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OYSTER INVESTIGATIONS IN THE BRAS D'OR LAKE AND STUDIES ON THE CONDITION FACTOR OF OYSTERS.

1939

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Introduction

The writer was in Cape Breton from May 16 until November 23, 1939, and continued the oyster investigations he had carried on there in 1938.

Besides the direct investigational work reported below a considerable amount of time was spent over the examination of grounds which had been applied for by prospective oyster farmers. These examinations were almost entirely confined to the Bras d'Or lakes.

Most of the experimental work reported here was carried out at Orangedale, Nova Scotia. The rest was done at the Prince Edward Island Biological Station, Ellerslie, Prince Edward Island, during the spring of 1939 and winter of 1940.

The writer is particularly grateful to his director, Dr. A. W. H. Needler for the advice and encouragement he has afforded in the analysis of problems met with in this investigations.

Rearing Experiments

Tray Rearing

Tray rearing tests similar to those carried out in the past were repeated in 1939. The results, presented in table I, are much like those obtained in 1938. They suggest that spat reared in floating trays do grow better than those placed on deep beds or on shallow flats (See table II of this report and Medcof '38, tables I and II). However, the advantages of tray rearing over bottom rearing are so slight in the Bras d'Or lake that they scarcely warrant the extra labour and expense involved.

The indication is that oyster farmers should stock their areas with oysters obtained by one or more of the following methods:

1. Gathering large "natural" spat from the shores. There is an abundance of stock available for this purpose in River Denys basin.

2. Separating spat caught on artificial collectors or on eel grass and rearing them in shallows where they are protected from the attacks of starfish.

3. By the "brush rearing" method proposed in the section of this report headed "Spat Collection on Brush".

Table I. Tray Rearing Experiments.

Place & Particulars	Density per 4'x12' tray.	Source of spat	Date set up	Date measured 1939	No in measured sample	Growth Increment during 1939	% mortality during 1939	% Increase in size during 1939
Stoney Point	10,000	1938 Coll.	June/39	Nov.11	100	19 - 31		63
	7,000	" "	"	" "	108	19 - 30		58
	5,000	" "	"	" "	105	19 - 29		53
Tray with wooden bottom	5,000	" "	"	" "	212	19 - 25	very high	32
"Fertilization" tray	2,000	1937 "	June-July 1939	" 10	54	30 - 46	0	53
Gillis cove	10,000	1938 Coll spat	June-July 1939	Oct.19	231	19 - 33		74
	5,000	"	"	"	171	19 - 34		79
	1,200	'37"natural" spat picked in fall of '38	"	Nov.12	123	30 - 49	0 (practically)	63
	1,600	"	"	"	130	30 - 48	"	60
Submerged lidless tray resting close to the bottom.	2,000	"	"	"	143	30 -53	"	77
This lot left in tray during both 1938 & 1939.	1,600	"natural" spat gathered in July '38 & reared in tray.	July/38	Oct.19	117	46 - 54	"	17
Malagawatch harbour	7,000	'38 brush spat	July/38	Oct.30	109	18 - 25	very low	39

Table II. Bottom rearing experiments

Place & particulars	Description of stock	Date planted	Date measured 1939	No. measured in sample	Growth increment during 1939 (mm.)	% mortality during 1939	% increase in size during 1939
Stoney P. Shallow Flats	'37 Coll.spat overcrowded	June-July 1939	Oct. 26	119	30 - 32	29	7
Behind 1st breakwater	'38 Col. spat	"	"	130	19 - 28	31	47
	'38 " " left on sections of Coll.	June-July 1939				high	low
	'38 brush spat left on pieces of brush.	"				high	low
Behind 2nd breakwater (water fertilized)	'37 Coll.spat held on trays during 1939	June-July	Nov. 10	86	30 - 39	5	30
Stoney point - Deep water plots. Depth 3 to 7 ft.	large '37 spat held on trays during 1938	July 1938	Nov. 8	42	34- 51	54	50
	'36 spat held on trays in '37	June 1938	Nov. 8	72	45 - 56	High	24
	'37 spat planted directly on bottom	June 1938	Nov. 8	65	41 - 51	High	24
North Basin R. Denys Deep water plto near R.Gillis lease (about	'36 spat planted after rearing in trays	June 1938	Nov. 10	42	47 - 49	high	4

Table II Continued.

Place & Particulars	Description of stock	Date planted	Date measured	No. measured in sample	Growth increment during 1939 (mm.)	% mortality during 1939	% increase in size during 1939
North Basin R. Denys							
Deep water plot near R. Gillis lease (about 6 - 8 feet deep).	'37 spat planted after tray rearing	June 1939	Nov.10	40	30 - 41	35	37
Gillis cove Depth about 4 ft.	'38 spat separated from brush and planted directly on the botto	June 1939	Oct.27	3	18- 30	90	67

latter being merely broken up into sections.

4. 1938 brush spat still attached to short pieces of brush.

Table II. shows that grwwth in these shallows was poor as compared with that at greater depths in Gillis cove in 1939 and at Gillis cove or Stoney point in 1938.

The growth of spat left on sections of collector was conspicuously poor and mortality high.

The brush bearing the 1938 spat, although badly eaten by Teredo, was still strong and had to be chopped up with an axe into short pieces 4 - 6" long, before planting. Many of the spat were killed in this process. It was found that wave action during storms, even though largely interrupted by the protecting breakwater, was sufficient to carry much of the brush ashore. The results of this type of rearing seem very unsatisfactory.

On the whole, the 1939 growth in shallows was not particularly encouraging. However, the summer mortality was much lower than at greater depths, and this partly compensates for the slow growth. There was some overcrowding of the stock on the plots this year which could be avoided in another test. It seems reasonable to continue the test of rearing on flats another year. So far there has been no chance to test the extent of winter killing on these areas.

Spat Collection.

On Concrete-Coated Egg-case Partitions.

This year 525 bundles were prepared and placed in the water, strung from horizontal poles, on July 27,28, and 29, that is, just at the spatfall maximum. Of these, 325 were exposed in Gillis cove, 100 in Orangedale bay and 100 in Martin's cove. The collectors were not uniform in that while most had been "dipped" early in the season and had had ample time to set firmly others were still " green" and barely dry when placed in the water. It was found that the "green" collectors caught almost no spat at all even when hugn adjacent to seasoned ones that, on the average, received heavy sets. It was noticed when, "green" collectors were being hauled tothe surface for examination, that a milky cloud appeared in the water about them, probably caused by the working loose of unset lime in the coating mixture. It was found that although the surfaces of the collectors had received almost no set, the concrete-coated wire wrappers of these had caught just as heavily as the wrappers of the seasoned bundles. It thus appears that the difference in efficiency between the two lots depended on the lengths of the times during which they were allowed to set and not on any peculiar difference in the composition of the cements of the lime used in their preparation. The results of Miller (1938, p.12, Note #2) suggest that the same sort of difficulty may have been met with in Prince Edward Island in 1938.

On the whole the results of spat collection and growth, using egg-case partitions, were satisfactory.

On Brush

The 1938 tests of the usefulness of brush for spat collection were repeated in 1939 with some elaboration. Parctically all the test material was exposed on July 28. Bundles of various kinds of brush - birch, spruce, alder etc. - were wrapped with wire and fastened to vertical stakes in such a way that they were submerged 1 to 4 feet below the surface.

From the 1938 tests it was learned that spat in the crowded central parts of bundles grew more slowly than those on the outer, more exposed brandes. This year clumps of small alders were cut off at the root in such a way that the natural positions of the separate stems were not disturbed and all the branches remained widely separated when submerged in water. Small spruce trees were cut and weighted so as to stand vertically like Christmas trees under water. Besides this several birch trees growing near the water were felled so that while their trunks remained attached to their stumps, practically their whole tops were submerged - some branches to a depth of 6 feet.

All these tests were conspicuously successful for the brush appeared to catch more spat than the laboriously prepared collectors. The growth of spat that settled on the whole bushes and tree tops was uniform and better than that at the centres of bundles of brush but not conspicuously different from than on the outer parts of the buadles.

Tray rearing appears to be impractical in the Bras d'Or lake and yet starfish predation is too extensive to permit the planting of small spat directly onto beds. Besides this, it is often difficult to find suitable flats for inshore rearing of small stock. It is planned, therefore, to leave some of the spat on this brush for two seasons. By the spring of 1941 it should be large enough for direct planting on deep beds without danger from starfish. This system of "brush rearing", if it could be developed, might help solve the lessees' problem of procuring stock for their areas at a low cost.

In this connection it is of interest to record some observations made on 1937 spat attached to brush that was fished from a small inlet off Gillis cove on August 29 this summer. The brush in question was left on the ice during the winter of 1936 and 1937 by wood cutters and must have sunk in the spring of 1937. The "bushyness" of the brush was such as to keep most of it off the soft bottom where small oysters would have smothered if they had been unsupported. It bore a heavy catch of living 1937 spat and almost no living 1938 spat. It may, therefore, be concluded that it caught almost no 1938 spat and that all the oysters involved in the counts, dead and alive, were of the 1937 set. Only oysters of 1 cm. or more in diameter were counted.

A total of 146 oysters, dead and alive, on brush taken from 2' of water showed a 20% survival with fair growth. Only one piece of brush could be found at a depth of 5' and it bore 21 oysters, dead and alive, and showed a 61% survival.

These observations suggest that the proposed method of "brush rearing" described above may have definite possibilities.

On Eel-Grass.

This year there was another heavy spatfall on the eel grass and a satisfactory growth until the fall mortality destroyed 95% of the year's catch. The possibility of exploiting this potential source of stock before the mortality strikes it, appeared worthy of investigation. A "threshing machine" for eel grass was designed using a rotating drum into which were set sections of mowing machine knives. It required some time to perfect this machine but in the end it was developed to such a point that it would chop up the "grass" into short lengths without apparent damage to the shells of spat. By working the drum in water a sorting of its product takes place. The short sections of leaf bearing spat sink to the bottom near the drum while the lighter sections, of grass only, are carried away by the action of currents produced by the rotation of the engine.

Unfortunately, by the time the machine was perfected, the spat mortality had passed its peak and there was little left with which to experiment but "grass" bearing empty shells. It is to be hoped that another year, tests can be made with living stock.

Artificial Stimulation of Spawning.

On the afternoon of July 3, a lot of about 50 oysters was fished from 6 feet of water in Gillis cove and placed in a floating tray at the water's edge. As far as could be determined no spawning had occurred among these oysters to date. The surface temperature ranged between 20 and 21°C.; the bottom temperature at 6 feet was 19.0°. The oysters were put in the tray at 3.15 p.m. By 3.25 some had opened their shells; at 3.35 all had opened but there were no signs of spawning. The spawn of two macerated oysters was, therefore, added to the water to stimulate spawning. After 32 minutes the first oyster, a female, began spawning. Notes were kept on the activity of 5 males and 4 females. Active spawning of the females lasted 21, 30, 33 and 35 minutes and the shell pulsations occurred at the rate of 1.2, 1.4, 0.6 and 0.5 per minute, respectively, for the four animals.

The spawning periods for the males, individually, were 11, 18, 18, adn 19, 21 minutes.

The lengths of the periods must be arbitrarily determined because spawning does not cease abruptly but rather is carried on for a long while at a low rate after the really active period is past.

The water at one side of the tray was shallow and its temperature at the beginning and close of the experiment was 20.8 and 20. 6°C. respecitively. On the deeper side it was 20.1 and 20.0. The first oysters to spawn were on the warm side of the tray.

The rate of pulsation of the female oysters during the act of spawning was lower here than is reported by other workers (Galtsoff 1938) and the length of the spawning period too is extended. These processes may be subject to temperature regulation.

Spawning and Larval History in 1939.

A study essentially like that of 1938 (Medcof 1938) was carried out for Gillis cove. The adults were very "poor" and developed only a thin layer of spawn. The temperature rise of July 5, 6 and 7 apparently induced the only important spawning of the season. The resulting brood of larvae was composed of a single compact age group.

Size-frequency distribution studies were made on samples of larvae taken in tows made with a #18 silk bolting-cloth plankton net, on various dates. Measurements were made using an ocular micrometer in combination with a Leitz 10X ocular and #3 objective. (1.0 ocular divisions equal 140μ). The results of the measurements appear in table III.

Spatfall was carefully followed by counts of spat settling on experimental collectors of the same type as those used in 1938. The results of the counts appear in table IV. The settlement maximum occurred on July 29. That day there was an average set of 7.7 spat per square centimetre of experimental collector. The results show that the mean free-swimming period lasted approximately 23 days. The daily average water tempeature during this period (taking the average of both surface and bottom readings) was 22.2°C. This result fits very closely with the records for Prince Edward Island (Medcof 1939).

Table III. Size-frequency distribution of heights of oyster leavae and

ize in Oc. Mic. ivisions (1.00 = 140 u)	Totals	.30	.35	.40	.45	0. .50	.55	.60	.65	.70	.75	.80	.85	.90	.95	1. .00	.05	.10	.15	.20	.25	.30	.35
ate: July 7						1	1	1		1													
July 9						11	21	2	1														
July 11					2	4	6	3	1	not enough													
July 13	40					1	11	17	9	1	1												
July 17	39									5	6	14	4	3	4	3							
July 20	72												2	4	9	9	16	18	6	5	1	2	
July 23	63																	1	4	3	3	6	7
July 25	115																						1
July 27	100																						
July 28	100																						
July 29	75																						
July 30	100																						
ly 26 - 28	82	Prodissoconch measurements of spat														# Mode							
ug. 1 - 3	93	"					"			" "													

spat prodissoconchs from Gillis cove 1939.

2.

.40	.45	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95	.00	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.7
8	7	11	3	2	2	3	1	2																			
2	1	4	8	12	11	13	14	14	9	3	5	2	3	4	4	0	. 1	4									
							1	2	3	3	5	4	3	11	11	13	10	9	14	5	3	1	2				
									1	2	2	4	3	2	5	9	11	9	17	14	11	8	1	0	1		
														1	1	2	2	8	8	14	12	14	12	1			
																2	3	7	14	15	24	12	14	5	1	2	
													1	1	0	1	2	10	13	12	14#	10	6	6	6		
																2	1	2	4	2	8	16#	16	15	13	11	

mature larvae of O. edulis and O. lurida. It seems reasonable to suppose that these inconsistencies are not due to faulty observation or racial differences in the various stocks of oysters concerned but are the natural result of environmental influence such as that just demonstrated for O. virginica.

The work of Nelson (1923) suggests a marked decrease in larval growth rate during the last three days of the larval period. If this were true then there should be a conspicuous accumulation of larger sized larvae about the time of settlement. This has not been observed. The year's results do show, nevertheless, a slight decrease in growth rate during the last two days. However, this is so slight that it is assumed to be the result of falling water temperatures observed on these dates.

The maximum sets occurred on July 29, so that the mean growth curve for the brood should not be continued beyond this date. It seems significant that if this date had not been definitely known we should have been tempted to extend the curve to include a point on the date line marked "July 30". If this had been done then the resulting curve would have taken on a shape approximating the sigmoidal type drawn by Nelson.

The same problem can be approached from a different angle. The results of the prodissoconch measurements of spat settling on July 27 (table III) show that 80% of the settling larvae fell into a compact size group ranging in size from 2.30 to 2.60 ocular micrometer divisions. The difference in size between these two extremes represents three days' larval growth (At this time the larval growth rate is approximately 0.10 ocular micrometer divisions or 14 μ per day).

Reference to the records of larval measurements for July 27 (table III) will show that the group of larvae clustered about the mode and ranging in size from 2.075 t 2.375 ocular micrometer divisions (The difference again between the two extremes is equivalent to 3 days' growth.) included 66% of the sample of larvae measured. Assuming larval growth rate to continue without slackening it might be predicted that within a three-day period centreing about July 29, 66% of the larval population would settle. The actual records (table IV) show that 62% did. The close agreement here seems to be fairly conclusive evidence against a decrease in larval growth rate about the time of settlement.

From this consideration and from studies of other broods by Miller (1938 and 1939) and Medcof (1938 and 1939) it may be safely concluded that there is normally no conspicuous slackening in the larval growth rate at the close of the larval period in the waters under consideration. It is possible that Nelson has made his curve sigmoidal because he lacked definite knowledge as to the position of its end point - that is, because he did not know the exact date of the settlement maximum for the brood studied.

Conclusions

In Gillis cove larval growth and maturation in 1939 were essentially like those recorded for 1938 and closely resemble those in Prince Edward Island waters.

High temperatures not only increase the growth rate and shorten the larval period but also reduce the ultimate size attained by larvae.

There is no conspicuous slackening in larval growth rate near the close of the larval period.

Spatfall on Experimental Collectors.

The same type of experimental collector was used this year as in 1938 (Medcof 1938) and the results of the counts on these appear in table IV. The data show several interesting features which are pointed out below.

The total set on the collectors this year was only 49% of that recorded for 1938. Besides this there are peculiarities in vertical distribution and in relative intensities of settlement on upper and lower surfaces which distinguish the two years.

These are summarized in the table below.

Depth of Collector	Ratio of set on upper: on lower surface.	% of total set	Ratio of set on upper: on lower surface.	% of total set.
Surface	100: 80	1	100: 60	4
1'	100:150	11	100: 90	8
2'	100:170	13	100:120	23
3'	100:380	26	100: 90	25
4½'	100:250	23	100:150	22
6½'	100:320	26	100:160	18
For total at all depths	100:260		100:120	

In both years the intensity of settlement was highest at a depth of 2 - 4 feet below the surface although there is little difference between this and the settlement intensity at 6½ feet which latter was only one foot above the bottom.

Of the total catch, the percentage settling on lower surfaces was higher in 1939 than in 1938.

In both 1938 and 1939 there was only one period of intensive spatfall lasting 9 and 8 days respectively. The catch came one week later in 1939 than in 1938. In both years spatfall, in greater or less amount, continued for over a month.

Table IV. Spatfall on experimental collectors in Gillis cove, 1939.

Date	Surface		1'		2'		3'		4½'		6½'		Total catch	Catch per day on 930 cm. of collector
	up	down	up	down	up	down	up	down	up	down	up	down		
July 24 a.m. to July 26 5pm.	1	0	0	1	0	2	1	1	0	0	0	1	7	3
July 26 to July 28, 5PM	0	2	128	239	137	252	111	777	218	681	155	649	3389	1695
July 28, 5PM to July 29, 5;25 A.M.	0	0	91	400	97	478	117	1510	100	870	255	940	4858	4858
July 29, 5:25 PM to July 30, 11:30 AM	0	0	12	19	54	65	62	78	108	107	80	169	754)	1162
July 30, 11:30 PM to July 30, 5:25 P.M.	0	0	37	4	34	30	32	34	73	89	13	62	408)	
July 30, 5:25 PM to July 31, 7:10AM	0	0	21	34	61	46	20	105	82	98	34	298	799)	1386
July 31, 7:10 A.M. to July 31, 5:25 PM	33	55	39	25	23	71	91	63	64	19	34	70	587)	
July 31, 5:25 P.M. to Aug. 1, 7:10 A.M.	23	6	32	22	36	64	44	98	61	51	50	66	553)	
Aug. 1, 7:10 A.M. to Aug. 1, 5:25 P.M.	13	5	25	43	37	18	33	26	37	40	23	29	329)	882
Aug. 1, 5:25 P.M. to Aug. 3, 5:20 P.M.	29	11	209	64	204	80	212	77	151	204	177	340	1758	879
Aug. 3, 5:20 P.M. to Aug. 5, 5:40 P.M.	4	0	5	3	6	9	12	28	8	28	8	22	133	67

Table IV Continued

Date	Surface		1'		2'		3'		4½'		6½'		Total catch	Catch per day on 630 cm. collector
	up	down	up	down	up	down	up	down	up	down	up	down		
Aug.5, 5:40 P.M. to Aug. 7, 5:50 P.M.	0	0	3	3	0	6	7	11	1	17	5	21	74	37
Aug. 7,5:50 P.M. to Aug. 8, 5:50 P.M.	0	1	1	0	2	3	1	5	3	13	8	24	62	62
Aug.8, 5:50 P.M. to Aug. 9, 5:5o P.M.	0	0	0	1	0	3	2	2	2	8	1	6	25	25
Aug. 9, 5:50 P.M. to Aug. 10, 5:5o P.M.	0	0	3	3	1	3	2	6	2	11	3	8	41	41
Aug.1 , 5:5o P.M. to Aug. 12 5:4o P.M.	0	1	1	0	1	1	3	8	0	6	3	15	39	20
Aug.12, 5:40 P.M. to Aug. 15, 5:40 P.M.	0	0	1	5	1	3	0	8	0	5	1	11	35	12
Aug. 15, 5:40 P.M. to Aug. 18, ~~xx~~ 7:00 PM	0	1	1	12	0	8	2	18	2	19	3	21	87	29
Aug. 18, 7:00 P.M. to Aug. 21, 6:00 P.M.	0	0	0	1	0	0	0	4	2	7	1	6	21	7
Totals	104	82	605	879	694	1162	752	2868	914	2275	854	2758	13,947	

The effect of Winds on the Distribution of Larvae.

A peculiar phenomenon was observed during the week of July 9. Small straight-hinge oyster larvae were captured in abundance in a tow made on July 7. During the afternoon of July 9 there was a strong southwest gale that set a heavy sea running in the main part of the lake and, no doubt, caused considerable disturbance even in such protected places as Gillis cove because the water temperature there fell 6°C. in that one day. After the water had quieted down a tow was made at 6 p.m. to see how the larvae had "stood" the blow. Whereas two days before hundreds of larvae were captured in a ten-minute tow, it was hard now to find a dozen in working over the catch. The picture was the same on July 11 when it was impossible to get enough larvae for a size-frequency study. On this day there was a fresh breeze from the east.

On the morning of July 13 there was a fresh northwest breeze that died out later in the day. On the last date a tow in Orangedale bay yielded almost no bivalve larvae whatever. A 25 minute tow in Gillis cove was made the same day., the net being hauled near the surface part of the time and part of the time at a depth of about 8 feet, which was as deep as could be managed with safety to the net. The catch was extremely scant for only thirty larvae were found after a long examination.

It was necessary to get more larvae for the study of growth rate so on July 18, a warm but breezy day, the tow was not made until 7:30 P.M. when the wind had died down and the water was quite still. A good catch of larvae rewarded a tow of only 12 minutes. No further difficulties were experienced in getting ample catches especially during the fair weather of the last few days of the larval period.

The writer has dwelt on the observed effects of wind it may explain a peculiar condition reported for the cove by Smith (1937). Larvae were difficult to find yet a satisfactory set was obtained. This appears to parallel the present experience. Miller (1938) has shown the effects of a two-day gale - July 9 - 10 - at the Prince Edward Island Biological Station. On July 11 larvae were present in the upper 4 feet of water in only 2% of their abundance at this level on July 8. By July 12 they had recovered their former distribution. Pump samples taken 6 inches above the bottom at such times showed no increase in the numbers of swimming larvae at that level. Other workers have made similar observations and the writer is inclined to agree with Truitt (1925) who believes that the larvae spend a considerable part of their time resting on the bottom during storms. Apparently the larvae recover very quickly from the disturbances.

Fortunately, there was little or no heavy wind during the period, July 29 to August 1, to interfere with the results of tests made to determine the effect of light on larval settlement.

Conclusions.

The churning of water by heavy winds forces the larvae away from the surface but as soon as the disturbance is past the former distribution of larvae is quickly restored. During the period of disturbance many larvae probably rest on the bottom.

The Effect of Light on Larval Settlement.

Cole and Jones (1939) found that the rate of spatfall of *Ostrea edulis* in tanks was approximately three times as great during daylight as at night. A crude attempt was made to test the effect of light on larvae settling under the more natural conditions of Gillis cove. Beginning the evening of July 29, the experimental collectors were renewed both morning and evening (instead of in the evening only) for three days, at the times indicated in table IV. Apparently the uppermost of the six collectors was not submerged during the first three periods of the test for no spat at all caught on it. Ordinarily it is submerged three or four inches below the surface. For the above reason calculations were based on records from the five collectors from the one to six-and-a-half-foot levels only. The following table summarizes the results.

Rates of Settlement (Expressed as number of spat per collector per hour of exposure).							
	Two upper collectors considered together		Mid-depth collector		Two deep Coll. considered together		Average for the three depths.
	Day	Night	Day	Night	Day	Night	
Upper and lower surfaces considered together.	7.2	5.0	10.3	8.9	10.2	13.1	Day rate 9.2
Day and night considered together	6.1		9.6		11.7		Night rate 9.0
Rate on upper surface along.	3.6	2.3	5.8	2.7	4.5	4.5	Day rate 4.6
Day and night considered together.	3.0		4.3		4.5		Night rate 3.2
Rate on lower surface alone	3.6	2.7	4.6	6.1	5.7	8.6	Day rate 4.6
Day and night considered together	3.2		5.4		7.2		Night rate 5.8

The results agree with those of Cole and Jones in that the sets, except at the bottom, were heavier during the day than at night. The difference, however, is not nearly so great in Gillis cove as in the Conway tanks. This discrepancy may be partly explained from the fact that, in the present test, each "night" collector was exposed to spat fall not only during several hours of darkness but also during some bright daylight and to both orning and evening twilight. The "day" collectors, on the other hand, were exposed only during daylihgt. In the results, therefore, differences in larval behaviour in light and darkness would tend to be obscured by the manner in which the present test was conducted.

Conclusions from study of the above table.

Considering sets on upper and lower surfaces of collectors together:

1. The intensity of spatfall increased with depth.

2. The rate was almost the same, on the average, during the day and night but heavier near the surface during the day than at night.

Considering the sets on upper and lower surfaces of collectors separately:

3. Upper surfaces caught more during the day than at night. The greatest change of this sort was observed at mid-depth.

4. Lower surfaces caught more at night than during the day.

5. The rates on upper surfaces of collectors (considering the night and day together) is very slightly altered with depth.

6. In the case of lower surfaces this rate increases with depth.

Most of the above observations can be explained on the basis of two assumptions. First, that the settling larvae are positively phototropic over the range of intensities experienced in the test and, second, that the intensity of settlement at any level is a measure of abundance, at that depth, of larvae that are prepared to settle. In the following explanation and discussion of the results these assumptions are made.

As the mature larvae swim about preparatory to settling, they gravitate towards the bottom and tend to settle near the bottom on lower surfaces. Just why lower surfaces are preferred is a point on which investigators disagree. The above picture is very clear during the night.

In the daytime many of the larvae are stimulated to swim upwards under the attraction of light and settle more heavily in the surface layers than they do during the night. In swimming upward they avoid the shadows cast by the horizontal collectors and hence, the under surfaces of collectors. The sets on upper surfaces are, therefore, relatively greater during the day.

Further explanations and conclusions based on these assumptions are tempting but seem hardly justified when the crudeness of the experimental method employed is taken into account. It is, nevertheless, interesting to indicate the results of other workers for comparison.

Cole and Jones, using clear and opaque glass plates and counting only spat on lower surfaces, concluded that larvae of O. edulis seek shade under surfaces for settlement. They explain the abundance of larvae near the surface of their tanks as the natural result of swimming habits which keep them in the brighter upper layers during the day in spite of their supposed negative phototropism.

Hopkins (1937), in experimenting with O. lurida found that although the upper surfaces of his test collectors caught no spat at all, still, the transparent glass plates took more on their under surfaces than did his opaque plates. The ratio 616 to 435, respectively, he did not consider significant and concluded "that the shadow under the opaque glass did not result in any increase in catch". The statement is clearly true and would support a belief in a preference, on the part of larvae, for better lighted surfaces. Other of his tests show that stage of tide, salinity, turbulence and pH. are important factors regulating the intensity of settlement. The observations of Miller (1938) and those of the writer discussed in the section "The effect of winds on larval distribution" suggest that weather conditions should be taken into consideration as well.

Prytherch (1934) states that he has no evidence from his study of O. virginica of any photosensitivity of larvae. Nelson (1926) states that settling larvae of this species seek the shade of under surfaces and are stimulated to swim until they find such locations. Truitt (1926), on the other hand, has made laboratory tests that clearly indicate a positive phototropic reaction of larvae of this species.

As far as the writer is aware, the present study of the relative distribution of settlement on upper and lower surfaces during the day and at night, is the first of its kind. This rough preliminary test indicates that further observations of this same type might do much to enlarge a very complete understanding of larval behaviour as influenced by light.

Conclusion.

The present results indicate that the larvae are positively phototropic.

Spat Mortality

As in 1938 there was a heavy mortality among the brood of the year but this season it was followed more closely and was found to have two maxima. The first was less conspicuous since the spat involved were chiefly microscopic having settled only a few days. The second was late in the season when the animals had attained their full season's growth. The fundamental causes of these are still obscure but several pertinent observations are mentioned here.

Summer Mortality (Immediately after the set).

4 This mortality, since it involved such small oysters, attracted no attention from the oyster fishermen. In most cases as in 1938 it appeared more serious in places where the spat were closely crowded together on plane surfaces as on egg-partition collectors, the blades of deciduous leaves and the smooth surfaces of oyster shells. Mortality was observed, nevertheless, among spat that settled in smaller numbers on twigs, blades of eel-grass, etc. Counts were made on spat observed under the compound microscope and the results are listed in the table below.

Ciliate protozoans were found between the valves of dead spat in cases where remnants of the soft parts of the body were still present. In a few instances they were also found between the shells of spat that were apparently still alive. Collections of the ciliates were made and smears, fixed in Bouin's fluid, 95% alcohol and formalin, prepared. No identification of these has been attempted yet. It was impossible

To decide whether the presence of the ciliate was primarily or secondarily related to the mortality.

<u>Summer Mortality.</u>

Date	Remarks		No.of spat examined	Mortality
July 30	Gillis cove spat on deciduous leaves and spruce needles: Some still retained the eye spots;			none
Aug. 5	Gillis cove, spat: on deciduous leaves: Some show ciliates between valves: all show some dissoconch shell			light
Aug. 7	Stoney Point: Collector spat: show cilates Eel-grass spat no cilates			high none
Aug. 8	Stoney Point :	spat on oyster shells	36	9%
		" " collectors	19	26%
Aug. 10	Gillis cove. spat	On eel-grass	44	48
		On deciduous leaves	48	52
		On spruce leaves	58	62
		On wire wrappers of collectors	22	~~XX~~ 41
		On sections of unseasoned collectors	22	77
		On " of seasoned collectors	30	60
Aug. 15	Gillis Cove: spat	On eel-grass	30	45
		On deciduous leaves	75	80
		Spruce leaves	26	79
		On plain cardboard (where concrete had chipped off collectors).	18	94
		on broad pieces of birch bark	900	98
		(On slender shreds of birch bark	400	96
S	Stoney P; spat on eel-grass	probably with better circulation	43	51
Aug. 19	Stoney Point; on oyster shells spat		74	31
Sept. 1	Stoney P. on oyster shells spat			100

A complete series of collectors was preserved with the hope of conducting a winter study of this mortality. Unfortunately it was impossible to distinguish on these dried collectors, the " living" from the "dead" spat. This fact has made the above table much less illuminating than it might otherwise have been.

Fall Mortality

The wholesale deaths occurring at this season attracted the notice of several local oyster fishermen. The spat by this time were thumb-nail-sized and the large number of empty shells occurring on the eel-grass hauled up on oyster rakes by the fishermen, was startling. Counts were made on October 27, on two collections with the following results. (Counts were made only on shells measuring at least 1 cm. in diameter).

	Number Counted	Mortality %
Gillis cove eel-grass spat	62	97
Morrison " " " "	110	71
" " spat on brush from a submerged bundle	69	6

The brush spat showed a very light mortality both in Morrison's and Gillis cove although no actual counts were made in the latter place.

It is to be noted that at this season the eel-grass became overgrown by a thick blanket of matted algae that weighed the blades down to the bottom and, no doubt, seriously interfered with the water circulation over them. Similar growths were found on collectors in the sheltered parts of

Orangedale bay and Martin's cove. In these two places the collector spat of about this same size suffered a general mortality ranging as high as 90% for some collectors. In exposed parts of Gillis cove no such fouling of the collectors was observed and no fall mortality among collector spat.

A further check on the fall mortality was possible since several bundles of spat had been brought from Gillis cove in August and left at Stoney point. Some of these were laid on the bottom behind the breakwater and were overgrown by algae as were those in Martin's cove. A similar mortality was also observed. Other collectors were placed in floating trays at Stoney point directly above those laid on the bottom. On the former the spat showed an unusually high percentage survival. In the trays the circulation is known to be good.

The available evidence points to the conclusion that the fall mortality was brought on simply by "smothering" by algae growths which interfered with the water circulation.

The Effect of Light on (Shell) Growth

In June two special floating trays were built. Each had four compartments 3' by 4', two of which were supplied with wooden covers. A third was covered with quarter-inch-mesh wire screening and the last by panes of window glass. One of these was moored at Gillis cove and the other at Stoney point. In each compartment of the Gillis cove tray 150 small oysters were placed. These were of the 1937 set and were "natural" spat gathered from the shore of the basin of River Denys in the fall of 1938. The Stoney point tray was similarly stocked with 1938 spat picked off the wire wrappers of bundles of collectors.

It was found that a vigorous growth of algae of various sorts developed on the wire bottoms of the compartment's covered by screen and glass. For this reason the trays were frequently hauled and thoroughly cleaned.

Measurements were made on these oysters in October and November. Modal values from size-frequency distribution studies of average diameters were used as the indices to size. The results are summarized in the table below.

Rearing	Gillis cove (1937 spat)			Stoney point (1938 spat)		
Conditions	No. Measured	Growth Increment (mm.)	Size Increase (%)	No. Measured	Growth Increment (mm)	Size Increase (%)
In the dark	92	37 - 59	60	159	18- 45	150
Under Glass	96	37 - 55	49	168	18 - 38	111
Under Screen	105	37 - 52	41	111	18- 39	117

The data suggest that light exercises a strong inhibitive effect on shell growth. This result checks with that obtained by Kerswill (1939) working with quahaugs, mussels (Mytilus edulis) and oysters in Bideford river and that of Huntsman (1921) who studied the mussel in the Bay of Fundy. Orton (1928), on the otherhand, has suggested that certain actinic rays stimulate shell growth.

These results have a practical interest because of certain changes that are being made in the methods of oyster culture. In the past it has been the custom to rear spat during their second summer in floating trays with wooden covers that protect them from all light. During the last few years more and more people have been rearing small stock in shallow tidal flats where they are left dry at low tide. Even when the tide is "in" these animals must be exposed to intense light on these shallows.

More than one factor, therefore, probably operates to reduce growth rate here: 1. Exposure at low tide reduces the feeding period. 2. The bright light probably depresses growth.

It would be interesting to compare the normal growth on these flats with that under protecting rooves that could be arranged to shade the oysters from direct light.

The Effect of Light on the Shell Proportions of the Oyster

The most uniform stock of oysters available for testing the effects of light were the "natural" or "eel-grass" spat of 1937 planted in the light test tray in Gillis cove. These were all "singles" and had the advantage of a smoothness and symmetry surpassing that of any spat taken from commercial collectors. Shell measurements of length, width and thickness were made on random samples taken at the beginning of the experiment and at the end of the summer's growth. The results are listed in the table below:

	Original Stock Measured June 30/39	measured September 30/39 After summer's growth under lids made of: Screen	Glass	Wood
Value of ratio $\frac{\text{thickness}}{\text{Average Diameter}}$ with standard error	0.345 0.007	0.349 ± 0.003	0.344 ± 0.003	0.334 ± 0.0
Difference from the original with standard error		$+0.004 \pm 0.008$	-0.001 ± 0.008	-0.011 ± 0.00
Number of specimens measured	33	30	75	75

When the standard error of the difference between two means is less than one=half the difference, then the means are usually considered to differesignificantly. (The standard error of the difference between two means is equal to the square root of the sum of the standrar errors of each of the two means being compared.) From the table it appears that in no case did the values of the ratio at the end of the season differ significantly from that at the beginning of the season.

If, however, the means for the screen, wood and glass sections be compared among themselves it will be seen that (1) the mean for the glass differs significantly from that for the wood (Difference 0.010 ± 0.004). (2) the mean for the screen differs significantly from that for the wood (Difference 0.015 ± 0.004). (3) The mean for the glass does not differ significantly from that for the screen (difference 0.005 ± 0.0025).

From the above analysis it may be stated that the animals grown in the glassed and screened sections were significantly thicker than those grown in the section with the wooden cover, but the thicknesses of those in the glass did not differ significantly from those in the screen compartment.

Criticism of Results.

An attempt was made to examine the reliability of the ratio $\frac{\text{Thickness}}{\text{Average Diameter}}$ as used in this experiment for testing shell proportion. The values of the ratio for the 20 smallest wooden-covered section of the tray were compared. These are listed below.

	For whole sample of 75	For 20 smallest	For 20 largest
Value of Ratio $\frac{\text{Thickness}}{\text{Av. Diameter}}$	0.334 ± 0.002	0.331 ± 0.0005	0.325 ± 0.007
Difference from mean for whole sample of 75		0.003 ± 0.002 (Not significant)	-0.009 ± 0.002 (Significant)

From this table it appears that the smaller animals do not differ significantly in thickness from the average for the sample but the larger, faster-growing ones do, being thinner. The same proved to be true in the case of large and small oysters in the section covered by glass. It is quite possible that the value of the ratio varies with size or age or growth rate taken either independently or in combination one with another. The slight difference pointed out above between the thickness of animals in the different compartments may have been produced by some factor other than difference in illumination. This point can be discussed better at the end of another season(growth when more data will be available. It is planned to carry the same stocks in these trays through the summer of 1940.

No comparison has yet been made of the values for oysters growing in shallow flats and at greater depths under more natural conditions. Such a comparison might be illuminating, for light intensities at depths are obviously much lower than on flats.

Effect of Artificial Fertilization of Water on Growth.

Cole (1939) has shown for O. edulis that the food supply may be the controlling factor in the growth of spat in rearing tanks. It has also been suggested (Medcof 1938) that the slow growth of River Denys basin oysters is directly related to a poor food supply. If this is true, then, conceivably, increasing the availability of food should encourage growth. To test this possibility a second and smaller breakwater than that already described was built on the shallow flat at Stoney point. A plot behind this in 1 - 2' of water was stocked in July with 1937 spat carried on trays during 1938. A small tray with a quarter-inch-mesh wire bottom was moored over the plot. To this was added each week, 6 dead perch (Morone) 6 - 10" long. The bodies of these disintegrated quickly and the small pieces sifted down over the oysters on the bottom. At the same time the fertilization tray itself was stocked (to a density equivalent to 2000 per 4 by 12' tray) with oysters from the same source.

Counts of flagellates made on July 30 show that fertilization greatly increased the abundance of these organisms which are known to be an important source of oyster food. (See section on "Plankton Studies").

In November measurements showed that both lots of oysters which had had the advantages of water fertilization had grown better and shown a better survival than oysters of the same stock which had not. (See tables I and II.) This observation along with the fact that adult oysters fattened better in fertilized water, and the results of the study of abundance of planktonic organisms lends support to the 1938 conclusion that food supply is a controlling factor in oyster growth in River Denys basin.

Plankton Studies.

Flagellate Counts.

During the season several counts were made on the abundance of minute flagellates in the water. The results for water samples taken at Stoney point from near the surface are presented below.

Date	Abundance per cu. mm.	Remarks
June 20	15	
July 13	15	
July 30	26	Sample taken from behind the larger breakwater over the shallow flats.
" 30	41	Sample taken from behind the smaller breakwater where the "fertilization" test was being carried out.
Sept. 6	80(?)	This is a high count for this district.

The results agree with those obtained last year (Medcof 1938) and suggest that the abundance of these organisms in the Bras d'Or lake is less than in Bideford river, Prince Edward Island. Since these are known to be of importance as oyster food it is not surprising that Stoney point oysters are generally in poorer condition than those in Bideford river.

Other Plankton Studies

In connection with the condition study of oysters described in another section of this report, a rough estimate of the total amount of plankton in the water at different seasons was made. This was done by measuring the depth of the deposit, poisoned with formalin, that settled to the bottom of a pint jar holding the catch from a ten-minute haul with a #18 silk bolting cloth net. A brief history of the changes in the amount and composition of the catches taken in River Denys basin, at Malagawatch and at St. Ann bay is presented in tabular form below.

River Denys basin.

Date	Place	Deerription of catch	Depth of the deposit in (mm.)
May 27	Stoney point	diatoms abundant. Testate ciliates present; dinoflagellates common	5
June 10	"	diatoms and other minute forms very common; copepods abundant; gastropod and bivalve larvae common	17
June 19	Gillis Cove	a small blue-green alga is common; diatoms and dinoflagellates are decreasing; more copepods now;	17
June 20	Stoney Point	only 1 type of dinoflagellate left now; some copepods; ctenophores common	2
July 7	Gillis cove	much floating algal mat off the bottom: diatoms present in small numbers: only 1 type of dinoflagellate left and it is rare: copepods have decreased; bivalve larvae common: Aurelia very common	5
July 20	Gillis cove	practically nothing in tow but molluscan larvae	-
July 31	Gillis cove	practically no phytoplankton but many molluscan larvae.	-
Aug. 15	"	Tow practically barren of everything	-
Aug. 31	"	very scant catch: diatoms and dinoflagellates rare	1
Sept. 7	Stoney Point	light catch: more diatoms and dinoflagellates	-
Sept.14	Gillis cove	light catch: several types of dinoflagellates present in fair numbers; some zestate ciliates: copepods rare	2

Fattening period

Table continued.

Fattening period.	Sept. 27	Stoney point	light catch: contained practically nothing but dinoflagellates:	-
	Oct. 19	Gillis C.	light catch: mostly phytoplankton	1 - 2
	Nov. 2	Stoney point	light catch: mostly phytoplankton: several ctenophores:	
			Malagawatch	
	June 19		dinoflagellates common: copepods abundant.	
	July 7		almost entirely dinoflagellates and diatoms; a heavy catch:	5
Fattening period	Sept. 6		Many dinoflagellates: diatoms present: Some copepods:	3
	Oct. 4		Heavy catch of phytoplankton	3
	Oct. 28		Heavy catch of phytoplankton	-
			South gut - St. Ann bay	
	Aug. 7		heavy catch:	8 (?)
Fattening period	Sept. 1		Heavy catch: mostly phytoplankton:	4
	Nov. 3		Heavy catch: many diatoms:	3

From the above table it is seen that the plankton catches from River Denys basin during the fattening period were consistently lighter than those taken at Malagawatch and at St. Ann bay. The condition of the oysters in the two latter places was better than in the first. There was, therefore, in the three places concerned a clear relationship between the abundance of plankton organisms and the condition of oysters. This fact combined with the conclusions from the studies reported under the headings "The Relation of Temperature to Fall Condition", "Effect of Artificial Fertilization of water on Condition" and "Effect of Artificial Fertilization of Water on Growth", suggests that food scarcity is one of the important causes of the poor growth and fattening of oysters in River Denys basin.

Jellyfish

According to the local oyster fishermen about Orangedale, Cyania is the common jellyfish in most seasons, about the Bras d'Or lake and Aurelia, although usually present, normally occurs only in small numbers. This was the condition observed by the writer in 1938. This year, however, the condiditons were completely reversed.

Besides the unusual general abundance of these animals great "schools" of them were observed several times during the summer. The groups were generally sharply outlined and compact. One was particularly conspicuous. It was found at Stoney point about 400' off shore where the water was about 18' deep, in the late afternoon of a calm bright day in early August. The school was about 125' long, 30' wide and extended at least to a depth of 12' which was as deep as the failing light permitted vision. The animals in the group were of all sizes ranging from 4-14" in diameter and were so crowded together that they were frequently touching one another. Only one Cyania was noted in the group. No explanation is offered for this peculiar clumping. The local fishermen state that this is not an infrequent phenomenon.

The Australian Mud Worm

In 1938 the writer made brief observations on the Australian mud worm Polydora ciliata in the Bras d'Or lake (Medcof 1938). During the condition tests carried on in 1939 there were opportunities for a better study. The results from the year's observations are summarized below.

Locality	Size of oysters	No.of oysters examined	% showing infection	Av. No. of worms per infected oyster
Stoney point (R. Denys basin)	Adults	76	40	1.6
Gillis cove (R. Denys basin)	"	61	25	1.5
Malagawatch lake	"	61	34	3.1
Crowdis bridge,'38	"		75	
Gillis cove & Stoney point,'39	Large tray spat	194	4	1.0

In all but one case the small oysters that were infected came from the lighted compartments of the "light-test" trays at Gillis cove and Stoney point.

Besides the above records, worms were found in 3 out of 10 examined oysters from the bar at Malagash on July 31, 1939. At no time has the writer seen blister worms in oysters from Malpeque bay or South gut.

The 1939 results are instructive because they show what was not observed in 1938, that the worm has a general distribution in the Bras d'Or lake occurring even in oysters found on very hard bottom. The last is clear from the

Malagawatch records where the percentage infection ran above average and the intensity of infestation of infected animals was higher than at Gillis cove where the bottom is much softer. Of the several localities mentioned, Crowdis bridge appears to provide the best conditions for the mud worm's activity. Here there are large shallow areas of soft bottom flooded by water of low salinity and heavily populated with oysters.

The results of the condition tests suggest that worm-infected oysters are not, on the average, conspicuously poorer than the uninfected. Of 55 oysters on which individual records were kept 30 were found to be below and 25 above average condition within their respective groups. The suggestion is that the mud worm does exercise a slight deleterious effect on its host. In spite of this, last year's conclusion still stands. There are no indications that the mud worm is likely to become a serious pest.

Resistance of Various Woods to Attacks of Shipworms

A number of local people about Orangedale insisted, during the early part of the season, that poplar wood was immune to the attacks of shipworm. In July, therefore, several pieces of wood were placed in the water and weighted with stones to anchor them. These were examined on November 12 with the following observations:

Pealed green poplar stake	- heavily infested
Poplar stake with bark left on	- worms had entered in small numbers at the knots where limbs had been cut off: otherwise not attacked.
Dry poplar board	- heavily infested
Spruce pole with bark left on	- not attacked
Malpe pole with bark left on	- not attacked
Dry spruce board	- heavily infested
Pealed green spruce stake	- heavily infested.

The results suggest that there is no special protecting quality shown during the first year's exposure of either green or dried poplar. The bark of the various woods on the other hand does seem to be effective in warding off the attacks of shipworms.

Specific Gravity of Oyster Shells

The hardness of the shells is an important character in the fishing, handling and shipment of oysters - a fact well known to the trade. Observations suggest that the harder a shell is the "heavier" it is. During the condition tests there was an opportunity to study the specific gravities of shells from different districts and from different types of environments. The results of the tests made are listed in table V.

The results for the Malpeque district show that the specific gravities increase towards the "open" bay. It is generally recognized that quality varies in the same way and that growth rate varies in a directly opposite fashion. Rapid growth, then, goes hand in hand with the production of lighter shells. Orton and Amirthalingan (1927) have suggested that "chalky" deposits can be formed much more rapidly than "normal" shell and chalky shells like those of the Bras d'Or lake have low specific gravities (table V). All these conditions may be directly related to one another.

There is a further consideration that bears on this subject. Orton and Amirthalingam have shown that in some stocks of oysters there are two layers of normal shell put down each year interspaced with a chalky deposit. They have also suggested that the laying down of the chalky deposit permits the even contact of the mantle with the shell. May it be that the "need" for chalky deposits is most acute at times when the oyster is in poor condition? If this were true then there is one available explanation for the extreme chalkiness of River Denys basin shells because these oysters are extremely poor for long periods during the summer.

The data appearing in table V indicate a clear relationship between salinity of the habitat and the specific gravity of shells. Throughout the Bras d'Or lake the salinities are low and so too are the shell specific gravities. It is peculiar that the transfer of Bras d'Or oysters to South gut has not brought about any change in the shell specific gravity. This may be because there has been little shell growth in the three years since the transfer.

There is some slight indication that oysters growing on flats where they are exposed to a strong light, have heavier shells than those growing in deeper waters near by. When small oysters are removed from flats and placed in floating trays their shell specific gravity goes down except in cases where they are exposed to light in these trays. There is more or less clear evidence that growth in deep water and in covered trays is faster than on flats and in lighted compartments of trays, respectively, so that the differences observed may be entirely due to this factor of differential growth rather than to any effect of light or exposure. The faster-growing 1937 collector spat that were tray reared in 1938 have lower specific gravities than the "natural" shore spat.

The problem opened up by these observations is interesting in its complexity and of sufficient importance to warrant further study.

Table V. Specific gravities of oyster shells.

Place	No. of oysters tested.	Av. value for sp. gr.	(Unless otherwise stated the values listed refer to adult oyst. of marketable size).
Bideford R.	15	2.24	From opposite stage & Totten bed
Cooper bed	25	2.37	
Malpeque bay Herman Beaton's deep bed	10	2.47	
Curtain Island flats	18 oysters tested in 4 lots	2.48	Small
Sedgewick cove	5	2.20	From flats
	5	2.12	" deep bed
Malagash	32	2.18	" bar
	20	2.19	" deep bed "outside"
Gillis cove	5	1.97	" 18" of water
	15	1.78	" 3' " "
	6	1.85	" 6' " "
N. Basin of R. Denys	15	1.93	Adult oysters
	2 lots of 11 each	1.94	'37 coll. spat; tray reared in '38
	2 " " 9 "	2.11	'37 shore spat; freshly gathered and tested directly.
	30 oysters in 4 lots	1.95	'37 shore spat after tray-rearing in 1939.
	6 " " 2 "	2.06	'37 shore spat after tray-rearing in '38 and '39.
Dark glass screen	18 " " 4 "	1.99)	These were all from "light test" tray in Gillis cove.
	20 " " 4 "	2.14)	
	20 " " 4 "	2.09)	
Dark	16 " " 2 "	1.96) 2.12) 2.19)	'38 collector spat reared during '39 in "light test" tray at Stoney point.
	2 lots of 6 each	2.02	'37 shore spat; tray reared in '39 in the submerged tray 7' below surface at Gillis cove.
South gut	30	1.95	Bras d'Or oysters transferred to South gut in '36.
Malagawatch	4	2.05	"Natives" from shallow water.
Pelliers harbour	9	1.92	"Natives".

Condition Studies.

Introduction:

A combination of characters influence popular judgment of quality of oysters. Shape, colour and consistency are important shell characters while "fatness", freshness (as opposed to staleness), saltiness, size, firmness, general colouration and presence or absence of a dark mantle margin are among the chief criteria for judging oyster meats.

The reported observations of Smith (1937) and Medcof (1938) and the results of transfer tests of Bras d'Or lake oysters to St. Ann Bay confirm earlier conclusions that the River Denys basin oysters are usually conspicuously inferior to the average as regards fatness. On the suggestion of Dr. A. W. H. Needler it was decided to carry out a systematic study of "condition" or "fatness" of oysters and to attempt a correlation of its seasonal fluctuations and its local differences with the more obvious environmental factors. From this study it was hoped that an explanation for the poor condition of the Bras d'Or oysters might emerge.

It was clear from the beginning that mere visual observation of oyster meats was insufficiently discriminating to be used as basis for the study and that some quantitative approach was required. To the writer's knowledge there is no published account of any study of condition as such. There have been several careful studies of progressive seasonal change in chemical composition and nutritive value of oyster meats but in no case has there been any expression of these in terms of yield per individual oyster. This last is the essential basis of the present investigation.

A Condition Factor for Oysters.

The ratio "weight : size" has been used as an expression of condition of animals by several workers (Hoar 1939), and seemed a sound basis for the present study. Both these values for fish can be quickly and accurately determined by weighing and measuring linear dimensions. This cannot be said for the oyster. In the first place the animal is housed in a non-living shell that is often several times the weight of the living parts. The weight of the shell is not likely to vary in the same way as the soft parts and therefore cannot be included in the "weight" measurement for the calculation. The soft parts, on the other hand, have a very high water content and as a result may vary widely in "fatness" without much corresponding change in weight. Besides, the weight is likely to vary in situations where there is much fluctuation in the salinity for the oyster's body is essentially an osmometer. The dry weight of the meats was decided on as the value to be used in calculating the ratio, since it is one of the values least likely to change suddenly without corresponding change in fatness.

It seemed reasonable to base an estimate of size on the shell since this rigid structure is less subject to sudden linear variation than the soft parts. Oyster shells, however, are very irregular in shape and thickness so it was decided to test out the reliability of several different possible indices to size and at the same time check the dependability of dry weight as a measure of "weight". Accordingly, 7 oysters of supposed uniform condition and shell character were subjected to several measurements, including the following, for each animal separately: total weight, total volume, total weight after the shell liquor had been allowed to drain away for five minutes by propping the shell open with a wooden wedge, total volume of this propped-open animal, weight of the meat alone immediately after removal from the shell, weight of the meats after being minced and allowed to drain for five minutes, dry weight of the meats, linear dimensions of the shell, volume of the shell and weight of the shell.

Manipulation of the values obtained from these measurements showed that the most nearly consistent rating of condition for the 7 oysters was obtained when "dry weight" and "volume of the space between the two shell valves" (the latter called "shell capacity" for the sake of brevity) were used. The final form of the expression was as follows:

$$\frac{\text{Dry Weight of Meats X 1000}}{\text{Shell Capacity}} = \text{Condition Factor.}$$

One of the most uniform samples of oysters tested came from the sand flats at Salutation cove, November 30, 1939. The Condition Factors calculated for 9 oysters showed an average deviation from the mean of only 2.3%. No other of several methods of rating condition that were tested gave nearly such consistent results. The same was true for other lots of oysters that showed variations in shell shape and size of specimens tested. The use of this expression, therefore, seems well founded.

Methods of Determining Condition Factor

In all tests the meats, placed in standard containers, were heated in a drying chamber until the weight was constant, The temperature of the drying oven was approximately 100°C. since it was heated over boiling water. The drying process has been found to require from 4 to 8 hours.

Shell capacity was calculated by subtracting the volume of the shell alone from the total volume of the oyster. Volume determinations were made by the "overflow" method. A rigid metal cylinder was filled with water and the surface smoothed with a disk of plate glass. By shifting aside the disk the oyster or shell, whose volume was to be determined, was introduced, the surface again smoothed and the water overflowing caught and weighed. The uncorrected figure expressing the weight of the water in grams was taken as the volume reading of the shell or oyster in ml.

Sources of Error in Method

Bleeding

There are several conspicuous sources of error in this method of calculation of the condition factor of oysters. Taking these in the order in which they are encountered their relative importance can be estimated. After opening, but before removing the meats from the shells, the free liquid was poured off. This practise was followed because it is impossible to avoid losing at least some of this at opening and the amount accidently lost varies considerably with the oyster depending on a number of factors - shell shape for one. It seems best, therefore, to discard the whole of the liquor in all cases. Sometimes it is impossible to avoid mangling the meats at opening in which case there is bound to be some blood escape into the shell liquor and hence lost. Then too, there is an error introduced because of the peculiar habit oysters have of "bleeding" into their shell liquor when stored in air. In either case the loss of blood with the discarded shell liquor would tend to reduce the dry weight. The extent to which natural bleeding into the shell cavity affects dry weight determinations is difficult to estimate but throughout the investigation it was probably not great for most oysters were tested almost immediately after fishing. Errors due to mangling were reduced by the practice of discarding badly damaged meats and using different oysters. All in all, the errors introduced here are probably small enough to be neglected.

Salinity Variations.

The oysters containing the same amount of organic matter will nevertheless yield different dry weights if fished from waters differing in salinity because of the greater or less amounts of salt included in their tissues. The year's observations were made on oysters that fall naturally into two groups - those fished from the Bras d'Or lake where salinities range around 20% and those takes from such places as Malpeque bay, Malagash and St. Ann bay where salinities range slightly below 30%. This difference is sufficiently great to warrant further consideration.

Observations on the 7 oysters mentioned above showed that for oysters of fair condition the water content of the freshly removed meats is approximately 90% by weight. From a rough calculation it would appear that in the Bras d'Or lake approximately 18% of the dry weight of oyster meats of this same condition would be composed of salt - for the other districts about 27%. To correct for this difference, therefore, all condition factors calculated for Bras d'Or lake oysters should be increased by 9 or 10% before comparison with the results obtained for other districts. Unfortunately the reliability of this conclusion has not been subjected to any experimental test. It is based on several assumptions that may be argued. Of course, errors due to faulty salinity corrections of the condition factors are obviated when making comparisons within either of the two groups.

Caramelization of Meats in Drying.

Tully (1936) states that in dryings at 100°C. there was evidence of caramelization of oyster meats. For this reason he carried out his dessications at 60°C. under reduced pressure. While mild caramelization, altering chemical components of oyster meats, might seriously effect the results of chemical analyses, it seems doubtful that it would seriously affect dry weights. The limitations of equipment have made reliable test of this conclusion impossible. Since all the present tests were carried out in the same way the results may be regarded as comparable for the present, at least.

Error in Weighing Dried Meats.

Another limit of accuracy was the sensitivity of the balances on which the weighings were done. These weighed to the nearest 0.1 gm. There is, therefore, a chance for an error of 0.2 gm. in the values expressing dry weights because the weights of the containers used were likewise measurable only to the nearest 0.1 gm. The average dry weight of the oysters generally tested was about 2.5 gm. The accuracy of the determination is, therefore, subject to a possible error of about 8% due to the limitations of the balances used. In view of the random variation in condition of the individual oysters themselves and the fact that in almost all cases the results for ten oysters were averaged to give the "Condition Factor" for the stock examined, this error is tolerable.

Error in "Size" Determination.

In the determination of the shell capacity there are fewer sources of error and these appear to be of less significance. Several tests were made to determine the accuracy of the apparatus used in measuring volumes. Successive measurements of volume of the same oyster have shown an average deviation from the mean value of only 0.3 ml. It seems that the chief source of error here is brought about by a failure to have the shell uniformly wet at the time of the volume determination. To overcome this it has been the practice to dip all shells in water just before the volume determination is made and to let them drain until they are wet but not dripping. The shell capacity of the oysters generally used for the tests averaged about 20 ml. This value, as stated above, is calculated by subtracting the shell volume from the total volume. The average error then ranges below 2 x 0.3 ml. or 3%. (It may be noted that this 3% includes the error brought about by the limitations of the balances used).

From the above criticism it appears that the total possible error involved in a condition factor determination is within 11%. In order to reduce this and to correct for natural variation in the stock of oysters themselves, the condition factor was calculated for 10 oysters separately at each test. The average for these was then taken as a reliable criterion of the condition of the stock in question. This leads up to a consideration of errors caused by faulty methods of sampling of stocks.

Factors Influencing Condition Factor.

Effects of Size and Shell Shape on Condition.

Attempts were made to discover the effect of size and shape on the condition factor of oysters. On December 7th, 1939, samples were fished from one small area on the Cooper bed in Malpeque bay, of large, medium and small cup-shaped oysters and of large second and third grade oysters. The results of condition tests made on these appear below.

Shell Grade	Approximate size	No. in sample tested	Condition Factor
L	Small 60. 52. 22 mm.	9	96
1	Medium 80. 63. 24	9	102
1	Large 100. 75. 30	10	114
2	Large	10	98
3	Large	10	91

The oysters tested in this experiment were from an area where the natural environmental conditions approach uniformity as closely as can be expected and the oysters were studied at a time when they might be expected to be most nearly uniform. None contained spawn, all had ceased feeding because of low temperatures and were near the autumnal peak of condition demonstrated below. If these animals may be considered as having been subjected to a uniform set of environmental conditions, then from the table, it appears that condition improves with increase in size and in regularity of shell. The latter seems to be of greater importance than the former in this relationship. Supporting this conclusion are the results of tests on small, medium and large oysters of uniform cup shape from Mr. Victor Travers' sand flats in Malpeque bay, December 5th (See table XI). In this case, however, the environment is so fluctuating (the flats are exposed at low tide) that the results may not be so indicative as those from the Cooper bed.

The conclusion from this discussion is that if a fair estimate is to be had of the condition of a stock of oysters, it is necessary to secure for the tests, a sample that is representative both as to size and shape.

The Effect of Light on Condition.

The influence of light is discussed in another part of this report to which reference may be made (page 71).

The Effect of Depth on Condition.

This problem is discussed in another part of this report to which reference may be made (page 73).

Conclusion

From the work reported in the two sections referred to it may be concluded that in sampling of stocks for condition tests it is essential that the animals tested be truly representative of the general population in respect to their exposure to light and as to the depths from which they are fished.

Results of Condition Tests on Adult Oysters

An attempt was made to follow, more or less closely, the seasonal changes in condition factor for five different stocks of adult oysters. There were:

1. Gillis cove oysters fished from 3' of water where they were growing naturally.

2. Stoney point stock on hard bottom in 4 - 5' of water. This lot was transferred from the leases of John Y. MacLean and Duncan C. Gillis, on June 15th.

3. Malagawatch lake on hard bottom in 4 - 5' of water on the lease of Toshie MacFadyne. These oysters were from the same source as (2).

4. Cooper bed oysters from Malpeque bay. Samples were shipped to the writer for testing at Orangedale.

5. Malagash, N.S. oysters were shipped to the writer for testing at Orangedale.

Besides these, many tests were made on miscellaneous samples of adult oysters. Included here were three samples of the 1936 transplant of oysters from the Bras d'Or lake to St. Ann bay. The results of the tests appear below in tabular form.

Table VI. Condition tests on Gillis cove oysters.

(Before comparison with values for oysters fished outside the Bras d'Or lake these values should be increased by about 10%).

Date	Condition Factor	Remarks (Where not otherwise stated, the record is the average of results for 10 adult oysters tested and these were fished from the 3' depth in the main part of the cove).
June 27	59	From 18" of water.
	68	From 3': only 5 oysters tested.
	78	From 6': " 6 " "
July 12	55	
18	47	
27	47	
Aug. 31	56	
Sept.25	57	
Oct. 19	92	
Nov. 10	52	This sample of oysters was taken from a group bedded in the fall of 1938, close together near shore in 18" of water and left there during the whole summer of 1939.
12	84	From 5' of water: this sample was fished from "up the brook" where there was considerable fresh water coming in.
16	56	From 3' of water in same place as No. 12 lot.
15	85	From 6" to 1' of water: this value seems high. The sample was fished for the writer by an assistant and may not exactly fit the specifications as to the depth.
22	73	From 6" to 1' of water: this sample was fished by the writer through the ice.
Dec. 16	64	Sample shipped to Ellerslie for testing.

Table VIII. Condition tests on Malagawatch oysters.

(Before comparison with values for oysters fished outside the Bras d'Or lake, these figures should be increased by about 10%).

Date		Condition Factor	Remarks (Where not otherwise stated the record is the average of results from 10 oysters tested, and fished from 4 - 5' of water).
June	16	73	Test made at the time of the transfer
July	6	63	There had been no apparent spawning.
	7	64	Sample of basin oysters transferred to Malagawatch late in the fall of 1938. Only 5 tested. Fished from 3' of water.
	7	103	Natives and large: only 2 tested because they were hard to find.
	14	70	
	19	46	Oysters transferred from River Denys Basin in fall of 1938 and bedded close to shore in 1 - 2' of water.
	24	55	Some of these seemed to have spawned, judging from appearance and temperature records.
	24	53	Fished from 2' of water. "Natives". These showed every indication of having spawned.
Aug.	11	61	Some animals still contained spawn.
Sept.	6	71	
Oct.	5	123	
Nov.	5	111	
	21	102	
	22	81	"Natives" fished from 2' of water near shore.
Dec.	15	93	Sample shipped to Ellerslie for testing.

Table VIII. Condition tests on Malagawatch oysters.

(Before comparison with values for oysters fished outside the Bras d'Or lake, these figures should be increased by about 10%).

Date		Condition Factor	Remarks (Where not otherwise stated the record is the average of results from 10 oysters tested, and fished from 4 - 5' of water).
June	16	73	Test made at the time of the transfer
July	6	63	There had been no apparent spawning.
	7	64	Sample of basin oysters transferred to Malagawatch late in the fall of 1938. Only 5 tested. Fished from 3' of water.
	7	103	Natives and large: only 2 tested because they were hard to find.
	14	70	
	19	46	Oysters transferred from River Denys Basin in fall of 1938 and bedded close to shore in 1 - 2' of water.
	24	55	Some of these seemed to have spawned, judging from appearance and temperature records.
	24	53	Fished from 2' of water. "Natives". These showed every indication of having spawned.
Aug.	11	61	Some animals still contained spawn.
Sept.	6	71	
Oct.	5	123	
Nov.	5	111	
	21	102	
	22	81	"Natives" fished from 2' of water near shore.
Dec.	15	93	Sample shipped to Ellerslie for testing.

Table IX. Condition tests on Cooper bed oysters.

Date	Condition Factor	Remarks (Where not otherwise stated the recorded value is the average of results from 10 oysters.
May 12	120	Only 5 oysters tested:
July 29	93	Some animals still contained spawn.
Aug. 25	107	No spawn present in these oysters.
Nov. 16	124	
Dec. 13	114	
Feb. 23	115	Fished through the ice.

Table X. Condition tests

Date & Place	Condition Factor	Remarks (Where not otherwise stated ther record is the average of results from 10 oysters tested).
Malagash, N. S.		
July 31	73	Sample fished from the bar
Aug. 26	99	" " " " "
Sept.27	126	From deep wa ter outside the basin.
27	144	From the bar
Nov. 20	131	From the bar
20	156	From outside the basin in deep water
South Gut, St. Ann bay, N. S.		
Aug. 7	81	Most animals were filled with spawn
Sept 5		
Oct. 2	120	
Dec. 18	126	Shipped to Ellersile for testing.
Miscellaneous samples from the Bras d'Or lake.		
June 15	73	North basin of River Denys off John Y. MacLean's shore:
Sept.28	81	Orangedale bay: from sewage polluted area.
Nov. 15	136	A single oyster from an island off Marble Mountain. This oyster was the smallest of 5 taken, all of which were of equally fine condition but 4 of them were too large for volume determinations and testing.
Nov. 18	106	Pelliers' harbour.

Table XI. Condition tests.

Date & Place	Condition Factor	(Where not otherwise stated the recorded value is the average of results from 10 oysters tested).
		Miscellaneous samples from P. E. I.
Salutation cove		
Nov. 30	87	Oysters were taken from flats exposed at low tide.
Malpeque bay		
Dec. 1	122	Harmon & Beaton's deep-water beds at Curtain island, 8 - 10' of water.
Dec. 5	102	Victor Travers' sand flats between little rock and Little Curtain island: only 6 oysters in sample and these were slightly smaller than the average size used in the tests. These were exposed at low tide.
Dec. 7	123	Sharp's Narrows beds: fished from 3 - 6' of water at low tide.
Bideford river		
May 8	67	Sample of 7 oysters collected at station landing stage in 2' of water at low tide.
Oct. 13	86	Totten bed oysters.
Nov. 16	79	Fished opposite the station in 4 - 6' of water at half tide.
Sedgewick cove		
May 11	73	Five oysters only: taken from tidal flats exposed at low tide.
	97	Five oysters only: from deep water never exposed during tidal cycle.
Nov. 30	90	From tidal flats exposed at low tide.
	97	From deep water: never exposed at low tide.

Table XII. Condition tests on small oysters.

Description of Stock	Date	Condition Factor	Remarks
"Natural" '37 spat used to stock light test tray in Gillis C.	June 16	65	This stock was carried over winter in a crowded tray until this date. The treatment received may account for the poor condition. Tested in two lots of 8 each.
"Collector" '37 spat used to stock the "fertiliaation test" plot at Stoney point	June 27	79	Tested in 2 lots of 9 each.
"Natural" 1937 spat reared on trays in '38 and '39 in Gillis cove	July 18	65	1000 in tray 4' by 6': teste in 2 lots of 11 each.
"Natural" 1937 spat reared on trays during 1939	Aug.16	56	1600 in tray 4' x 6': tested in 2 lots of 9 each.
"Natural" 1937 spat Same as July 18 sample	Aug. 16	76	1000 in tray 4' by 6': tested in 2 lots of 3 each.
"Natural" 1937 spat same as August 16	Sept.25	82	1600 in tray: tested in 2 lots of 6 each.
1938 stock from light test tray at Stoney point	Sept.29	81	In "dark" section tested in 2 lots of 8 each.
	"	79	Under glass: 2 lots of 8 eacl
	"	80	Under screen: " " " " "
1937 stock from light test tray at Gillis C.	Oct. 3	80	In dark: 2 lots of 4 each.
	"	86	Under glass: 2 lots of 5 ea
	"	88	Under screen: " " " " "
Same as Oct. 3	Nov. 10	79	In dark: 2 lots of 5 each.
		81	Under glass " " " "
		92	Under screen: " " " "
1937 stock from sbumerged tray 7' below surface		90	Tested in 2 lots of 6 each.

Table XII Continued.

Description of Stock	Date	Condition Factor	Remarks
From Victor Travers' sand flats between Little rock and Little Curtain island: exposed at low tide.			
Small oysters about 65. 55. 20mm.	Dec. 5	108 #)	Tested in 2 lots of 5 each
Medium-sized oysters 78. 55. 20 mm.	" "	109 #)	Tested in 2 lots of 4 each.
Large-sized oysters 90. 70. 25 mm.	" "	102 #)	Only 6 oysters in sample: each tested separately.

These values are above those recorded for small oysters from the Cooper bed on December 8, 1939, and suggest that the conditions on some flats exposed at low tide are favourable to fattening. (See section "Effect of Size and Shell Shape on Condition").

Seasonal Change in Condition Factor

Gillis cove oysters, never disturbed by transplantation, were considered as a sort of "control" stock for the other series of Bras d'Or lake oysters whose conditions were followed. The condition of these oysters shows more or less clearly several phases that are listed.

A. A period of steady decline during the month of June and July.

B. Following "A" a very gradual recovery ensued. This began in the last week of July and lasted until the last week of September.

C. A period of rapid increase in condition factor to a peak reached in the third week of October.

D. Following the maximum there was a slow decline during which the condition factor descended to a level lower than that observed in June.

E. After the decline there was a long period during the winter when there was practically no change in condition.

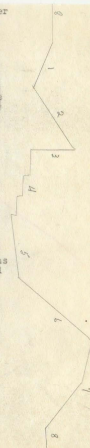
With minor variations this same course of change may be traced in the records for the other districts concerned. Unfortunately the data are not sufficiently complete to make a general analysis possible. The Malagawatch records suggest a rise in condition factor just previous to spawning and correlated, no doubt, with the development of masses of germ cells. This was followed by a sudden fall presumably due to spawning. These latter changes might be expected in stocks of oysters less peculiar than those of River Denys basin. Two extra phases between "A" and "B" may, therefore, be anticipated in the normal cycle of condition. From these results it is possible to compose a picture of what changes might be sought in a stock of ideal oysters. This picture is presented in figure 1. The annotations are deductions from discussions appearing below and from the reports of other workers such as Orton (1928) and Nelson (1928).

<u>The Effect of Spawning on Condition Factor</u>

A clear indication of the effects of spawning on condition might be expected in the records for Gillis cove, Stoney point and Malagawatch because condition tests were made on these three stocks just before and just after spawning was known to have taken place. At the first two stations (tables VI and VII) the only significant spawning of the year took place on July 5, 6 and 7 but the observed changes at this time were very slight. The reason for this probably lies in the fact that these oysters produced such a small amount of spawn that its loss altered the dry weights very little.

The sudden fall in the condition factor in Malagawatch (table VIII) between July 20 and 25 may have been brought about by spawning for the temperature during this period ranged about the critical level of 20°C. and the oysters were ripe to spawn. Besides this, they appeared lank for a period after this date. In spite of these observations no larvae were found in tows made in the lake so that definite proof that spawning did take place is lacking. The animals, if they did spawn, did not "spawn out" completely because 5 of the 10 specimens examined on August 11th still contained large numbers of germ

Figure 1. #Chart showing hypothetical change in condition factor of oysters.



8 Hibernation level continuous throughout colder part of the winter

1 Period of loss when temperature is too high for hibernation to continue but not high enough to permit sufficient feeding for maintenance of condition. Shell deposition probably goes on at this time.

2. Period of fattening and development of gonadial products. Temperature rises above 15° which is high enough to permit active feeding. Probably no shell growth at this time.

3 Sudden drop in condition is due to major spawning.

4 Lesser spawning activity and production of further quantities of germ cells at the expense of general body tissues. Temperature is too high for feeding to maintain condition level.

5 Period when germ cell production ceases but feeding is poor. Shell production probably goes on at this time.

6 Period of declining water temperatures (15 - 20°C): feeding conditions are good and shell deposition probably ceases. All energy is deveoted to fattening.

The maximum condition is achieved when the temperature falls below 15°C. After this time feeding activity is reduced.

7 Gradual fall off to hibernation level during which the animal is active but not able to maintain itself. The decline is slow at first but as the temperature falls the breach between anabolic and catabolic activity is widened and decrease in condition factor proceeds at a faster pace.

8 With the arrival of very low temperatures hibernation sets in and there is little further change until spring.

It should be emphasized that this figure and its annotations are tentative only.

cells. These 5 had condition factors that averaged 8 units higher than the general average while the "spent" animals averaged 8 units below average. The indication is clear from this that spawning results in a noticeable change in cases where animals produce and release any quantity of germ cells.

The record for South Gut (table X), St. Ann Bay, is of interest since this stock failed to spawn in spite of the fact that considerable amounts of spawn were developed and ripened. The results are fragmentary but the conditions observed probably represent the maximum of phase 2 (figure 1) maintained until it merged with phase 6, all the intermediate phases being omitted.

The records for the Cooper bed (table IX) are peculiar and suggest a remarkable stability throughout the season. Had more samples been made near the spawning time, the picture might have been different. As it was, no record is available after the temperature rose above 10°C. in May, until late in July when part of the year's spawning had taken place. Spawning temperatures were first reached over this bed during the first week of July. Phases 2 and 3 have been omitted and 4, 5 and 6 seem to have been merged.

The Effect of Crowding on Condition Factor

Pending shipment of their catch, Bras d'Or fishermen make a general practice of bedding oysters under badly crowded conditions in shallow water and often in waters with low salinity. Frequently the oysters are not sold during the fall and the animals are left in heaps close to shore where many suffer winter killing. Surviving oysters that had received this treatment were taken from Malagawatch lake (July 19) and from Gillis cove, (November 10) and tested (Tables VI and VIII). The results for these showed that their factors were lower than those of uncrowded oysters from the same depths and much lower than those of oysters taken from greater depths. These differences amounted to 20 and 30 points respectively in Gillis cove.

The results of the November 19 and 21 tests for Stoney point oysters show that the same effects are produced, even by mild crowding, at greater depths (table VII).

Clearly, then, crowding has an injurious effect on oysters.

The effect of holding oysters in waters of low salinity has not been investigated.

Effect of Light on Condition.

Table XII lists the results of tests made on samples of small oysters grown in the light test tray at Stoney point and Gillis cove. It will be seen from the table as a whole that the condition factor for small oysters does not fluctuate so widely as it does for older animals in the same water.

It is also clear, except in the case of the samples tested on September 29, that exposure to light tends to raise the condition factor. In the section "Effect of Light on Shell Growth", it has been shown that light strongly depresses shell growth and in the section "Effect of Light on Shell Proportion", it has been shown that light exposure encourages the development of a "cupped" shell. Huntsman (21) has shown that light produced the same three effects on the mussel (Mytilus edulis).

The Relation of Temperature to Fall Condition

The fall "fattening" of oysters was a point of particular interest in this investigation and every suggestive lead was followed up with a hope of throwing some light on the factors important in the process. Particular attention has been paid to the positions of the two kinks in the curve representing fall condition. These kinks (figure 1) are at the beginning of the sudden improvement and at its maximum where the fall decline begins.

Table XIII has been drawn up listing the pertinent data. These are limited in amount so that correlations among them may be purely co-incidental. The table shows:

1. The fall rise in condition factor did not begin until the water temperature dipped below 20°C. and sometimes showed a lag of a week or more after this time. Fattening then proceded to a maximum.

2. The fall decline following the maximum, set in sharply when the water temperature fell below 15°C. The degree of correlation between the progess of temperature change and condition change is higher here than in (1). It appears that,

in a rough way, improvement continued just so long as the water temperature hovered between 15 and 20°C, and that the higher the temperature, within these limits, the greater was the rate of fattening. The difference between the final conditions of oysters in different districts seems to depend upon the varying theme levels. In this connection it is interesting to note that at Malagash fattening ceased earlier in the shallow basin, where chilling of the water comes early, than in the deep water outside the basin where the fall in temperature is probably delayed (Adams 1939). This would have the effect of extending the fattening period and permitting an ultimately higher condition factor for the deep-water stock.

Effect of Depth on Condition

A perusal of the results presented in tables VI, VII, VIII, X and XI will show:

1. Exposure at low tide usually results in a lowering of the condition factor. This is probably related to the decreased length of the daily feeding periods.

2. Oysters in shallow inshore waters have low condition factors, even if they are never exposed. This principle is generally recognized by the Bras d'Or fishermen who consider "shallow water oysters" as identical with "poor quality oysters". The reason for this peculiarity may be that in shallows the oysters are exposed to a certain amount of disturbance due to wave action. It is conceivable that the water in such places frequently carries a considerable amount of inorganic sediment making feeding difficult and that the

bottom, scoured by the waves, may be less productive of diatom growths. The net result of any of these conditions would be a decrease in available food and consequently poorer feeding conditions than in deeper waters where fattening was found to proceed more readily.

3. Condition improves with depth out to about 3 feet but beyond this there is little or no change in condition with increasing depths. Apparently the stability of conditions at a depth of three feet is near the optimum for fattening.

The early fall conditions at Malagash fit this picture of depth relationships but tests made late in the season show the exact reverse. This peculiar reversal has been explained elsewhere in this report on the basis of temperature differences which permitted a longer fattening period in the deeper waters outside Malagash basin than in shallows inside.

Conclusions

The general conclusions from this section are that oysters in shallow water where they are subject to wave action, even if never exposed during tidal cycles, (this condition is to be found in the Bras d'Or lake), are poor in condition. Oysters exposed during tidal cycles are poorer than those submerged at considerable depths. These facts are of importance to oyster farmers and should be taken into consideration in the handling of stocks.

related to temperature.

Stock	Beginning of Improvement: Date	Beginning of Improvement: Water temperature at time	Beginning of Decline: Date	Beginning of Decline: Water temperature at time	Length of period of improvement days	Amount of improvement in units of C. F.	Change in units of Condition Factor per day.	Av. Temp. during Period.
Gillis cove	Sept. 20	18°C.	Oct.15	14°	25	36	+ 1.4	16°
Stoney point	Sept. 1	21° (about)	Sept. 27	16°	27	25	+ 0.9	17°
Malagawatch	Sept. 6	20.5	Oct. 7	15	31	53	+ 1.7	18°
South Gut	Sept. 2	18.5	Oct. 2	15.3	30	41	+ 1.4	17°
Cooper bed	Oct. 7	13°(not clear)	Nov. 15?	30?about Not clear				
Malagash	July 31	?	Sept. 28	14.0 +	58	72	+ 1.2	?

Effect of Artificial Fertilization of Water on Condition.

The attempts to "fertilize" the water at Stoney point have been described in another section of this report. Two lots of oysters were fished on August 15th, from 4 - 5 feet of water and placed behind separate breakwaters beneath floating trays in shallow water ranging in depth from 1 to 2 feet. Tests made September 25 and 26, showed that the oysters exposed to the "fertilized" shallow water were in almost as good condition as those in 5 feet of water. The shallow water "controls" were inferior in condition by 9 points (table VII).

The conclusion is that although feeding conditions may be difficult in shallow water they may be relieved by a greater availibility of food. It is also suggested that one of the factors contributing to the generally poor condition of River Denys basin oysters is food scarcity.

On the Cause of the Poor Condition of River Denys Basin Oysters

It has been shown that the fall condition of River Denys basin oysters is definitely poor. From the foregoing discussion there appear to be two principle and inter-related causes for this: 1. Scanty food supply. 2. Temperature peculiarities of the basin waters.

Food Scarcity

As has been pointed out, the phytoplankton production of the basin during the fattening period was scant as compared with that of Malagawatch lake. The poverty of these waters may be caused by the influx of river water that is poor in nutrient minerals. Such a condition has been demonstrated for some districts by Morton (1931). Besides this, the basin is "bottled up" by a long narrow exit, the Boom, so that it may be that there is little actual interchange with new lake water from outside. There is enough, however, to keep the salinity nearly constant during the greater part of the summer. The wind protection afforded by the surrounding hills may also prevent a vertical circulation of basin water and result in uneven vertical distribution of nutrient salts. A low supply near the surface might be responsible for the poor yield of phytoplankton.

It would be instructive to study the chemical composition of the waters of the basin and of such places as Malagawatch where condition factors ranged so much higher.

The results of the fertilization test made at Stoney point suggest that if more food were available, the animals would be in better condition.

Temperature Peculiarities.

The limited exchange of basin water with that of the lake outside; the protection of the waters by the surrounding hills from violent storms and consequent vertical circulation during the summers and the presence of broad shallows all combine to produce sudden spring rises in temperatures and, similarly, rapid fall declines. The length of the periods when the water temperatures hovered between 15 and 20°C. in the fall of 1938 and 1939 were very short. It has been suggested in an earlier part of this report that the length of this interval largely determines the extent of fall fattening. It would seem, therefore, that River Denys basin is hydrographically unsuited to extensive fall fattening of oysters.

It is clear that there is little possibility of controlling either of the two factors that appear to regulate fall fatness in River Denys basin. The only remedy seems to lie in practising the transfer of basin stocks to such waters as Malagawatch for conditioning before shipment. This procedure has been followed for several years by one or two of the local buyers.

Hydrographic Observations for Cape Breton.

1939.

The observations were carried out in precisely the same fashion as in 1938 (Medcof 1938) using the same instruments.

The records are summarized.

Hydrography - Gillis cove

Readings made with Knudsen
Hydrometer # 5020.

Date	Time	Depth	Tide	Weather	Temp.	Hydrometer reading	(T)	Sal.	Remarks
May 23	4.00 P.	Sur.	H	Fresh E, bright	11.5	10.2	21.6	14.4	
June 10	11.00 A.	6'				13.5	22.7	19.5	.
June 12			L	Part cloudy	15.4				Secchi disk
				light SE					visible on
									bottom 3½ fa
June 26	3.00 P.	Sur.	½	Bright:freshE	15.8	15.1	20.1	20.4	
		11'			14.4	15.4	20.3	20.9	
June 30	4.30 P.	Sur.			20.0				
		4½'			19.8				
July 1	4.30 P.	4½'			19.5				Temps.on Jul
2	4.30 P.	4½'			19.3				1 & 2 by R.
3	3.00 P.	Sur.(near		shore)(outer	20.0)	15.1	20.4	20.5	Gillis
		5'		20.3.	19.0	15.2	20.3	20.7	
5	12.15 P	Sur.			20.4				
		5'			17.4				
	7.30 P	Sur.			22.2				
		3'			19.8				
		6'			18.3				
6	5.20 P.	Sur.	½	Bright:light E	22.6				
		3'			2[illegible].8				
		6'			19.7				
7	5.00 P.	Sur.	½	Part cloudy	23.4				
		3'		light NW	22.3				
		6'			21.4				
8	4.50 P.	Sur.		Bright	26.0				Temps on
		5'			25.0				July 8&9 by
9	6.00 P.	Sur.		Part clo[illegible]	21.0				R. Gillis
		5'			18.0				
10	4.00 P.	Sur.			22.5	15.0	20.8	20.5	
		5'			22.5	15.1	20.7	20.7	
11	11.00 A	Sur.			20.8				
		5'			20.8				
12	4.00 P	Sur.			21.0 R				Records marked
									"R" were made b
									R. Gillis.

Hydrography - Gillis cove continued.

Date	Time	Depth	Tide	Weather	Temp.	Hydrometer reading	(T)	Sal.	Remarks
July 14	1.30 p.m.	Sur.			20.5				
		5'			20.5				
15	4.15 p.m.	Sur.			21.0				
		5'			21.0				
16	5.00 p.m.	Sur.			20.0				
		5'			20.0				
17	5.00 p.m.	Sur.			24.5			20.7	
		5'			20.8				(Sal. at
18	5.00 p.m.	Sur.			22.5				Stoney P.
		5'			21.8				
19	5.00 p.m.	Sur.			22.0				
		5'			22.0				
20	5.00 p.m.	Sur.			20.4				
		5'			20.3				
22	5.00 p.m.	Sur.			22.0			20.4	
		5'			22.0				(sal. in
24	4.40 p.m.	Sur.			22.5				Morrison's c.
		5'			22.0				
25	4.15 p.m.	Sur.			23.0				
		5'			21.7				
26	3.45 p.m.	Sur.			25.0				
		5'			24.7				
27	5.00 p.m.	Sur.			26.0	R			
		5'			26.5	R			
28	1.33 p.m.	Sur.			25.8				No rain during this period and salinities rose probably with little fluctuation.
		5'			25.5	(5.25 p.m.)			
30	10.30 a.m.	Sur.			24.0	26.8			
		5'			23.4		25.0		
31	5.30 p.m.	Sur.			25.8				
		5'			25.8				
Aug. 1	5.30 p.m.	Sur.			26.0				
		5'			26.0				
2	5.20 p.m.	Sur.			21.0				
		5'			20.5				
3	5.15 p.m.	Sur.			22.5				
		5'			22.5				
4	5.40 p.m.	Sur.			22.0				
		5'			22.0				
5	5.50 p.m.	Sur.			23.0				
		5'			23.0				
6	5.50 p.m.	Sur.			26.0				
		5'			24.0				
7	5.50 p.m.	Sur.			26.5				
		5'			24.0				
8	5.50 p.m.	Sur.			24.0				
		5'			23.0				
9	5.50 p.m.	Sur.			24.0				
		5'			24.0				
10	5.50 p.m.	Sur.			25.0				
		5'			24.5				

Hydrography - Gillis cove continued.

Date	Time	Depth	Tide	Weather	Temp.	Hydrometer reading	(T)	Sal.	Remarks
Aug. 12	5.50 p.m.	Sur.			23.0				
		5'			23.0				
15	5.50 p.m.	Sur.			22.9	15.8	20.3	21.5	Gillis C.
		6'			21.6	15.8	20.2	21.5	" "
18	5.50 p.m.	Sur.			24.5				
		5'			24.5				
25	5.50 p.m.	Sur.			24.5				
		5'			24.5				
28	5.50 p.m.	Sur.			24.0				
		5'			24.0				
30	5.50 p.m.	Sur.				16.1	20.5	21.8	
		6'				16.0	20.4	21.7	
Sept. 5	5.50 p.m.	Sur.			24.3				
		5'			24.2				
		Sur.			18.5				
		5'			18.5				
15	5.50 p.m.	Sur.				16.2	18.7	21.8	
		6'				16.6	19.0	22.1	
16		Sur.			16.7				
		5'			16.9				
20	5.15 p.m.	Sur.			18.0				
		5'			18.0				
23	5.35 p.m.	Sur.			17.0				
		5'			17.0				
27	5.20 p.m.	Sur.			16.0				
		5'			16.3				
Oct. 3	5.15 p.m.	Sur.			16.0				
		5'			16.0				
11	5.30 p.m.	Sur.			15.0				
		5'			15.0				
19	11.00 a.m.	Sur.			9.4	18.1	12.5	22.5	Yesterday was almost a gale; water well mixed.
25	10.00 a.m.	Sur.			6.5	7.6	14.4	9.2	
		6'				17.7	13.3	22.3	
		12'				18.4	14.3	23.3	

Hydrography - Stoney point.

Date	Time	Depth	Tide	Weather	Temp.	reading	(T)	Sal.	Remarks
May 23	3.00 p.m.	Sur.	H	Fresh E, bright		10.2	21.7	14.5	
June 9	2.00 p.m.	Sur.	½	Cloudy	12.0	13.8	21.5	19.1	
		6'			12.0	13.6	21.6	19.0	
June 12	4.00 p.j.	6'	½	Bright	14.9				Secchi disk disappears @ 5 reappeas.
June 20	4.00 p.m.	2'	½	Cl udy light N		13.8	22.6	19.5	@ r av.
26	2.30 p.m.	Sur.	½	Fresh E, bright	16.3	15.8	19.8	21.3	4½ fathoms
		12'			15.7	15.8	20.2	21.5	
30	10.20 a.m.	Sur.			18.0				
July 1	11.30 a.m.	4'			17.0				
2	2.00 p.m.	4'			17.3				
4	2.00 p.m.	Sur.		Fresh NW, bright	18.6	15.4	20.3	20.9	
		4½'			18.6	15.5	20.3	21.1	
5	11.45 a.m.	Sur.			18.1				
		4½'			17.8				
	8.00 p.m.	Sur.			18.8				
		5'			18.5				
6	7.20 p.m.	Sur.	½	Overcast, light E.	20.0				
		6'			20.0				
7	4.00 p.m.	Sur.			20.9				
		4'			20.8				
8					high				
9	4.00 p.m.	Sur.			22.3				
		4'			22.3				
12	4.00 p.m.	Sur.			20.7				
13	3.00 p.m.	Sur.			19.6				
		5'			19.7				
17	7.00 p.m.	Sur.			20.0				
18	7.00 p.m.	Sur.			20.1				
30						15.1	20.7	20.7	
August	See records for South point, they are like those for Gillis cove								
Sept. 7		Sur.			18.8	16.0	21.0	22.0	Stoney pt.
		9'			18.7	15.9	20.4	21.6	" "
14		Sur.			16.5	16.5	19.5	22.1	" "
		6'			16.5	16.6	19.6	22.2	" "
27	Su	Sur.			16.5	19.1	12.4	23.8	
		6'			16.5	19.1	11.8	23.7	
Oct. 18		Sur.				18.9	12.5	23.6	
23	11.00 a.m.	Sur.		Calm day	12.6	8.3	14.3	10.2	These samples
Station A		3'				15.8	13.8	21.2	were made to
200' off		18'				18.2	13.7	22.9	test the
shore		effect of the heavy rain which preceeded these samples and continued during October 24.							
Station B.		Sur.			12.7	10.2	13.8	15.1	
600' off shore		3'			11.4	16.6	13.6	20.8	
		12'			10.7	18.1	13.8	23.2	
Nov. 2		Sur.			9.0	15.9	19.6	21.3	
		6'			8.8	15.8	18.9	21.2	
" 13		Sur.			6.7	18.1	19.2	24.2	
		6'				18.3	18.8	24.3	

Hydrography - Malagawatch Transplant 1939

Date	Time	Depth	Tide	Weather	Temp.	reading	(T)	Sal.	Remarks
June 14	4.00 p.m.	Sur.		Cloudy light E	14.5	15.6	22.8	20.9	
		8'			13.5	16.0	22.0	22.2	
July 5	2.30 p.m.	Sur.		bright	19.5	15.6	20.3	21.2	
		4'			17.4	15.0	20.3	21.1	
17	3.30 p.m.	Sur.		bright	17.3	11.5	20.8	15.9	There have
		4'			16.7	15.0	20.6	20.5	been heavy
Aug. 12		Sur.			19.1	16.9	20.3	22.9	rains during
Sept. 6		Sur.			20.3	16.7	21.3	22.9	the past
		6'			20.5	16.6	20.8	22.6	week
Oct. 3	11.00 a.m.	Sur.			14.3	19.2	12.6	23.7	
		6'				19.2	12.5	23.7	
28		Sur.			9.4	18.0	17.7	23.6	
		6'				17.8	17.6	23.3	
Nov. 20		Sur.			3.9	17.9	19.0	23.8	
		6'				17.9	19.6	23.9	

Miscellaneous Hydrographic Observations.
1939

<u>Other Bras d'Or Observations</u>

Date	Time	Depth	Tide	Water Temp.	Hydrometer reading	(T)	Sal.	Locality & Remarks
Nov. 2		Sur.		9.3	2.3	18.3	3.1	(South Basin of R.
		6'		9.6	14.8	17.6	19.5	Denys) At Mrs. M. Livingston's lease
Aug. 12		Sur.		19.0	16.8	21.2	23.0	Marble Mountain at John MacKenzie's lease.
Sept. 5		Sur.			14.7	22.8	20.8	Nyanza bay
		3'			14.7	22.8	20.8	(River was high)
Sept. 8		Sur.		18.3	15.4	23.3	21.8	MacKinnon's Harbour.
		6'		18.7	15.9	23.5	22.5	At. A. D. Mack's lease.
Sept. 9		Sur.		19.7	17.7	19.0	23.6	MacIver's cove
		8'		18.7	17.4	18.7	23.0	Upper Washabuck
Sept. 9		Sur.			17.6	19.6	23.6	Christmas Island
Sept.13		Sur.		17.3	17.6	21.1	21.4	Ottawa brook at
		6'		17.1	17.4	21.3	23.9	(James MacDonald's
Sept.20		Sur.			17.1	15.6	21.8	lease). South side Whycocomagh bay.
					17.2	15.7	22.0	At MacRitchie lease
				Other Observations				
Sept.15		Sur.	LF	15.3	22.3	20.6	30.1	Grand Ance at
		6'		15.1	23.0	20.7	31.0	Marchand lease, C. Breton Island.
Sept.15		Sur.	LF		22.2	19.7	29.7	River Moulin at
		6'	LF		23.6	20.1	30.6	Marchand lease, CBI
Nov. 7		Sur.	½R	7.8	22.3	18.0	29.1	
		6'			22.7	17.0	29.6	Fox pond, Hastings, Cape Breton Island.
Aug. 3		Sur.		15.3	22.1	20.4	29.9	South gut, St.
		6'		14.2	22.0	20.2	29.6	Ann bay.
Sept.2		Sur.		18.5	22.0	20.5	29.7	
		6'		18.5	21.8	20.2	29.3	
Sept. 30		Sur.		15.3	24.0	14.0	30.5	
		6'			24.1	12.8	30.4	
Nov. 3		Sur.	½F	8.5	22.3	18.0	29.3	
		6'			22.5	17.8	29.6	
				Malagawatch District				
June 14		Sur.	low. Cloudy	14.4	16.1	22.7	19.5	Big Harbour
		9'	light E.	11.2	15.9	22.9	18.1	Malagawatch
July 24		Sur.			15.6	20.3	21.2	Pond at Toshie MacFadgenIs Malagawatch
July 26		Sur.		21.4	14.6	26.0	21.7	Little Harbour,
		5'		20.3	15.3	25.1	22.3	Malagawatch
Aug. 8		Sur.			15.4	24.6	22.2	Pelliers Harbour.
		5'			15.2	24.1	21.8	

Date	Time	Depth	Tide	Water Temp.	Hydrometer reading	(T)	Sal.	Weather
Juen 22	5.00 p.m.	Sur.			9.9	22.8	14.4	Pond above the road at Stoney P.
July 5	5.00 p.m.	Sur.		20.0				Orangedale bay at wharf
		5'		18.0				
July 21					15.1 15.2	19.8 19.7	20.4 20.5	Morrison's cove
July 21		Sur. 6'		21.0 20.5	14.5 14.4	22.0 22.0	20.8 20.7	South basin of River Denys at John N. MacLean's lease.

Meteorological Records for Orangedale, N. S.

The observations were made in precisely the same way as in 1938 (Medcof 1938) with the use of the same instruments.

A magnet for setting the indicators of the maximum minimum thermometer was not obtained until June 10th. There are, accordingly, gaps in the early records.

1939

Date	Time	Max.°F	Min.°F	At time °F	Weather
May 28			Froze last night		Cold: light rain (first rain for some time)
May 29			Froze last night		Cold: rained all last night
May 30	10.00 a.m.		" " "	48	Clearing: light NW
	6.15 p.m.		" " "	48	Cloudy: light SE
May 31	9.00 a.m.		" " "	44	Cloudy: light N: heavy night rain: clear
June 1	9.00 a.m.		" " "	50	
	7.00 p.m.			47	
June 3	8.00 a.m.	66	" " "	66	Still clear
June 5	9.00 a.m.	80	Mild	66	Rain last night: light N.cle
	6.00 p.m.	80	Mild 64	64	Clouding over: still
June 6	8.00 a.m.			60	Cloudy light rain: light SE
	8.00 p.m.			43	Rain: light E.
June 7	9.00 a.m.		Almost frost last night	44	Cloudy: light north
	6.00 p.m.		Very cold day: snow in Halifax	43	Cloudy: light NW
June 8	5.00 p.m.			48	Cloudy: light NE
9	9.00 a.m.		Cool night	53	Pt. cloudy: light SE
	Strong SE gale during afternoon: no temperature records				
June 10	7.30 a.m.	65	43	49	Cloudy: still
	5.00 p.m.	75	49	64	Clear: light E.
	7.45 a.m.	71	38	71	Bright: light W.
	7.20 p.m.	84	38	61	Bright: fresh E.
June 12	9.00 a.m.	61	50	54	Foggy: light SE
	6.00 p.m.	61	82	70	Bright: SW light
13	9.00 a.m.	74	65	64	Bright: fresh NW
	6.30 p.m.	82	54	70	Bright: light W
14	9.00 a.m.	70	48	65	Cloudy: light W
	6.30 p.m.	77	62	62	Cloudy: " "
15	8.30 a.m.	64	56	56	Cloudy: fresh NW
		72	65	56	Clear: light W.

Date	Time	Max.	Min.	At time	Weather
June 16	9.00 a.m.	66 °F	39 °F	57°F	Cloudy: SE light
	6.00 p.m.	64	58	54	Cloudy: light E
17	8.00 a.m.	60	45	59	Bright: fresh E
		64	48	48	Bright: fresh W
18	8.00 a.m.	54	34	52	Bright: fresh to str. NE west
	6.00 p.m.	55	46	47	Bright: fresh to strong NW
19	9.30 a.m.	60	30	60	Bright: light NE
	6.00 p.m.	64	54	54	Bright: light NW
20	8.00 a.m.	29	57	62	Cloudy: light E
	5.30 p.m.	67	57	64	Part cloudy: light E
21	9.30 a.m.	64	48	64	Cloudy: light NW Rain last night
22	10.30 a.m.	72	50	60	Part cloudy: light E
	7.00 p.m.	65	47	47	Clear: light NE
23	9.00 a.m.	53	42	53	Cloudy: light N
	7.00 p.m.	66	50	50	Bright: light W
24	10.00 a.m.	62	36	62	Bright: light W
	6.00 p.m.	76	62	65	Bright: still
25	9.00 a.m.	66	44	54	Cloudy: light to fresh SE
26	8.30 a.m.	70	51	62	Bright: light E
	5.30 a.m.	70	58	58	Cloudy: fresh E
27	9.15 a.m.	58	48	56	Cloudy: light E.
7	7.00 p.m.	68	50	50	Cloudy: fresh E
28	10.20 a.m.	54	43	54	Bright: fresh E
	5.30 p.m.	62	54	56	Bright: light E
29	7.20 a.m.	60	34	60	Bright: light E.
	5.30 p.m.	76	60	70	Bright: light W
30	8.00 a.m.	70	38	63	Bright: light SE
	5.00 p.m.	76	64	68	Light SW
July 1	9.00 a.m.	68	55	64	Bright: light NE
	5.30 p.m.	68	64	62	Stoney SW raining (Heavy rain)
2	11.25 a.m.	62	52	60	Fresh SW: heavy rain
	6.15 p.m.	64	56	58	Light NE, clearing but foggy
3	7.45	60	50	52	Foggy: still
	6.00	72	52	62	Bright: light E.
4	8.00 a.m.	62	53	58	Fresh E: cloudy
	7.30 p.m.	72	56	58	Bright: light W
5	10.00 a.m.	76	44	76	Bright: light W
	7.15 p.m.	89	75	75	Bright: still
6	9.00 a.m.	78	58	58	Bright: light E.
	6.30 p.m.	87	74	74	Bright: light W.
7	8.00 a.m.	74	55	70	Bright: light E.
	6.00 p.m.	84	68	77	Bright: light fresh W
8	8.30 a.m.	78	56	78	Bright: light SE
	10.00 p.m.	94	68	76	Part cloudy: still
9	8.45 a.m.	76	64	74	Part cloudy: NE fresh
	7;00 p.m.	74	58	60	Clear: light SW
10	9.00 a.m.	70	38	70	Bright: light E
	5.30 plm.	76	62	62	Part cloudy: fresh NW
11	9.00 a.m.	64	56	62	Cloudy: still (showers last night.
	6.15 p.m.	72	58	66	Cloudy: light E

Date	Time	Max.	Min.	At time	Weather
July 12	8.30 a.m.	64	58	62	Cloudy: fresh E
	6.00 p.m.	64	60	60	Bright: light E
13	10.00 a.m.	62	62	47	Cloudy: still
	6.00 p.m.	68	56	56	Raining: light W
14	8.30 a.m.	68	44	68	Bright: light E
15	9.00 a.m.	74	68	52	Heavy rain last night fine rain: lgith E
16	10.00 a.m.	74	58	63	Raining last night. Cloudy: light SE
	8.00 p.m.	70	55	70	Bright: light W
17	6.00 p.m.	80	70	70	Part cloudy: light NW
18	8.30 a.m.	70	46	63	Bright: light W
		77	63	63	Bright: fresh W. shower this afternoon
19	8.30 a.m.	67	47	67	Bright: light E.
	6.00 p.m.	74	61	73	Bright: light W
20	8.30 a.m.	64	46	62	Bright: light E
	5.15 p.m.	75	58	58	Cloudy: Fresh E.
21	8.00 a.m.	60	54	60	Bright: fresh W.
	6.00 p.m.	69	57	57	Bright, fresh NW
22	8.00 a.m.	70	46	70	Bright: light W.
	7.00 p.m.	82	70	70	Bright: still
23	12.00 a.m.	89	49	89	Bright: light W.
	6.00 p.m.	93	77	77	Bright: light W
24	8.30 a.m.	77	46	61	Cloudy: still
	6.00 p.m.	70	61	67	Cloudy: light E; raining
25	8.00 a.m.	70	58	68	Part cloudy: light NE
	6.00 p.m.	88	68	75	Bright: light SE
26	8.30 a.m.	78	46	72	Bright: light E
	6.00 p.m.	88	72	72	Bright: light W
27	9.00 a.m.	73	50	73	Bright: light E
	6.00 p.m.	87	68	68	Bright: fresh W
28	8.00 a.m.	68	58	66	Cloudy: fresh W
29	8.00 a.m.	80	48	72	Fair light E
	8.00 p.m.	82	66	66	Fair: light W (SE today)
30	9.00 a.m.	74	50	74	Fair: fresh to light W
	7.00 p.m.	84	74	72	Fair: light W
31	8.00 a.m.	74	69	65	Cloudy: light SE
	6.00 p.m.	78	74	69	Cloudy: light SE
Aug. 1	5.00 p.m.	84	69	79	Bright: fresh W
2	8.00 a.m.	79	55	62	Bright: fresh-strong NW
	5.30 p.m.	66	58	60	Bright: light W
3	8.00 a.m.	63	33	63	Bright: light W
	8.00 p.m.	78	60	60	Bright: light W
4	9.00 a.m.	68	55	68	Cloudy: light W
	6.00 p.m.	78	66	66	Cloudy still: raining
5	9.00 a.m.	74	66	66	Cloudy: light W
7	10.00 a.m.	86	63	81	Bright: light W
	6.30 p.m.	83	72	72	Cloudy: light SE
8	8.00 a.m.	72	83	70	Cloudy: still
	6.15 p.m.	84	69	69	Clear: light E

Date	Time	Max. °F	Min.°F.	At time°F	Weather
Aug 9	8.00 a.m.	72	45	72	Bright: still
10	8.00 a.m.	84	70	64	Cloudy: light to fresh W
	6.00 p.m.	85	79	77	Clear: light to fresh W
11	8.00 a.m.	77	61	71	Clear fresh NW
	6.00 p.m.	81	67	67	Clear: fresh NW
12	8.00 a.m.	69	60	69	Clear; still
	8.00 p.m.	91	66	66	Clear: fresh W
13	9.00 a.m.	76	46	46	Clear: fresh W
	9.00 p.m.	89	65	65	Clear: fresh W
14	8.00 a.m.	70	58	69	Cloudy: fresh SW
	6.00 p.m.	82	67	72	Bright: light W
15	7.00 a.m.	72	48	64	Bright: light W
	6.00 p.m.	88	64	70	Bright: light E
16	8.00 a.m.	70	62	64	Cloudy: light E, fog
	5.30 p.m.	70	64	66	Cloudy: light E
17	7.00 a.m.	66	62	62	Cloudy: still
18	9.00 a.m.	74	55	74	Part cloudy: light W.
19	8.30 a.m.	66	58	68	Part cloudy: fresh E
19	6.30 p.m.	80	64	64	Clear: light NE
20	9.00 a.m.	78	46	78	Bright: lightE
21		Hot, bright day			
22		"	"	"	
23		Very "	"	"	
24		Very very hot and bright			
25	10.00 a.m.	97	64	71	Cloudy: fresh E
	6.00 p.m.	74	68	68	Cloudy: fresh E.
26	9.00 a.m.	70	64	70	Cloudy: bright
		83	69	71	Cloudy: still
27	9.00 a.m.	73	56	73	Bright: light W
28	8.00 a.m.	86	34	62	Bright: light W
	6.00 p.m.	82	62	64	Bright: light & fresh W
29	8.30 a.m.	64	32	64	Bright: light E
	5.20 p.m.	75	62	62	Bright: fresh W
30	8.00 a.m.	63	36	63	Bright: still
	6.00 p.m.	85	63	68	Bright: light to fresh E
31	8.00 a.m.	68	52	58	Cloudy: strong E
	7.00 p.m.	68	54	54	Light rain: strong E
Sept. 1	8.00 a.m.	58	52	56	Cloudy fresh E. shower last night
	6.00 p.m.	62	55	59	Cloudy: light to fresh E
2	8.00 p.m.	77	60	60	Part cloudy: light E
3	9.00 a.m.	64	54	64	Part cloudy: still
5	10.00 a.m.	82	52	69	Cloudy: light W
	8.00 p.m.	72	68	68	Cloudy: still
6	9.00 a.m.	72	65	72	Bright: fresh to strong SW
	6.00 p.m.	75	58	58	Part cloudy: fresh W
7	8.30 a.m.	58	45	50	Raining: light W
	8.00 p.m.	68	49	49	Cloudy: light E
8	8.00 a.m.	56	46	56	Bright: light #
	6.00 p.m.	68	56	56	Bright: light to fresh NW
9	7.30 a.m.	57	43	55	Bright: light W (rained today)
5	6.00 p.m.	74	56	56	Bright: light W

Date	Time	Max. °F	Min. °F	At time °F	Weather
Sept 10	9.00 a.m.	60	33	60	Part cloudy: light W
	6.00 p.m.	70	60	60	Clear: still
11	8.00 a.m.	62	50	61	Cloudy: strong SE
	5.30 p.m.	64	57	64	Heavy rain in p.m.: clearing:
12	8.00 a.m.	64	50	58	light W. Pt. cloudy: light fresh W.
	7.00 p.m.	64	53	53	Raining: light fresh NW
13	8.00 a.m.	62	56	62	Part cloudy: light NW
	6.00 p.m.	70	53	53	Bright: light W
14	8.00 a.m.	60	38	60	Bright: light W
	6.00 p.m.	80	70	60	Part cloudy: light W
15	8.00 a.m.	70	58	62	Rain last night: cloudy light W
	8.00 p.m.	78	54	54	Clear: light W
16	8.00 a.m.	54	44	54	Cloudy (fog): light W
17	10.30 a.m.	83	54	83	Bright: light to fresh W
18	8.30 a.m.	84	45	54	Bright: fresh E.
19	8.00 a.m.	60	29	50	Bright: light W.
20	8.00 a.m.	70	30	64	Bright: light W.
	7.00 p.m.	76	57	57	Clear: light W
21	8.00 a.m.	58	47	56	Cloudy: light W.
	7.00 p.m.	71	47	47	Clear: light W
22	8.00 a.m.	50	42	42	Cloudy: raining: light E.
	6.00 p.m.	56	50	49	Clear: light W.
23	8.00 a.m.	52	30	52	Bright: still
	6.00 p.m.	73	51	57	Part cloudy: light W.
24	10.00 a.m.	61	50	56	Part cloudy: fresh W.
	7.00 p.m.	65	43	43	Clear: light W.
25	8.00 a.m.	52	26	52	Clear: light W.
	6.00 p.m.	62	49	49	Raining: light SW
26	8.00 a.m.	67	48	67	Part cloudy: fresh W.
	7.00 p.m.	72	46	46	Heavy rain: light SW
27	8.00 a.m.	47	30	47	Bright: light E.
	7.00 p.m.	64	43	43	Bright: light W.
28	9.00 a.m.	54	41	54	Raining: light E.
	6.00 p.m.	79	54	54	Cloudy: light SW
29	8.00 a.m.	54	45	50	Cloudy: light E.
	6.00 p.m.	57	50	51	Cloudy: light SW
30	8.30 a.m.	56	48	56	Cloudy: light SW
Oct. 1	9.00 a.m.	72	62	72	Clear: light W.
	6.00 p.m.	74	66	66	Raining: light SW
2	5.00 p.m.	66	50	50	Cloudy: light W.
3	8.00 a.m.	50	33	44	Clear: light W.
5	11.00 p.m.	66	54	54	Clear: misty today: light W
11	8.00 a.m.	65	38	60	Cloudy: light W: heavy rain yesterday.
	6.00 p.m.	70	50	50	Bright: fresh NW
12	8.00 a.m.	51	47	47	Cloudy: light E
13	8.00 p.m.	63	40	40	Clear: light W
	9.00 a.m.	49	28	49	Bright: light W
14	5.15 p.m.	60	49	56	Cloudy: light fresh W
	Heavy rain during night of 14 to 15				
16	8.00 a.m.	56	30	40	Clear: light W
	10.00 p.m.	60	38	38	Clear: still

Date		Time	Max. °F	Min. °F	At time °F	Weather
Oct.	17	6.00 p.m.	52	47	30	Part cloudy: fresh E.
	18	6.00 p.m.	47	32	32	Snow: cloudy: fresh NW
	19	9,00 a.m.	33	27	33	Snow: ¼" last night Bright: fresh NW
		6.00 p.m.	42	33	40	
	21	11.00 a.m.	63	38	44	Part cloudy
	23	11.00 a.m.	58	30	56	Last night the heaviest rain of season began: still going on.
	24	9.00 a.m.	57	36	36	Cloudy: fresh W (rained all yesterday)
	25	8.30 a.m.	38	32	35	Cloudy: fresh NW: ½" snow yesterday.
	26	8.00 a.m.	44	28	40	Clear: light W
		5.00 p.m.	60	38	40	
	27	10.00 a.m.	46	38	46	Misty: light - fresh E
	28					Heavy rain a.m. and p.m.
	29	9.00 a.m.	60	39.	39	Cloudy: strong W.
	30	9.00 a.m.	45	25	37	Clear: light E, bright
	31	3.00 p.m.	54	30	54	Heavy rain this a.m. Light W. cloudy.
Nov.	1	8.30 a.m.	63	54	61	W. gale: cloudy withrain
	2	8.30 a.m.	63	40	43	Part cloudy: light W.
	3	8.30 a.m.	51	25	39	Clear: lgith W.
	4	9.00 a.m.	48	30	38	Clear: light W. (light snow last night)
	5	10.00 a.m.	46	27	46	Clear: light W.
	6	4.00 p.m.	58	34	53	Fresh E: raining
	7	8.00 a.m.	48	36	42	Still and bright
	9	6.00 p.m.	54	30	39	Still rainign (yesterday and most of today bright)
	11	12.00 a.m.	50	29	50	Cloudy: light W.
	12	6.00 p.m.	52	30	32	Pt. cloudy: light NW
	13	11.00 a.m.	36	28	33	Part cloudy: light to fresh NW
	16	8.00 a.m.	39	18	30	Part cloudy: light NW
	18	10.00 a.m.	44	31	38	Part cloudy: rain yesterday
	19	10.00 a.m.	43	21	33	Part cloudy: light fresh W. (Snow yesterday morning)
	20	9.00 a.m.	42	22	32	Part cloudy: still
	22	12.00 Noon	36	22	36	Cloudy: fresh E.

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