then the volume. It has already been shown that length-growth occurs suddenly (Medcof 1941) and necessarily precedes volume increase. The latter is slow and depends on the calcification of the flexible margin of the upper valve. It is not quite so easy to explain the lack of coincidence of the volume and weight maxima especially when the data on volumes is not complete. A possible explanation is that under the observed conditions the meats which are heavier than water (see p. 40) were able to grow faster than the shells could expand. This would produce a crowding of the meats. After the rate of meat growth fell off the shells could continue to grow and enlarge the shell cavity enough to allow for the accommodation of extra shell liquor. If this were the case the amount of shell liquor could be shown to vary and the specific gravity of the whole oyster could be shown to vary.

B. Temperature Effects

The experiment does not begin early enough or continue late enough to indicate the critical temperature levels for commencement and cessation of growth. Growth was already in process when the experiment began at temperatures just above 10°; it was still going on but probably nearly over when the experiment closed at a temperature about 12°.

The spring maximum was attained when the temperature ranged about 20°.

The summer depression occurred when the temperature ranged between 20 and 25°. It may be attributed to spawning activity. Needler (1933) has shown that oysters even of this small size do spawn and the results of the 1942 growth experiment show that in adults there is a sudden stoppage in shell growth at spawning time.

C. Other Conclusions

The total amount of growth for the season varied greatly from place to place. On the Wharf bed the increase for "large" and "small" stocks was 66% and 91% respectively. At the boat mooring near the bottom the corresponding increases were 18% and 3800%. By the end of the season the Wharf bed oysters had just reached the size attained by those at the boat mooring in July. Tentatively the differences are attributed to differences in water circulation.

These data indicate the need for great care in the selection of rearing areas to ensure maximum growth. The common practice of selecting up-stream locations for rearing on account of wind protection may not be justified if growing conditions in trays resemble those in cages. A careful comparison of growth in trays and cages

should be made to reveal the facts.

A comparison of the two cages at the boat mooring shows that growth was slightly greater near the bottom than at the surface.

The data indicate that length measurements are a poor index to growth. Length changes are smaller than those in volume and weight and are, therefore, subject to a greater percentage error in measurement. Furthermore, it is seen that weights and volumes continue to increase rapidly (fig.1) for a considerable time after length growth has stopped. Lengths alone do not, therefore, truly indicate what is going on.

The relation of volume to weight is very regular regardless of size. By plotting out the data and drawing a curve through the points the most representative value for specific gravity seems to be 1.78.

The results of this experiment are most stimulating and it should be repeated with certain added features in order to show such things as the relation of growth in trays to growth in cages, the threshold temperatures for shell growth, the features other than temperature (currents food supply etc.) that influence growth that bring about the great differences in growth, from place to place. Such information would be of considerable importance to the industry.

GROWTH AND GROWING CONDITIONS OF OYSTERS IN 1942

Introduction

There are available in the station records many series of measurements of oysters grown under ^agreat variety of conditions. It is difficult to analyze some of these results partly because there is no uniform standard for comparison and partly because the sampling methods used in obtaining the data were not as systematic as is required for strict comparisons. In many cases crowding was an important growth-limiting factor in the early tests and this has interfered with the usefulness of the results. There is, therefore, a need for gathering more precise information relating to the growth characteristics of oysters as a basis for answering the questions that arise during the development of the oyster industry.

The present experiment was designed as preliminary to others to be carried out in 1943. When the results of the two years are available and are considered along with those of earlier workers they should show how growth is influenced by such factors as water temperature and spawning, water circulation, exposure at low tide, depth of submersion at various distances from shore, submersion in trays at various depths in mid-channel and by disturbance during handling.

In this report no attempt has been made at this stage of the investigation to present a synthesis of the writer's results and those of earlier investigators working at Ellerslie. It is planned to prepare a comprehensive record of this sort when the 1943 experiments have been completed.

Procedure

Adult Cooper bed oysters in lots of 50 and 1940 spat (tray-reared in 1941) in lots of 100 were selected as experimental stock and set out early in May before any oysters in the district, native or cultivated, showed any growth (see table X in section entitled "Seasonal changes in shell characters"). The only exceptions to this were lots 1A - 4A which were put out when earlier plants had already grown 1 - 3 mm.

Most of the plots were set up just northwest of Mr. H. B. Forbes's house opposite the bend in the biological station lane. At this point the bottom near shore is sandy and grades off into sand-mud, into mud, and finally into hard shell bottom. There is moderate exposure to winds and a slight growth of eel grass below low water mark. The water temperatures are almost identical with those at the station landing stage.

A preliminary attempt was made to hold inshore lots of oysters on the bare sand beach but these failed. Two devices were resorted to to maintain these plots. The first was to build a wall of stones 6" high enclosing an area 2' square. A few stones were placed inside the square and the 100 spat scattered among these. Four such plots (lots 1 - 4) were set up. Even with this protection the spat were frequently buried during heavy wind storms. A second and more successful device was to set lots of 64 spat lying on their left sides, in blocks of wet concrete measuring 2' x 2' x 1½". These blocks with the firmly attached oysters (lots 1A - 4A) were set out with lots 1 - 4.

In order to recover lots of oysters planted beyond low water mark they were placed on ^{wooden} trays measuring 2' x 4' x 4" filled with a mixture of sand and mud. These were bridled with rope and buoyed so that they could be raised to the surface without tilting and spilling the oysters.

A vertical series of wooden-covered wire-bottomed ($\frac{1}{4}$ " mesh) trays was arranged in the deep water at the edge of the channel. The first measured 2' x 4" x 6" and was fitted with legs which kept it 6" off the bottom. The second was of the same dimensions and suspended 3' above the bottom from two tripods. The third was floating and measured 4' x 6' x 4" and was divided into three 2' x 4' sections - all with wire cloth bottoms. In one of the three (#13) lath slats were nailed outside the wire cloth with cracks $\frac{3}{16}$ " wide between them.

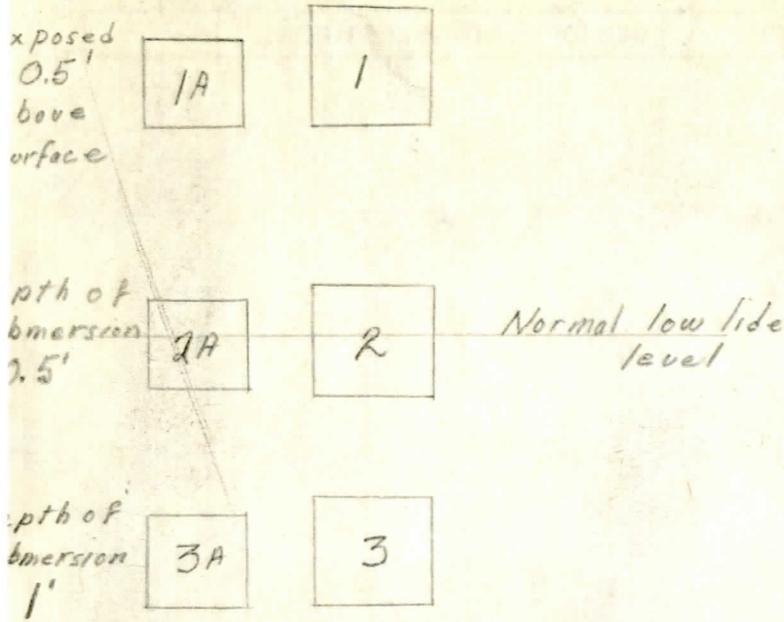
Besides the plots set up near Mr. Forbes's house a floating tray (#18) and a tray with legs (#19) to keep it 6" off the bottom was placed on the Cooper bed. Further down the bay near Curtain island two submerged trays were set out - one (#20) in 20' of water and the other (#21) in 2' of water measured at low tide. Each of these was stocked with 100 spat. Storms carried away all four of these trays at one time or another. Some were never recovered.

Figure 3 shows the experimental set-up.

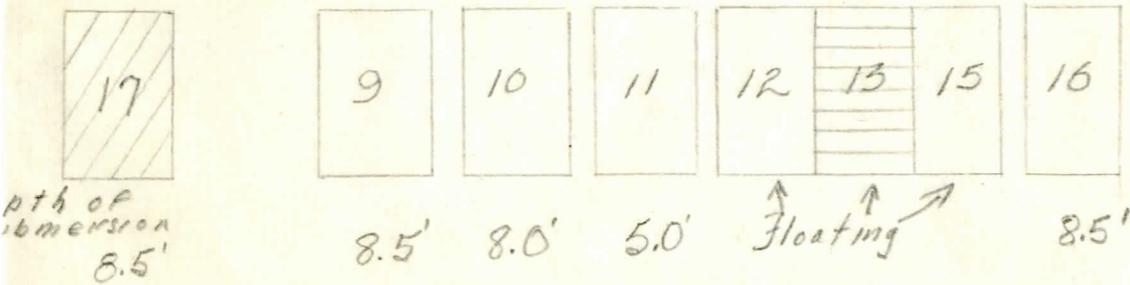
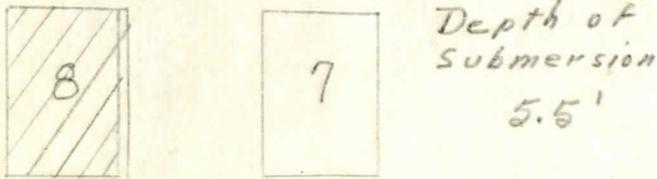
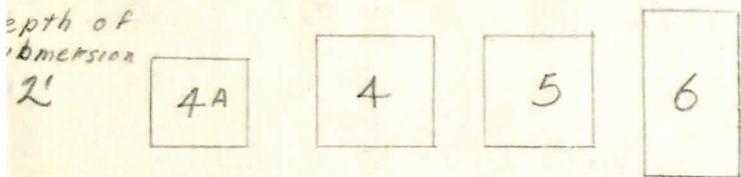
From these descriptions it will be seen that the small oysters were planted, on the average, 15 to the square foot and the large ones 6 to the square foot. This density is approximately 10% of that met with in commercial rearing trays and accordingly crowding has not been considered as a growth-limiting factor in the tests.

Normal high tide level

Figure 3. Showing arrangement of experimental lots in the growth experiment. Numbers inside the squares are the lot numbers referred to in Table IV and in the text. The data on submersion or exposure are calculated for normal low tide corresponding to a staff gauge reading of approximately 2' in the tide records.

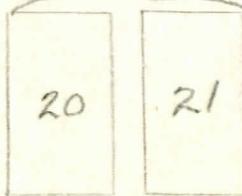
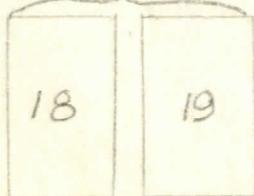


Level of extreme low tide



Cooper bed

Curtain Island



Depth of submersion

Floating

3'

20'

2'

Table VIII. Showing for various dates the mean (arithmetic) values, "M", for the lengths of oysters in each lot together with the number "N", of measurements used in calculating this mean

Lot Number	Lot 1A		Lot 2A		Lot 3A		Lot 4A		Lot 1		Lot 2		Lot 3		Lot 4	
	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N
May 8, 1942	----	---	----	---	----	---	----	---	26.8	97	26.2	105	26.7	97	26.3	87
" 20	M 22 27.3	65	M 22 28.2	63	M 26 27.1	63	M 26 28.1	63	26.8	56	27.3	53	28.7	71	28.0	61
June 15	J 16 30.6	63	J 16 30.8	64	J 16 29.8	63	J 16 31.1	64	----	---	28.7	61	31.9	56	31.6	49
" 28	----	---	----	---	32.3	63	34.6	64	----	---	28.5	48	33.2	38	31.8	41
July 27	34.9	64	39.5 ***72	39.0	63	42.0	63	----	---	39.6	43	40.8	49	37.7	48	
Aug. 27	A 31 43.3	60	A 31 49.7	64	A 31 46.5	59	A 31 47.2	63	----	---	42.1	34	47.6	43	44.6	40
Sept. 30	S 19 44.3	61	S 19 53.9	63	49.4	59	49.2	63	----	---	46.2	23	51.9	38	45.0	13
Oct. 27	45.5	60	55.5	56	49.5	60	49.4	63	----	---	----	---	51.3	42	48.7	10
Nov. 13	41.9	60	54.8	64	49.0	59	49.4	63	----	---	----	---	----	---	----	---
May 4, 1943	----	---	54.4	61	48.9	60	49.6	55	----	---	----	---	----	---	----	---
Total No. of measurements	433		507		549		501		153		367		434		349	
% increase in length up to Sept. 30	67		97		82		75		----		77		95		74	

M stands for "mean size"; N stands for "number in sample".

*** Lot 2A, July 27. Eight of the oysters were apparently remeasured because there were only 64 in the sample.
 † Lots 10 and 11, Oct. 20/42 to May 4/43. These lots were apparently interchanged through some error.

The data are, therefore, to be disregarded.

Dashes in the table indicate that no observation was made on the date indicated.

Where the date of any measurement does not correspond with that in the "date" column it is included

Lot 15		Lot 16		Lot 17		Lot 18		Lot 19		Lot 20	
M	N	M	N	M	N	M	N	M	N	M	N
M 11 82.5	47	81.1	50	82.2	47	26.1	99	M 11 26.5	99	M 11 27.1	99
M 21 85.0	38	M 22 84.7	44	----	----	----	----	lost	----	----	----
J 16 90.0	47	J 16 87.5	44	----	----	----	----			----	----
J 26 90.8	45	----	----	----	----	----	----			----	----
94.0	44	J 28 89.5	45	----	----	J 17 40.6	74			J 22 33.4	98
S 1 99.5	46	S 2 91.5	45	----	----	S 8 53.8	70			lost	
O 8 98.8	47	91.5	39	91.9	45	lost					
O 20 100.0	46	O 20 91.1	30	----	----						
98.5	44										
N 13 97.3	48	N 14 91.2	28	----	----	Cooper bed tray floating					
95.8	46	----	----	----	----						
	498		297		92		243		99		197

A tide gauge was installed on the station landing stage at the biological station so that exposure times could be measured for plots on the tide flats.

Measurements were made on the oysters in each lot (except lots #8 and #17) at the beginning of the experiment when the water temperature had barely reached 10° and at intervals throughout the season at approximately the time the temperature -

- | | |
|----------------|----------------|
| 1. Rose to 15° | 4. Fell to 15° |
| 2. Rose to 20 | 5. Fell to 10 |
| 3. Fell to 20 | 6. Fell to 5 |

It is hoped to make measurements again next spring before the growing season begins.

A millimetre scale was used in measuring lots 1A - 4A but all the rest of the measurements were made on a recording caliper. During the winter the data, consisting of over 10,000 measurements, were translated and analyzed with the assistance of Miss Molly McIntosh and Miss Fae Hallet. The observations are summarized in table VIII. The standard error of the means for lot #7 calculated for May 8 and September 30 were 26.7 ± 0.21 and 48.0 ± 0.94 respectively. Lot #7 is typical and the values of the standard error indicate the scattering in size of the oysters and the significance of differences to be observed in table VIII.

Results

The results are discussed under various headings to illustrate the effects of environmental factors.

Depth of Submersion

A. In the channel

The results for lots 10, 11 and 12 in the vertical series of wire-bottomed trays show how growth varied at different depths

below the surface. The comparison is not strictly justified because the floating tray was subject to more disturbance by wave action than the other two. If this feature is disregarded the results indicate that growth was best at mid-depth, next best at the bottom and poorest at the surface. These differences are probably brought about by differences in the amount of water circulation. Water currents are usually strongest at mid-depths.

B. At different distances from shore below low water mark.

A comparison of lots 6, 7 and 9 growing in mud-filled trays shows that growth was better in shallow water near shore than in deep water further out. This also may be caused by variations in water circulation.

C. At different levels on the tid flat.

Data for lots 1 - 4 and 1A - 4A show that growth was best at a level just above low water mark. Records from the tide gauge show that lots 1 and 1A suffered air exposure during 30% of the time. If a 30% allowance is made for growth stoppage during intertidal exposure, it appears that otherwise growing conditions for lot 1A were just as suitable as for lot 2A which was exposed only 1% of the time.

Effect of Wave Action in the Intertidal Zone on a Sand Beach

There is no indication that exposure in itself has any harmful effect on the growth of oysters as pointed out in part C of the section on "Depth of Submersion" but, as mentioned before, it was found impossible to keep lots 1 and 2 in place on the beach without the protection of stone inclosures. Even with the protection lot 1 was thrown about by the waves and lost early in the season and many of the spat in lot 2 were intermittently buried in the sand and had to be dug up. Oysters in lots 3 and 4 were

not disturbed by the seas.

Oysters of lots 1A and 2A in the concrete blocks were covered by sand only on rare occasions and seldom remained in this condition for long. A comparison of lots 2A and 3A suggests that by analogy lot 2 should have grown better than lot 3 had it not been covered by sand so frequently. These results show that wave action, not exposure, is the limiting factor for growth in the intertidal zone on a sand beach.

Lots 2, 3, 3A and 2A in the intertidal zone were never covered by weedy growths and grew into good shaped oysters. Lots 4 and 4A just below the intertidal zone were overgrown by a dense mat of algae in July and August and developed a poorer shape. Kerswill (1941) has shown that weedy growths hamper the free circulation of water over the bottom and impede growth in the quahaug and the disadvantage of poor shape in oysters is patent to all. The good shape and freedom from weedy growths in the intertidal zone seems to be brought about by the scouring action of wave-borne sand.

After the growing season was over there was a falling off in the mean size of the oysters in lots 1A to 4A. This was greatest in lot 1A and least in lot 4A. The decrease in length is partly accounted for by damage during handling but it is considered to be largely the result of the scouring action of the wave-borne sand. Apparently this scouring action and handling have the same advantages and disadvantages in oyster growth. Taken together the results show that there is a zone of the beach just above low neap tide where oysters grow rapidly to a good shape.

Disturbance by handling.

Lots 8 and 17 were measured only on May 8 and September 30 being undisturbed throughout the experiment when other lots were being measured. Comparing their growth increases with those of regularly handled lots at comparable depths (lots 7 and 16) it appears that gentle handling with occasional removal from water promoted the growth of small oysters by 10% and of large by 6%.

After the growing season was over the mean values for length in several cases fell off, e.g. lots 15 and 16. It is unlikely that this was due to shrinkage and the obvious explanation is that the thin shell margins were broken in handling. Thus it appears that any favourable effects handling had on growth must have been indirect, such as, for example, the removal of silt that retards growth by interfering with circulation. A comparison of lots 8 and 17 with 7 and 16 showed that in addition to promoting growth, handling had the effect of improving shell shape.

Water Temperatures.

The season's growth did not begin until the water temperature rose to 10°. Young oysters showed their most rapid growth during the period of highest temperature with no sign of a spawning lag. As compared with adults young oysters are in this respect like young snails. (Medcof, 1940). After the temperature dropped below 20° the oysters grew very little.

The growth of adult oysters was most rapid in spring when the temperature was below 20°. It was arrested for about a month and a half in the spawning season and continued again in late July and August. The post-spawning growth was only 40 to 70%

of the pre-spawning. No increase took place after the temperature fell below 20°.

It will be impossible to tell until the next set of measurements are made in the spring of 1943 if growth takes place during the winter period of low temperatures as Galtsoff (1934 and 1936) has claimed. Earlier observations by the writer (Medcof 1941) indicate that there is none.

Judged from the above information the effects of temperature on growth are not clear. It is sometimes indirect through its relationships with other functions such as spawning. At other times it appears to be direct and there does seem to be a threshold level for shell development at about 10°.

Water Circulation

A comparison of data for lots 12 and 13 shows that the slats on the bottom of the tray reduced growth by about 30%. In other words, growth in trays with slatted bottoms is in no way superior to that on the bottom itself.

One end of the slatted 2' x 4" compartment of this tray was made of wire cloth stimulating the wire-covered ends of the wooden-bottomed trays that have been used in rearing tests at the Biological station in recent years. Presumably growth in a longer tray with a slatted bottom would be even less than that observed here.

Besides the above, more evidence of the effect of water circulation in growth may be had from a comparison of data for lots 4, 5, and y all at the same level on the beach. These show that growth improved when circulation was increased. It was poorest inside the stone enclosures, (4), better on the unobstructed bottom (5) and best on the mud flat (6) which was raised 4 inches off the bot-

tom. Presumably water circulation is even better in wire-bottomed trays than on mud flats. A comparison of lots 9 and 10 shows that growing conditions were better on the wire-bottomed tray than on the mud-filled tray at the same depth. Comparing lots 10, 11 and 12 it is clear that growth in the channel was best at mid-depth, poorer near the bottom and poorest at the surface. Kerswill (1941) has shown that current speed, i.e. water circulation, is greatest at mid-depths.

From these results it appears that water circulation is one of the most influential of all factors affecting growth.

Position in the inlet.

Growth of lot 18 in the floating tray over the Cooper bed was 87% of that of lot 12 on the Forbes area. Growth of lot 20 in deep water near Curtain island was only 26% of that of lot 10. These data indicate that growing conditions are less favourable down the bay than in the river. However, the comparison of lots 18 and 20 with lots 10 and 12 cannot be strictly justified because the former were not cleaned and handled as often as the latter. The Cooper bed tray accumulated many mussels and the Curtain island tray became badly silted. Both these conditions are known to be unfavourable to growth. In a repetition of this experiment provision should be made for more attention to these down-the-bay trays.

Growth on the bottom in deep water

The results obtained here do not directly tell us what growing conditions on the bottom in deep water are like. Since most oysters, natural and cultivated, are growing in such places it is important to know something about this. It was shown for spat, that in shallow water growth on the bottom (lot 5) up to the end of

August was about the same but slightly less on the mud-filled trays (lot 6) and about 83% of that in the floating tray (lot 12). Kerswill (1941) found at about the same distance from shore that quahaug growth on mud-filled trays was considerably greater than on the bottom and that oyster growth was less influenced by changes in water circulation than quahaug growth. For the present we will assume that oyster growth on the bottom and on mud-filled trays is identical both in deep and in shallow water. If this is true then growth of spat on the bottom in deep water is approximately 63% of that in floating trays. If oyster growth resembles quahaug growth then the percentage would be considerably less than this.

Assuming that adult oysters in deep water grow as well on the bottom as on mud-filled trays (lot 16) then their annual increase in length is only 64% of that they would attain in floating trays (lot 15).

Very little precise information is available as to growing conditions on different sorts of bottom either in deep or shallow water.

All together there is a great need for more information on the growth of oysters on the bottom.

Growth on Trays

The data for lots 10, 11, and 12 show the great advantage of rearing oysters in the covered trays with the wire cloth bottoms. These grow better than oysters given any other treatment. Lot 11 at mid-depth grew best of all. Besides growing faster these oysters were cleaner. They were never covered either by mussel spat or by heavy autumnal growths of hydroids. Both these probably hinder

growth and were found in the surface tray (lot 12). The possibility of developing methods of spat rearing that would take advantage of the favourable features of the mid-depths should receive more attention.

The data discussed in part B of the section "Depth of Submersion" show that in mud-filled trays growth improves towards shore. The question immediately arises as to the most suitable location for floating trays with relation to depth and to distance from shore. This should be explored.

Methods of rearing spat other than on floating trays

At the present time the supply of wire cloth needed for the construction of rearing trays has been cut off. Temporarily at least methods of rearing young oysters other than on wire-bottomed, floating trays must be resorted to. The data indicate that trays with slatted bottoms do not provide conditions that are in any way superior to the bottom itself if growth alone is to be considered.

A. Growth on Tide flats

The data show that next to wire-bottomed trays the lower reaches of tide flats provide the most satisfactory conditions for growth. Rearing on flats is already practised to some extent and the possibilities of improving growing conditions is highly important. It is clear that there is a band from just above to just below low water mark where growth is most rapid. There are few weeds in this zone.

The possible effect of light in retarding growth on flats has been briefly discussed in earlier reports (Medcof 1939), (Kerswill 1941). If sunlight could be eliminated from this zone it is to be

expected that growth would be favoured in two ways - (1) by protection from the actinic rays that directly retard growth (Medcof 1939) and (2) by preventing weedy growths that are known to retard growth by their effect on water circulation (Kerswill 1941). The effects of this treatment should be explored.

B. Growth on Platforms

Platforms have been suggested as a means for conditioning and rearing adult oysters (Nelson 1923, Seno and Hori 1927). It is possible that they might be suitable for rearing young oysters. Submersion to mid-depths would seem to be the best treatment for these but unless they were covered it is questionable whether they would succeed because of plant growths that are likely to develop.

It is likely that losses from storms and the action of predators would be greater on platforms than on floating trays. However, the possibilities of this treatment should be explored.

C. On Brush and Tarred Rope

The possibility of rearing oysters from settlement to maturity on tarred rope as practised in California (McMillin and Bonnot 1931) and as tested by Elsey (1934) in British Columbia should be studied in our waters. The commercial application of this practise if it proved successful would not be possible immediately because of shortages of rope, but after the war this obstacle will be removed. What results have been obtained in Cape Breton island from rearing oysters to maturity on brush, suggest that trials with tarred rope should be successful (See section of this report entitled "Shell Characters of Gillis Cove Brush Oysters" for a further discussion of this matter.) Trials should be made in 1943.

Growth on Collectors

A phase of the growth problem that has not been treated in the present study and one that has received too little attention of late is the possibility of improving the growing conditions provided for young spat by the type of collector now in use. Spat that settle in the central parts of bundles grow more slowly than those on the wire wrappers around the collectors and slower than those on the edges of the collectors themselves. This feature is most conspicuous in the Bras d'Or lakes where water circulation is poor.

The differences in growth have been attributed to differences in water circulation. It is possible that a collector with wider openings and deeper sides such as duck-egg-case-fillers, would give better results than those used at present. They could be bound in groups of two instead of four making a bundle of approximately the same length and width but thinner. Water circulation through this type of collector should be better; the potential catch of spat would be smaller because the surface area would be reduced but the conditions should produce larger spat of a more uniform size. This type of collector should be tested.

Significance of the Growth Studies

The results of experiments on oyster growth have an important bearing on the work of the biological station. A result of importance to investigators to mention only one thing is the criticism of length measurement as an index to growth which has been made in reporting the Needler-Clark growth experiment. On the practical side the discovery that the limits of the growing season are determined by water temperature is of importance to every oyster farmer.

Looking forward, the results indicate the need for a more

comprehensive study of growth. This is especially apparent in regard to the obscure relationships of temperature and the more difficult problems of availability of food and circulation of water. It is planned that next year the investigation will have a wider scope and that several of the problems that have arisen during this preliminary study will be clarified.

V (a)

SPECIFIC GRAVITY OF OYSTER MEATS AND SHELL LIQUOR

At the time the "condition factor" was being worked out it was found convenient to measure the specific gravity of drained oyster meats and the liquor found in the shell cavity mixed with that which drained from the meats themselves. The determinations were made at room temperature (about 20°) by weighings to the nearest tenth of a gramme and by taking volumes to the nearest cubic centimetre with a graduate. The values obtained appear in table III.

The average value for specific gravity of meats turned out to be 1.07 which compares favourably with 1.06 obtained by Havinga (1938) for O. edulis.

The average value for the specific gravity of the liquor was 1.026. The Cooper bed salinity averages 29% which at room temperature would correspond to a specific gravity of 1.022. These data indicates that there is about 0.5% of organic matter in the shell liquor.

These observations have a bearing on the index used in measuring growth. The specific gravity of the meats is very little greater than that for sea water as shown above. It has also been pointed out that sea water replaces body tissues during starvation of marine animals. If live-weights were used as an index to growth oysters whose shells were of about the same weight could not be distinguished even though they might differ considerably in fatness of meats.

a

Table III shows that there is/direct relationship between specific gravities of meats and indices of condition at different seasons but specific gravities were too crudely determined to show

the exact relationship. The data do illustrate the need for making condition tests along with weighings and linear measurements in growth studies.

V (b)

SHELL PROPORTIONS OF OYSTERS

In 1940 and 1941 a study was made of the relation of shell thickness to shell length of oysters at different seasons. Thickness was measured at the hinge ^h where changes in thickness were slight and consequently changes in the ratio of thickness to length were also slight. This year the study was continued but thickness measurements were made on the longitudinal axis 65 mm. from the hinge end.

Two sets of observations were made. The first applied to the oysters used in the calculation of the "condition factor" and the results appear in table III. From these it appears that for oysters growing on the Cooper bed in 1942, the same cycle of change took place as in former years (Medcof 1941). The only irregularity is in the ratio for the May 11 sample which seems low. This can be accounted for in part, at least, by the fact that the sample included more than the usual number of very small oysters. For a just comparison samples of oysters of approximately the same size should be chosen.

The data also show that growth in length follows a different seasonal cycle from growth in thickness. In the spring and summer thickness growth is relatively much less than length growth. In autumn the conditions are reversed.

The second set of observations on shell proportion were made on the 50 oysters in lot 16 of the growth experiment described elsewhere in this report. The data are summarized in table IX. The oysters were removed from shell bottom on the Cooper bed in the spring and placed on a tray filled with sand-mud. The change in environment may account for the results which differ from those just described in some respects.

Growth in thickness went on at an almost constant rate from May 11 until the end of October. Growth in length, on the other hand, showed changes in rate being most rapid in late June and dropping to nothing by the end of August. In the main, the picture is similar to that obtained from the first set of observations.

Both sets indicate that any single linear measurement taken by itself is not satisfactory as an index to growth. In the growth experiment carried out this year and in almost all those carried out in former years, length has been used almost exclusively as a growth index. These results show that this practise should be altered. It is suggested that either weight or volume or some combination of linear measurements including thickness should be used as suggested earlier in this report.

In the section headed "Specific gravity of oyster meats and shell liquor" it is shown that even this combination of measurements would be incomplete and that some account should also be taken of the fatness of meats.

Table IX. Summary of observations on lengths and thicknesses of oysters of lot #16.

Date	No. measured	Length (L) (mean)	Thickness (T) 65 mm. from anterior end.	$\frac{T}{L} \times 100$
May 8	50	82.7	11.1	13.4
May 25	44	83.8	11.6	13.8
June 16	44	87.4	12.1	13.8
July 28	46	89.7	13.4	15.0
Sept. 2	45	91.7	14.2	15.5
Sept. 30	39	91.6	14.8	16.2
Oct. 20	30	90.9	15.3	16.8
Nov. 14	28	91.3	15.4	16.9

VI

SEASONAL CHANGES IN SHELL CHARACTERS

Supplementary to the study of oyster shells carried on during the past few years, records were kept of the appearance of most of the shells of oysters gathered this year. The results are summarized in table X.

These observations conform with those of earlier years and accord with the conclusions drawn up in the paper recently submitted for publication (Medcof 1943). In addition the data show that all changes begin earlier on the up-river Sand bed than on the down-river Cooper bed and that the total amount of linear growth and chalk formation is greater on the Sand bed than on the Cooper bed.

Table X. Summary of observations on oyster shells.

Date	Source of oysters	Growth	General Character of inner faces	Chalky deposits	General observations
May 5	Sand, Pulpit & wharf beds	None	Hard flat	None	
7	Sand and Wharf beds	some "internal growth	Mostly hard flat except marginalley	none	
17	Cooper bed	none	hard flat	none	
20	Cooper bed	none external	partly glossy	none	
21	Sand bed	Small amount of external	Mostly glossy but small dull central area	none	
June 1	Cooper bed	Little or no external	Glossy all over	#1 deposit present but very small	
	Sand bed	Vigorous: up to 12 mm.	Glossy all over	#1 & 2 deposits appearing	
9	Sand bed	"	"	"	
	Cooper bed	Maximum is 5 mm.	"	"	
26	Cooper bed	Considerable	" some yellowness appearing	Chalk in small patches	
	Sand bed	More than on Cooper bed	Glossy: some yellowness	Chalk patches small	Spawned June 30
July 20	Sand bed	Much	Glossy	Extensive	
	Cooper bed	Considerable	Glossy: much yellowness	Common but areas small	
Aug. 29	Cooper bed	-----	Glossy: much yellowness	Covering has started	
Sept. 1	Sand bed	-----	Some soft-flat: rest in late yellow phase	Covering far advanced	
Oct. 7	Sand bed	-----	Mostly hard flat: a few valves in the soft-flat phase	All covered	
Nov. 10	Sand & Cooper bed	-----	All hard flat	all covered	

VII

SHELL CHARACTER OF GILLIS COVE "BRUSH" OYSTERS

On October 30, 1943, the writer collected from Gillis cove a sample of oysters that had settled in 1939 and grown to maturity on bundles of brush. The meats were removed from these within a few days and the shells allowed to air-dry in the laboratory until they were examined on January 14, 1943. They were of a very chalky texture. The specific gravity of the dried shells averaged 1.45 - 9% lower than for bottom-grown oysters (Medcof 1943).

The value of the ratio $\frac{\text{Shell Capacity}}{\text{Shell volume}} \times 100$ was 78 as compared with 50 for bottom-grown shells (Medcof 1940a). The shells of brush oysters are therefore roomier per unit of weight. Similarly they were more fragile and sharper about the bills and accordingly harder to handle and even less suited for shipping than the regular cove oysters.

A large proportion of them were above legal size for fishing ($3\frac{1}{2}$ " in length), had full meats and were of good shape.

The observations indicate that:

1. Rearing oysters to maturity on brush in the Bras d'Or lakes should provide a type of oyster suitable for shucking purposes.
2. They can be produced with less labour and in at least a year less time than by the present methods of bottom rearing.
3. The advantage of this method of production is that it can be carried on in areas where the bottom is too soft or too irregular for bottom rearing.

VIII

THE EFFECT OF STORAGE ON SHELL CHARACTERS

Dugal (1939) has shown that the quahaug (*Venus*) when held in air at room temperature respire anaerobically and buffers the by-products of anaerobiosis by dissolution of calcium carbonate from the shell. This dissolution is from a limited central area of the shell and produces a conspicuous erosion of the shell face. His observations on carbon-dioxide content of shell liquor of oysters suggests that they too undergo anaerobiosis when held in air at 13 and 29°. No observations were made on oyster shells during the process.

Some shells of oysters shipped in November 1942 from Bideford, P.E.I., to St. Andrews, N.B., and placed in cold water in the basement tanks of the biological station showed a fine etching of the shell face just anterior to the adductor muscle scar. It appeared as though the surface lamella of pearly shell had been etched away in patches and the lamella below seemed to be showing through. Some of these shells were submitted to Dugal for examination. His comment was that while the scarring resembled that he had observed in the quahaug it was not nearly so extensive. Thus, while in the quahaug it was not nearly so extensive. Thus, while in the quahaug shell erosion may be regarded as evidence of anaerobiosis having taken place, the conditions in the oyster are not clear.

Any information comparing the behaviour of air-stored oysters with hibernating oysters is of interest because of its possible bearing on the problems of self-purification of sewage-contaminated oysters. (See section of this report entitled, "Self-

Purification of Sewage-Contaminated Oysters"). It was decided to study the amount of shell erosion produced by oysters treated in different ways with the hope of finding out whether or not erosion could be considered as indicative of anaerobiosis.

Experiment I.

From December 1 until March 9 one series of oysters was held in air at approximately 8° in a moist part of the basement of the St. Andrews station. Samples of these were examined from time to time and records made of the number of oysters that showed shell erosion and the number of valves affected. When only one valve was eroded it was almost invariably the left. The results appear below:

Date	No. of days of air storage	No. of oysters affected	No. of valves affected
Jan. 14	44	# 5/9	5/18
Jan. 30	60	5/7	8/14
March 9	98	10/10	16/20

The figure above the line indicates the number showing erosion; the figure below, the total number in the sample examined.

The last sample (March 9) showed much more extensive erosion than either of the earlier ones.

On January 26, 1943, Mr. H. R. Found of Ellerslie, P.E.I., co-operated in this study by fishing a sample of oysters from the Cooper bed through the ice. He opened these within four hours after fishing and shipped the shells to the writer for examination. The oysters showed 13/23 and the valves 16/46 positives for shell erosion. In most cases the amount was slight.

Eroded areas were not observed in the late fall of 1942 although many shells were examined at that time during condition studies. This is not to say definitely that they were not present in the fall shells for they might have been there and escaped notice. The suggestion is that they were developed during the period of hibernation.

5 The results of the experiment and the observations on the Cooper bed oysters show:

1. During air-storage the amount of shell erosion increases but according to Dugal, not nearly to the same extent as in the quahaug.
2. It is probably safe to attribute erosion to anaerobiosis and conversely to regard shell erosion as indicative of anaerobiosis having taken place.
3. By January 26 50% of the hibernating Cooper bed oysters were found to have shells more or less eroded.
4. It may be concluded but not without reservation that anaerobiosis goes on to some extent in hibernating oysters.

Experiment II.

Starting January 18, 1943, a more elaborate experiment was carried out. This involved four lots of oysters.

1. An air control held at approximately 15° and kept moist.
2. A cold water control held in circulating sea water at 0° approximately.
3. A lot kept in air at 15° for periods of 5 days alternating with periods of 2 days in flowing sea water at 15°.
4. A lot held in flowing sea water at 0° for periods of 5 days alternating with periods of 2 days in flowing sea water at 15°.

The idea of transferring back and forth was conceived from Dugal's data (1939, p. 238). These show that after 5 days of air-storage oysters have accumulated close to their maximum amount of carbon-dioxide and that after this the production rate falls off rapidly. A short period (2 days, for example) in water following air-storage should permit the oysters to rid themselves of the products that suppress carbon-dioxide production and of all the lime they they might have dissolved from the shell face during air-storage. By successive transfers of the sort described the oysters while they are in air, should be in the phase of high carbon-dioxide production and should, therefore, erode their shells faster than if they were left in air constantly.

The results of the examinations of samples from each lot at the end of each 5-day period the shell erosion increased slightly in the air controls but remained practically unchanged in the other three lots. This result is not very illuminating and a partial explanation for the obscurity is that the experimental stock was not free of shell erosion when the test began and that the samples taken at each examination were too small to offset the variation in the stock.

The experiment should be repeated using different stocks and varying the lengths of the periods in and out of water.

Table XI Results of Experiment II. Showing the numbers of oysters and shell valves examined and the numbers exhibiting shell erosion.

Date	Air Control		Cold Water Control		Air-Water series		Cold-Water-Warm-Water Series	
	Oyst. Valves	Oyst. Valves	Oyst. Valves	Oyst. Valves	Oyst. Valves	Oyst. Valves	Oyst. Valves	Oyst. Valves
Jan. 18	#7/10	#10/20	7/10	10/20	7/10	10/20	7/10	10/20
23	2/3	3/6	3/5	4/10	2/5	2/10	2/5	4/10
30	1/5	2/10	2/5	3/10	3/5	5/10	2/5	3/10
Feb. 6	4/5	6/10	3/3	4/10	4/5	7/10	5/5	8/10
12	----	----	2/5	3/10	3/5	5/10	4/5	7/10
19	----	----	2/5	3/10	4/5	5/10	2/5	3/10
27	----	----	2/5	3/10	4/5	7/10	5/5	7/10
Mar. 12	7/8	12/16	6/10	11/20	4/8	5/16	6/11	7/22
Apr. 12	----	----	2/9	4/18	----	----	----	----

The figure above the line indicates the number showing erosion; the figure below indicates the total number in the sample studied.

IX

EFFECT OF TEMPERATURE ON CONDITION AND ON SHELL GROWTH OF
WINTER OYSTERS IN TANKS

Random samples of Cooper bed oysters taken from the storage tank (see section entitled, "The effect of storage on shell characters") on January 18 were placed as follows:

1. In water at approximately 15°C
2. In water at approximately 10°C
3. In water at approximately 0°C
4. In air at approximately 15°C

Between February 14 and March 14 the temperature of the 15° tank fell below the level considered suitable for fattening. The temperature of the 10° tank often rose for short periods above the 10° level. The cold tank had the evenest of all the temperatures and ranged from -1 to +1°.

During the course of the test a considerable brownish growth of diatoms developed on the shells of the oysters in all the tanks but the water itself remained almost barren of plankton.

Condition

The index of condition for the different lots on various dates appear below.

Date	15° tank	10° tank	0° tank	15° Air
January 18 (beginning)	111	111	111	111
February 11	121	114	112	Several dead
March 8	117	108	113	130
April 12	91	111	114	---

The results of the tests were intended for a check on the conclusions from studies using field samples (Medcof 1941a) and show:

1. There is no change in the index of condition at temperatures near freezing.
2. There was no improvement at about 15° as might have been expected. This may have been because of food shortage.
3. At 10° there was little or no change observed although a falling off was expected from the results of the field tests.
4. There was an apparent improvement in the condition of the air-stored oysters. This could easily have been caused by selective mortality of poor conditioned oysters because several oysters in this lot died during the experiment. Only one death occurred in all the rest of the test stocks and this was in the 0° tank.

A repetition of the experiment under more favourable and better controlled temperature conditions might be instructive, but the winter shortage of plankton in the water on which the oysters might nourish themselves is probably too great to make the tests worth repetition.

Shell Growth

A marginal growth of very fragile shell was observed in both the 10° and 15° tanks but none in the 0° tank. In the 15° tank the margin on some oysters was 3 mm. wide and the average was about 1 mm. In the 10° tank growth did not occur in all oysters and the amount added was seldom more than 1 mm.

The internal faces of the shells in the 15° tank showed the development of the glossy phase over the median parts, but it was not nearly so striking as the development that would have been expected from oysters living on their natural beds in spring. The interiors of the

of the 10° oysters was scarcely different from the 0° ones except perhaps marginally where they were slightly glossier.

These observations check very well with the results of field observations reported elsewhere (Medcof 1943).

X(a)

THE EFFECT OF STORAGE ON THE FLAVOUR OF OYSTERS

To study changes in flavour a tasting panel was chosen from the members of the station staff. Before the various samples were tested they were all allowed to come to the same temperature by exposing them on the laboratory table. This precaution was considered necessary in a test of this kind. Care was also taken to prevent prejudice on the part of the tasters by identifying the lots of oysters by numbers only. No information was given them as to the history of the numbered lots to be tasted.

The oysters tasted were those used in the experiments described in sections VIII and IX of this report.

Repeated tests showed that differences in flavour were detectable by most members of the panel between oysters taken directly from the cold water storage tank (0°C) and those which had been held in moist air at 15° for four days after removal from the same storage tank before testing. The difference between these two classes of oysters was detectable by all members of the panel when the period of moist-air storage was increased from four to ten days. At the same time it was often difficult to detect any difference between oysters stored for five days and those stored for ten days in air at 15°.

In all cases where the tasters detected any difference they preferred the oysters taken directly from the cold tank. They claimed these oysters were "sweeter" and that they lacked a "storage taste".

In the writer's opinion, too, the taste of the air-stored oysters was definitely inferior to that of oysters removed directly from the cold tank but not sufficiently inferior to be considered unpleasant. As far as could be recalled the flavour was about the same as that of half-shell oysters bought in former years in Toronto during the winter.

A comparison was made of (1) oysters taken from the 0° storage tank and placed for two days in running sea water at 15° and (2) oysters taken from the 0° tank, held in air for five days, then placed for two days in running sea water at 15°. The members of the tasting panel were unable to separate these but several tasters considered both lots to be inferior to oysters taken directly from the 0° storage tank. All were agreed, however, that they were better than oysters that had been air-stored for five days at 15° and tasted without any preliminary "bath".

As far as could be detected there was no change in the flavour of the oysters from early December to early April while they were held in the cold tank. On the contrary, after two months' storage in moist air at 15° the oysters developed such a strong flavour as to be unpalatable.

Conclusions

1. In air-stored oysters at 15° there is a rapid accumulation of substances, probably by-products of anaerobic respiration, that detract from their flavour.

2. After two months under these conditions the oysters become unpalatable.

3. Oysters rid themselves of this accumulation if exposed for a short time to water at 15°. No test was made to see if there was a similar improvement in water at 0° or in air 0°.

4. There is no comparable accumulation in oysters held in flowing sea-water at 0° and 15°.

Discussion

These results when considered with those reported earlier (Medcof 1940 p. 17.) are of industrial interest. Before consumption, oysters used in the half-shell trade in Upper-Canada are subject for several days during shipment and handling to temperatures above what is considered optimum for storage and are held in air throughout their storage period. This means that the flavour is not so good as could be expected in maritime areas where oysters could be impounded in sea-water until immediately before use.

The results of these few observations made incidentally to other experiments indicate that the effect of storage on flavour should be carefully studied. There are other reasons to argue not only for this sort of study but also for comprehensive investigations of several storage problems constantly besetting the industry.

X(b)

SEEF-PURIFICATION OF SEWAGE-CONTAMINATED OYSTERS

BY A. G. Campbell and J. C. Medcof.

Introduction

According to present regulations sewage-contaminated oysters may be marketed only after they have been relaid for one month in pure water. During this period they become clean and fit for consumption. Many have expressed the view that this period is unnecessarily long and that a more satisfactory system of handling than that now in practice could be developed if the period could be reduced without risk to public health. To date, there has been no body of pertinent information which could be used to criticize this point of view.

The investigation described in this report was undertaken to improve our understanding of the cleansing process. Experiments were designed to show differences in rate of cleansing:

1. When the oysters showed different degrees of original contamination;
2. When they are crowded more or less;
3. When they are continuously or intermittently covered by water during tidal cycles;
4. When water temperatures stand at different levels;
5. When water circulation varied;
6. When the meats alone were dirty and when both meats and shells were dirty.

Another experiment was designed to show whether oysters could cleanse themselves when stored in air.

The study involved bacteriological tests of both oysters and water samples. To supplement the bacteriological results, hydrographic data were gathered and meteorological records compiled at the P. E. I. Biological Station sixteen miles distant from the site of the experiment were available. These latter data appear in tables XIX and XX. The bacteriological information is presented in the text.

The generous assistance of Mr. Colin MacKinnon, Fisheries Guardian at Summerside, throughout the full course of the investigation is gratefully acknowledged.

Special Methods Used in the Study.

Attempts were made to study separately the rates at which filth disappeared (a) from the outsides of the shells (b) from the meats both when the shell exteriors were clean and dirty.

There was no recognized technique for measuring the dirtiness of the outsides of oyster shells. Our method was to wash the sample of closed oysters in a litre of sterile water. Each oyster was held in turn with the sterile forceps dipped, and swished around four or five times before removing. The number of coliform organisms in this "wash water" was then taken as a measure of dirtiness of the shell exteriors. Obviously the method is crude but the results are considered reliable because the process was carried out in precisely the same way each time.

One of the experiments required stock that was clean inside and dirty outside. Such oysters were not available in the natural state so "artificial contamination" was resorted to. This consisted in placing clean oysters in a tub filled

with water taken from near the sewer outlet in Summerside harbour. Considerable mud was included with this water to insure a dirty film over the shells. While the oysters were immersed in this they were stirred vigorously all the time to discourage them from opening and taking dirt into their meats. After five minutes in the bath the oysters were removed and allowed to dry before being put on test. The process just described is referred to in the report as "tub-contamination".

Special treatment was given the experimental stocks before they were removed from the contaminated area. After they were gathered by hand, with tongs and rakes from the wharf site where they occurred at various depths and in different degrees of crowding and on different substrates, they were cleaned and separated and scattered thinly on the bottom below low tide level in a plot in the contaminated area and left undisturbed for a few days. In this interval it was assumed that the oysters had a chance to adjust themselves and become uniformly contaminated before the experiment began.

Locale

Contaminated oysters were found in abundance in Summerside harbour at Reid's (Schurman's) wharf. A test lot taken at this point on August 21 showed an M.P.N. value of 4200.

Relaying was done in Sedgewick cove. This body of water is not itself completely free of contamination as was shown by the surveys carried out by Mr. Campbell on August 28, 1942, (results listed in figure 4) and by the earlier survey conducted in 1937 by Mr. James Gibbard and by the water samples taken during the

course of the experiments to be described. ^{preliminary} Two/test lots were gathered from Sedgewick cove. One was of native oysters from the tide flats taken August 21 and the second taken September 29, was from Mr. Sharbell's lease. The Sharbell oysters were relaid in Sedgewick cove from Summerside harbour during the month of July. The M.P.N. values were:

Sedgewick natives from tide flats	80
Oysters relaid on lease in July	80

There is some evidence that this contamination of Sedgewick cove comes from Summerside harbour. Judging from the contours of the coast (figure 5) this could be easily true when wind action is taken into consideration.

Limitations of the Investigation

Sedgewick cove was chosen as the site for the experiment because of its accessibility and because considerable relaying for purification is carried on there commercially. Because of this choice, information obtained in the experiment probably illustrates what happens in practice.

Considering the data presented above we should not expect the end point in the purification of the experimental stocks to be of a lower M.P.N. value than about 80. When this value is reached therefore the oysters will be spoken of as "clean".

The experiments were carried out in two series, August 24-September 11 and September 24 - October 2. The second series was in many respects a repetition of the first. By repetition it was hoped that the effect of water temperature on the rate of

cleansing would be reflected in the results. (The temperatures dropped 5-10°C in the interval between the two series.) Unfortunately, perhaps, there was a most severe wind and rain storm September 21-24. Ten inches of rain fell at Charlottetonw between these dates (See table 20). The storm so stirred up the water and caused such a heavy "run-off" from the land that the water at Sedgewick cove became very dirty - even salinities were depressed (see table XIX) by the great amount of fresh water flowing in. However, they never fell below 20 which is the lower limit for normal functioning of the oyster's ciliary mechanism (Hopkins, 1936). Another heavy rainfall occurred on September 28 and introduced further complications.

The unfortunate effect of these storms was to completely obscure any effects temperatures might have had on the results of the experiments. From another view point the complication of the results by the storms is of interest as it shows what extremes are met with even in areas that are normally clean and also the need of some legal provisions for regulating the oyster fishery during such emergencies.

Experiment IA The cleansing of Contaminated meats when shells are clean

Purpose

During the normal cleansing process oyster meats may free themselves from contamination and then be recontaminated by filth clinging to the shell exterior. The purpose of this first experiment and the one to follow (IB) was to measure the length of the period required for oysters to clean out their meats when there is no chance of their being recontaminated by dirt from the shells.

To insure this the outsides of dirty oysters were cleansed by chlorination before relaying.

Procedure

Three hundred contaminated oysters were fished from Summerside harbour and placed for $1\frac{1}{2}$ hours in a tub of sea water to which chlorine had been added. The solution was regularly tested (using Orthotolidine) and its strength kept high by the addition of more chlorine when required.

The oysters were taken to Sedgewick cove and 150 of them placed in a small, weighted, screen-bottomed ($1\frac{1}{2}$ " mesh), uncovered tray measuring 2' x 4'. It was supported by legs so that the oysters were kept 6" off the bottom. The other 150 oysters were scattered thinly on the bottom near the tray.

Samples of the oysters were tested bacteriologically just after chlorination and at intervals after they were placed in the pure water. The results are summarized in table XII.

Experiment IB

An experiment like IA was carried out in September but this time no plant was made on the bottom. The results appear in table XIII.

Conclusions from Experiments IA and IB

1. When there is no dirt on the outside of the shells to recontaminate them, oysters can clean out their meats in from 4 to 16 hours.
2. The better water circulation supposedly provided by placing oysters on a tray was no advantage over scattering oysters thinly on the bottom because the length of the cleansing period was the same in both cases.

Table XII

Summary of Bacteriological Data for Experiment IA

Date	Sampling Time	For water samples	M. P. N's		Site and Notes
			On Tray	For oysters On Bottom	
Aug. 24	6:45 p.m.	1500 +			Schurman's wharf. Just after fishing Sedgewick Cove At time of Relay 4½ hours after relay
	5:45 p.m.	0	22.000	22.000	
	10:15 p.m.	0	1860	860	
Aug. 25	10:00 a.m.	0	0	80	16½ hours after relay
Aug. 26	8:00 p.m.	0	80	0	50 hours after relay.

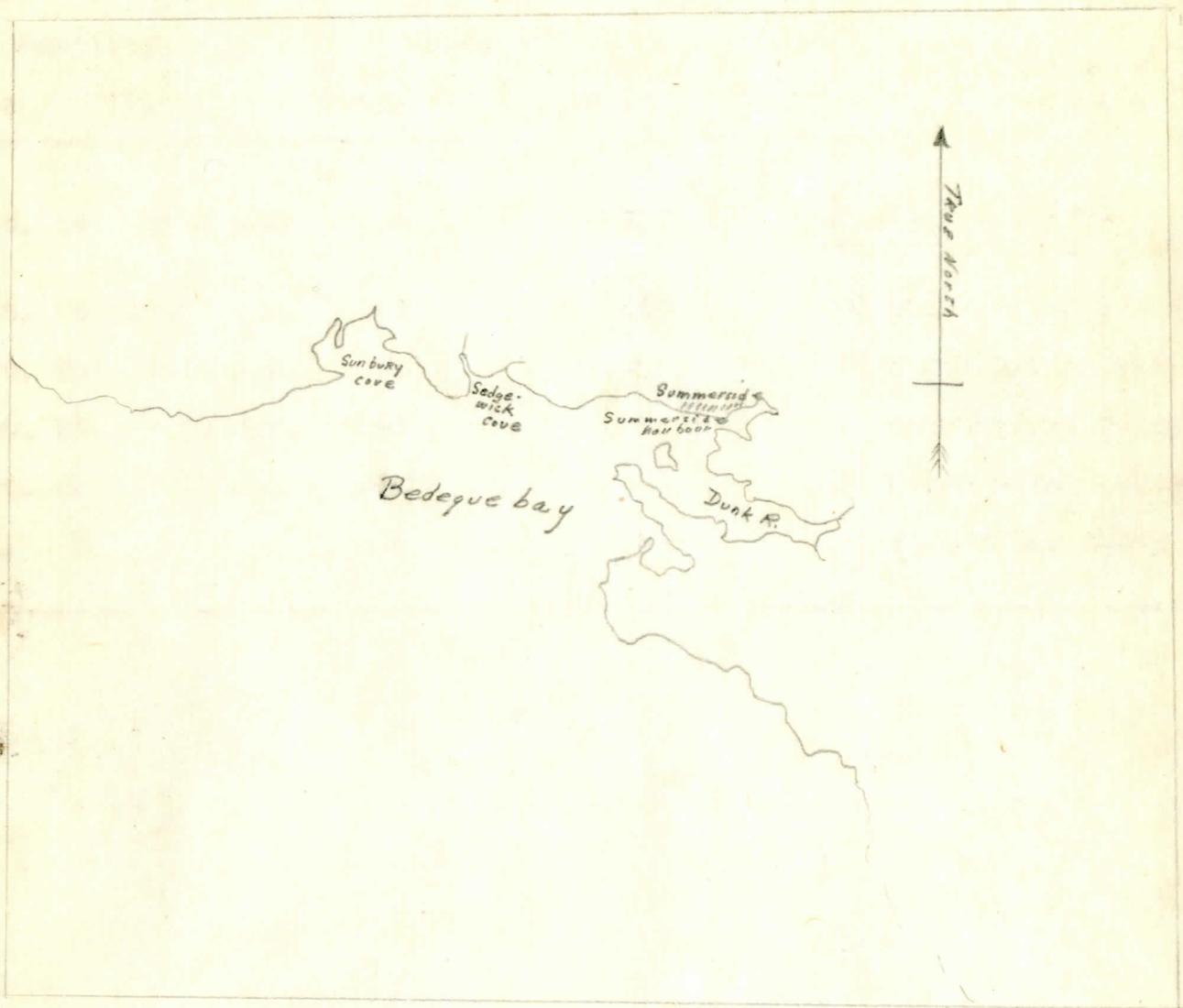


Figure 5

Chart showing the relative positions of the areas
involved in this study. Scale 1" = 5.95 miles

Table XIII.

Summary of Bacteriological Data for Experiment IB

Date	Sampling Time	M. P. N's		Notes on Sampling
		Water Samples	Oysters on tray	
Sept. 24	4:00 p.m.	4	30,000 +	Immediately after chlorination of shells
Sept. 25	10:30 a.m.	29	460	16 hours after relay
Sept. 25	6:50 p.m.	93	22,000	27 hours after relay
Sept. 26	7:30 a.m.	93	780	40 hours after relay
Sept. 29	9:35 a.m.	240	0	67 hours after relay
Oct. 1		9	80	7 days after relay

3. On account of the storm experiment IB was a failure as far as determining the length of this period is concerned but it did show how rapidly the M. P. N. values of oysters shift with changing water conditions.

Experiment 2.

Purpose

This experiment was designed to show how the rate of cleansing is affected by:

1. The extent of original contamination of the oysters
2. Crowding during the purification period
3. Differences in water circulation

Procedure

All together 22 bushels of oysters were gathered on August 25th and 26th from the wharf side. Half of these were scattered in a plot 40 yards west of the nearby sewer outlet and the other half 500 yards to the eastward of it in the same depth of water. It was hoped that the first lot would show gross pollution and the second light.

Just 9 bushels were recovered from each of the plots. One lot was fished on August 28 the other on August 29. Both were taken to Sedgewick cove where they were planted just far enough from shore so that they were never exposed at low tide.

In relaying, the oysters were subjected to two degrees of crowding both on the bottom and on trays. The trays were 3' by 6' with wire netting bottoms (1" mesh) and board sides 6" high. They all had legs to keep them 6" off the bottom. Oysters planted on the bottom were laid adjacent to the trays in plots of approximately the same dimensions (3' by 6'). "Crowded" trays or plots were given

three bushels of oysters each which meant piling up the oysters three or four deep. "Not crowded" trays or plots, received $1\frac{1}{2}$ bushels each which meant spreading the oysters mostly in a single layer and never more than two deep.

Unfortunately the plans for a series of tests on these stocks were interrupted by the illness of one of the investigators and the first tests were made 8 days after the relay.

The samples taken for the second series of tests of these stocks were fished on September 11 at 6:45 P.M. and shipped by express from Summerside to Mr. Campbell at Charlottetown and put on test the night of September 12. There is a chance that the M.P.N. values for these are higher than if they had been tested immediately after fishing. (U. S. Public Health Department - Personal communication to Mr. J. Gibbard).

The samples from the various stocks were so far as possible "random". Each was taken from near the middle of the plot or tray in question and, where there was crowding, all the oysters from top to bottom of the pile were gathered from a selected spot.

The wash waters from three lots were tested.

The results of the experiment are summarized in table XIV.

Conclusions from Experiment 2.

1. Almost all the oyster meats were clean 8 days after the relay.
2. Even two weeks after relay when the meats had cleaned up, there was still considerable filth attached to the outsides of the shells.
3. The data show that the slowest oysters to clear were the "lightly contaminated, crowded, on the bottom", but the difference between these and the other lots was scarcely

Table XIV Summary of Bacteriological Data Obtained in Experiment 2.

Grossly Polluted Oysters		Aug. 28	M. P. N's Sept. 5	Sept. 11
Crowded	On Tray	30,000 +	0	--
	On Bottom	30,000 +	0 ww 43 #	60 ww 23
Not Crowded	On Tray	30,000 +	80	--
	On Bottom	30,000 +	80	--
Lightly Polluted Oysters		Aug. 29 x		
Crowded	On Tray	22,000	0	1860 ww 240
	On Bottom	22,000	180	80
Not Crowded	On Tray	22,000	0	--
	On Bottom	22,000	0	--

"ww" indicates "wash water" from outsides of shells

x Water sample taken in Sedgewick cove at point of relay showed M.P.N. of 0.

enough to be considered significant.

4. There was little difference at any stage in the experiment in the extent of pollution of the two stocks that were expected to be lightly and heavily contaminated. The results accordingly reflect no significant differences in the rates of cleansing.
5. There is no evidence that crowding produced any difference in rate of cleansing.
6. There is no clear advantage in placing oysters on trays rather than on the bottom so far as the rate of cleansing is concerned.
7. The results are such as to prevent a comparison of the rates of cleansing of oysters whose shells are dirty and of those whose shells have been chlorinated previous to relaying (see experiment IA).

Experiment 3.

Purpose

Experiment 3 was in many respects like Experiment 2. It was designed to show how the rate of cleansing is affected by:

1. Exposure at low tide as compared with complete coverage throughout the tidal cycles.
2. Differences in water circulation introduced by placing oysters on trays and on the bottom.
3. Crowding.
4. Water temperature. For this the results were to be compared with those of Experiment 2.

Table XV Summary of Bacteriological Data Obtained in Experiment 3.

M. P. N'S						
Deep Water		Sept. 24	Sept. 26	Sept. 29	Oct. 1	Oct. 2
Crowded	On Tray	30,000 + ww 1500+	60 ww 75	180 ww 240		0 ww 93
	On Bottom	"	220 ww 1500 +	300 ww 460		0 ww 1500+
	On Tray	"	60	180		0 ww 460
Not Crowded	On Bottom	"	1860	300		0 ww 93
	Shallow Water ($\frac{1}{2}$ tide)	Sept. 25 93	93	240	9	0
Crowded	On Tray	"	0	180 ww 93	ww 240	460
	On Bottom	"	22,000	180 ww 460	ww 64	0
	On Tray	"	460	460	ww 23	60
Not Crowded	On Bottom	"	300	180	22 93	0

Miscouche Point

Summer
Cot-
Tages

x 0

x 0

x 0

x 0

x 0

x 0

x 0

x 0

x 9

x 0

x 0

x 15

x 0

x 0

x 4

x 4

x 4

x 0

x 7

450
Oct. 1.

23 Oct. 1.

3 Aug. 21.

4 Sept. 29

A. 0 Aug. 27
24 Sept. 29
9 Oct. 1
0 Oct. 2

B

4 Aug. 21.

43 Av
460 Se
H. 00

Figure 4. Showing Sedgewick cove and the stations (marked with "x's") at which water samples were taken in the public health survey with corresponding M.P.N's for coliform bacteria. Plots A and B are the relaying areas.

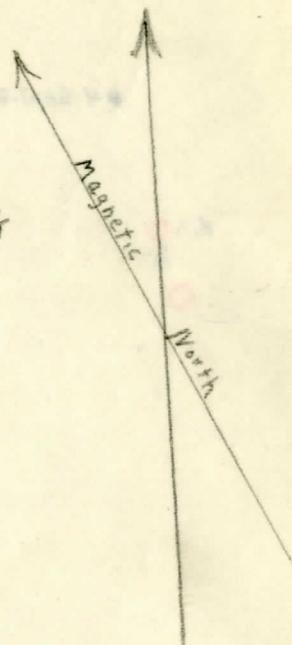
SEDGEWICK COVE.

Scale - Approx. 1" = 500'

Blue - High tide MPN'S
August 28, 1942

Red - Low tide MPN'S
August 28, 1942.

● Wading samples in black
at low water.



x 4

x 0

Procedure

This time 22 bushels of oysters were gathered from the wharf site (September 19 to 21) and these were all placed in the one plot 40 yards westward from the sewer outlet. Only 18 bushels were recovered and taken to Sedgewick cove on September 24.

Half the oysters were placed on the tide flats in such a position that they were exposed to air one-half to one-third of the time. The other half were planted in the same position as was used in Experiment 2, where there is never any exposure at low tide. The same two degrees of crowding were used, as in Experiment 2, and plantings were made both on trays and on the bottom.

The water temperatures had ranged between 19 and 23°C. during Experiment 2 but not stood between 11 and 15°C. (see table XIX).

Any

There were many wash waters tested during the experiment.

Conclusions from Experiment 3.

1. The results show no differences in the cleansing rates of meats for oysters held in deep water and at half tide level on the beach.
2. The filth on the outsides of the shells disappeared more quickly from oysters held on the beach than from those held in deep water. This is probably due to stronger wave action.
3. In spite of unfavourable water conditions encountered during this experiment, practically all the meats were clean 8 days after relay.
4. The filth remained on the outsides of the shells even after the meats were clean.

5. Because of unfavourable water conditions during Experiment 3, a comparison of the results with those of experiment 2 is not possible. The effects of temperature differences have been obscured.
6. The conditions of the experiment do not permit a comparison of the rate of cleansing of meats when the shells exteriors are dirty and when they have been chlorinated (see Experiment IB) previous to relay.
7. Crowding to the degree experienced in these tests had no marked effect on the rate of cleansing of meats but it did reduce the rate at which filth disappeared from the shell exterior.

Experiment 4.

Purpose.

Experiments 2 and 3 have shown that when oysters are relaid, the meats clean up more quickly than the shell exteriors. Experiment 4 was designed to see how great the risk is of carrying filth from the shell exterior into the meats when oysters with dirty shells are opened in the ordinary way by consumers. This ordinary way is termed the "kitchen sink method".

Procedure

A supply of experimental oysters was brought from Sedge-wick cove and a sample tested bacteriologically. After this the rest were "tub-contaminated" by the method already described. One sample of meats from these was obtained by Mr. Campbell who opened the oysters only after chlorination of the shell exteriors following the regular bacteriological technique. Another lot was obtained by Mr. Medcof who opened the oysters following the kitchen sink method.

No special pains were taken to avoid contamination of these meats during the opening process.

The shells from the "kitchen sink" method that remained after opening were given the wash water test.

Fifteen to twenty oysters are required for each test.

The results of the tests appear in table XVI.

Conclusions from Experiment 4.

1. In spite of the stirring during tub-contamination the oysters seem to have taken some filth into their meats.
2. The amount of contamination carried from the outside into the meats at the time of opening was not great. All the differences observed could be accounted for by experimental and sampling errors.

Experiment 5

Purpose

The purpose of this experiment was the same as that of Experiment 4.

Procedure

Experimental oysters for this test were taken from the stock relaid on September 24 in deep water, crowded on the bottom in Sedgewick cove for Experiment 3. After September 25 these showed meats that were almost clean but shells that were still dirty outside.

Samples of these were opened on three different dates, by the two methods - the regular bacteriological by Mr. Campbell and the "kitchen sink", by Mr. Medcof. The results appear in Table XVII.

Conclusions from Experiment 5

1. The results indicate that there is little or no filth carried into the mass when oysters are opened by the kitchen sink method even when the shells are quite dirty.
2. This conclusion is in agreement with the results of Experiment 4.

Experiment 6.

Purpose.

The way in which oysters clean up in nature at the onset of hibernation is well known and has been studied by the present workers (Gibbard et al 1942). To date no critical test has been made to see if a similar cleansing goes on when oysters are held in air at temperatures between 0 and 5°. Experiment 6 was designed to show whether this cleansing does or does not take place.

Procedure

A sample of oysters was fished at low tide during the morning of September 29 and placed at noon in the cold room of the "Sanitary Meat Market" in Summerside. According to the manager of the store, the temperature of this room never fell below 32°F and never rose above 40°F. If these conditions had prevailed they would have been ideal for the carrying out of the test. However, the temperature records show that this was far from true. At noon on October 1 a maximum-minimum thermometer was placed in the oyster storage box and "set" after three hours. Earlier records were made from readings of an ordinary thermometer. These were:

September 29	3:00 p.m.	43°
October 1	5:10 p.m.	47°
October 3	12:00 noon	Max. 51, Min. 43 At time 48°

Table XVI Summary of Bacteriological Data Obtained in Experiment 4.

Description of Sample	Dates and M. P. N's	
	September 25	October 1
Oysters from Sedgewick cove tested before "Tub-contamination"	80	80
Tub-contaminated oysters opened following regular technique	180	180
Tub-contaminated oysters opened by "kitchen-sink" method	80	460
Wash water from shells after "tub-contamination"	460	---

Table XVII Summary of Bacteriological Data for Experiment 5

Description of Sample	Dates and M. P. N's		
	September 26	September 29	October 2
Test of meats opened by regular technique	220	300	0
Test of meats opened by "kitchen sink" method	180	80	0
Wash water from shells of oysters as they came from Sedgewick cove	1500 +	460	1500 +

Table XVIII Summary of Bacteriological Data Obtained from Experiment 6
Storage Test

Sept. 29	Oysters from Summerside harbour at start of storage test	9,200
Oct. 1	After 48 hours storage	30,000 +
Oct. 3	After 96 hours storage	22,000

The oysters used in the tests were never placed evenly scattered on the bottom in a plot like those used in earlier experiments. However, they were a small uniform lot gathered from a limited area on top of the old wharf site and may be considered as uniformly contaminated.

The results of the bacteriological tests made appear in table XVIII.

Conclusions from Experiment 6

1. There was no observed decrease in the M. P. N. values for the oysters.
2. On the second day an M. P. N. increase was observed. This may or may not be significant but is reminiscent of the results obtained in Experiment 2 of the Buctouche storage tests carried out in 1940 by the authors (Medcof 1940a) and of the results reported by the U. S. Public Health Department in a personal communication with Mr. J. Gibbard of the Canadian Department of Pensions and National Health.
3. The temperatures encountered during the storage test did not fulfil the requirements and the experiment should be repeated under more favourable conditions.

General Conclusions and Discussion

At the temperature levels encountered during the tests it has been shown that when the shells of oysters are clean and only the meats dirty, oysters can cleanse themselves in 4 to 16 hours in clean water.

When both shells and meats are dirty the meats require 8 days to free themselves of contamination.

Crowding to the extent experienced in the tests did not seriously alter the rate of cleansing of meats but did reduce the rate

at which the shell exteriors cleaned up.

The better water circulation supposedly provided by placing oysters on screen-bottomed trays rather than directly on the bottom did not improve the rate of the extent of cleansing.

Dirt still remained attached to the shell exteriors after the meats cleaned up.

The data show that the danger of carrying dirt from the shell exteriors into the meats at the time of opening is slight. This fact has an important bearing on the winter fishery of oysters from polluted areas such as Buctouche river, N. B. Apparently filth is firmly attached to the shells. It does not come off readily to interfere with the self-purification of the meats during the relaying period or the cleanliness of the meats when oysters are opened by the consumer.

Taken together these observations indicate that the cleansing period now required (1 month in pure water) might be substantially reduced without danger to public health. The results are favourable enough to warrant an extension of this work with the specific purpose of gathering information on which to base new regulations.

Apparently flats that are exposed at low tide provide relaying conditions that are just as good as and perhaps better than beds that are submerged at all times. This discovery probably has more immediate importance to the industry than any other made during the investigation. The reason for this is that a much higher percentage recovery of oysters is possible from beaches than from deep water and that it does not require calm weather or skilled oyster fishermen to gather oysters from tide flats. Furthermore, planting and refishing on tide flats can be carried out more quickly and with less handling and less equipment than in deep water.

The results show the need for inspection of relaying areas previous to refishing to make sure the water at such times is pure. If it is dirty there should be some means of arresting operations until it is considered safe to recommence.

The storage test, (Experiment 6 of this report) should be repeated under favourable conditions.

Table XIX Hydrography

Summerside Harbour

Date	Time	Tide	Weather	Depth	Temp.	Salinity
Aug. 24	4:15 p.m.	LR	Bright, light NW	Sur.	21.9	28.0
Aug. 29	10:20 a.m.	$\frac{3}{4}$ R	Bright, fresh NE	"	19.0	27.1
Sept. 24	1:45 p.m.	HF	Bright, mod. W.	"	17.1	27.7
<u>Sedgewick Cove</u>						
Aug. 24	5:45 p.m.	LR		"	22.9	27.9
	10:00 p.m.	HS	Clear, calm	"	21.6	29.1
25	10:15 a.m.	HS	Bright; light NW	"	20.0	28.9
26	7:15 p.m.	LR	Bright, light NE		19.3	28.1
28	1:00 p.m.					26.7
29	11:00 a.m.	HR	Fresh NE.	"	18.3	28.7
Sept. 5	1:30 p.m.	LS	Calm	"	20.8	28.1
11	6:40 p.m.	LS	Fresh SW		17.9	
24	2:40 p.m.	$\frac{3}{4}$ F	Bright, mod. W.	"	16.7	27.9
25	10:30 a.m.	HR	Cloudy, fresh SW	"	14.8	23.9
	6:50 p.m.	LS	Bright, mod. SW	"	15.2	25.3
26	7:05 a.m.	LS	Bright, light E	"	12.0	26.8
29	9:45 a.m.	LS	Bright, mod. NW	"	11.0	24.2
Oct. 2	10:50 a.m.	LS	Bright, mod. SW	"	11.1	26.8

Table XX Weather Records from the Biological Station, Ellerslie, P.E.I.

Date	Time	Weather	Temperatures °F.		
			At time	Max.	Min.
Aug. 24	9:00 a.m.	Cloudy; mod. NW	62	78	51
25	9:10 a.m.	Bright; light NW	54	62	49
	4:53 p.m.	Bright; light N	62	62	54
26	8:40 a.m.	Bright; calm	--	--	--
27	9:30 a.m.	Bright; light NW	57	63	50
	4:55 p.m.	Bright; light NW	72	72	57
28	9:25 a.m.	Pt. cloudy; mod. SW	61	72	51
	4:35 p.m.	Cloudy; light SW	68	68	61
29	8:10 a.m.	Cloudy; mod. NE	59	67	59
	11:55 a.m.	Bright; fresh NE	60	69	60
31	9:50 a.m.	Bright; mod. SW	57	64	47
	4:45 p.m.	Bright; light SW	78	78	57
Sept. 1	9:00 a.m.	Pt. cloudy; mod. SW	68	78	66
	4:35 p.m.	Bright; calm	84	84	68
2	8:25 a.m.	Bright; mod. SW	66	84	64
	4:50 p.m.	Bright; mod. SW	86	86	67
3	8:25 a.m.	Bright; mod. SW	69	85	67
	4:45 p.m.	Bright; fresh NE	60	71	60
4	8:25 a.m.	Bright; light SE	49	60	49
	4:52 p.m.	Pt. cloudy			
5	8:15 a.m.	Bright; light SW	59	67	59
	11:45 a.m.	Bright; mod. SW	65	65	59
	8:30 p.m.	Pt. cloudy; mod. SW	60	74	60

Table XX Continued

Date	Time	Weather	Temperatures °F.		
			At time	Max.	Min.
Sept. 6	9:10 a.m.	Pt. cloudy; strong NW	54	54	42
	8:30 p.m.	Pt. cloudy; str. NW.	52	60	52
7	8:30 a.m.	Clear; strong W.	60	60	41
	7:45 p.m.	Pt. cloudy; str. W.	60	73	60
8	9:30 a.m.	Cloudy; mod. NE	52	70	45
	4:45 p.m.	Bright; mod. NE	56	56	52
9	8:15 a.m.	Bright; calm	38	56	36
	5:05 p.m.	Bright; light SW	66	66	38
10	8:15 a.m.	Cloudy; calm	51	66	50
	4:45 p.m.	Cloudy; mod. SE	60	60	52
11	8:30 a.m.	Cloudy; light NE	60	61	58
	4:50 p.m.	Cloudy; mod. NE	61	62	59
20	7:10 a.m.	Pt. cloudy; str. SW	68	70	65
	8:00 p.m.	Cloudy; raining; strong NE	52	79	52
21	8:30 a.m.	Cloudy; raining, mod. NE	53	70	53
	4:40 p.m.	Raining hard, Fr. NE	52	54	52
22	8:20 a.m.	" " " "	55	58	55
	4:40 p.m.	Cloudy; fresh NE	56	57	56
23	8:15 a.m.	Cloudy; mod. NW	52	55	53
	4:55 p.m.	Bright; mod. NE	57	60	56

Table XX Continued

Date	Time	Weather	Temperatures °F		
			At time	Max.	Min
Sept. 24	8:10 a.m.	Bright; mod. NW	48	54	47
	4:55 p.m.	Bright; light W.	61	61	48
25	8:10 a.m.	Cloudy; mod. SW	54	58	52
	4:45 p.m.	Bright; mod. SW	58	60	58
26	8:15 a.m.	Bright; mod. NW	44	57	43
	4:40 p.m.	Bright; mod. NE	53	59	53
28	8:30 a.m.	Raining, cloudy, Mod. SW	50	70	52
	4:35 p.m.	Cloudy; raining, mod. NW	53	70	52
29	7:45 a.m.	Cloudy; mod. NW	42	49	45
	4:40 p.m.	Bright; mod. SW	45	48	47
30	7:45 a.m.	Bright; mod. W.	46	52	48
	4:45 p.m.	Bright; mod. SW	53	60	53
Oct. 1	7:45 a.m.	Cloudy; mod. SW	45	52	46
	4:45 p.m.	Cloudy; mod. S.	52	60	52
2	7:45 a.m.	Cloudy; mod. NW	46	52	48
	4:40 p.m.	Cloudy; raining, mod. SW	48	50	48
3	7:50 a.m.	Cloudy; strong NE	50	60	51
	11:45 a.m.	Cloudy; strong NE	50	66	50

XI
OYSTER INVESTIGATIONS IN THE SHIPPEGAN DISTRICT, N. B.

In 1942 four trips were made to the Shippegan district - May 13-18, June 18-25, August 4-19 and October 21-26 - to study the oyster situation. The investigation was undertaken by the Fisheries Research Board to assist in the development of oyster culture in New Brunswick, even though there was no transfer of jurisdictional powers from the New Brunswick provincial Department of Lands and Mines to the federal Department of Fisheries.

The objects of the visits were:

1. To obtain general information regarding the extent and suitability of grounds that might be leased for oyster cultural purposes.
2. To assist applicants in discovering suitably located ground for oyster leases.
3. To visit lessees of the district who have already begun work on their ground to see what results are being obtained.
4. To examine the difficulties and problems peculiar to the area and if possible foresee what influence these may have on the future development of oyster culture in that district.

The results of the investigation are presented under the headings just suggested.

Extent and Suitability of Unoccupied Grounds

There are extensive areas available in most parts of St. Simon Inlet, Shippegan Sound, and the bays about Shippegan and Miscou Islands that can still be leased without interfering with the public fishery. This is less true of the South Branch of St. Simon Inlet, Brule bay, and Basse bay, than of other areas

Table XXI Hydrographic data for the Shippigan Area.

Date	Time	Depth	Tide	Temp.	Sal.	Location
May 18	10:30 a.m.	Sur.	$\frac{3}{4}$ F	11.3	27.5	Pt. Brule in channel
		6'		--	27.5	
		18'		11.2	26.8	
	4:00 p.m.	Sur.	$\frac{1}{2}$ R	12.1	27.1	Pt. Brule in channel
		6'		--	26.8	
		25'		11.3	27.2	
	18 11:20 a.m.	Sur.	$\frac{1}{4}$ F	14.9	27.1	Over lease #32, S. branch St. Simon inlet
	5'		15.2	26.8		
	18 11:45 a.m.	1 $\frac{1}{2}$ '		16.9	27.7	Mouth of Risseau Canoe
		12:00 noon	Sur.	LF	17.4	
18 11:50 a.m.	Sur.	LF	17.0	28.7		Off mouth of " "
18 2:45 p.m.	Sur.		LR	16.3	23.9	St. Simon, off wharf
		3'		--	24.2	
		8'		15.1	24.9	
June 20	10:00 a.m.	Sur.	--	13.8	25.3	Brule bay
	22	Sur.	--	--	26.6	At lease #28, S. branch St. Simon inlet
Aug. 8	2:30 p.m.	Sur.	HS	20.7	25.7	St. Simon wharf, N. branch of St. Simon river.
		9'		19.8	24.9	
	3:05 p.m.	Sur.	HS	19.8	26.0	Off Pt. Brule in channel
		12'		19.2	25.9	
	10 3:00 p.m.	Sur.	HS	19.7	25.8	At lease #28, S. branch St. Simon inlet
	5'		19.7	25.0		
	11 10:00 a.m.	Sur.	LS	--	26.6	Money Island (Wilson's point)
	12 4:00 p.m.	Sur.	HF	21.3	18.6	Pok3mouche river at junction with Waugh river
		4'		21.1	18.8	
		12'		19.6	21.7	
12 10:30 a.m.	4'	$\frac{1}{2}$ R	18.7	25.5	Tracadie Lagoon at Windmill point.	

like the southern part of Shippegan sound (including Caribou bay), parts of Lameque bay, Little Lameque bay, and the large body of water sheltered between Miscou and Shippegan islands.

The prospects are that availability of suitable ground in the district will not be a controlling factor in the development of the oyster industry within the next few years at least.

The proportion of the total areas of these inlets that is suited to oyster farming is surprisingly high as compared with other districts. In this area bottoms that would be judged too soft by Prince Edward Island standards, produce surprisingly well-shaped oysters. This may be due to the high proportion of clay in the mud. There is usually no difficulty in finding ground that is sufficiently sheltered from winds, free of eel grass and deep enough to avoid killing through ice action.

The quality of the oysters encountered in the explorations was high except in the upper parts of the Pokemouche river where it joins the Waugh river and in the North Branch of St. Simon inlet above the property granted to Bernard Albert.

Salinities and temperatures in the district are indicated in Table XXI. These are such as to permit successful reproduction of oysters and the development of high quality shells and meats.

In brief, physical and hydrographic conditions in the district are highly favourable to the production of large quantities of high class oysters and there is ample ground for the continued expansion of the industry.

Assistance to Lessees in Choice of Ground

The areas applied for by thirty-eight people were examined and reported on. Most of these were in the South Branch of the St. Simon inlet but there were some in the North Branch, Brule bay, Basse bay, Caribou bay, Lameque bay, Little Lameque bay, and Tracadie Lagoon. Satisfactory locations were found for most of these people. In some cases there was confliction because the ground of the applicant's choice was too close to public fishing areas to meet the approval of the local fisheries inspector, Mr. L. J. Landry, and the regional forest ranger, Mr. A. F. Losier. These men make recommendations to the New Brunswick Department of Lands and Mines for approval or disapproval of all applications for oyster leases.

In the case of the Tracadie Lagoon area, conditions seemed to be so doubtful that the applicant decided to wait the results of an experimental plant of oysters made on the area this year before proceeding further with the proposed lease.

Work of Lessees

A small number of people have already done considerable work on their leases. No attempt was made to estimate its amount or its success except in a few individual cases. The most enterprising of the 150-odd lessees are outsiders such as Dr. Cormier of Moncton, the Robichaud Freres of Buctouche and Mr. Smofski of the local Gulf Trading Company. There are, nevertheless, several/people of smaller means who have worked hard and effectively.

So far the activity in oyster farming has been strictly limited to one operation - the gathering of small oysters from on-shore areas and the planting of these in deeper water on leases. Several thousands of barrels have been so treated since 1937. The survival and growth of these transferred oysters has been very satisfactory in most cases. The leases have, in nearly all cases, been favourably located so that there has been little winter killing and no loss through the action of storms during open water seasons.

In a good many instances, however, the plantings of small oysters have been much too heavy. Crowding has brought its attending evils - distortion of shell shape, even clustering in some cases, and thinness of meats. It would not be too late to partly correct this crowding by refishing and planting more thinly over the ground.

Several lessees have already come into production and last year sold their oysters to good advantage. The oysters appear to have been well received on the markets, rated high for quantity of meats and hardness and shape of shell, and to have brought good prices. This year the prospects are that yields from leased areas will be higher than in 1941.

In the last two years there has been a sudden flurry of interest in the leasing of oyster ground in the district. This seems to have been stimulated by the favourable results of the first marketings of oysters by the holders of the oldest leases. The writer's personal impression is that many, if not most, of the people who are applying now for leases are likely to do very little oyster farming if left to their own devices. This is

because they are by nature "climbers on" and also because by starting now they are confronted by an obstacle hat did not present itself to the older lessees when they began. This difficulty is the increasing scarcity of naturally produced seed oysters. The problem will be more fully dealt with below.

The writer has learned of only two attempts that have been made to collect seed oysters artificially and both these were on a purely experimental scale. About 1938, Dr. Cormier exposed some concrete-coated cardboard collectors in the North Branch of St. Simon inlet. According to Doctor Cormier these received a good set and the spat grew well. In 1939 Bruno Mallet brought several bushels of oyster shells from Buctouche and scattered them in deep water on his lease. (N.B. #27). These took a good catch of spat. Some of these 1939 oysters were examined and measured on August 8th, 1942. They had not grown very large in the four seasons but they were strong-shelled and well shaped.

To summarize- the enterprise of the holders of the oldest leases and the great abundance to date of naturally produced seed oysters have combined to permit a small but flourishing development of oyster farming in the district. The development is based on a single simple operation - the gathering of naturally produced seed oysters from the beaches and planting them on leased areas. The marketing of these "farmed" oysters has stimulated interest in leasing but the prospects for a beginner now are not so bright as they were four years ago.

Difficulties Peculiar to the Area

A difficulty that has confronted lessees of this district is the lack of reliable information and advice to guide their

efforts. Offsetting this is their peculiar good fortune in having, available from 1937 until now, what has seemed to them an unlimited supply of naturally produced seed stock. This has made oyster farming a ridiculously simple operation that can be carried on with very little technical knowledge.

Starfish have not been a serious menace because the oysters planted on the leases were usually large enough to resist their attacks. During the last two years, however, the numbers of large starfish seem to have increased and several people are much concerned by the damage done. Others do not even know that starfish are important enemies of the oyster. Apparently nothing whatever is being done to destroy the starfish by any of the lessees.

One of the most heavily infested areas visited was that of Bruno Mallet. Large numbers of starfish of all sizes up to seven inches in diameter were found. Some were destroying even market-sized oysters.

No signs were found of destructive activity by oyster drills of any species.

At one time eel grass grew on much of the ground that is now leased, according to the report of the lessees. There are increasing signs of the plant's recovery in the district. If it should attain even half its former abundance and luxuriance it would seriously interfere with oyster farming. The same problem faces oyster farmers in other districts, of course.

In the past the lessees have been able to gather large numbers of single, well shaped small oysters from almost every pebble beach in the district. The last two years have seen a sharp

decrease in the abundance of these seed oysters. This shortage seems likely to become more acute and to threaten the maintenance and development of the industry.

Because of its great importance special attention was given to this problem and a separate section of this report is devoted to it. At the conclusion of that section a solution of the difficulty is proposed.

On the Increasing Shortage of Seed Oysters in the Shippagan District
History

Starting about 1937 small oysters were found in large numbers on almost every pebble beach throughout this district. They were distributed in a zone between the half-tide and the dead low-tide level on the beaches. They were small, single, well shaped oysters, nearly always attached to pebbles. They were not found on sand beaches or on mud flats.

According to the older residents this condition was never observed before. It must have been brought about by a set of conditions in 1936 that were unusually favourable to reproduction and survival of oysters. What these conditions were it is now too late to say but they have been associated with the sudden disappearance of eel grass from the region a few years previous. It is interesting to note that precisely the same combination of events was observed in the Bras d'Or lakes in Cape Breton island in 1938.

Since the appearance of the small oysters, leases have been taken out and there has been great activity in the gathering of the seed as already described. After any beach was thoroughly picked over, and it can be easily stripped because the oysters occurred in a band just above low tide level, there were not many oysters to be found there the following year. However, the seed occurred in so many places that the number of small oysters gathered was maintained at a high level by exploiting new areas.

According to report, each year the average size of the seed oysters gathered has tended to increase.

Few of the lessees seem to comprehend these conditions or if they do they apparently have failed to appreciate their significance. The picture is a clear one:

1. The population of these areas by oysters in the first place was fortuitous. It cannot be relied on for a constant supply of seed.
2. The oyster stocks must be composed of only a few year classes.
3. Depletion of beach stocks is going on rapidly and nearing exhaustion due to intensive picking.
4. Depletion is likely to be severe because there are increasing numbers of lessees who will want stock for their areas.
5. Depletion not only reduces production in the immediate future, but because it eliminates spawning stocks, it is likely to reduce production to a low level for a long period of years.

Year Classes and Size Frequency Distribution in the Oyster Stocks

To obtain more precise information than was gathered from the study of general conditions, an analysis was made of random samples of oysters from the flats where seed are gathered by lessees and from beds that support a public fishery. The age of

each oyster was estimated from the annual rings on the shell and the shell length was measured. The data gathered from these is plotted out below.

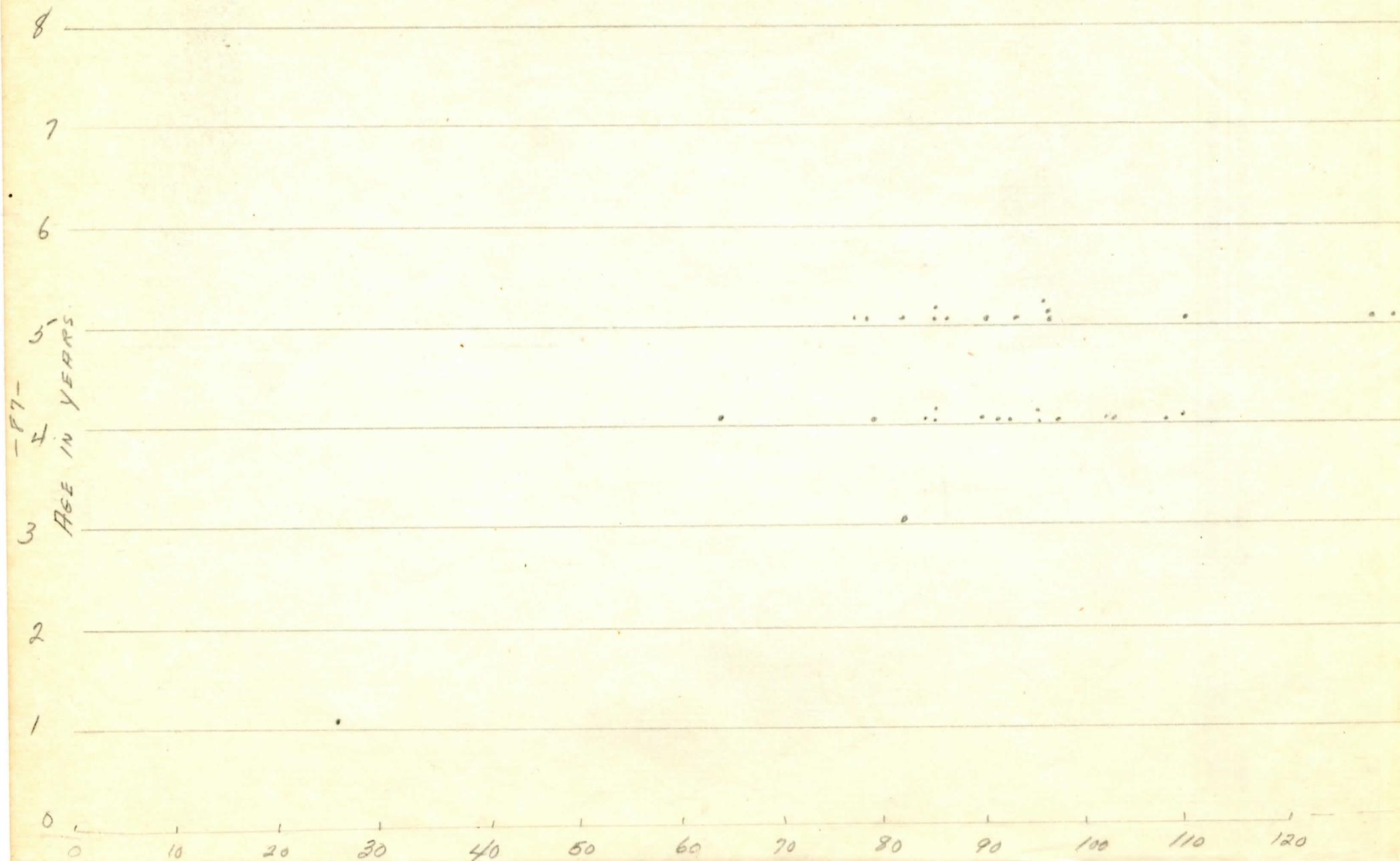
Note re figures 6 - 14

In reporting age determinations the growing season of 1942 was not included. That is to say, an oyster born in 1941 and measured in August 1942 is reported as one year old even though it has experienced more than one year's growth, or again an oyster born in 1937 is recorded as five years old. In measurements, however, the whole overall length including the 1942 growth was taken. There was no 1942 growth showing in the May samples, a small amount was showing in the June lots and a considerable annulus of growth was found in the August specimens. In the last case the growth averaged about one centimetre. These peculiarities of the records should be borne in mind while considering the data presented in the figures.

There has been some difficulty in discerning the annulus marking the end of the first year's growth. Determinations of age, then, are subject to an error of plus or minus one year.

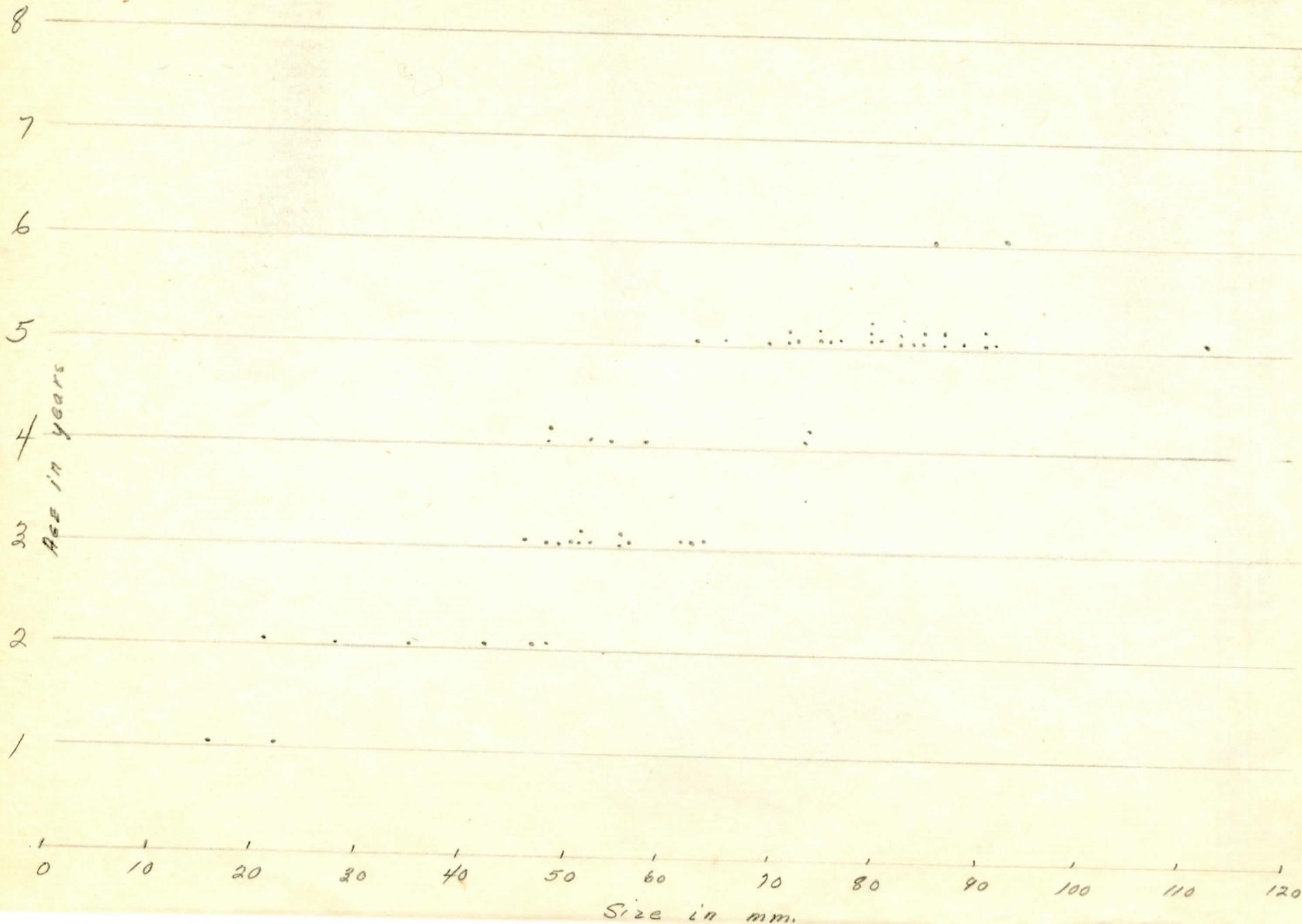
Age and size distribution of 33 oysters
in sample from Pokemouche river bed
at Junction with Waugh river. August 11th, 1942.

Figure 6



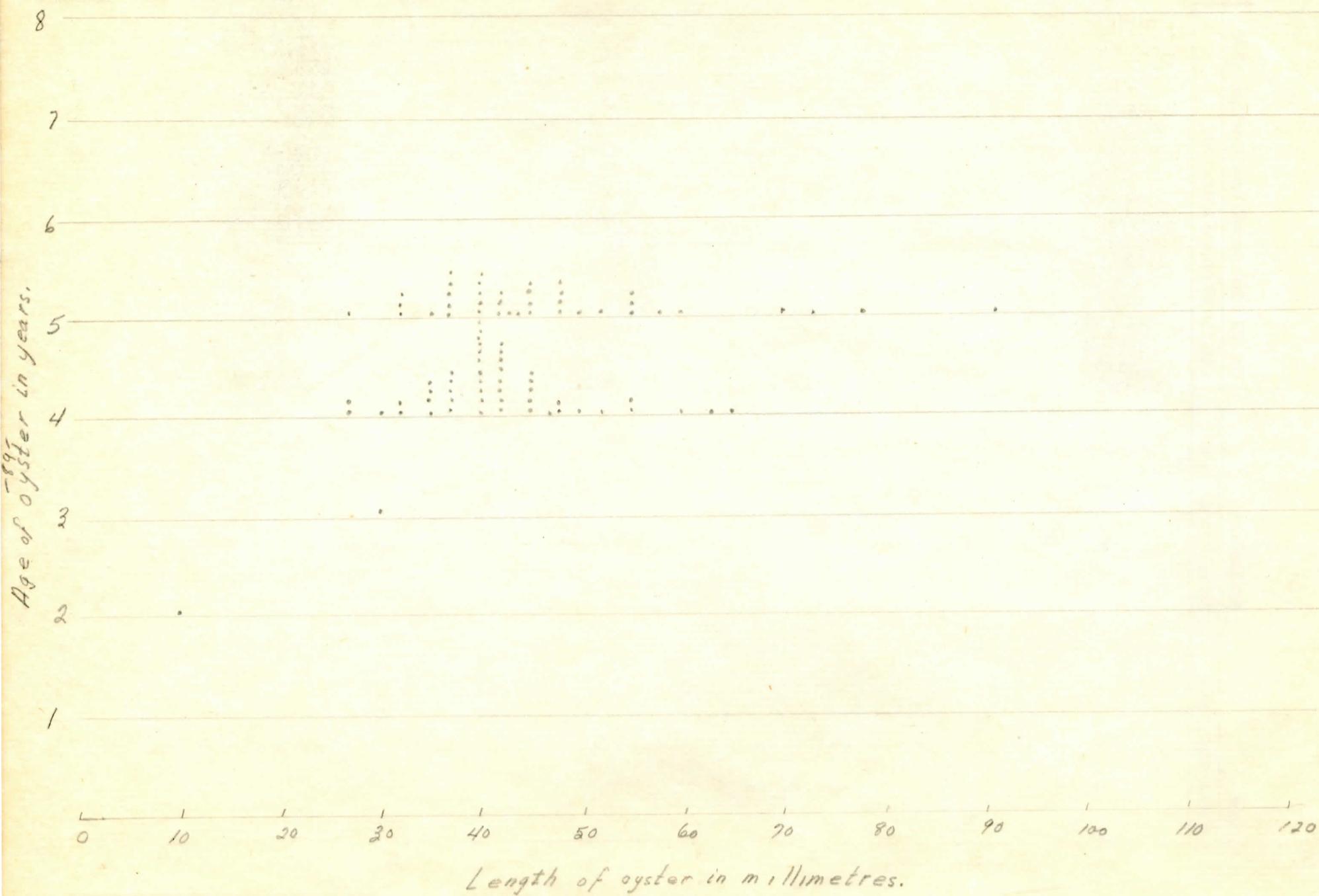
Age and size distribution of 56 oysters
in a sample from the Risseau Canoe bed.
Sampled June 23rd, 1942.

Figure 7.



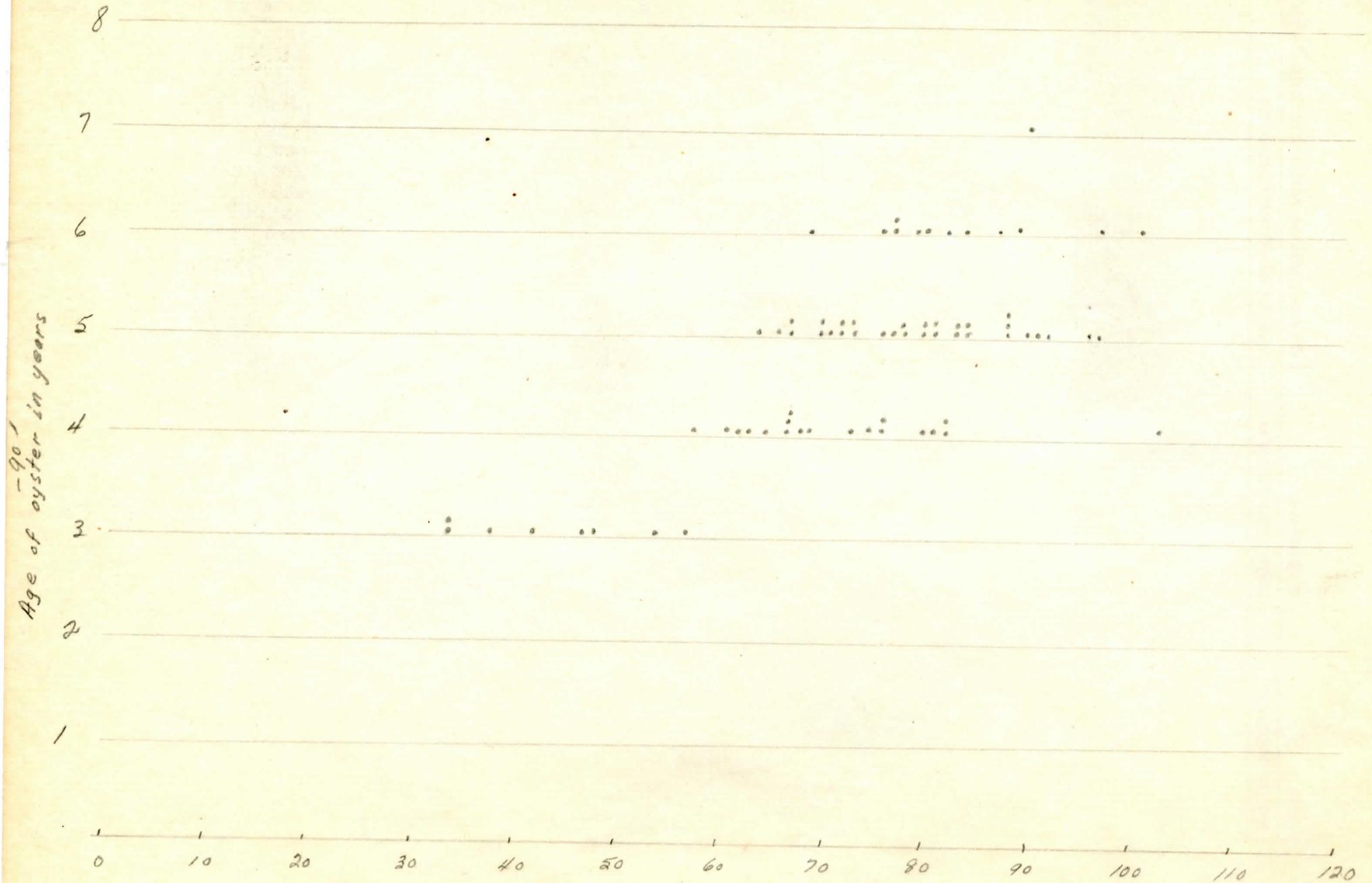
Age and size distribution of 94 oysters
in a sample from Basse bay flats,
Shippegan, N. B. May 21st, 1942.

Figure 8



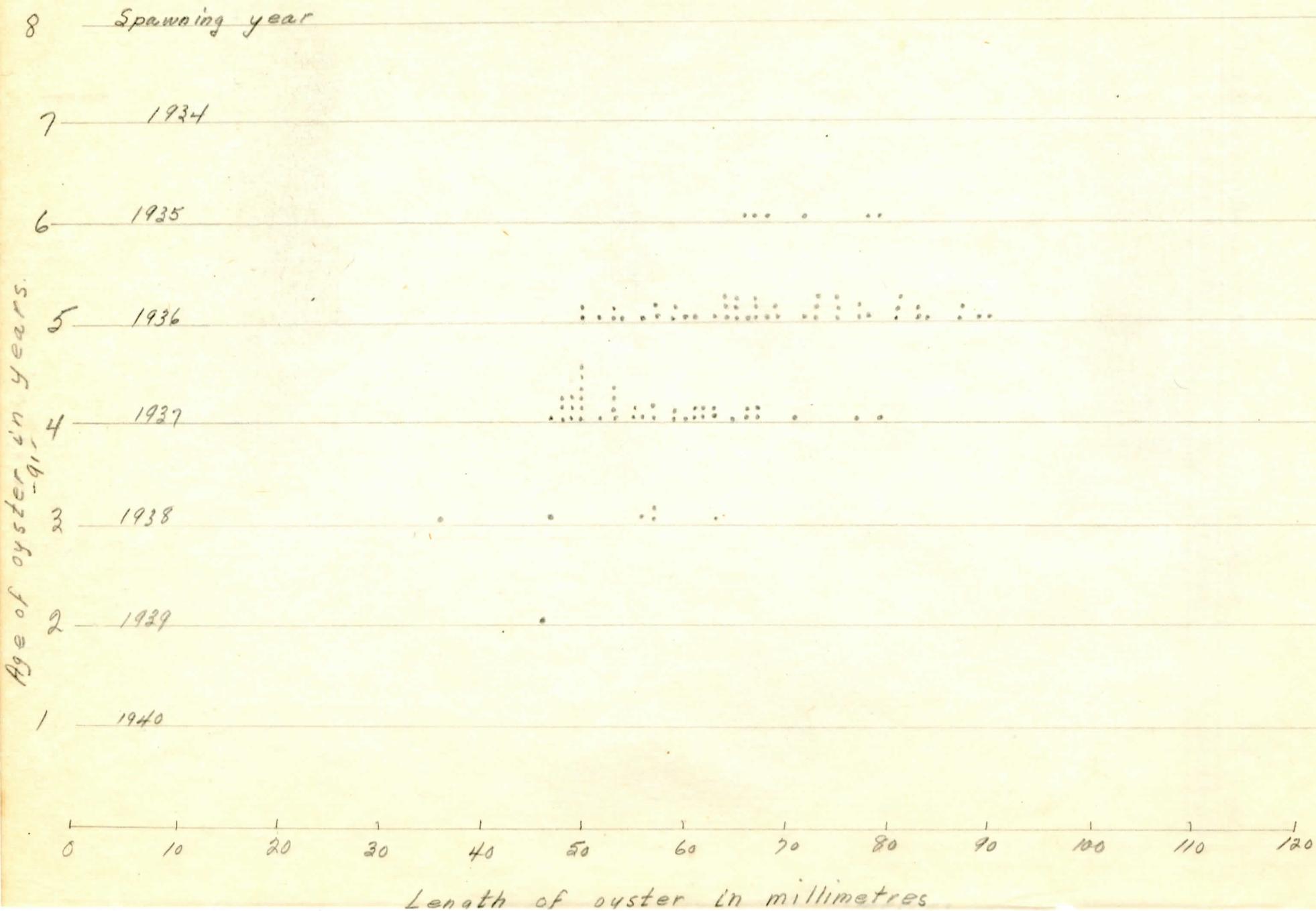
Age and sizedistribution of 72 oysters
in sample from Lameque bay bed, Shippegan,
island, N. E. August 7th, 1942.

Figure 9



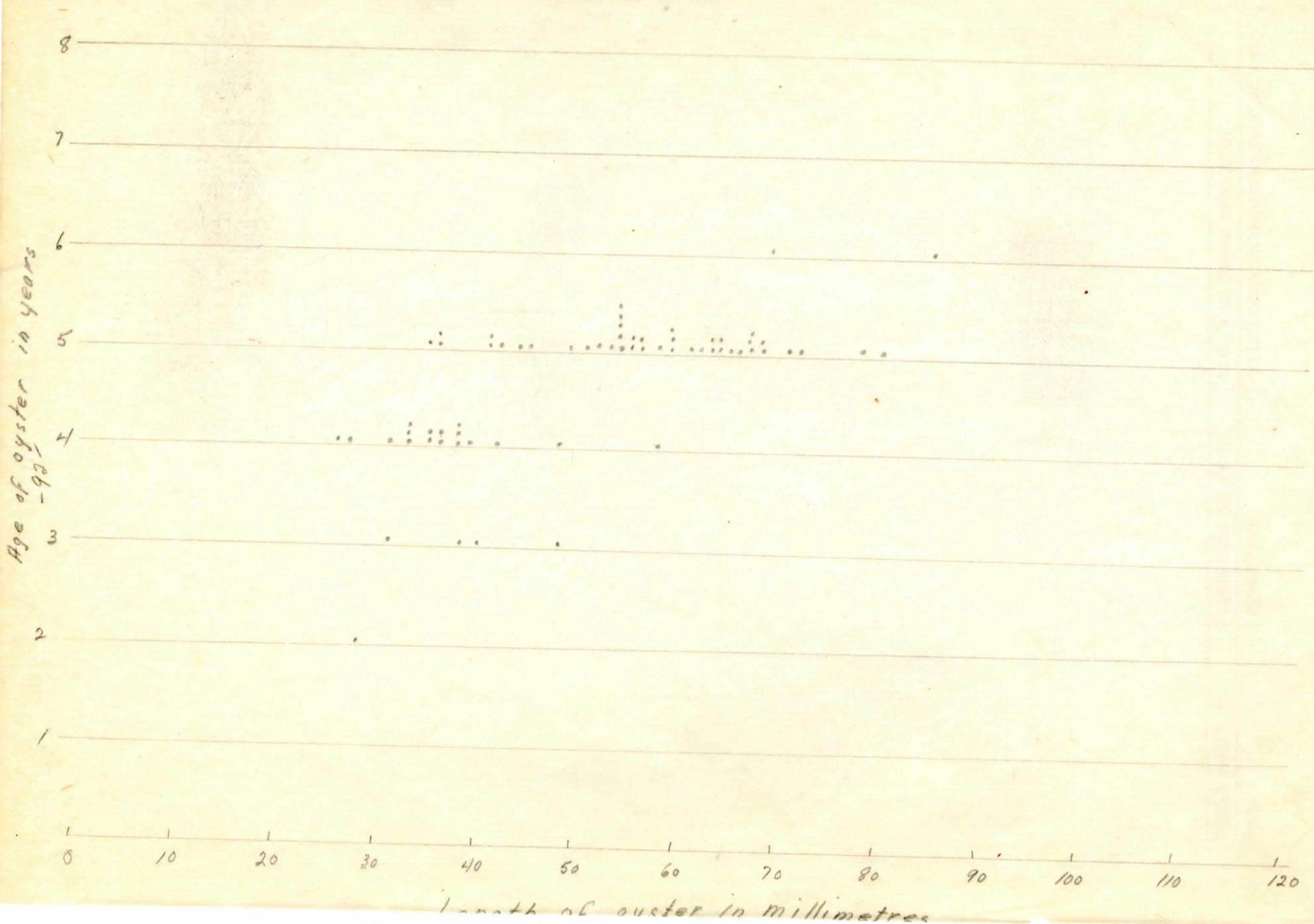
Age and size distribution of 103 oysters
in a sample from Lamequē bay flats,
August 2nd, 1942. Shippegan island, N. B

Figure 10.

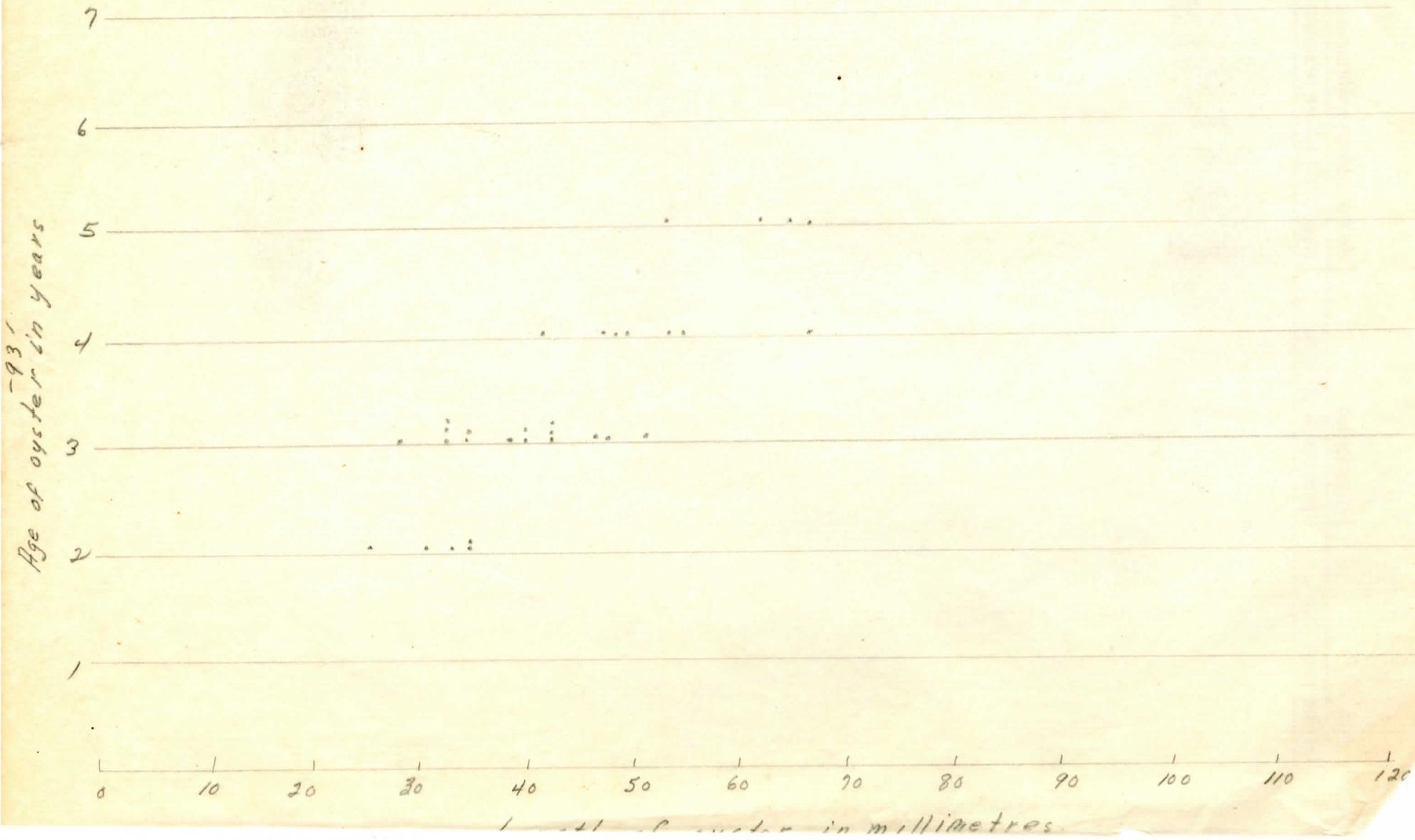


Age and size distribution of 64 oysters
in a sample from Campbell's river flats
Shippegan island, N. B. June 21st, 1942.

Figure 11

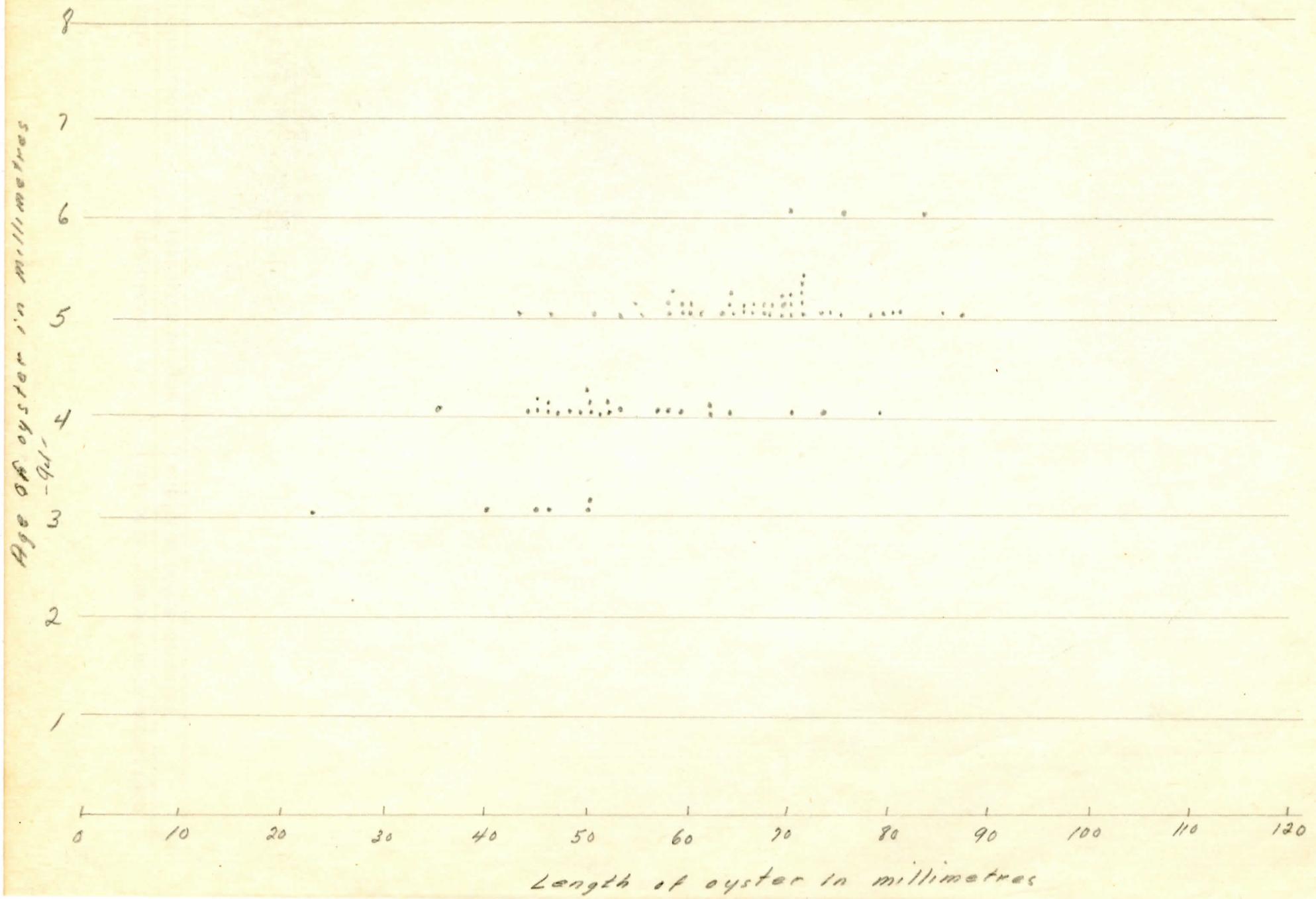


Age and size distribution of 31 oysters
in a sample from Landry's brook flats
Shippegan island, N. B. August 11th, 1942.



Age and size distribution of 80 oysters
in a sample from Wilson's point flats
Miscou Island, N. E. August 11th, 1942.

Figure 13



Size and age of oysters found on
shells exposed in Bruno Mallet's lease
in 1939. Measured August 8th, 1942.

Figure 14

Size of oyster in years
20 - 95

• •• : : ••

The above data support the conclusions reached from the general study and show further that:

1. The vast majority of oysters on the flats appear to be either four or five years old.
2. There has been almost no reproduction on these grounds during the past three years and little or none this year.
3. The notable scarcity of oysters that are more than five years old suggests that there was little reproduction previous to 1936 or 1937.
4. The size range within one year class is so great that it overlaps with that of other age groups.
5. Growth on the beaches is considerably slower than on the deep beds.
6. The two prominent year classes that are found on the beaches are present, but not so outstanding, in the oyster population of deep beds.
7. The oyster leases are stocked with oysters from flats. This means that there are probably only two significant year classes represented there.

Prospects for Future Development

The prospects are that during the next two or three years the oyster production of the Shippegan district will continue to rise rapidly as the two prominent year classes mature.

After this a sudden slump may be expected.

This slump is likely to be more marked in the production from leased areas than from natural beds.

Recovery after the slump will take several years. This seems probable because depletion is likely to proceed, due to the effects of the intensive picking now going on, until the population is reduced to a very low level.

Needs of the Industry

If the industry is to avoid the expected slump in production, what is required, and required at once, is the discovery of a new source of seed oysters. One way to insure this is to import seed produced in other districts but this seems impracticable. A more feasible solution would be the initiation of a regular programme of artificial spat collection such as is now carried on in other parts of the maritimes.

Encouraging results have already been obtained in trial connections on an experimental scale by two lessees. There is no reason to believe that spat collection could not be carried on equally well on a commercial scale. Before this is possible, however, the lessees have much to learn and it is extremely doubtful that they will be able to initiate this programme before the expected slump has become a reality. The writer regards the discovery of this need as the most important result of his investigation.

It is recommended that the lessees be given every possible encouragement to develop a satisfactory method of spat collection.

XII

PRELIMINARY REPORT ON THE DISTRIBUTION OF IRISH MOSS ON
THE GULF COAST OF NEW BRUNSWICK

At various intervals during late June, July and August of 1941 a somewhat cursory exploration was made of the gulf shore of New Brunswick from Johnson point which is between Cape Tormentine and Cape Bald, to Richibucto Village. Weed and rocky ledges near shore were searched at low tide by wading with rubber boots. Sometimes dories were available and in such cases they were used to row about during the search for growths of the moss.

Small quantities were found growing on ledge rock near shore at Cape Bald, Point à Buveau (near Cape Bald), and Point Brule (near Shediac), Shediac island, Caissie cape and Dixon's point. No quantity of moss was found on the beaches at any of these places.

Later in the fall Mr. Maple MacDonald did some test raking in deeper water on ledge bottom off Point Brulé, Shediac island and Caissie cape. The quantities of moss found at these places was too insignificant to be of commercial interest.

In 1942 the search was resumed. On August 10 a trip was made to the shore just four miles south of Tracadie. There are ledge bottoms there but they supported no growths of moss and none was found in the wrack.

On August 13 Mr. Clay Williston of Baie du Vin was visited at Escuminac point where he was gathering moss with the assistance of several employees, mostly women and small boys.

They were tearing off moss in clusters from separate stones near shore not off ledge bottom at low tide. At that time no raking had been done in the district although Mr. Williston had a rake. He had also bought some moss separated from beach wrack and this seemed to be of good quality. So far he had bleached all that he had taken.

Mr. Williston is a former lobster fisherman and has an intimate knowledge of the coast in this part of the province. He had lately interested himself in the distribution of moss and volunteered this information. Moss is found continuously from Flaker's light (which is about two miles up-river from Escuminac wharf) to Escuminac point. It ceases here and is to be found again at Spruce point which is several miles to the south. There is none in the bay toward Eel river from Escuminac point. Below Spruce point there is a long gap without moss until Chapel reef which is just north of Point Sapin. From here southward there are heavy growths extending even southward of Point Sapin itself. After this there is another log gap until Richibucto cape.

At Point Sapin the writer visited Mr. D. S. Roy who has an interest in mossaing that could be described as "very mild". The other people of this settlement were even less enthusiastic, as far as could be determined, in spite of the fact that Mr. Williston has tried to arouse their interest. In late October a brief visit was made to Maisonette on Chaleur bay where small quantities of moss were found on the beach. According to Mr. Alonzo St. Pierre, of the Maritime Fisherman's Union, the local fishermen have discovered extensive growths in the district that would be accessible to rakers.

and Mr. St. Pierre.

The Escuminac and Sapin and Maissonette districts have growths of the plant that are encouraging indeed. Since there has been no deliberate examination of these areas with moss rakes and since there is now some interest being demonstrated it would seem advisable to estimate the resources of the district that might be exploited and give what assistance we can to those who are enterprising enough to engage in the business. This is the only place in New Brunswick where any moss work is being done. If time permitted some further search might be made in the Cape Bald district where there might be some moss on the off-shore ledges.

XIII

REFERENCES

- Dugal, L. P. 1939 The use of calcareous shell to buffer the products of anaerobic glycolysis in *Venus mercenaria*. *J. Cell. and Comp. Physiol.* 13(2) : 235-251.
- Elsey, C. R. 1934 The Japanese oyster in Canadian Pacific waters. *Proc. Pan. Pac. Sci. Congr.* 5 : 4121-4127
- Galtsoff, P. W. 1934 The biochemistry of the invertebrates of the sea. *Ecol. Mono.* 4 : 481-490.
1939 Biology of the oyster in relation to sanitation. *Am. J. Pub. Health* 26 : 245-247.
- Gibbard, J. A., A. G. Campbell, A. W. H. Needler and J. C. Medcof 1942 Effect of hibernation on the content of coliform bacteria in oysters. *Am. J. Pub. Health* 32(9) : 979-986.
- Grave, C. 1912 A manual of oyster culture in Maryland. *Rep. Shellfish Comm. Maryland* #4.
- Havinga, H. 1928 The daily rate of growth of oysters during summer. *J. du Cons. Perman. Intern. Explor. Mer.* 3 : 321-245
- Herdman, W. A. 1923 *Founders of Oceanography.* Longmans, Green Publishers.
- Hopkins, A. E. 1936 Adaptation of the feeding mechanism of the oyster (*O. gigas*) to changes in salinity. *Bull. U.S. Bur. Fish.* 48(21) : 345-364.
- Kerswill, C. J. 1941 Some environmental factors limiting growth and distribution of the quahaug, *Venus mercenaria* L. Thesis submitted in conformity with etc. Ph.D. Toronto.
- McMillin, H.C. and P. Bonnot. 1931 Oyster culture in California. *Calif. Fish and Game* 17(3) : 246-251.
- Medcof, J. C. 1939 Oyster investigations in the Bras d'Or lakes and studies on the condition factor of oysters. *An. MS Rep. to Fish. Res. Bd. Can.*
1940 On the life cycle and other aspects of the snail, *Campeloma*, in the Speed river. *Can. J. Res. D.* 18 : 165-172.
1940A Oyster investigations in 1940. *An. MS. Rep. to Fish Res. Bd. Can.*
1941 Oyster investigations in 1941 *Ibid.*
1943 The structure, deposition and quality of oyster shell (*Ostrea virginica* Gmelin). MS submitted for publication in *J. Fish. Res. Bd.*
- Medcof, J.C. and A. W. H. Needler, 1941 The effect of temperature and salinity on the condition of oysters, (*Ostrea virginica*) *J. Fish. Res. Bd. Can.* 6 : 253-257.
- Needler, A. B. 1933 Sex reversal in *Ostrea virginica*. *Contrib. Can. Biol. N. S.* 7 : 283-294.
- Nelson, J. 1915(1916) Report of the Department of Biology. *N.J. Agric. Col. Exp. Sta. for year ending Oct. 31, 1915, pp.* 237-260.

- Nelson, T. C. 1929 (1930) Ibid for year ending June 30, 1929, pp. 95-104.
- Nelson, T. C. 1934 Platforms for growing and conditioning oysters. Fishing Gazette, October issue.
- Quayle, D. B. 1940 Condition factor in oysters. Sum. Rep. Pac. Biol. St. for 1940 : 76.
- Seno, H, and J. Hori 1927 A new method for the fattening of oysters. J. Imp. Fish Inst. 20(4) : Japan.