MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 174

OYSTER INVESTIGATIONS IN 1940.

by

J. C. Medcof.

FISHERIES RESEARCH BOARD
OF CANADA

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Introduction

After leaving the Biological Station at Ellerslie,
Prince Edward Island, on May 7, 1940, the writer spent the
greater part of the open water season at or near Shediac
Bridge, New Brunswick (May 13 to December 11). A little work
was done in Cape Breton Island, Nova Scotia (May 8-13,
August 19, November 12-14).

The season's work involved the supervision of several
small rearing tests in Cape Breton, carried out largely by Mr.
Robert Gillis. At Shediac Bridge two main investigations were
carried out. The first was a study of the fate of oyster larvae
in Shediac bay and the second, and more time consuming, was a
study of "condition" in oysters. From the middle of September
until the return to the Biological Station about a third and a
half of the writer's time was spent at Buctouche, N.B., carrying
on a joint investigation with Mr. A. G. Campbell of the Department
of Pensions and National Health on sewage pollution of oysters.
The same study was resumed at Buctouche for two weeks in January,
1941, Jan.9-23).

PART I. CONDITION OF OYSTERS.

Seasonal Changes in Condition.

A new name "Index of Condition" has been assigned to the value referred to (Medcof 1939) as "Condition Factor" a year ago. This latter name has been used by Quayle (1940) to describe a different value used in the study of condition of oysters. To avoid ambiguity it was considered best to use a separate term.

In 1940 the study of condition begun in 1939 was continued and extended. a report summarizing the work is now in press (Medcof 1941) and may be referred to for a discussion of temperature and salinity effects on condition. Series of samples were taken from several places. In Shediac bay and other waters in New Brunswick the oysters were fished, with one or two exceptions, by the writer himself or by someone in the boat with him. These samples may be regarded as having come consistently from the same parts of the beds consigned. Samples from Gillis cove, Stoney point,Malagawatch and South Gut, except as noted below, were fished, packed and shipped to the writer by Mr. Robert Gillis of Orangedale working in cooperation with Mr. R.F. Morrison. In the writer's opinion Mr. Gillis's work can be consistently relied on for its care and precision. In the early spring of 1940 some samples were obtained by Mr. W.A. McIntyre of Orangedale. The results from tests on these appear in tables 2 and 4 and are quite misleading. Later samples made by the writer suggest that the McIntyre samples were not taken from the right places. This is only one illustration of the caution necessary in making samples for condition studies. Samples made from the Cooper bed were sometimes misleading but not to the degree apparent in the McIntyre lots. Tables 5 and 7 show the same irregularity for June 25 when the writer had an assistant collect the samples for him.

Technique. A few modifications in the procedure for index determination were introduced this year. The ten oysters to be tested were "run" in two lots of five each instead of individually as in 1939. This greatly reduced the routine work and required new and larger drying pans and buckets for weighings. Receptacles of both types were made to weigh 100.0 g. which simplified calculations.

In order to hasten the drying of the meats and adjustable ventilation port was made in the drying oven. This could be left open during the early stages of drying while the meats were still moist and closed during the last two hours at which time it was not important to have the temperature controlled.

The results of the tests appear in tables 1 to 12.

Table 1. Index of Condition of Oysters from Gillis Cove, N. S.

Date	Index of Condition Old place	New place	% water content of meats Old place	New place	Shell capacity x 1000 Shell volume Old place	New place	Remarks on shell deposits, shell growth, etc.
Apr.30	72				50		
May 9	40				76		Not a good sample, made in shallow water.
24	63 ½				56		
June 3	60				67		No shell growth; meats glossy; no chalk.
14	60				64		" " " "
28	54		91		54		Very small deposit in 2 oysters; slight marginal growth,if any.
July 4	47		92		63		Very small dep. in a few oysters.
12	43		93		64		Chalk dep.very small; no evidence of 1940 growth.
16	48		93		65		Few " " evident.
Aug.5	41		94		65		Dep.mostly small but present in over ⅓ oys. No sign 1940 s.gr.
24	57	66	92	89	62	55	Dep. more common & larger.
Sep.5	69	74	92	91	58	54	" very large,some evidence of coverage;small margin of 1940 growth.
19	60	72	92	91	60	58	Dep,being covered ".
Oct.1	69		90		93		Coverage nearly complete
16	87		90		49		Coverage complete; small margin 1940 shell;"washed appearance"of shells lacking
Nov.8	81		90		43		All deposits covered now
16	73		90		60		" " " "; nacreous layer covering chalk is thin.
Dec.9	87		90		53		All deposits covered now.

Table 2. Index of Condition of Oysters from Malagawatch, N. S.

Date	Index of Condition	% water content of meats	Shell cap. x 1000 vol.	Remarks
Apr.27	84		50	sample obtained by McIntyre (not reliable)
May 11	98		49	
Jun.11	95		57	spawn appearing.
Jul. 5	82	90	54	no chalky areas; little marginal growth of shell appearing.
19	110	90	54	nearly all showed some and several had lge.chalky areas
Aug.7	86	89	49	chalk present in all; some very large areas.
24	93	89	51	some very large areas, may cover ½ area of shell; chalk shows a peculiar "veined" pattern like that in mantle.
Sept.5	95	89	50	Most have extensive areas; chalky areas being covered;
20	110	87	49	chalky areas being covered; a small margin of 1940 shell.
Oct.1	116	86	47	chalky areas all covered now.
17	87 101	89 88	48	chalk all covered;"washed" appearance present.
Nov.4	105	88	49	chalk all covered now.
15	100	88	50	chalk all covered; nacre rather thin over the chalk
Dec.15	111	88	50	Chalk all covered.

Table 3. Index of Condition of Oysters from South Gut, N.S.

Date	Index of Condition	% water content of meats	Remarks on shell growth.
May 7	104		
June 25	73		no chalky areas exposed; no apparent external shell growth; "wash" appearance present on shells; no gonad devel. yet
Aug. 4	96	88	most have very small chalky dep. in muscle scars; gonads developing now.
26	122	88	most have moderate-sized area of chalk present in typical positions; gonads are full of spawn now.
Sept.12	94	88	most have extensive chalk dep. show no evidence having spawned; meats have a brownish colour; eggs abnormal in shape & appearance, seem to be withering.
25	47	92	chalk dep. present in some; coverage may be underway; some evidence of marginal shell growth; no trace of gonads left
Oct.18	81	91	no exposed chalky areas; no "wash" appearance covering the nacre.
Nov.2	84	89	no exposed chalk; little 1940 shell showing at margin.
15	79	91	no exposed chalk; the covering nacre is very thin.
Dec.18	95	88	no exposed chalk.

Table 4. Index of Condition on Oysters from Stoney Point, N.S.

Apr.20	91		McIntyre shipment; fished from wrong place.
May 10	70		fished by the writer.
24	61		" " " " "
June 3	77		no 1940 shell growth; no chalky deposits
14	68		" " " " "
28	70	88	1-2 mm. 1940 shell showing; chalk dep. common but small.
July 2	60	89	" " " " " "
16	49	92	" " " " " "
Aug. 6	60		chalky dep. extensive and present in all little or no 1940 shell show.at margin
23	65	88	chalk dep. largest yet and present in all

Table 5. Index of Condition of Oysters from Malagash, N.S.

Oct. 2	130	85	From bar.
"	116	87	From deep bed outside basin.

Condition of
Table 6. Index of Oysters from Poirier bed, Shediac Bay, N. B.

Date	Index of Condition	% water content of meats	Shell cap. / Shell vol. x 1000	Remarks
June 1	132		53	Transplant made June 1
17	125		54	very small chalky dep.apparent in some and very small amt.
20	133		56	chalky dep. larger and more common; some oysters have grown 3 mm.of 1940 shell.
26	125		55	sample was of poor-shaped oys. shell characters as above with possibly more marginal growth.
28	140	84	53	large chalk deposits in almost all shells; may be in process of coverage.
July 3	142	84	51	almost all have deposits
8	110	87	48	almost all have chalky areas
15	100	88	55	a general growth of 4-5 mm. of 1940 shell; chalk dep. common.
25	103		52	chalky areas common and large
31	96	90	49	all oysters had chalky deposits
Aug. 14	100	89	46	very large chalky areas present.
23	109	87	51	" " " "
Sept. 7	114	87	50	all have chalky areas in process of coverage.
18	110	86	49	in half of oysters chalky areas are covered.
27	133	87	50	all areas covered with nacre; nacre not glossy but covered with a chalky "wash"
Oct. 5	133	86	49	all areas covered.
23	124	90	50	all covered; "wash" appearance still evident except at marginal regions of the shell.
Nov.22	128	86	49	chalk covered; shells show "wash" less conspicuously.

Table 7. Index of Condition of Oysters from Wilbur bed, Shediac Bay,N.B.

Date	Index of Condition	% water content of meats	Shell cap. x 1000 / Shell vol.	Remarks
May 22	124		51	
June 4	138		48	about 1 mm. of new shell present.
19	148		49	small chalky dep. present in most; 0-5 mm. of new shell.
26	137		51	a poor sample; small chalky areas present.
30	149		52	areas mostly small; averages of 3 mm. 1940 sh. growth.
July 7	136	84	51	chalky areas in all oysters
17	121	85	47	most oysters have larger areas; 4-5 mm.new shell showing.
23	127	86	49	most oysters have larger areas; 5-8 mm. new shell showing.
Aug. 9	102	89	47	areas appear even more extensive now; not much spawn left.
26	117	88	49	areas extensive but appear smaller than those for Poirier bed; hard to distinguish 1940 shell growth now
Sept.7	132	86	43	chalky areas smaller
18	128	87	47	most of chalky areas covered; "wash" of chalky material pres. over nacre.
27	147	85	44	chalky areas all covered; ditto to 18th.
Oct. 9	134	86	45	This sample contained several very poor-shaped oysters; no exposed chalky areas.
30	137	84	53	small oysters; aver.length 2½"
30	146	85	47	no exposed chalky area
30	155	84	57	small exposed chalky oysters; aver.length 2½"
Nov.21	138	85	52	

Table 8. Index of Condition of Oysters in submerged trays, Shediac Bay, N.B.

Date	Index of Condition	% water content of meats.	Shell cap. Shell vol. x 1000	Shell cap. Total vol. x 100	Shell vol. Total vol. x 1000	Remarks
June 1	132		53	66	35	Date of set up; Probably 1940 shell gr. and no chalk deposits.
July 8	82	90	53	66	35	Considerable 1940 shell apparent; chalky dep. uncommon and very small; extensive yellowish patches on nacre; these were of very hard texture.
Aug. 28	97	89	44	70	30	little recent shell gr. showing; chalky dep. in typical positions but of very small size.
Sep. 28	104	89	49	66	33	little new shell apparent; all chalky areas covered now.
Oct. 29	102	88	50	66	33	no exposed chalky areas; little recent shell growth.

Table 9. Index of Condition of Oysters in Scoudouc river, N. B.

June 11	94

Table 10. Index of Condition of Oysters from Kouchibouguac R. transplant.

May 31	114		date set up.
June 29	124		
July 19	121	87	
Sep. 27	118	88	

Table 11. Index of Condition of Oysters from Buctouche, N. B.

Oct. 1	74	92	in 8' of water	river oysters planted in Buctouche bay in July.
	80	91	" 4' " "	
	72	92	" 1' " "	
	79			oysters fished opp. the sewer.
	91			oysters fished at Irving's mill.
Oct.15	120	87		Native Buctouche bay oysters.

Table 12. Index of Condition of Oysters from Cooper bed, Malpeque Bay.

Date	Index of Condition	% water content of meats	Shell cap. Shell vol. x 1000	Shell vol. Total vol. x 100	Total vol. Shell vol. x 1000	Remarks
May 1	110		49	67	33	no apparent shell gr. shells nacreous within.
30	108		54	66	33	no apparent hard sh. gr. but a thin layer of periostracus (?) is forming at margin of upper valves.
June 28	123		52	67	33	almost all have very small chalk deposits; slight 1940 marginal gr.evident.1-3 mm. wide.
July 5	127	86	50	67	33	all oysters show new shell 1-5 mm.wide; almost all have chalky deposits.
10	106	87	53	66	33	all have new shell and most have chalky deposits of fair size.
26	105	88	51	66	34	all show sn. growth and extensive chalk deposits.
30	96	89	49	67	33	all show chalk dep. now quite large; seem to be in process of coverage; several shells show yellowish blotches.
Aug.29	126		46	69	31	nearly all have lar. size dep.chalk.most show a fresh margin of shell.
Sep.10	123	87	44	70	31	large chalk dep. on nearly all shells.
24	123	87	46	69	32	almost all chalk dep. completely covered with nacre. Surface of nacre not glossy but has a powdery "wash" over it; hard to tell what mar.gr. of shell new and what old.
Oct.16	137	85	46	69	32	This sample not fished from regular place.
23	128	87	47	89	32	no exposed chalky dep. the "washed" or unglazed appearance still present near the nacre.
Nov.21	117	87	50	67	34	no exposed chalk.

Discussion of results of condition studies. A publication shortly to appear in the 1941 Journal of the Fisheries Research Board may be referred to for a discussion of the effect of temperatures and salinity on condition. It will be seen from this that the results of the 1940 data corroborate and extend the conclusion of last year's study (Medcof 1939a) The critical nature of the spring temperature level 15° is suggested by the observation of Nelson (1928) who states that at 15° the deposition of yolk in the developing ova begins. He further remarks that higher temperature levels are necessary for the final stages of maturation.

The results of the present investigation suggest that in acme cases the index of condition halted at an upper limit. Beyond this to increase took place regardless of the fact that hydrographic conditions seemed favourable to continued fattening. This peculiarity appears in the results for the Wilbur bed stocks in late June and early July,1940, when the index level reached 148 (table 7). It seems to have developed in the Cooper bed stocks in the fall of 1940 at a level of 125 to 130 (table 12). On this latter there is lack of certainty because there was more chance for sampling errors on the Cooper bed than on the Wilbur bed where the author did the fishing. It may be significant, however, that a year ago (Medcof 1939a) the highest recorded index for the Cooper bed was 124.

It seems logical that there should be an upper limit to the value of the index because (1) when oyster meats completely fill the shell there is no more room for fattening and (2) there must be a limit to the specific gravity of oyster meats. The significance of the levelling off, however, is not clear. It might be simply from a cessation of activity by the animal after it attains this fat state. What seems more probable is that shell growth regulates it. By continually enlarging the shell cavity to accommodate a growing body such a fixed level of condition could be maintained by the oyster. Orton (1928) has shown that shell growth and fattening may proceed together. So there are not sufficient data assembled to analyze the behaviour here very thoroughly. For further discussion see "The relation of condition to growth".

The Relation of Condition to Growth.

A study of the relation of condition to shell growth was begun this year with the hope of getting some information that might serve as a guide to further and more comprehensive work. A series of 100 "wip" oysters 7 to 10 cm. in length was selected from Poirier bed stocks fished on June 4. Of these 50 were reserved for consecutive observations on shell length and total volume (after cleaning and scrubbing). These were placed on the Poirier bed in one section of a submerged tray, the top and bottom of which were made of 1½" mesh fox wire. The other 50 oysters were placed in a separate compartment of the same tray and at each observation 10 were used to determine the index of condition.

Observations were made at what might be considered the turning points in the course of fluctuations in index of conditions:-

(1) June 5, near the beginning of the spring fattening period.
(2) July 8, immediately after the major spawning burst.
(3) August 27, at the close of the summer period of poor condition.
(4) September 28, at the close of the fall fattening period.
(5) At the end of the fall decline as the oysters were going into hibernation.

It is hoped that a sixth observation will be made in the spring of 1941 to discover what changes, if any, take place during the winter. Tables 8 and 13 summarize these observations.

From the tables it will be seen that the amount of growth in length during the season was comparatively slight. Had it been greater the results might have been more illuminating. Oysters on the bottom nearly seemed to have grown more and besides to have developed greater areas of chalky deposits. Their index of condition was always higher than the tray oysters. The nacreous layers in the tray oysters took a yellowish colour and seemed to be harder texture than normal. In the face of these differences it would be well to study both bottom and tray conditions in any future work.

The data show that there was just one period of rapid growth in length and this was during the period of spring fattening. There was little or no marginal growth during the periods of fall fattening and fall decline in condition in spite of the fact that much nacreous shell was being laid down covering the chalky areas on the inner surfaces of the shells. It appears that active marginal shell growth, when it occurs at all, goes on when the water temperatures range between 15 and 20°C. A similar condition seems to obtain for O₂ edulis for according to Orton (1928) shell deposition in that species goes on only when the water temperature ranges between 10 and 15°C. (approximately). Belding (1910) has shown that in the scallop shell growth goes on only when temperatures are above 47-48°F. Galtsoff (see Higgins 1933) states that shell growth continues throughout the cold season.

Conditions among Gillis cove oysters (Table 1 and Medcof 1941) suggest that even if temperatures are favourable low salinities will prevent shell growth. There may be a difference in the relationship between the behaviour of old and young oysters. When the writer visited Gillis cove in the second week or May, older oysters showed no external evidence of shell growth. On the other hand, spat which settled in 1939 seemed to have already developed a new margin of shell. The water temperature at this time war only 9°C.

Table 13. Summary of observations on Poirier bed tray oysters.

Length in mm.	June 1	July 8	Aug.27	Sep.28	Oct.29	
79-73	5	5	3	1	1	
74-79	3		1		1	Size-frequency
78-81	12	6	5	7	8	distribution
82-85	8	8	7	7	8	for lengths
86-89	11	13	14	17	18	of oysters.
90-93	3	6	10	9	9	
94-97	3	6	4	4	3	
98-101		2	1	1		
102-105	1	1	1	1	0	
106-109		1		1	1	

little or none	consider-able	not much	not much		notes made (on dates indicated) on new natural shell growth.
little or none	small areas present	chalky areas larger	chalk covered by nacre	all chalk covered	notes on chalky deposit.
pre-spawn-ing fattening	post-spawning low	fall fatten-ing	fall fatten-declining	hiber-nation plateau	phase of fattening being entered.
132	82	97	104	102	Index of condition
50	49	49	48	48	No.oysters measured
2289	2344	2501	2557	2576	total volume
45.8	47.9	51.2	53.3	53.6	average vol, per oyster.
53	53	44	49	50	Value of ratio Shell Cap./Total vol. x 1000
35	35	30	33	33	Value of ratio Shell Cap./Total vol. x 1000
66	66	70	67	67	Value of ratio Shell Vol./Total vol. x 1000

The change in total volume did not follow the same course as growth in length. On the contrary it was during the spring fattening period and the greatest change took place during the post-spawning period of low condition. It was observed on July 8 that, although considerable growth in length had taken place, the amount of "useful" space between the valves seemed to have changed very little. This was because the fresh "shoots" of small of upper and lower valves were in contact only at their inner ends and flared apart further and further towards their free margins. This peculiarity seems to have disappeared by August 27. Little increase in length took place during the summer period of low index but the volume did increase considerably. It was also observed that the flexible margin of the upper valve accommodated itself to the shape of the right lower valve. This permitted a "swelling" of the oyster shell and a consequent increase in volume without any accompanying increase in length. Unfortunately no measurements of thickness were made on the oysters or this change in shell proportions might have been detected in them.

The swelling of the shells with the consequent increase in shell capacity would influence the values obtained for the index of condition by reducing them unless there were a contemporaneous increase in the amount of the "meats". Failure of the increase in the weight of the meats to keep pace with the increase in shell capacity is a possible explanation for the characteristic post-spawning period of low index noted in the condition studies.

During the period of fall fattening a moderate increase in volume was observed. This is the time when nacreous layers are put down over the chalky deposits noted on the insides of the shell. This process may reduce the shell capacity.

With the hope of throwing more light on the complicated series of changes, several other calculations were made. The ratios $\frac{Shell\ Capacity}{Shell\ Volume} \times 1000$ and $\frac{Shell\ Volume}{Total\ Volume} \times 1000$ and $\frac{Shell\ Volume}{Total\ Volume} \times 100$ are listed in tables 8 and 13. Changes in the values of these ratios seem to be systematic. To test this apparent cycle in the changing values calculations of the value of the first ratio were also made for other series - Cooper Bed, Gillis cove, Malagawatch, Poirier bed and Wilbur bed (tables 12, 1, 2, 6 and 7). The values obtained agree in suggesting that there is a cyclic change. The results for the Cooper bed are the most systematic. This might be expected since the Cooper bed stocks were the most regular oysters dealt with in as far as shell shape was concerned. All were of the first of "XXXX" grade. The other two ratios mentioned above were, therefore, worked out for the Cooper bed series.

The average value of the ratio $\frac{Shell\ Capacity}{Shell\ Volume} \times 1000$ varied with the stocks. It was highest for young oysters (table 7).

Among the adults the Gillis cove oysters had the highest value -58.5. Next came the Poirier bed and Malagawatch oysters. 52 and 51 respectively. The lowest values were obtained for the Cooper and Wilbur bed stocks, both being 48. Since the values vary with season they should not be taken as absolute. It does seem as if well-shaped oysters have smaller shell cavities than poor-shaped ones.

The value starts high in the spring, dips to a low in late summer and rises again in late fall. The low point is reached at the time when the chalky deposits on the shells (see section "Chalky deposits on oyster shell") reach their greatest extent. The unusually great volume of this deposit on the inner surface of the shell at this time may in itself explain the low value of the ratio for the deposits must reduce the shell capacity. The same process may explain the maximum observed for the Cooper bed and the Poirier tray stocks in the value of the ratio $\frac{\text{Shell Volume}}{\text{Total Volume}} \times 100$. Why the value for the ratio $\frac{\text{Shell Capacity}}{\text{Total Volume}} \times 1000$ should at the same time reach its minimum value for the season is obscure.

The gradual rise in the condition factor in the middle and late summer while the water temperature is still high and not conducive to extensive feeding may be due not to actual fattening but merely to a reduction in the shell capacity by the appearance of chalky deposits as mentioned above. Because of the method of calculating the index of condition any reduction in the shell capacity would produce an increase in the index of condition without any actual increase in fatness.

The results of a further study of shell proportions is presented in the section "Shell proportions of oysters."

Summary.

Marked increases in shell length occurred only in the spring during the fattening period when water temperatures ranged between 15 and 20°C.

Low salinity seems to interfere with shell growth even though temperatures at the time may be favourable to it.

The limits of temperature and salinity which control shell growth may be different for young and older oysters.

The shell growth is marginal at first (length and width increase). Later the valves move apart (thickness increases). It is possible that only then does the useful space between the valves increase to any great extent.

Condition and shell growth seem to be very intimately associated and further study of the same general type would be advantageous in clearing up the problem.

Studies of shell proportion show that there are complicated cyclic changes in these. They are most conspicuous in late summer but their significance is not clear.

The Influence of Sex on Condition.

Quite often in sampling a stock of oysters it happens that the numbers of males and females do not bear the simple one-to-one ratio. If the samples of oysters are small, as in condition tests, and if there chanced to be any consistent difference in the indices of condition for males and females then it would be important to measure this difference in order to allow for it. During the course of the investigation on condition several determinations were made separately for males and females from the same lots of oysters. The results appear in the following table:

Table showing results of Sex-Condition study.

Date	Index of Male	Condition Female	Source of oysters	Remarks
July 3	145	138	Poirier bed	Oysters full of spawn.
July 7	142	131	Wilbur bed	" " " "
25	129	125	" "	Animals appear to still contain much spawn.
Aug. 5	88	83	Malagawatch	lot contained 2
				" " 1
Aug.28	88	99	South Cat	Oysters full of spawn.

In addition to the above tests another observation was made on a lot of ten Cooper bed oysters fished July 30. These were arranged in order of their condition, simply by inspection, the fattest being placed first in order and the poorest last. After this the sexes of the specimens were determined and the order proved to be;

Although the data assembled so far are not extensive enough to permit generalization they do not suggest that the females are conspicuously fatter than the males as in the case in _O. gigas_ according to Masumoto et al (1932). Field (1911) has shown that in August the carbohydrate content of male sea mussles is higher than that of females. It has been impossible, therefore, to take any account of possible irregularities in the results which might have been introduced by unequal numbers of males and females in the samples tested.

Failure to Spawn Affecting Condition.

The behaviour of South Cut oysters in 1930 was apparently different from that in 1939 (Medcof 1939a). In spite of failure to spawn there was a drop in condition during which degenerating ova were observed in the gonads (table 3). This fall came about at a time when temperature conditions favoured normal fattening. In addition there was a slow recovery which continued, peculiarly, according to the results, even after the temperature fell below the 1939 level. This strange rise suggested by the data may not be actual. Faulty sampling on one date - September 23 - could explain this apparent exception to the rule that fattening ceases when the temperature falls below 15°C. Quayle (1940a) states that failure to release spawn interferes with fall fattening although Orton (1928) suggests that such oysters should be continuously fat. This latter seems to have been the case in 1939 but not in 1940. The South Cut stock presents peculiar problems. In 1938 and 1939 they were poor in the month of May. At the same time in 1940 they were apparently fat and apparently will be poor again in May,1941.

The Effect of Storage on Condition.

A stock of oysters fished during the first week of December 1939 and held in the warehouse of the Biological Station until December 23 were placed in the basement water tanks. Fresh sea water ranging in temperature between 8 and 10°C. was allowed to flow over the oysters. Most of them opened and seemed to be "pumping" normally. after two hours of this treatment three lots of 170 each of the most vigorous ones were selected. (The more quickly an oyster closed its shell when touched the more vigorous it was assumed to be). The first two groups were placed in covered wooden boxes and the third in a galvanized iron box. They were handled as follows:

(1) Placed in the basement of the Biological Station.
(2) In the sub-basement of the Biological Station
(3) In a wooden box placed outside the station. This box was lined with rock wool and the temperature thermostatically controlled at 1.1°C.

A sample of ten oysters, some taken from each of the three lots, was tested for condition at the beginning. From time to time water was sprinkled over the oysters, the dead counted, and samples removed for condition tests. Temperature records were made from maximum-minimum thermometers kept in the two boxes inside the station. The experimental results are listed below in tabular form:

Results of Condition Tests and Mortality Counts on Stored Oysters.

Date	Basement storage Index of Condition	No. dead	Sub-basement Index of Condition	No. dead	Thermostat Index of Condition	No. dead
Dec.23/39	126	0	126	0	126	0
Feb. 7/40	112	27[1]				
" 8			109[2]	46		
" 10					117[3]	1
Apr.23	75	77				
" 24			98[4]	104	112[5]	70

Note: (1) Have a vile and lingering taste; some very dry inside and a number had a bubble of gas within the ventricle of the heart.
 (2) The meats of these were flaccid and stale smelling.
 (3) Some of these were a little dry inside but were well-flavoured.
 (4) Only four of the oysters of this lot were sound enough for the condition test; quite unfit to eat.
 (5) These oysters had a stale odour and taste that made them unpalatable.

Temperature record for storage test (°F)

Date	Max.	Min.	Pres.	
Jan.5/40	53	48	51	
" 15	54	49	49	
" 22	55	40	48	Basement temperatures
Feb.3	58	42	46	
Dec.30/39	53	49	51	
Jan.10/40	54	48	48	
" 24	50	48	50	Sub-basement temperatures
Apr.23	50	48	48	

Note: The heating unit of the thermostat "blew out" during the second week of February but it is unlikely that the weather during the rest of the experimental period was cold enough to freeze the oysters within the low temperature storage chamber.

The results of the experiment show that:

During storage there is a gradual falling off in the index on condition. This is slow and does not conflict with the finding of Russell (1923) according to which there was no loss in glycogen content during a two-day period of storage in air.

Part of the loss may have been from drying out of the meats for in the later stages of the test many of the oysters had very little shell liquor left.

This falling off was more pronounced at higher than at lower temperatures.

The mortality of oysters is similarly higher and more rapid at higher than at lower temperatures. See also section "The abundance of coliform organisms in oysters during storage".

The flavour of oysters suffers during storage and two months storage at basement temperatures makes them inedible.

During one and a half months' storage at 1 to 2°C (which is approximately the temperature of commercial cold storage compartments for oysters)there was practically no mortality and less than 10% of a falling off in the index of condition. After four months' storage under these conditions the mortality had risen to 40% and the fall off in index of condition was less than 15%. These conditions may be compared with the results of observations on oysters allowed to hibernate undisturbed on the beds discussed elsewhere (Medcof 1939a and 1941).

In considering these results it should be borne in mind that the oysters used in the test were held in storage in the station warehouse for over two weeks before the experiment was set up.

On the Water Content of Oyster Meats.

Several series of observations were made this year on the water content of oyster meats. The results are listed in the tables with the index of condition. It will be seen from these that the cycle of changes are much the same as those described for C₂ glass by Masumoto et al (1934). The present results are on the average higher since the Japanese authors dealt not with meats that were fresh but with those that were drained and dried on filter paper and cotton cloth for 1½ hours.

By plotting the index of condition against percentage water content it will be seen that there is a roughly straight line relationship between the two. The results for the different districts seem to group themselves about slightly different lines. This may be partly due to differences in the salinity of the sea water which to a large extent constitutes the body fluids. Such differences would effect dry weights and, consequently, the volumes of the index of condition.

From the above it might be considered feasible in general to use the percentage water content in place of the index of condition in describing the condition of oysters. The advantage would be a great saving in time and work in arriving at a figure. As yet, however, the relationship of the two factors is not sufficiently clear to warrant the substitution. It is not possible to say without a study how the water content would be effected by rapid changes in salinity such as are found in many estuaries where oysters abound. Generally speaking the values for percentage water content obtained for each of the two lots of five oysters which constitute a sample for the tests were in much closer agreement than the values for the index of condition. On the other hand the range in percentage values is much more restricted than for the index values and the accuracy of the former may not therefore be any greater.

Condition Studies by Other Authors

The condition of oysters has been studied by surprisingly few investigators. This may be explained by the lack of an obvious and simple quantitative method of analysing changes in condition. As far as the writer has been able to discover in reviewing the literature, the first systematic approach was that proposed by Captain C.C. Yates, described and applied by Grave (1912) and later made use of by Nelson (1930). By this system the volume of the fresh drained meats and of the cavities of the shells from which the meats have been removed is measured. The percentage value of the expression

Volume of drained meats

Volume of cavities between the shells is then used as an index of condition. This same measure has been developed, seemingly independently, and applied by Quayle (1940). The only difference in the system is that Quayle has not reduced the value of the fraction to a percentage and has standardized the length of the period during which the meats are allowed to drain before volume determination. The importance of this latter precaution, overlooked by Grave, is well discussed by Malcolm (1912).

Grave studying O. virginica made monthly observations on condition and plotted his results. He never criticized the accuracy of his methods of measuring condition or of sampling the oyster stocks. Daniel (1922) has noted the importance of care in sampling in an investigation of this sort and the present study has demonstrated the necessity of every precaution in this matter. Because of the long intervals between successive samples and failure to standardize technique, Grave's results indicate only the broadest and most general trends in the seasonal cycle of changes in condition. His results demonstrate the hibernation plateau and the post spawning depression. Nelson (1930) used the Captain's system while following the "fattening" process of oysters planted on different types of beds. Quayle (1940) working with Pacific coast oysters, has classified certain beds according to the fatness of the oysters reared on them.

Orton (1928) used an even simpler method. He measured fatness by taking the volume of meats derived from supposedly uniform samples of oyster meats. From this study he concluded that fattening in O. edulis went on while water temperatures ranged between 10 and 15°, roughly. This temperature band seems to correspond to that between 15 and 20° described by the writer for O. virginica.

As far as the writer is aware these four investigators are the only ones besides himself who have studied condition as such. There are in addition several careful treatments by biochemists of the seasonal changes in the chemical composition and nutritive value of oyster meat. These have provided some interesting and suggestive leads but on the whole their observations are scarcely pertinent to an analysis of condition changes. This is partly because the sampling dates were chosen quite arbitrarily, usually at monthly intervals, and without regard for the sequence of biological and physical changes going on in the oyster and its environment. It would be pointless to review the several investigations individually. These are referred to in the table to references appearing at the end of this report. It does seem worth while, on the other hand, to draw attention to certain problems raised in these studies which are explicable on the basis of conclusions from the present study.

Milroy (1909) has reported and left unexplained wide year to year differences in the fattening behaviour of oysters laid in sea side ponds or "calsses" into which fresh water penetrates. This peculiarity has appeared in Gillis cove and if O. edulis behaves in the same fashion as O. virginica the irregularities can be ascribed to the same cause - hydrographic differences from year to year that prove favourable or unfavourable (as the case may be) to fattening.

Elsey (1934) has noted that O. virginica transferred to cold British Columbia waters usually become thin quickly, remain poor and frequently die. The same behaviour in English waters frequently followed by death during the second season has been reported for this species by Orton (1935). This condition may be due simply to starvation brought about by temperature experiments unfavourable to feeding. The same explanation might be proposed for the poor condition of O. edulis held over winter in tanks at Conway, England (Cole 1939).

Loosanoff and Engle (1940) have taken issue with Prytherch's theory (1928) according to which spring water temperature regulate the quantity of spawn developed. These workers suggest without much evidence that the quantity and quality of food available is more significant in this process. The present study lends support to Prytherch's ideas for it seems that the longer the spring temperature ranges between 15 and 20°C. the greater is the amount of spring fattening (gonad development).

PART II. THE REPRODUCTION OF OYSTERS IN SHEDIAC BAY

Introduction

In the summer of 1940 an explanation was sought for the erratic production of oysters in Shediac bay discussed by Fisher (1935) and Needler (1932 a & b, 1933, 1934). This area had been closed to public fishing from the spring of 1936 until the late summer of 1940 when it was re-opened for the fall fishing.

Study of Shediac Bay Oyster Stocks

The first step in the investigation was a study of the size and age composition of the stocks of oysters on representative beds. The results of examinations of Wilbur bed and Indian Island Shoal samples taken May 22 are listed in the two accompanying tables. Contrary to what was generally reported, the total oyster population of this grounds was not great. The basis for the misleading report seems to have been the fact that the population consisted almost entirely of larger oysters, there being practically no spat present. There was an agony or an agony of mortality of yearling oysters or, for that matter, of any oysters. The spat from the Aras d'Or lakes transferred to the Poirier bed and Indian Island Shoal grew well suggesting that the bay favours growth of young oysters. There was a conspicuous scarcity of starfish on the grounds and all the oysters seemed to be in a particularly vigorous state.

The ages listed in the table are subject to an error of ± 1 year because of the great difficulty in determining the position of the first annual growth ring. Allowing for this the results still strongly suggest that spat production in the bay has been very poor for the last ten years except for two seasons - apparently 1933 and 1938. This picture is less clearly shown by the table illustrating the size composition of the oyster stocks but the obvious scarcity of the smaller groups definitely suggests failure in reproduction during the last few years. A study of the size composition of a sample of mussels (Mytilus edulis) taken from Indian Island Shoal on July 17 and of clams (Mya arenaria) taken from the Poirier flats in early December, demonstrates the same peculiarity of size frequency distribution in these two species as mentioned for the oyster. The inference may be drawn that there is one single factor or set of factors interfering with successful reproduction of bivalve molluscs in Shediac bay and that this is responsible for the erratic production of the oyster fishery and the peculiarities of age composition of the clams and mussels.

Table showing age-frequency distribution of Shediac Bay oysters as determined from growth rings, May, 1940.

Estimated age in years	1	2	3	4	5	6	7	8	9	10	Total number in sample.
Frequencies for Indian Isample	0	2	0	10	6	1	11	2	0	1	33
Frequencies for Wilbur bed sample	1	1	6	12	9	2	1	3	0	0	39

Size-frequency distribution of Shediac Bay bivalves

Size in cm.	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	Total no. in samp.
Frequency for average diameters of Indian Island oysters.	0	0	1	8	9	7	4	3	0	1	33
Frequencies for average diameters of Wilbur bed oysters.	0	2	0	6	15	10	2	4	0	0	39
Frequencies for lengths of Poitier bed clams (Mya)	0	5	8	15	5	0	0	0	0	0	33
Frequencies for lengths of Indian Island mussels (Mytilus)	0	0	11	45	23	2	0	0	0	0	83

On the basis of the above conclusion it seems safe, temporarily at least, to neglect several explanations offered by the local people for the poor condition of the oyster fishery. The most common of these were: (1) that silting of the beds (while they were undisturbed during the closed seasons of 1938 and 1939) had not only smothered all the little oysters but also rendered the bottom unfit for further settlement of spat; (2) that conditions were quite favourable to spat settlement but that fishing of small oysters by poachers and overfishing (particularly of the rivers, previous to the closure of the area) had reduced the spawning stock to such an extent that there were not enough larvae produced to populate the area.

Reproductive Cycle in 1940.

The oysters all seemed perfectly sound and in the course of the spring developed large quantities of spawn. This was shed principally during two spawning bursts - July 7-8 and 24-26. Small rose-coloured oyster larvae were found in limited numbers in tows made over the Poitier bed on July 10 and 12; abundant on July 13; rare on July 14 and increasingly rare thereafter until July 31 when three-and four-day-old larvae of the second spawning burst were making their appearance. On the last date they were numerous in the tows; rare on August 2; surprisingly common on August 9 with representatives of both the old and new broods present; rare on August 13 and completely absent on August 23.

Tows made in the middle of the bay near the Wilbur bed showed: July 17, no oyster larvae; July 18, larvae very rare; July 28 and August 7 very rare.

In Shediac river conditions were similar. On July 13 just below the highway bridge they were present in the tows in large numbers; July 27, 1½ miles up-stream from the highway bridge, no larvae; July 29, 1 mile above highway bridge, no larvae.

The conditions in the Scoudouc river were somewhat different. Although oyster larvae were found in fair numbers in the lower reaches of the river near Dr. Webster's wharf on July 13, they were rare July 14 and completely absent from the tows on July 17. In deep parts of the upper reaches of the river near Fishery Officer Caissie's camp, oyster larvae were found to persist in fair numbers - July 24, common; August 2, abundant; August 12, rare. It would be noted that the age group, spawned on July 4-8, persisted in the catches until July 24 when they were approximately half-grown. On August 12 when settlement was expected no mature larvae could be found. Larvae of the brood spawned July 24 had replaced the older group by this time.

At no time during the investigation were there any empty larval shells found or larvae that appeared in the least sickly. Other paleripod larvae and gastropod larvae were usually common in the tows and always in a vigorous state. Observations on minute flagellates like those described earlier (Medcof 1938) as the food of larvae, were almost as common as in Bideford river. From these facts it would appear that conditions inside the bay are not unfavourable to larval developments.

The Distribution of Oyster Larvae by Water Currents.

Because Shediac bay is unusually shallow for its size tidal currents in it are strong. In trying to discover what becomes of the larvae it was decided to examine the possibility of their being carried out of the bay by these currents. A series of tows was made, special care being taken between each tow to wash the plankton net thoroughly so as to avoid contamination of one catch by "left-overs" from the last. A list of these and a report of the examination of the catches is presented in the following table (see page 24).

Although the total number of larvae discovered were in all cases small these data indicate that there are sometimes just as many oyster larvae to be caught in the surface waters of the strait opposite the mouths of the bay as in the bay itself. The inference is that the currents bear the larvae out of the bay in considerable numbers.

If oyster larvae were passive plankters and never settled to the bottom one could estimate the percentage of the total population in the bay which would be carried out into the strait with each ebb tide. This could be done by simply computing the water exchange between the bay and the strait. Because so little is known of larval behaviour it is impossible to say what percentages would be carried out but a knowledge of water exchange might be instructive.

Report on tows for oyster larvae in Northumberland strait and Shediac

Date and place	Time	Tide	Wind	No. of larvae found during 15 minutes examination
July 17				
Over Hamilton bed	10:30A	HF	Fresh SW	none
Northumberland strait ½ ml.off Pt.du Chene	3:45P	LS	" "	5
In strait 2 ml.off Pt. du Chene	4:15P	LS	" "	none
July 18				
In middle of bay	1:45P	½F	Calm, bright	5
In strait ½ ml.off Pt. du Chene	2:10P	"	" "	2
Same, 1½ mile off	2:40P	LF	" "	none
In strait 2 ml. off Grandigue	3:15P	"	" "	search 2 difficult because of much sand in tow.
In strait ½ mile off Grandigue	3:30P	"	" "	4
July 26				
In middle of bay	1:30P	½F	Fresh	2
In channel airway Pt. du Chene	4:10P	LS	"	none
In strait ½ mile off Pt. du Chene	5:00P	LR	"	none

Water Exchange between Shediac Bay and Northumberland Strait.

The Shediac Bay Yacht Club issues a chart of the bay with
a complete series of soundings (made at low tide) plotted on it.
By laying off the bay in squares, then counting them and summing
their depths, it was found that the average depth for the bay at
low tide was 4.9 to 5.0 feet. The tide tables show that for August
the fluctuation in water levels from low to high tide at the time
of spring tides was 4.5 feet. It may be assumed that the tidal
flats (the areas of which are also shown on the chart) are covered
to a depth equal to half the difference between high and low tide
levels (in this case half of 4.5 feet which equals 2.3 feet). On
this basis the water exchange between the bay and Northumberland
strait was calculated. This showed that 33% of the bay water went
out to the strait when the tide changed from high to low at the
"spring" phase. At the neap phase the exchange would be somewhat
less.

Study of Water Currents at the Entrance to Shediac Bay.

The next step was to try to discover what chances larvae
had, after being carried out into the strait with the ebb tide, of
being returned to the bay with the following flood tide, an approach
to this problem was made through an attempt to study water move-
ments in the strait.

For this study two vertical floats were prepared. These
were made of round spruce wood, three feet long and, except at
their upper ends where they were tapered with four size flanges
eight inches square, at the lower end to "grab" the water, and with
lead weights to make it float upright with only the top six inches
exposed above the water. The design was such that there was prac-
tically no "drift" even during fresh to strong winds. At the same
time the floats were borne along easily by very slight water
currents.

On two dates, August 6 and 30, the floats were released
in the channel at Point du Chene just as the tide turned to flow
outward. The course taken by the floats was traced from a motor boat
and plotted in figure 1. It may be noted that the courses followed
on the two days are roughly similar and that on August 30 the
floats ended up nearly two miles from their starting point. It is
possible that the floats would have returned to the bay again
within a reasonable length of time. On the other hand it seems un-
likely that this would have taken place (if it were to happen at
all) at a time earlier than that of the next flood tide.

The observations indicate that in the surface waters at
least there is an eddy in the strait just east of Shediac Island.
In completing the circuit of the eddy, the floats would travel
approximately six miles.

Figure 1.
Course of Floats in Shediac Bay, N.B.

Tidal Cycle for August 30/40.

——— Course on August 6, 1940.
- - - - Course on " 30, 1940.

Tidal Cycle for August 6/40.

Scale of Miles
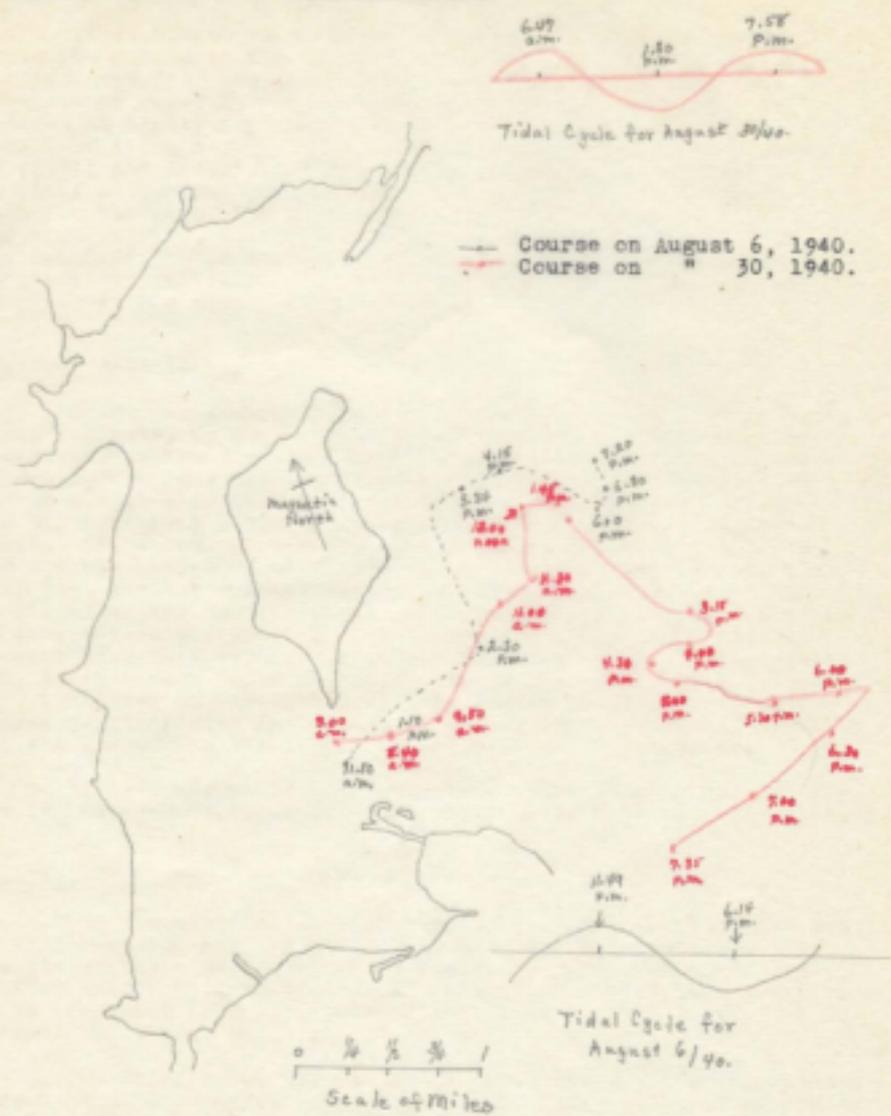
If we assume that the paths taken by the floats truly indicate the nature of the water movements then, since oyster larvae are carried out into the strait, it seems that many of them will be permanently removed from the bay. Although this happening is considered as highly improbable by such workers as Prytherch (1928) this sort of thing may go on much more commonly than is suspected. Elsey (1934) and later Elsey and Quayle (1939) has shown that it takes place on the Pacific coast. This drainage of larvae would account for the pro sets in the bay and the low periods in the oyster productivity. Since years larger numbers of larvae than usual may be retained in the bay and this would account for the peaks in the productivity already referred to but the basis for year-to-year differences in the amount of spatfall is obscure.

Spatfall in Shediac bay

There was a slight spatfall in peculiar positions in 1940. This may indicate, as would be expected from the above discussion, that some larvae remained in the bay and matured to settlement size. On august 8, numerous one- to two-day-old spat were discovered on the under surfaces of the upper valves of some "clunkers" (dead shells still hinged) left by transplanted adult bras of'of oysters that died. There were also a few on the shells of oysters held four inches off the bottom on wire netting in the submerged tray on the Pointer bed. Smaller numbers were discovered on a commercial collector placed on the netting cover of the same tray at a distance of eight inches from the bottom. None were found fifty feet away on collectors suspended vertically with their lower ends one foot above bottom. No spat were found on washed shells (but very thoroughly washed) scattered on the bottom at this latter place. The reason for these peculiarities is obscure. The spat grew apparently normally and at the end of the season averaged 3 to 5 mm. in diameter.

No 1940 mussel or clam spat were found suggesting that the larvae of these two species suffered the same fate as the oyster larvae.

Discussion.

The comparatively large numbers of spat present on the small areas that received any set at all and the general absence on other apparently suitable surfaces nearby, raises several questions. It seems that larger numbers of larvae could have settled in the bay than would be suspected from observations merely on natural cultch and on commercial collectors exposed in the conventional way.

The modal values for height measurements of 48 prodissoconch measurements made on august 8 on spat on the inner surfaces of oyster shells was 374 , a high value. The larvae,too,seem to have had a long free-swimming period for they were probably spawned July 7-8. These two facts suggest that the larvae developed under temperature conditions different from those recorded for Shediac bay (Medcof 1939a and b). The question arises as to whether the development went on in the bay in a normal way. Were the larvae which settled just previous to august 8 brought into the bay just before settlement, say from the strait where the water is colder? If the larvae spent their entire

lives in the bay why was it that they were so "uncatchable" as to appear only sporadically in the town? Did they spend most of their time on the bottom as the suggested by Frytherch (1928)? Some behaviour similar to that in Gilija cove (Medcof 1938a) may have given the appearance of scarcity of larvae.

These are some of the questions that might be answered after further study which will be continued in 1941 if opportunity permits.

Conclusions

The results of the study to date indicate that reproduction, in so far as the adult oysters are concerned, is perfectly normal in Shediac bay.

The larvae, when found, seemed at all times to be developing normally. In other words, no disease seems to be present, nor was there evidence of large numbers of animals predaceous on larvae.

The settled spat grew, although slowly, without conspicuous mortality and in other respects quite normally. There are peculiarities in settlement behaviour that are not yet explained.

The larval period was peculiarly long - 31 days. This and the large size of the mature larvae (374 as judged from prodissoconch) suggests that the conditions under which the larvae developed were not what might be expected in the light of present knowledge of larval development and the hydrographic conditions in the bay.

Over 50% of the water leaves the bay during the "spring" phase when the tide falls from "high" to "low". A large percentage of swimming oyster larvae have, therefore, a chance to be carried out into the strait.

There seems to be an eddy current in the strait just outside the bay and east of Shediac island.

Considerable numbers of larvae are carried out into the eddy just referred to as proved by the study of plankton catches.

From the behaviour of the floats it is doubtful that many of these oars ever returned to the bay after being once carried out.

This loss of oyster larvae from the bay would explain the poor sets which are characteristic of Shediac bay. On rare occasions (about one year in five) heavier sets take place. The reason for this is obscure.

Together, the last two features could account for peculiarities of size frequency distribution observed in the oyster stocks in the bay and the irregular productivity of the oyster fishery.

The 1940 broods of clam and mussel larvae seem to have shared

the same fate as the oyster larvae for no spat of these species were found.

The peculiarities of size-frequency distribution in the bay populations of these two species can be attributed to the same factors as produced like features in the oyster stocks.

Further study is necessary before a solution of the problem can be claimed.

PART III. OYSTER POLLUTION PROBLEMS AT BUCTOUCHE, N. B.

Introduction

The two sections to follow entitled "The Abundance of coliform organisms in oysters during storage" and "The effect of hibernation on the abundance of coliform organisms in oysters" are nearly identical with the summary reports prepared by A.G.Campbell abd J.G.Medcof on the work carried out jointly for the Fisheries Research Board of Canada and the Department of Pensions and National Health.

The Abundance of Coliform Organisms in Oysters during Storage
by A.G. Campbell and J.C. Medcof.

Two experiments were carried out at Buctouche, N.B., to discover what changes, if any, take place in the abundance of coliform organisms in sewage-polluted oysters held in storage.

Experiment #1. In the first experiment native Buctouche river oysters were used. These were fished on September 16 and 17 from nine or ten feet of water just opposite the sewage outlet on the west side of the highway bridge at Buctouche. They were not taken at any one stage of the tide. These oysters were poor and probably not in a vigorous condition. Their "Index of Condition" as measured by the standard described by Medcof (1941) ranged from 60 to 80.

On September 18 the oysters were separated at random into three lots after being well mixed together. Each lot consisted of 150 oysters and was placed in a wooden box. The first of these was placed in a constant temperature chamber thermostatically controlled and set for 25°C. The second was in a similar chamber set at 20°C. while the third lot was kept in a storage box in an oyster ware-house belonging to Robichaud Brothers. In this last the temperature was variable.

Records of temperature readings from maximum-minimum thermometers placed in each of the boxes were kept - a set of readings being made on each sampling date.

From time to time "most probable numbers" of bacteria# per 100 cm.^{3} of oyster meats and liquor were determined according to the American standards for water and oyster analysis.

In addition to the above it seemed desirable to find out what changes, if any, take place in the abundance of living bacteria in the dirt on the outsides of oyster shells during storage. To learn this each sample of oysters taken from the warehouse for the tests described above was washed off with a sterile brush in 1 litre of sterile water and the "most probable number" of bacteria per 100 cm.^{3} of this "wash water" was determined.

Together with the results of the bacteriological examinations there are some observations on the mortality of the stored oysters. These figures were worked out from counts of living and dead oysters removed from the boxes at each sampling.

The results of the experiment are presented in the tables below.

Table showing the results of Experiment #1.

Date	Length of storage in days	Temperature of Storage Chambers						Wash water M.P.N.
		25°C.		20°C.		Variable (warehouse)		
		M.P.N.	Mortal- ity %	M.P.N.	Mort- ality %	M.P.N.	Mort- ality %	
19/9	1	4,800	0	4,800	0	9,200	0	110,000
24/9	6	30,000	25	860	0	860	0	460,000
26/9	8	----	88	4,800	52	3,000	--	73,000
1/10	13	----	--	--	70	30,000	73	1,100,000
3/10	15	----	--	--	--	4,800	75	46,000

Table summarizing the temperature observations for Experiment #1

Date	25°C Chamber			20°C Chamber			Warehouse Chamber		
	Max.	Min.	Pres.	Max.	Min.	Pres.	Max.	Min.	Pres.
19/9	94°F.	78°F.	87°F.	68°F.	62°F.	62°F.	60°F.	56°F.	59°F.
24/9	82	75	74	70	62	65	73	64	66
26/9	77	75	76	69	66	68	61	52	54
1/10	--	--	--	67	65	66	58	48	50
3/10	--	--	--	--	--	--	54	49	52

For brevity the word "bacteria" is used in this report to refer to that group of coliform organisms which in routine bacteriological examinations gave reactions typical of *Escherichia coli*.

Experiment #2. For this test a stock of supposedly more vigorous oysters was employed. These were Poirier bed oysters from Shediac bay, N.B., fished on October 8,9, and 10. The Shediac oysters are in better condition than were the Buctouche "natives". The index of condition ranged from 120 to 130. Poirier bed oysters are relatively free of sewage pollution as they were placed in the Buctouche river water opposite the sewer outlet at the same place from which the oysters for the first experiment were fished. They were put down at 10:00 p.m. on October 10 at high tide. The following morning at 9:00 a.m. at high tide a sample was re-fished and tested. The M.P.N. value for the test was 860.

The whole lot was fished on October 14 during the period of low water before and after the noon hour. The salinity of the water at the bottom where the warehouse chamber was 19.2 per mills. A random sample of these when tested on the date fished showed an M.P.N. value of 1860. The oysters were separated into two lots at random and one stored in the warehouse referred to above. The second lot was placed in the 20° chamber. Records similar to those described for Experiment #1 were kept. The results and observations are presented in the table below:

Table showing the results of Experiment #2.

Date	Length of storage in days	20°C Chamber		Warehouse Chamber		Wash water M.P.N.
		M.P.N.	Mortality %	M.P.N.	Mortality %	
14/10	0	1860	0	1860	0	
22/10	8	22,000	0	860	0	230
29/10	15	3000	12	4800	---	1400
		---	---	860	---	
7/11	24	860	70	460	20	164

Table showing temperature observations for Experiment #2.

Date	20°C Chamber			Warehouse Chamber		
	Max.	Min.	Pres.	Max.	Min.	Pres.
14/10	66°F	66°F	66°F	54°F	54°F	54°F
@ 22/10	66	49	50	56	30	34
29/10	64	30	62	43	31	35
7/11	65	61	62	45	30	42

@ On this date it was discovered that someone had meddled with the temperature control device. It was set correctly and the temperature regulator was not altered during the rest of the experiment.

Conclusions and Discussion of Results

The results of the two experiments suggest that there was no great reduction in the numbers of bacteria within oysters stored under the conditions described.

The results of the first test with Buctouche river oysters were particularly erratic and inconclusive.

The results of Experiment #2 suggest a slight progressive reduction in the M.P.N. values during storage.

Altogether the results do not raise great hopes for the possible development of a method of purification of sewage-polluted oysters by simple storage.

There was no great decrease in the number of viable bacteria in the dirt on the outsides of the shells of oysters during storage.

It is not possible to detect in these records any effect of temperature on the rate of change in bacterial content of stored oysters.

The length of life of stored oysters is greatly reduced by high temperatures [see also section "The effect of storage on condition].

Oysters with a high "condition factor" lived longer during storage than those with a low.

The stocks of oysters used in these tests were all fished from water of low salinity - for the second lot the salinity record was 19.2 per mille. This is not a typical of the conditions in the Buctouche river where the pollution is most severe. It should be pointed out, however, that at this low salinity certain physiological functions such as feeding rate (Hopkins 1936) and fattening (Medcof 1941) are drastically impaired. It is quite possible that, if there is a mechanism by which stored oysters eliminate bacteria from their systems, its operation might be likewise impaired by low salinities, that is to say, that polluted oysters fished from water of higher salinity than that experienced here might yield results quite different from those observed.

It would be worth while to repeat the storage test when higher salinities were experienced.

It would be worth while to repeat the experiment holding the oysters at a fixed temperature well below 5°C thus simulating temperature conditions experienced by oysters on the beds during hibernation. This seems justifiable because in the next section of this report it will be seen that bacteria disappear from oysters during hibernation after a certain interval at really low temperatures.

The Effects of Hibernation on the Abundance of Coliform Organisms
in Oysters. By A.G. Campbell and J.C. Medcof.

The following report deals with a study of the numbers of
Bacteria# found in the oysters and water of Buctouche harbour during
two periods of investigation - the first from the middle of September
to the early part of December, 1940, and the second from the first
to the third week of January, 1941. The writers were particularly
interested in the periods when the water temperatures drop below
5°C and the oysters quit feeding and hibernate. Bacteriological ex-
amination of water and oyster samples from each of four stations in
the harbour were carried out tri-weekly and the most probable numbers
of bacteria (M.P.N.) per 100 c.c. of samples were calculated. The
four stations were:

(1) the northwest corner of Barnes' oyster lease where the
water is five feet deep at low tide;

(2) opposite Irving's sawmill in the channel - twenty feet
deep;

(3) the flat opposite the sewer outlet just above the high-
way bridge - eight feet deep;

(4) in the channel 100 yards above the highway bridge -
twenty feet deep.

The results of the observations appear in the following table. In
addition to the above investigation weekly surveys were conducted to
discover the extent of pollution in the harbour. The results of
these surveys are not reported here.

The changes in M.P.N. values for bacteria in the water
and oysters are roughly parallel up to October 20 as shown in table
14. In four cases out of every five the values for the oysters are
higher than for the water. In this same period the changes in the
oysters are more erratic than in the water. This may be due to a
greater difficulty in making a fair sample of an oyster population
than of the water.

Relationships during the first three weeks of the invest-
igation. September 14 to October 7, showed a general decrease in the
pollution of both water and oysters. The trend was doubtless in
the nature of a return towards more normal conditions after the
unusual turmoil caused by the gale and heavy rains of September 13-17.
The river and bay water remained brown with sediment throughout the
greater part of this period.

The M.P.Ns for station #1 (Barnes' bed) were usually low
and changed less erratically than those for the up-river stations
nearer the source of pollution. That is, the sewage seems to be more
evenly distributed the further one goes from the source of pollution.

For the sake of brevity the word "bacteria" is used in this
report to refer to that group of coliform organisms which in
routine bacteriological examinations gave reactions typical
of Escherichia coli

Table 14. Showing the M.P.N. values for oyster and water samples
from Buctouche river stations.

	1		2		3		4				
Date N.W.	Irving's corner old mill Barnes' lease (shallow sample) (deep sample)		Near mill sewer outlet (shallow sample)		Channel above bridge (deep sample)		above bridge (deep sample)		Sal. ‰ (p.p.m. at 15 to 25)	Temp. hr. of dep- °C. ths	Weather Remarks
	Oys.	Wat.	Oys.	Wat.	Oys.	Wat.	Oys.	Wat.			

M.P.N. of E. coli per 100 c.c. of:

Date N.W.	Oys.	Wat.	Oys.	Wat.	Oys.	Wat.	Oys.	Wat.	Sal./Temp.	Weather Remarks
14/9	460		860		860		140		HF 20 24 16	lt. rain
20/9	1840	240	22,000	460	180	1500	1860	93	LB 20 24 16	calm
23/9	460	150	300	93	180	460	180	210	LS 21 22 13	fr.breeze
25/9	0	23	300	15	30000	150	1860	1100	98	12 hr. rain
27/9	460	1500	9200	1500	1860	1300	460	1500	LF 4 7 12	cl.lt.wl.
30/9	460	93	300	150	180	1300	300	93	HF 20 24 11	lt. NW.
2/10	860	93	180	43	1840	240	460	75	R 22 24 12	calm,lt. N. clear
4/10	180	150	0	93	460	460	80	43	R 20 19 10	Lt.N. "
7/10	180	23	0	93	1860	240	1840	240	HF 23 21 11	cl.lt.S
9/10	80	23	140	23	80	9		80	HLF 18 19 14	h.ra.NW lt.
11/10	180	43	860	43	460	3	300	25	HF 18 12 14	W.air
14/10	0	23	80	9	4600	75	460	18	20 23 11	clr.calm.
16/10	60	7	180	93	860	43	300	93	HF 23 2?9 7	calm,lt. N. hv.rain la. night.
18/10	80	0	93	23	1860	460	460	43	HF 18 25 26 9	cl.lt.SW.
21/10	0	43	0	15	60	9		93	HS 24 24 4.4	o1.mod.NW. 8? snow la.r
23/10	0	240	0	23	0	240	180	43	LB 19 23 2.8	clad.clr.
25/10	0	43	0	43	80	460	0	150	HF 22 26 4.2	clr.lt.NW.
28/10	0	150	80	23	0	1100	180	23	HF 29 ?5 3.3	old." R.
30/10	0	15	0	9	0	43	0	4	HS 26 27 3.9	o1.lt.W.
31/10	0	0	0	0	11	0		3	HS 26 26 3.4	fr.W.clr
4/11	0	460	0	75	0	23	80	23	LB 20 22 6.4	cl.clr.m.
6/11	0	23	0	75	80	43	0	43	LH 22 26 --	cld.lt.SW
9/11	0	0	0	93	0	0	5	0	LLF 22 24 9	cld.lt.S.
11/11	0	15	0	0	15	460			LS 19 24 5.4	cl.lt.S.m.
13/11	140	0	0	9	180	20	0	460	LB 23 24 6.4	- "
15/11	120	240	180	240	0	1100	0	240	HS 13 15 5.1	str.Ne ra.
18/11	60	43	860	25	93	93	460	24	HF 21 24 4.6	mod.W.rain
20/11	180	93	460	1100	180	93	460	93	L 13 17 3.2	cld.calm.W
23/11	0	23	0	43	0	93	0	43	LF 10 16 3.7	cld.lt.S
25/11	80	0	80	9	0	93	0	4	HS 23 22 2.0	ice formed 24th.
2/12	0	0	0	21	80	23	0	75	HH 23 23 -0	mod.NE.mi.
5/12	0	0	0	23	140	15	0	23	LF 15 16 -0	mod.W.clr.
9/12	0	0	0	0	0	0			HS 20 23 -0	mild
15/1	0	4	0	9	0	0			23 --	very cold
18/1	0	0	0	43	0	23	0	0	LB 23 22 -1.3	mild
20/1	0	0	0	15	0	93	0		LS? 28 -1.3	mild

After the heavy snowfall of October 20 the water temperature dropped suddenly to a level below 5°C. The effect of temperature on oyster activity is well known. Galtsoff (1928b) has shown that feeding ceases at this level. The inability to feed is not due to the cessation of ciliary activity but because the coordination of ciliary activity breaks down at this temperature level (Gaktsoff 1928a). The shells, however, remain closed and thus to a great extent shut off the animal from its environment. That some kind of internal activity may continue below 5°C is also suggested in the present records by the fact that the bacterial content tended to fall away after the temperature dropped below this level.

In the week of October 20-26, after the temperature dropped below 5°C, the M.P.N. for the oysters were lower than for the water in the great majority of cases. This reversal in the earlier conditions was very sudden (see records for October 18 and 21).

According to Dodgson (1938) shellfish, after their shells have been cleaned, require only about twenty-four hours to rid their bodies of B. coli I placed in clean water. This, however, may apply only when temperatures are at such a level as to permit active filtering of water. Under these conditions he considers that the bacteria are entangled in the mucous and thrown out with the faeces or pseudo-faeces. Pseudo-faeces consists of the masses of mucous and its contents that are rejected at the mouth of the labial palps after they have come from the food-collecting apparatus. Pseudo-faeces, therefore, never pass through the digestive tract but are, nevertheless, swept away with the faeces by water currents from the shellfish.

During the early period of "hibernation" several cases arose in which the M.P.N. values for the water rose sharply without any corresponding increase for the oysters (e.g. Oct.28, Nov.4). By way of contrast it may be noted that there is sometimes an increase in the oyster M.P.N's simultaneous with those for the water though the oysters are supposedly "hibernating". (See records for Oct.28, stations 2 and 4; Nov.4, station 3; Dec.4, station 3). This finding corresponds to that of Nelson et al (1928). Nelson, in analyzing this situation for oysters that were transferred from clean salty water to polluted fresher water gives three possible explanations for the rise:

(1) The oysters may have been damaged and rendered "leaky" during the handling in the polluted water.

(2) In response to the mechanical stimulation received during handling oysters sometimes will open their shells. By either of these two means (1) or (2) bacteria could be artificially introduced into the shells.

(3) Oysters are considered to relax their adductor muscles during hibernation on rare occasions without special external stimuli. This would have the same contaminating effect as (1) and (2).

During the present tests the oysters were probably subject to less handling than those dealt with by Nelson. Besides, each lot

was carefully examined and any "leaky" oysters discovered were
discarded. Thus, although the first of the three possibilities
of contamination during hibernation listed by Nelson is largely
eliminated, and second and third are still present. The possibility
that these may have affected the present results should be borne
constantly in mind. They offer a possible explanation for the few
cases in this study in which hibernating oysters showed small
numbers of bacteria.

November 13-14 brought heavy rains and November 12-15
heavy winds. Probably such winds combined to produce
the observed rise in M.P.N. values for the water which set in on
November 12 and lasted until November 20. At about the same time a
rise in M.P.N. values for the oysters set in. It may or may not be
significant that the rise for the oysters began before that for
the water. If this is regarded as significant then the water
temperature becomes of peculiar interest. November 9 was a warm
day (see Meteorological records for Shediac bridge) and water
temperatures rose to the hibernation threshold. These temperatures
remained high until November 13-17. What seems to have happened is
that the oysters emerged from hibernation and began filtering water
so that their M.P.N. values rose from below to above that of the
water bathing them.

After the M.P.N's for the oysters rose those for the water
began building up too. The result was a great accumulation of bac-
teria in the oysters. The water temperature gradually fell away
again about November 18 and for the second time during the season
the oysters went into a hibernation from which they were not dis-
turbed. The accompanying fall-off in M.P.N's however, was much less
sudden than in October and it was not until after November 23 that
the oysters were really "clean" again. This type of behaviour sugg-
ests that the threshold for hibernation is not sharply defined by
temperature. The suddenness of the temperature decline may influence
the rate of elimination of the contaminating bacteria - the more
sudden the fall the more sudden and complete the onset of hibernation.

The January sampling was done through holes in the ice.
By this date conditions may be regarded as having "settled down"
for the winter. Temperatures were well below zero and the oysters
were perfectly free from bacteria in spite of the fact that the
water bathing them was polluted with sewage. The oysters had all
had time to lost all the contaminating bacteria and showed no
tendency to come out of hibernation as they did while in the init-
ial stages.

It seems impossible from the present data to show any
clear relationships between the M.P.N. values for water and oysters
and the stage of the tide or the salinity of the water.

Just what mechanism is affective in eliminating bacteria
from the oyster when water temperatures are too low to favour their

active expulsion with water currents, is a question on which there is little definite information. According to Yonge (1926) the leucocytes are effective in ingesting food particles and other finely divided foreign materials at almost any part of the animal's body. It is conceivable, therefore, that it may be the mollusc's blood system that eliminates the bacteria during "hibernation".

The "serum" of oyster blood and the shell liquor of oysters is composed essentially of sea water. It is not impossible then that the disappearance of bacteria from the oyster is due merely to a naturally short survival period for bacteria in sea water. Once the shell is closed at the onset of hibernation the possibility of further contamination is greatly reduced and the enclosed bacteria may simply die out. This theory seems to be partly discounted by the results of the experiments reported in the section "the abundance of coliform organisms in oysters during storage". Whatever the true explanation may be, it is certain, as present records indicate, that elimination does occur below 5°C.

There are apparently many factors influencing the extent of pollution of the water and oysters at a given time or at any particular phase of the tide. It seems only desirable that each factor should be separately studied before further conclusions can be drawn from the accumulated data.

Some of the problems that have suggested themselves are indicated below:

How long does it require at a given temperature level for an oyster to clear itself of any given amount of pollution?

To what extent does the feeding rate influence the rate of clearance? Considerable information has been obtained by American writers relative to salinity and temperature change in the feeding rate of oysters.

Would the picture of the changes have been greatly altered had sampling (both oysters and water) been done always at the same stage of the tide? There is evidence from our data that it would have been different.

To what extent were the M.P.N's reported influenced by changes in amount of sewage entering the water and changes in the "run-off"?

Conclusions

When water temperatures range above 5°C. the changes in the M.P.N's for oysters and water are roughly parallel.

During this time the M.P.N. values for oysters are usually higher than those for the water bathing them.

Changes in M.P.N. values are more erratic for oysters than for water.

Heavy winds and rain vastly increase the extent of pollution of both oysters and water.

M.P.N. values for both water and oysters from near the source of pollution show wider fluctuations that do those for more distant points.

The results indicate that within less than a week after water temperatures drop appreciably below 5°C. a conspicuous decrease takes place in the bacterial content of oysters independent on M.P.N. values for the water.

The rate of fall-off in M.P.N. values may be influenced by the suddenness of the temperature decline - the more gradual the decline the longer is the period following the drop below 5°C. that is required for complete elimination of bacteria.

Hibernation, in its early stages, can be easily interrupted by rises in temperature as slight as 1.5°C. above the threshold. At these times the M.P.N's for oysters quickly rise above those for the water.

After an extended period of hibernation at really low temperatures (below -1°C.) all the oysters were found to be "clean" and remained clean without sporadic recurrences of contamination characteristic of early stages in hibernation.

The method by which the bacteria are eliminated from the oysters is obscure.

PART IV. MISCELLANEOUS STUDIES

The Effect of Temperatures on the Maturation of Oyster Larvae in Canadian Waters.

Knowledge of the larval history of the Canadian Atlantic oyster summarized by Medcof (1939b) has been added to during the three summers since 1937. Conditions in Bideford river, P. E. I. were followed by Miss Miller, and in Gillis cove, Bras d'Or lakes N.S., by J.C. Medcof. The body of new information is summarized below in two tables - 13 and 14 - and three figures -2, 3 and 4.

Temperature and larval growth rate. The data of table 13 together with that already published in 1939 is represented in figure 2. To make the 1936 data comparable 0.4°C. has been substracted from each of the temperature readings. This amount was the mean difference in 1937 between the surface temperature reading (which alone was taken in 1936) and the average for both bottom and surface at the temperature station concerned. The position of the curve in figure 2 is better defined than formerly and slightly different.

The curves in figure 3 were derived by the method described before (Medcof 1939b). The new data extend our knowledge of the temperature-growth relationships by including two new curves - those for 22° and 23°. Besides this the new data are more precise and have permitted a surer position of the curves. The old curves had less "sweep" than the new and thus indicated a lower growth rate for late larvae than now seems justified.

These new curves should be more satisfactory for prediction work than those formerly available.

The former data gave no support to Nelson's (1923) conception of the sigmoidal growth curve for larvae. At the time of publication, however, (Medcof 1939b) no one brood had been studied closely enough to prove this as well as do the data for the 1939 brood in Gillis cove represented in figure 4. These show that there was no slackening in the growth rate during the last few days and that the larvae continue to grow until they settle out at an approximately uniform size.

Larval size at settlement. In the past the larval size at settlement has been considered to vary from place to place but to be more or less fixed and characteristic for each district. Miller (1939) first drew attention to the fact that it may vary strikingly from time to time at a given place. Table 14 summarizes the available information on this subject. From this it will be seen that there are no striking differences in larval size at settlement between Bideford river and the Bras d'Or lakes in spite of considerable hydrographic differences. There is an indication, but it is by no means a clear one, that water temperatures, especially during the last few days of the free-swimming period, regulate the ultimate size of larvae - the higher the temperature the smaller the larvae.

Figure 3.

Growth curves for oyster larvae at different temperatures.
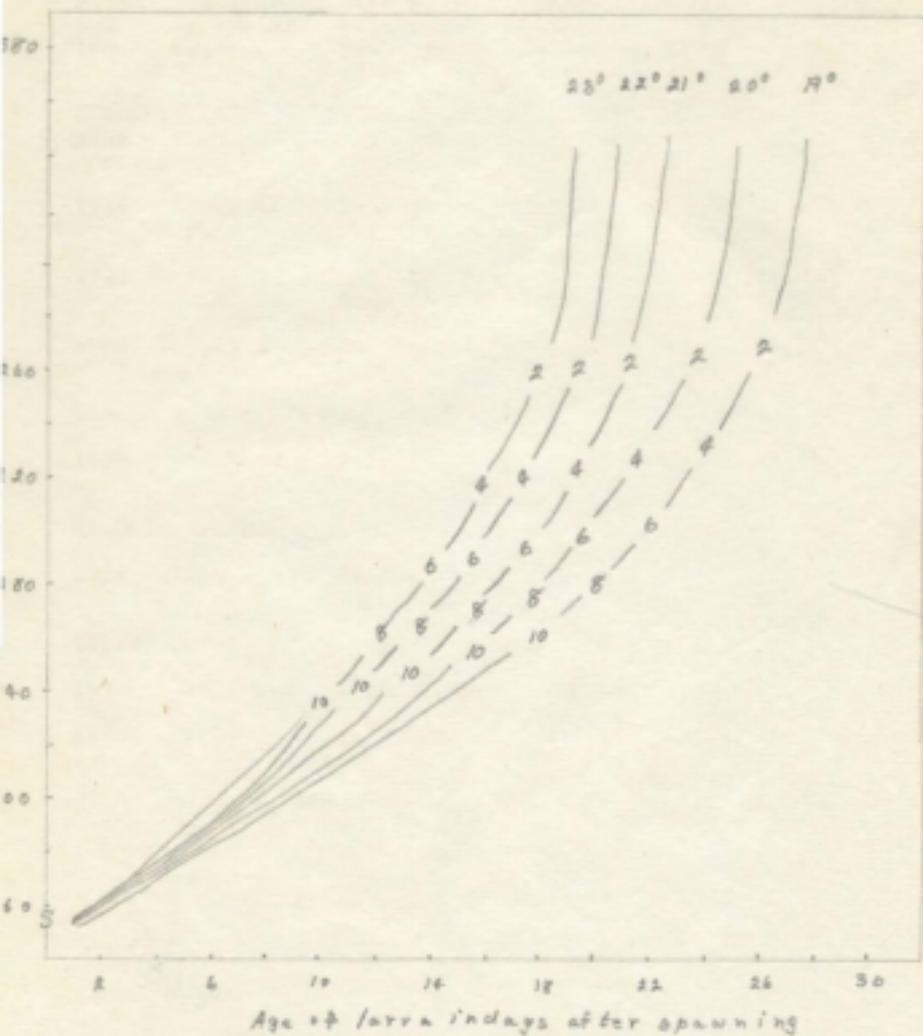
Figure 3. *Larval growth at various water temperatures.*

Table 15. Summary of Brood Histories.

Place and Year	Date of spawning peak	Date of settlement peak	Length of larval period in days	Av. temp. during larval period °C.
Bideford river				
1938	June 14 July 8	July 7 " 30	23 21-23	20.2 21.9
1939	July 1 July 24	" 23 Aug. 14	22 19-21	21.7 23.2
1940	July 6	July 27-28	21-22	21.5
Gillis cove				
1938	June 22	July 20	28	19.2
Crowdis Bridge				
1938	June 22	July -	28+	19.7
Gillis cove				
1939	July 6-7	July 28-29	22	22.2
1940	July 7	July 27	20	22.0

- 40 -

Table 16. Mean values for prodissoconch heights of young oyster
spat together with other data.

Date	Source of spat	Modal values for prodissoconch heights	No. of measurements made.	Av. water temp. for last 2 or 3 days before set °C.	Av. water temp. during larval period °C.
About					
(1) July 26/37	Bide-Cord R.	357	130#	23-24	22.0
(3) July 24/38	"	350	110	22.8	21.9
(2) July 24/38	"	343	16	22.9	21.9
(2) July 31/39	"	320	28	24.5	22-
(3) Aug.2-4/39	"	330	15	21.4	22-
(2) Aug.15-17	"	310	23	24.0	23.2
(2) July 26-29/40#		350	211	22.3	21.5
(3a) July 26-29/40#		357	39	22.3	21.5
(1) July 19-22/38	Gillis cove	336	93	23.4	19.2
(3) July 19-22/38	"	354	100	23.4	19.2
(2) July 26-29/39	#	330	64	23.6	22-
(2) July 26-28/39	"	343	79	23.6	22.2
(3) Aug. 1-3/39	"	357	93	23.1	22-
(2) July 27/40	"	350	14	23.6	22-

Notes: (1) Age of spat unknown; may have been several days old.

(2) Measurements were made from spat which had less than
33 μ of dissoconch shell.

(3) Measurements from older spat often with as much as 300 μ of
dissoconch shell.

(3a) From spat with more than 33 μ but less than 70 μ of
dissoconch shell.

Data obtained in 1941 correspondence from Miss Miller.

Some of the present records of mature size of larvae and length of the larval period approximate to the low values reported by American workers such as Prytherch (1929) and Nelson (1923), although they do not completely bridge the gap they come so close as to suggest that reported differences are due either to differences in the methods of study employed by the various workers or to differences in the environmental conditions experienced by the larvae. It seems unlikely that there is any genetic difference in the stocks of oysters themselves.

Part of the obscurity in the results of studies of the ultimate size of larvae seems to be due to crudeness in the method of study. No consideration has been made of factors influencing the values obtained from prodissoconch measurements. One of these factors is discussed below. If the method of study is refined it seems reasonable that the problem should be clarified.

When the spat first settles the height-axis of the upper (right) valve of the prodissoconch is inclined to an angle to the plane of the substrate, as the dissaconch shell is deposited this angle is decreased until the height-axis comes to lie practically parallel to the plane of the substrate. If prodissoconch measurements are to be made on a scale held parallel to the plane of the substrate, as is the case in ocular micrometer measurements, it is clear that the value of the measurement obtained will vary with the amount of dissaconch shell present even if there are no actual differences in prodissoconch size. If results are to be comparable then it will be necessary to deal always with spat at the same stage of growth.

The data presented in table 15 for Bideford river, 1938 and 1940, and for Gillis cove, 1938 and 1939, show that measurements of prodissoconchs of spat from the same brood of larvae vary depending on the size of the spat from which the measurements were taken. The larger spat always gave the larger prodissoconch measurements as would be expected. This difference does not seem to be explicable on the basis of temperature differences on the settlement dates for the different groups.

Summary. New and improved curves relating temperature and larval growth have been derived. These should be of assistance in predicting spatfalls for the benefit of the oyster industry.

The ultime size of larvae is not fixed for each other but may vary from year to year.

Water temperatures seem to influence this variation, high temperatures reducing the size.

Values obtained from prodissoconch measurements are influenced by the size of the spat (amount of dissaconch shell they have deposited).

Refinements in method are necessary before much progress can be made in studying the ultimate size of oyster larvae.

Spatfall on Experimental Collectors in Gillis cove.

The 1940 spatfall on the ten days covering the main period of settlement was followed by counts on experimental collectors. This year the collectors were changed both night and morning at approximately seven o'clock. Table 17 lists the results. From this it will be seen that the amount of spatfall was less than one-quarter of that in 1939. This lightness of set may be correlated with the much better survival observed as commercial collectors this season. In 1938 and 1939 heavy mortalities were attributed to over-crowding of the spat (Medcof 1938 and 1939a).

Table 17. Spatfall on Experimental Collectors, Gillis cove, 1940.

Period of Exposure	¼' up.	¼' low.	1¼' up.	1¼' low.	2¼' up.	2¼' low.	3½' up.	3½' low.	5½' up.	5½' low.	7' up.	7' low.
July												
23 7:00pm.to												
24 7:12a.m.	0	0	0	1	0	0	0	0	0	0	0	0
24 7:20 pm.to												
7:pm.	0		1	0	1		2		2	1	0	3	0	3
25 7:20 a.m.	0		2	1	2		3	1		5		0	24
25 7:00 pm.	0	0	0		1		1		5	4	3	4	2	12
26 7:20 a.m.	0	3	0	0	2	6	4	19	3	2	0	15
26 7:00 pm.	6	3	25	18	42	14	21	25	27	26	46	92
27 7:00 am.												
27 7:20 a.m.		5	11	11	6	20	19	124	14	147	11	107
27 7:00 pm.												
28 7:10 a.m.	16	11	0	2	35	48	35	51	26	130	43	240
28 7:30 a.m.	0	0	1	9	3	7	6	11	1	24	1	15
28 7:00 p.	8	5	2	12	4	16	13	29	17	56	11	18
29 7:20 a.m.	0	2	0	6	1	1	2	7	8	7	2	8
29 7:00 p.	9	7	13	9	3	7	9	26	8	45	12	16
29 7:20 p.												
30 7:30 a.m.	1	0	0	2	0	6	3	5	1	5	4	5
30 7:00 p.	5	13	14	10	12	24	12	28	4	21	0	12
30 7:00 pm.												
31 7:00 a.	4	18	2	8	1	11	3	6	3	37	1	9
31 7:20 a.												
7:00 p.	0	3	5	5	6	6	17	49	20	41	15	32
31 7:20 p.												
Aug.1 7:00 a.m.	0	1	5	6	1	0	5	5	2	5	1	3
1 7:00 a.												
7:00 p.	7	8	3	0	30	34	11	28	13	53	9	26
1 7:00 p.												
2 7:00 a.	8	2	3	0	5	0	2	1	3	0	1
2 7:10 a.												
7:00 p.	1	0	0	0	3	1	0	1	5	8	7
2 7:00 p.												
3 7:20 a.	3	3	12	5	4	3	12	5	16	17	18	31
Totals												
Night	12	31	33	52	19	61	57	183	50	252	38	220
Day	52	51	61	57	136	153	125	242	119	384	144	458
Night & Day	64	82	94	109	155	214	182	427	169	636	182	678
GRAND TOTAL	2992											

Day-to-Night Differences in Spatfall.

The data presented in table 17 have been re-arranged in table 18 for ease in discussion.

These data show clearly that more larvae settled during the day than during the night, suggesting that light stimulated them to activity. There is, however, no well-marked daily vertical migration such as is found with some planktonic forms because the percentage distribution of the set with depth is much the same by day and by night. This suggests that the reaction is not truly phototropic.

The intensity of settlement varied directly with depth. This might indicate an ineptitude of the larvae to settle swimming under such conditions. Pyefinch (1928) suggests that they spend a good deal of their time resting on the bottom. It may be that they rest more at night than during the day.

There was always more settlement on lower surfaces than on upper except near the surface during the day. It is supposed that this preference for lower surfaces is due to the close anatomical position of the foot and velum and to the animals peculiar swimming posture. The shell-covered body acts as a plumb bob, keeping the foot and the extended velum uppermost during swimming. It is for this reason that the animal seems unable to swim actively except in one direction - vertically upwards. In order to move downward the animal merely withdraws the velum, closes the shell and sinks. Extensive lateral movements are possible only through the effect of water currents.

It seems more likely that a larva would crawl over (and subsequently settle on) a surface which it encounters directly with its foot during swimming than one onto which it might fall. The "bump" at contact with such a surface might well be a sufficient mechanical stimulus to induce renewed swimming activity carrying the animal away again. From this point of view one might expect more larvae to be crawling over lower surfaces than upper. The possibility of this sort of reaction may or may not explain the heavier sets generally found on lower surfaces.

Table 18 shows that the larval operations are modified during the day in the upper levels of the water where the lights and shadows are stronger. Under these conditions more spat settled on the upper surface than on the lower. Such a behaviour can be explained if we assume the larvae to be stimulated by light. In their upward movements they would cease swimming when they entered the shadows cast by the horizontal collectors and thus avoid contact with lower surfaces. As a result the proportion of the larvae settling on upper surfaces would be increased.

Table 18 shows that the increase in the intensity of settlement with depth was always greater, both by day and by night, for lower than for upper surfaces. The significance of this condition is not clear.

Conclusions. Further work is desirable on this problem in order to make the relationships more clear. Differences in temperature from day to night might account for some of the differences observed because larvae may be assumed to be more active at higher than at lower temperatures. By further dividing up the day into say four intervals instead of two or possibly into more which overlap, the differences might show up more clearly.

To date the results of the experiment show the same features as those of the 1939 investigation (Medcof 1939a). They support a belief that mature oyster larvae are stimulated to greater activity by light within the range of intensities encountered in the test.

There is not much evidence of a positive or negative phototropism controlling the movements of mature larvae.

Table 18. Settlement rate of oyster spat expressed as number of spat per unit area of collector (50 sq.cm.) per hour of exposure

	For two upper collectors considered together		For two mid-depth collectors		For two deep collectors		Average for three depths	
	Day	Night	Day	Night	Day	Night	Day	Night
	Av.of D & N		Av.of D & N		Av.of D & N		Av.of D & N	
Average for upper and lower surfaces combined	0.48	0.27	1.4	0.65	2.4	1.2	1.4	0.71
	0.37		1.0		1.8		1.1	
For upper surfaces alone	0.49	0.19	1.1	0.51	1.1	0.36	0.90	0.29
	0.34		0.70		0.73		0.60	
For lower surfaces alone	0.46	0.34	1.7	1.0	3.6	1.9	1.9	1.1
	0.40		1.4		2.8		1.5	

The Effect of Light on Oysters in the Bras d'Or Lakes.

In 1939 an experiment was begun in Cape Breton (Medcof 1939a) to test the effect of light on the growth of oysters. In November 1940 a final set of observations was made. In addition certain calculations of shell proportions were made from data collected in 1939 but only worked up during the past few months.

The results of the 1940 measurements on the Gillis cove stocks are summarized below:

Gillis cove, 1940.

Factor	Lighted section (glass)	Dark section
Median value for av. diam. of shells in mm.	62	65
Semi-interquartile range	5	4
Number of oysters in sample measured	182	187
Increase in av. diam. since Sept.1939	11%	7%

Mean value for ratio

| $\dfrac{\text{Thickness}}{\text{Av. Diam.}}$ with standard | 0.340± 0.003 | 0.341± 0.003 |

The results show that in 1940 the oysters in the light section were "catching up" in their growth with those in the dark section of the tray. Besides this the difference between the values of the ratio of thickness to average diameter for the two stocks does not seem to be significant.

Comparing the value of this ratio for 1939 and 1940 it appears that it decreases with age or size. This was postulated from last year's results. It might be concluded,therefore, that the difference (apparently significant) between the ratio values for the two stocks observed in 1939 was not due to any direct effect of light on shell proportions. The difference in the rate of shell growth which produced larger oysters in the dark compartment in 1939 would account for the difference in the ratio values.

The ratio was calculated from 1939 measurements of the Stoney point stocks. The results are presented below:

Stoney Point 1939 Observations.

Factor	Lighted section (glass)	Dark section
Median value for av. diameter in mm.	38	44
Semi-interquartile range	3.5	4
Number in sample measured	166	159
Median value for ratio Thickness / Av. Diam. with st. error	0.317± 0.005	0.309± 0.006

These figures show that there was more shell growth in the darkness but no significant difference in the thickness ratio as was found in the Gillis cove stocks in 1939. Fewer calculations were made from the 1940 measurements of Stoney point stocks. Such observations as were made are summarized in the table below:

Stoney point, 1940

Section of tray	Av.diam.mm. (medium value)	Semi-inter-quartile range	No.in sample measured	Increase in av.diam.since 1939.
Glassed Screened } Lighted	50 51	4.5 4.5	196 99	32% 31%
Dark	51	4	161	13%

These results are similar to those for Gillis cove in 1940 in that they show a "catching up" in the growth of oysters in the lighted compartments as compared with those in the darkened section. The significance of this condition is not clear but may be related to improper cleaning of the screen and glass covers of the tray. These quickly develop overgrowths of algal scum and require frequent cleaning if they are to properly transmit light. During 1940 the writer was unable to superintend the experiment personally and it is possible that cleaning was not systematically carried out. Neglect to the experimental trays was evidenced by the relatively small amount of shell growth noted in 1940 in all the compartments as compared with the 1939 conditions and further by the fact that the oysters were all matted together and to the bottoms of the trays by the byssus threads of countless small mussels.

It may be expected that such growths would cut down the light intensity in the lighted sections of the tray and reduce conditions of illumination throughout the tray to near uniformity. The mussel sets were observed to be much heavier in the darkened than in the lighted sections. These conditions might have reduced growth enough there to account for the apparent "catching up" of the stocks in the lighted compartments as already noted.

Another explanation might be offered for the difference. The shells of the oysters were thicker, no doubt, at the beginning of 1940 than at the beginning of 1939 because of growth. This change may have rendered the oysters less susceptible to whatever effects light has on them. Such a hypothesis is, however, discounted by the fact that the Gillis cove oysters were a year older than the Stoney point stocks and yet they showed the effects of light in 1939.

The results of other observations are summarized below:

	Gillis cove						Stoney point					
	Glassed section		Screened section		Dark section		Glassed section		Screened section		Dark section	
	'39	'40	'39	'40	'39	'40	'39	'40	'39	'40	'39	'40
Shell cap. / Shell vol.	91	77	83	-	95	74	96	87	100	86	89	83
Shell cap. / Total vol.	47	43	46	-	48	42	49	46	50	44	46	45
Shell Vol. / Total Vol.	53	56	54	-	52	58	51	54	50	54	53	55
Index of condition	86	89	88	-	80	88	79	80	80	80	81	73
Water content of meats	-	90	-	-	90	-	91	-	91	-	91	-
Shell Specific Gravity	2.20	-	2.17	-	2.07	-	2.12	-	2.19	-	1.96	-

Although the 1940 results of the experiment are not useless they do leave much to be desired. It may be said in conclusion that exposure of oysters to light has the following effects in the Bras d'Or lakes:

It reduces the growth rate of the shells in average diameter.

It does not clearly alter the thickness of the oyster relative to its length and width.

It reduces the amount of shell produced relative to the total volume of the oyster as shown by the values for the ratio Shell volume.
Total volume.

      The shells become roomier, that is to say, per unit of shell volume and total volume there is a greater shell capacity.
      It increases the specific gravity of the shells.
      It increases the index of condition.
      It does not appreciably alter the water content of the meats in spite of the increase in the index of condition. This may or may not be significant. See section "On the water content of oyster meats".

      It is interesting to compare these results with those from tests on much smaller samples of stocks from Mr. C.J. Kerswill's 1939 experiment in Bideford river. The next section described these.

The Effect of Light on Quahaugs, Mussels and Oysters in Bideford river.

      In 1939 Mr. C.J. Kerswill reared small quahaugs, mussels and oysters in a specially constructed floating tray similar to that used by the writer in Gillis cove (Medcof 1939a). The tray was moored in Bideford river near the Biological Station. One end was darkened with a wooden cover and the other was open to light being covered by a transparent celluloid-coated screen. Condition tests were carried out by the writer on small samples of these animals and a study of the shell proportions of the oysters was made. The results are listed in the following table:

	Index of Condition		
	Quahaugs	Mussels	Oysters
Reared in light	59	52	94
Reared in darkness	45	20	73

Shell proportions of oysters (12 in sample from light compartment and 10 in sample from dark compartment)

	Lighted	Dark
Av. diameter in mm.	48	53
Thickness		
Av. Diam.	0.45	0.33
$\frac{\text{Shell Cap.}}{\text{Shell Vol.}} \times 1000$	103	98
$\frac{\text{Shell Cap.}}{\text{Total Vol.}} \times 1000$	51	49
$\frac{\text{Shell Vol.}}{\text{Total Vol.}} \times 100$	50.	51
Shell Specific Gravity	2.34	2.28

A further treatment of the effects of light on shell proportions may be found in Mr. Kerswill's doctorate thesis.

Discussion.

Exposure to light produced clearer effects on the index of condition in the Bideford river than in the Bras d'Or lakes oysters. This may have been because of differences in the care with which the covers were kept clean.

As judged from the values for index of condition, the mussels and quahaugs are affected by light in the same way as the oysters.

The shell proportions of oysters are altered in the same way as those in the Bras d'Or lakes except for the fact that the difference between the values for the thickness ratio is much greater. This may be a direct effect of light rather than indirect as suggested for the Gillis cove lots. This point should be further investigated.

The shell specific gravity is greater in light than in darkness but the difference between the values for light and dark is not so great as in the Bras d'Or lakes.

On the Spawning Date for Bideford River Oysters in 1940.

It was necessary to analyze Miller's data (1940) while composing the section of this report "The effect of temperature on the maturation of oyster larvae in Canadian waters". It was found that the spawning date which produced the sharp settlement peak of July 27-28 had not been closely determined because of the late date (July 15) on which this brood of larvae was first sampled.

Measurements were made by the writer on the heights of oyster larvae found in a tow made by G.J. Kerswill on July 10 at 6:00 p.m. The size frequency distribution of these measurements is shown below.

Height of oyster larvae in oc. mic. divisions.#	0.50	0.55	0.60	0.65	Total number of measurements
Frequency distribution	1	10	15	3	29

1.00 ocular micrometer divisions equals 140µµ

The data suggest that under the conditions experienced (the water temperatures ranged just below 22°C) the larvae were approximately 4 days old. The station records for water and air temperatures for this period indicate that July 6 was the spawning date for it was on that day that a sudden rise in temperature took place.

The establishment of this date has permitted a calculation of the length of the larval period because Miller kept records of the spatfall. The information has been incorporated into the study already referred to.

Chalky Deposits on Oyster Shells.

In studying the condition of oysters notes were made
on the appearance of chalky deposits on the inner surfaces of
the shells and, as far as possible, on the appearance of marginal
growths. These notes have been summarized for several series of
oysters and included in this report along with the records of the
indices of condition [tables 1-12]. The following discussion is
based on these observations.

The first chalky deposits appeared in the spring immed-
iately after but not before the period of rise in index of con-
dition and of external shell growth. In Gillis cove there was no
spring rise in the index of condition and the appearance of chalky
areas was delayed until after spawning.

At first the areas are small in size and typical in
their locations. Later they may become larger and even confluent
and, consequently, more difficult to study. Still later, just at
the close of the fall fattening period, the areas are completely
covered over by nacreous shell and obscured. For these reasons the
conditions at the time of first appearance of the deposits were
chosen as best suited for study. The positions of the chalky
deposits have been classified. They appeared:
At the anterior end of the adductor muscle scar
Posteriorly to the posterior end of the adductor muscle scar
Along the straight recurrent margin of the shell.
Along the curved incurrent margin of the shell.
In miscellaneous positions.

The following table [19] summarizes the study of distri-
bution of the areas and their frequency in the several positions
where they were found.

The Gillis cove sample was made the earliest of all in
the phase of chalk deposition and shows that the first place the
chalk appears is in the depression at the anterior end of the
muscle scar. This deposit is so small that it can be easily over-
looked and in some cases it is soon obliterated by nacreous shell
over-growing it.

An examination of a few oyster shells will show that the
purple coloured muscle scar is ordinarily depressed below the general
level of the inner surface of the oyster shell. The depression is
greatest at the anterior end where the chalk appears and least
at the posterior end where the muscle, in its posterior migration
during growth, is just encroaching on fresh shell surface. This
depression and its peculiarities may be explained if we assume that
muscle fibres have a smaller capacity, or none at all, for shell
deposition than the adjacent mantle tissues. Under such conditions
during growth the part of the shell longest covered by the muscle
(that is the anterior part of the scar) will be furthest "behind"
the rest as regards shell deposition and will, therefore, be deepest
depressed below the general surface. The part of the shell which
has just been covered by the retreating muscle (the posterior end
of the scar) will be practically on a level with the rest of the
shell and show no depression.

Table 19. Showing the numbers and positions of chalky deposits appearing on the internal surfaces of oyster shells.

Numbers and Positions of Deposits

Source of oysters and date of fixing	Valve	Amt. and position of muscle scar	Posterior of muscle scar	Along escarement margin	Along insurb margin	Miscellaneous positions	Number of valves examined	Total number of deposits observed
Poirier bed Sheatho bay June 13/40	Lower	1	1	3	4	1	7	15
	Upper	2	3	1	2	0	5	10
Wilnut bed Sheatho bay June 15/40	Lower	4	4	1	1	1	7	11
	Upper	1	4	0	0	0	7	7
Malaguenabd July 15/40	Upper	3	2	2	1	0	5	8
South Oat Aug. 6/40	Lower	3	0	1	3	3	4	10
Gillis cove July 18/40	Lower	2	0	0	0	0	3	3
	Upper	3	0	1	0	0	5	5

When the muscle shifts backwards during spring growth it will be seen that there is a deep pit left just anterior to its new position. It is in this pit that the animal lays down its first deposits of chalk in the spring thus producing an even shell surface for contact with the body.

The second deposit to appear is the most conspicuous and characteristic of the whole group under discussion. It is usually oval-shaped with its long axis running dorsoventrally and lies just posterior to the adductor muscle. Its appearance seems to be part of a series of changes which also involve deposits along the shell margins. These changes seem to be in the nature of a spring re-novation of the shell interior subsequent to marginal shell growth which alters the general pattern of the cavity.

The interior of an oyster shell is not asymmetrically curved, as one might think from cursory examination, but shows several grooves. The most conspicuous of these may be traced in both upper and lower valves. It runs dorsoventrally just posterior to the muscle scar and lateral to the excurrent chamber and ends at the dorsal shell margins. The second chalky deposit, just referred to, appears just at the anterior border of this groove and just over the edge of it a little. The effect of the deposition is to move the groove posteriorly. From its position it seems probable that the presence of this groove facilitates the flow of water through the excurrent chamber (Nelson 1938). Similarly from its position the second chalky deposit seems to be merely an adjustment of the interior of the growing shell in order to maintain contours of this groove that favours water discharge.

A second groove in the shell may be observed between the muscle scar and the dorsal margin of the shell. From its position this, too, seems to be associated with water flow in the excurrent chamber (Nelson ?). Chalky deposits appearing in this region are usually small but long and narrow and seem to maintain the contours of this groove in spite of changes in the size of the shell. The deposits along the indolent border of the shell may be in some way associated with the economy of water flow through the animal as well. Deposits appearing in miscellaneous positions not included in the four categories discussed are frequently found to have been put down in irregular depressions and are probably formed for various reasons depending on their position.

It is to be observed from the table that the deposits generally occur more frequently in the lower than in the upper valves of the shell. Besides this they are generally of a larger size and greater thickness in the lower valves. This produces a difference in the specific gravity for upper and lower valves. (See "Specific gravity of oyster shells").

The greatest activity in the secretion of chalky deposits involving the expansion and even confluence of such deposits as have already been begun takes place during the post-spawning period when the index of condition is low and rising very slowly.

At Gillis cove and South gut well over half the inner surface of the lower valves may be covered at this time with a continuous layer of chalky shell more than a millimetre deep. Oysters from the Cooper bed, Malpeque bar, and from the Wilbur and Poirier beds in Shediac bay have hard, heavy, well "cupped" shells and never develop extensive deposits. Oysters from the first mentioned areas become extremely thin during the late summer while those from the latter places never get very poor. The inference is that the poorer the animal becomes during the summer the more chalky shell is put down. The chalky deposit when secreted in great sheets such as those observed in Gillis cove oysters, seemed to be laid down for the sole purpose of filling up the extra space within the shell occupied by a much shrunken body. This filling up may permit a greater economy in the animal's functioning.

Such a reduction of the shell capacity would influence the values obtained for the index of condition as suggested in the section headed "The relation of condition to growth". The appearance of extensive chalky deposits in middle and late summer may, therefore, account for the gradual rise in the index of condition when water temperatures are still too high to favour extensive feeding activity.

Towards the close of the fall fattening period all the deposits are covered by hard nacreous shell. The relationship of this process to marginal shell growth has not been explored yet,nor is there any exploration as to why coverage should take place.

The conclusions from this study of chalky deposits are in agreement with those of Orton and Amirthalingam (1927) except that the latter workers did not deal with the pattern of the grooves in the shell that have been pointed out in the present study. It appears that the relatively large amounts of chalk in proportion to the quantity of nacreous shell is responsible for the low specific gravity of oyster shells previously discussed (Medcof 1939). See also the section of "The Specific Gravity of Oyster Shells",). Ultimately, then, the same factors determine the shell structure and the condition of oysters - good oysters have good shells and poor oysters have poor shells.

Shell Proportions of Oysters

In another section of this paper "The relation of condition to growth" a study of shell proportions has been reported. A few further observations are presented. These include data on two oysters dredged off rock bottom from deep water in the Hillsborough river (Needler 1931).

The two tables summarizing the data are self-explanatory;

1. The results indicate that the values of the ratios A and B decrease and of C increase with the size (age) of oysters. That is to say, per unit of weight, large old shells are less roomy.

2. A and B decrease and C increase as shell shape improves. This shows that well-shaped shells are less roomy than poor ones.

3. Values of A and B are higher and of C lower for tray-reared apart than for those reared on the bottom. In other words, shell deposition is carried out more economically on trays. Per unit of weight it provides a roomier shell.

4. A and B are higher and C lower for oysters reared in light than for those reared in darkness. This would justify the same conclusion as (3).

5. The effects of depth as an independent factor in influencing shell proportions are not indicated clearly by the data.

6. Oysters reared on flats have values for A, B and C. intermediate between those for oysters from trays and the Cooper bed. The reasons for this are not clear. Perhaps wave action on trays tend to produce the tendencies discussed in (3). Oysters on flats would be subjected to somewhat the same wave action and may, therefore, develop these similarities. The exposure of the flats oysters to light of greater intensities than those experienced on the Cooper bed may account for certain differences between these two stocks. Other factors related to depth may also be important.

7. The data for the Hillsborough river oysters show that in shell proportions they are extreme. They resemble large, old, symmetrical oysters grown in darkness. The significance of these features is in question. They may have been brought about by factors not represented in this study such as current action on the rocky bottom where they grew.

Table showing Shell Proportions of Oysters

Description of Oysters	$\frac{\text{Shell capacity}}{\text{Shell volume}} \times 1000$	$\frac{\text{Shell cap.}}{\text{Total vol.}} \times 1000$	$\frac{\text{Shell vol.}}{\text{Total vol.}} \times 100$	Sampling date
Cooper bed oysters				
Small XXXX	57	36	64	Dec. 7/39
Medium XXXX	58	37	63	
Adult XXXX	47	32	45	
Adult XXX	52	34	45	
Adult XX	51	33	47	
Bray oysters from C.J. Kenwell's Foreland river experiment	Grown in darkness	98	49	51	Sep. 29/39
	Grown in light	103	51	50	
XXXX oysters from Certain Island sand flats, Malpeque bay.	Small	64	46	41	Dec. 7/39
	Medium	62	39	42	
	Adult	59	38	39	
Oysters from deep beds (Heaton & Harmon leases) on Certain Island.	58	34	54	Dec. 7/39
Hillsborough river #1	37	27	73	
#2	27	21	79	

Table showing shell measurements of deep-water
oysters from Hillsborough river.

	Oyster #1	Oyster #2
Linear dimensions of entire oyster in centimetres.		
Length	8.6	7.2
Width	7.2	5.3
Thickness	4.9	6.0
Total volume in ml.^{3}	71.1	64.8
Volume of shells. above in ml.^{3}	52.0	51.0

The effect of light on shell proportions of the oyster.

The most uniform stock of oysters available for carrying out the test was used. These were the "natural" spat of 1937 which had settled on eel-grass. They were all "single" and had the advantage of a smoothness and symmetry surpassing that of any spat taken from commercial collectors. Two collections of this material were made from River Denys Basin. One lot was taken in July, 1938, at which time a floating tray with a wooden cover was stocked and moored in Gillis cove. This same lot was left in the tray during 1939. Some of the measurements for the study were made in July and some in August, 1939. The second lot was collected in October, 1938, and held over winter. From this lot was selected the stock that was placed in the various compartments of the "light test" tray and in the submerged lidless tray in Gillis cove in June, 1939. The measurements of these experimental animals were made in November, 1939.

The ratio describing the original shell proportions of these oysters which were used to stock the experimental trays was high, 0.345. This value is characteristic of animals that have been exposed to the effects of light as well be seen later. Most of the spat collected in River Denys basin were taken near shore in water less than one foot deep. In such a position they would be subject, no doubt, to very intense light. In considering the experimental results it should, therefore, be borne in mind that we have started with a stock of a definite "cupped" type.

Results of shell proportion study on experimental oysters in 1937 set showing the effects of light in Gillis cove, Orangedale, N. S.

	At beginning of test	After 1 summer under screen cover	After 1 summer under glass cover	After 1 summer under wooden cover	After 2 summers under lidless cover	After 1 summer runner in lidless tray submerged 7" below surf.
Average value of ratio Thickness Av. Diam.	0.345	0.352	0.353	0.323	0.295	0.32
No.of oysters measured as basis for calculation.	33	40	50	50	28	12

From the results of the test it would appear that the oysters became even more "cupped" in the glass - and screen-covered compartments and tended to "flatten out" more and more as time went on, when protected from light by the wooden cover. The animals in the submerged lidless tray seven feet below the surface where light intensity is no doubt low, tended to flatten out too and almost to the same extent as those protected from all light in the wooden-covered floating tray.

The difference in the value of the factor describing shell proportions of animals grown in the dark and light for a single summer are of the same order (12%) as those obtained in C.J. Kerswill's experiment in Bideford River, P. E. I.

Reliability of the test. In the various parts of the "light test" growth increments were different so that it becomes necessary to examine the stability of the ratio "thickness, average diameter", for oysters which have grown to different sizes under the same conditions. Several comparisons were made.

1. The first was worked out for large and small oysters raised in the wooden-covered section of the "light test" tray during one summer in Gillis cove. Twenty of the larger spat ranging from 44-53 mm. in average diameter were measured and yielded a ratio value of 0.325. For twenty small, 43-54 mm., spat the value was 0.331. The average for the whole lot of fifty from this compartment that were measured was 0.325 and the variation from this average was less than 2%. The original value for both lots as indicated in the table was 0.345. The two values just quoted show that both lots were "growing away" from the cup shape and that the faster growing spat had merely progressed further in this same direction than their more slowly growing neighbours.

2. A comparison was also made of large and small animals held under the glass where the ratio appears to have been least altered from its original value. The average value for twenty large spat with average diameters of 59-62 mm. was 0.341. For twenty small, 31-49 mm., it was 0.345. The average for the whole fifty measured from this section was 0.353. There is thus a spread of 3.4% from the average. In this case the faster growing animals become slightly flatter than the more slowly growing ones that become thicker. This difference is of such a nature as to suggest that lighting in the tray may not have been uniform in all parts of the light compartment. This variation is, nevertheless, within the limits of the differences observed between the various compartments.

3. In connection with condition studies carried on by the writer several lots of oysters of various sizes and ages were taken from the Little Curtain Island sand flats and measured. These animals were reared from "collector" spat on the ground in question and suffered exposure and drying throughout their lives at each low tide. They must, therefore, have been subjected at regular intervals to intense light. These gave the following results:

	10 small spat aver. diameter 34-62 mm.	8 medium-sized spat, aver. diam. 62-72 mm.	6 large spat aver. diam. 70-88 mm.

Value of ratio

Thickness Av. Diam.	0.363	0.340	0.365

The average value for the whole lot was 0.353 and there was an extreme variation from this average of 4.5%.

From the above three comparisons it appears that within a group of oysters subjected to approximately the same conditions of light exposure there is some variation in the ratio and that this difference may in some cases be related to age or to differences in the rate of growth for oysters of the same age. These differences, however, are not sufficiently great to explain completely the changes observed in the experiment. The factor is a convenient expression of shell proportion. Changes in the shell proportion observed in this experiment can be definitely attributed to the effects of light on the animals studied.

Discussion. That sunlight affects the shell proportions during growth in the oyster has been observed under both "natural" and experimental conditions. The same tendency, but to a less extent, has been noted in an experiment with quahaugs (Kerswill). although it was Huntsman's work with the mussel which first aroused the writer's interest in this problem the results of the present test do not indicate that the material shell-proportions were affected by differences in exposure to light.

The results of the "light test" on oysters are of interest from the practical standpoint (See section "Effect of Light on Growth"). Single "day" oysters are desirable for the trade and at present certain changes in the methods of oyster culture are being made. In the past it has often been the practise to rear spat during their second summer in floating trays with wooden covers thus protecting them from all light. During the last few years more and more people are rearing small stock on shallow tidal flats often exposed at low tide. This study suggests that under the new treatment oysters will begin to "thicken" or "deepen" earlier than they did by the method of tray rearing. Here on exposed flats the light exposure might be expected to partly offset any tendency such bottom might have to produce "crooked" oysters.

There has been no attempt to explain the exact means by which light produces this difference in shell shape. We are able only to agree with Huntsman's earlier conclusions that direct sunlight hinders growth by affecting some or all body tissues and that the functioning of shell-secreting margin of the mantle, the most severely exposed part of the animal, is probably the process most effected of all. The result is the tendency on the part of the animal to produce the most housing space for the soft parts with the least shell-production effort, that is, to become cup-shaped.

The Specific Gravity of Oyster Shells.

It was noted last year (Medcof 1939a) that the more chalky the shell, the lower is its specific gravity. A few scattered observations of this year add to what has already been found. It has been noted that in the Bras d'Or lakes small oysters develop smaller amounts of chalky shell in proportion to their size than large ones. This will account for the records of last year that show higher specific gravities for small than for large oysters.

In the section of this report "Chalky deposits on oyster shell" it is pointed out that chalky deposits are commoner and more extensive in lower than in upper shells. On March 14, 1941, specific gravity determinations were made on upper and lower valves from ten Gillis cove oysters fished on August 24,1940, and on ten Wilbur bed oysters fished September 7,1940. The shells, which were quite dry, were soaked in tap water for a day before testing. The results were as follows:

Specific Gravities of Oyster Shells

Source of Oysters	Sp.Gr. for upper valves	Sp.Gr. for lower valves
Gillis cove	1.72	1.55
Wilbur bed	2.42	2.22

The results support the conclusion drawn earlier that the more chalky the shell the lower is its specific gravity.

A specific gravity determination on May 24th for Wilbur bed shells gave an average value of 2.34. On June 4th the readings (for separate lots) which are averaged to give the final value, differed considerably, being 2.31 and 2.23. It was observed that in the lot which gave the low reading there were two shells badly riddled by the boring sponge, Clione. A specific gravity determination for the more seriously perforated shell by itself gave the value 1.82.

The observations just reported and those cited indicate the importance of care in the choice of shell samples for the determinations of specific gravity. They should be uniform as to size, type (upper or lower valves) and condition (bored or unbored with Clione) if results for different lots are to be strictly comparable.

A series of observations on Scoudouc river shells showed that the specific gravity for stocks from the neighbourhood of Inspector Caissie's camp was 1.87. Lower down the river in Dr. Webster's cove where there is more salt water it was 2.02. The value for the centre of the bay (Wilbur bed) has already been quoted,2.34.

These observations are like those made last year (Medcof 1939a) for Malpeque bay. Together with the results of condition tests (tables 1-12) they show that the quality of both shells and meats improves towards the open bay.

PART V. OYSTER CULTURAL OPERATIONS

The Buctouche Bay Transplant

Between July 22 and 31 the Department of Fisheries had 80 barrels of oysters fished from the seriously polluted part of the Buctouche river opposite the town. These were placed on the departmental reserve area in Buctouche bay each day immediately after fishing. In as far as possible the clusters were broken up and only separate oysters planted. Three plots were chosen such that at low tide they were covered by 1, 3 and 5 feet of water respectively. The type of bottom ranged from hard sand at the shallow plot to firm mud at mid-depth and to soft mud at the deepest plot. Forty barrels were placed on the middle plot and 20 on each of the others. The middle plot measured 40 x 100 feet while the other two measured 40 x 50.

The transfer was made at a time when the river oysters showed great individual variation in fatness because they were in different stages approaching the "spawned-out" condition. It was considered pointless to make a July condition test for this reason. Table 11 summarizes some observations made on these and the following table adds to these. The data show that there was no conspicuous difference in the fatness of oysters from the three plots at the time of re-fishing. The firm mud seems to have been the most suitable type of bottom for survival, the inshore sand was next and the soft mud poorest of all.

Table showing mortality and condition of oysters on departmental reserve.

	Shallow plot	Mid-depth	Deep plot
Number in sample	104	94	96
% mortality	6	3	10
Index of condition	92	91	92

None of the transferred oysters fattened to the same extent as the "natives" at similar depths near by. These latter had an index of 120. A strict comparison, however, is not possible since the "natives" were of much better shape than the transferred. Shape has been shown to influence the value of the index of condition(Medcof 1939a). The transferred oysters on the other hand became just as fat in their new position as they would have had they been left in their old places. Table 11 shows that the average index for the river oysters was about 83.

There was very little or no apparent marginal shell growth by these transferred oysters during the three months on the departmental bed. This may not be significant if we consider the growth of the 3⅔ tray oysters in Shediac bay as typical. More information is desirable on the effects that transfer has on condition.

The Kouchibouguac River Transplant

Early in 1940 it was considered that a transfer of Shediac bay oysters to the Kouchibouguac river for cleansing before marketing might be a practical venture. At that time the Shediac oysters were barred from direct marketing because of public health restrictions. The Kouchibouguac river is free of any great amount of sewage pollution and a small transfer of Shediac oysters was made to see how they fared.

The subsequent re-opening of the bay to public fishing has largely removed the need for developing a regular system of relaying at such a great distance from the point of fishing. A report on the 1940 transfer follows:

On May 1st two barrels of oysters freshly fished from the Poirier bed in Shediac bay were transferred to a point one mile below the highway bridge on the northwestern side of the channel. They were placed on a flat covered by three feet of water at low tide. Tidal currents are very strong here and during the year seldrains, which had been sparse at the time of transfer, encroached over a considerable part of the plot. Several samplings of this stock were made during the year. Results of condition tests are reported in table 11. These show that the oysters fattened to come extent in the spring and early summer. Gross examinations during August indicated that they spawned. Small oyster larvae were found in plankton catches there on July 24 but none were taken on July 24 and 29 or on August 12. There was no settlement as spat on the commercial collectors exposed over a piece of old shell bed one-half mile below the highway bridge.

In the fall the oysters fattened normally but their final index (table 10) was not nearly so high as that for the Poirier bed stocks on the same date (table 4).

Transfer of Bras d'Or lake Spat to Shediac Bay.

A half-bushel of 1939 Gillis cove spat separated by the threshing machine was shipped from Orangedale to Shediac Bridge on July 31st. These were planted largely on Indian island shoal but a few were put on the Poirier bed.

On several occasions during the summer samples of these were fished up. Their vigorous growth and high percentage survival would indicate that conditions in the bay were favourable to spat development. This, together with the results of the transfer of Buctouche spat still on the collectors, indicates that stocking of areas in Shediac by night be carried out without much difficulty.

Spat Collection Trials in New Brunswick.

One hundred bundles of spat collectors were sent to Shediac Bridge from Malagash, N.S., These were exposed, together with bundles of brush, on dates which would have been suitable for catching spat according to the results of predictions based on larval measurements. The results of the trials were as follows:

Buctouche. On July 23rd, sixty bundles were hung from two tripods just above the highway bridge where they were sheltered from the wind. By July 30th these had all received a good set. Several of the bundles were transferred to other areas where they were used to test conditions regulating the development of small oysters. In the course of the season those that were left became heavily coated with silt and encrusting growths. This seriously limited the growth of the spat which attained an average diameter of little better than 1 cm. by the end of the season.

The gale of September 16-17 was responsible for the destruction of one tripod which a loose boat is said to have rammed. In November the bundles from the remaining tripod were placed on the department's reserve in Buctouche bay for the winter.

The bundles of brush received very light sets judging from the examination of July 30th. The spat must have died almost immediately, perhaps from smothering by silt, for none were observed after this date.

Buctouche bay. No collectors were exposed here to test the spatfall but bundles were transferred from the river tripods to the departmental reserve where they were suspended from stakes. Growth seemed to progress just as well if not better than in the river during the summer. A final examination for comparison was impossible because the gale of September 16-17 reduced the bay bundles to a pulp.

Shediac river. On July 19th collectors were exposed, hung from a tripod, one-quarter mile below the highway bridge. No set was observed on either the brush or the collectors. Buctouche spat transferred here grew very well.

Shediac bay. (a) Poirier bed. Collectors were exposed on two dates; July 19, at a time just previous to a predicted settlement of mussel larvae. July 26, just previous to the predicted peak in the settlement of oyster spat. No set either of mussels or oysters was observed on the brush of commercial collectors except (as described in section "The reproduction of oysters in Shediac bay") for a very few spat on one collector that happened to be lying close to the bottom on top of the special tray placed on the bed.

(b) Indian island shoal. Collectors were exposed here suspended from stakes. Unfortunately they were not well anchored and the heavy wave action experienced in August and September carried them away.

Buctouche river. (a) Caissie's camp. On July 25th collectors were exposed from a stake in a deep part of the river near Fishery Officer Caissie's camp. No settlement was observed on these but Buctouche spat transferred here grew better than at any other place tested, by the close of the season the average diameters ranged from 1.5 to 2.5 cm. Growth was remarkably uniform over the whole extent of the collectors.

(b) Dr. Webster's camp. On July 19th collectors were exposed here hung from a tripod. No settlement was observed here except for two spat on the 15 bundles exposed. No teak with Buctouche spat was made at this point.

Kouchibouguac river. On July 29th collectors were exposed from a tripod one-half mile below the highway bridge over an old shell bed. No sets were obtained but the Buctouche spat transferred here grew well.

Discussion. The results of the New Brunswick trials were not encouraging except in several places. The results here might have been better had the trials been made further down the river where there is less turbulence and probably less likelihood of fouling the collectors. There is evidence that conditions are not unfavourable to growth and survival at all the places where trials were made. The results of the transplantation of the brus d'or spat together with those just described suggest that even if local spat cannot be obtained rearing could be successfully carried out in several of the places studied.

Spatfall on Commercial Collectors in Gillis Cove

Through the cooperation of Mr. William Gillis of Orangedale plankton samples and records of water temperatures for the cover were obtained for the writer at Shediac bridge, N. B. Examination of the town showed the following:

June 14: No oyster larvae but a heavy catch of other fauna including dinoflagellates and crustacea.

July 4: 8:00 p.m. Some straight-hinge larvae that might be oysters. The two were very scant.

July 5: 6:00 p.m. A few oyster larvae of average height, 80-90 - probably spawned July 1. Tow very scant.

July 8: 9:00 a.m. No oyster larvae apparent. Tow scant.

July 16: A scanty tow but about one-third of all the molluscan larvae in it were oysters. Two broods were represented. The older probably spawned July 1st (height 142-170). The younger and more numerous probably spawned July 7th (height 120-150).

The settlement peak was predicted for the period July 26 to 31. The collectors were exposed earlier than usual, being hung out July 22nd. The catch on the collectors was abundant but not nearly so dense as in 1938 and 1939. The survival and growth seems to have been much better than in the two years mentioned - perhaps because of less crowding, or it may have been associated with greater "aging" of the concrete coating in one water previous to the settlement of the spat on it. Little information is available on this point although it is of practical significance.

There was only a very light set on the eel-grass this year.

Rearing Tests in Gillis Cove.

It has been decided that tray rearing of spat in the Bras d'Or lakes is impractical. Two alternative methods of rearing small oysters were tested this year - flats rearing and brush rearing. The flats rearing tests were also those carried out in 1939 at Stoke's point. Freshly separated 1939 collector spat and 1938 spat tray-reared during 1939 were placed on flats in Gillis cove in places protected from heavy winds. The water varied in depth from one to two feet at low tide.

As controls for the flats rearing test, stocks of 1939 spat were held on trays stocked to a density of 5,000 spat per 4 x 12' tray. These controls consisted of two lots: (1) spat picked off the wire wrappers of bundles; (2) spat separated by the spat threshing machine.

These same two lots served also as controls for the brush-rearing test proposed in last year's report (Medcof 1939a). Measurements were made on samples of brush spat which had been left undisturbed from the time of settlement to the date of sampling.

The results of measurements of random samples of the various stocks taken near the beginning and at the end of the growing season are presented in table 20. (See page 65).

Discussion. As regards growth the results of the flats rearing tests were somewhat better than those obtained on the Stoney point areas in 1939 and about the same as those obtained in Gillis cove at greater depths in 1939. No careful observations were made on mortalities but they appeared to be low compared with those observed in the 1939 tests just referred to. In both years growth on flats was less than on trays.

Brush seems to offer conditions for spat growth that are more favourable than trays or flats.

Table 20. Summarizing Results of Rearing Tests in Ollis Cove, 1940.

Brook	Geo-logical date	Median value for av. diam.cm.	Semi-inter-quartile range	No.in sample	Geo-logical date	Median value for av. diam.cm.	Semi-inter-quartile range	No.in sample	Increase for av. diam.since Sept.1939
'38 spat tray reared in 1939	May '40	33	3.5	107	Nov.'40	44	4.5	94	33%
'39 spat from threshing machine on flats in '40	July '40	17	2	101	Nov.'40	26	3.5	138	45%
'39 spat picked off wire wrappers of collectors on logs in '40	July '40	13	3.5	194	Nov.'40	35	4.5	200	113%
'39 spat from threshing machine on logs in 1940	July '40	17	2	101					
'39 spat left on brush since settlement	May '40	17			Oct.or '40	43	3.5	300	150%

Samples collected and measured by S.P. Morrison.

Appendix I.

All the readings listed here except where otherwise
noted were made by the writer at Shediac bridge, N. B. The
maximum-minimum thermometer used was the same instrument as
used at Orangedale, N. S., in 1938 and 1939. It was housed in
the same fashion as at Orangedale (Medcof 1938).

DATE	TIME	MAX. °F.	MIN. °F.	PRES. °F.	WEATHER
June 18	9:00P			64	Warm day and heavy wind
					Fresh SW, pt. cldy
19	9:00A	64	60	60	Fresh SW, light rain most of day
	3:00P	65	60	60	Light W, pt.cldy., showers
20	10:00A	64	57	54	Light E, clearing
	5:30P	59	58	55	" cloudy
21	8:30A	58	46	52	Light W, clear
	8:00P	50	60	52	" "
22	8:00A	58	57	44	Light fresh N, clear
	8:00P	60	52	52	Light N, light rain
23	10:00A	52	50	48	Light SW, light rain
	5:00P	62	51	54	" N, bright
24	9:00A	58	46	58	" "
	5:45P	63	47	62	Light fresh E, bright
25	9:30A	60	44	54	Still, cloudy
	9:30P	62	54	60	Light E, bright
26	9:00A	60	54	58	Light SE, raining
	9:30P	61	58	61	Fresh SW, cloudy
27	8:30A	62	52	58	Cloudy, fresh SW
	6:15P	71	66	58	Cloudy, light fresh SW
28	7:15A	64	46	52	Cloudy, light SW
	6:30P	78	52	50	Bright, light SW
29	8:45P	70	53	54	Cloudy, light SW
30	10:00A	70	53	57	Bright, fresh W
	7:15P	78	67	68	Bright, light fresh W
July 2	8:30A	68	62	52	Bright, light SW
	7:15P	79	52	66	Cloudy, strong W, rain
3	9:15A	68	46	64	Bright, light fresh SW
	7:15P	81	66	74	Bright, fresh SW
4	9:00A	74	55	57	Cloudy, rain, light SE
	6:00P	59	56	56	Heavy rain, fresh NE
5	9:45A	62	50	60	Light NE, pt. cldy.
	9:00P	77	60	70	Light SE, bright
6	11:00A	68	50	68	Light N, bright
	6:15P	79	60	74	Light SE, bright
7	7:30A	70	58	58	Light N, "
	6:30P	86	59	64	" SW, "
8	8:30A	86	58	72	Light, NW, "
	6:30P	76	62	72	" "
9	8:45A	86	60	79	Light W, "
	7:15P	90	75	75	Pt.cldy., fresh W
10	8:30A	78	63	64	Pt.cldy., thd.storm, light NW
	?				Cloudy
11	9:00A	82	58	64	Light fresh W,clr.rain last nt.
	6:00P	80	64	73	Pt.cldy. light fresh W.

DATE	TIME	MAX.	MIN.	PRES.	WEATHER
July 12	8:30a	57	54	58	Light NW, clear
	6:30P	76	58	66	Fresh NE, bright
13	7:30A	60	47	54	Light W, pt. cldy.
	6:30P	82	54	70	Fresh NW, clear
14	8:30A	70	50	64	Light fresh NW, clear
15					Warm clear day
	7:15A	64	48	58	Light SW, clear
	5:15P	82	58	70	Fresh SW, clear
16	8:30A	77	54	62	Light S, cloudy
	7:30P	83	62	73	Light SW, clear
17	7:15A	73	54	60	Light fresh SW, cloudy
	7:30P	79	50	71	" clear
18	8:15A	71	57	64	Light SW,clear) calm most
	7:00P	95	66	80	" of day
19	8:45A	75	61	73	Light fresh N, clear
	6:30P	82	71	73	Light NE, cloudy
20	8:00A	72	58	60	Cloudy
					Heavy rain during night
21	9:00A	74	59	63	Light SE, cloudy
	9:15P	69	62	63	Light E, cloudy
22	9:00A	68	62	65	Cloudy, calm
	9:45P	74	62	63	Light W, cloudy
23	6:15A	60	59	64	Light SW, cloudy
	9:30P	83	62	73	Light SW, clear
24	9:00A	65	54	64	Fresh SW, cloudy
	10:00P	71	64	68	Cloudy
25	8:15A	68	61	68	Fresh SW, bright
	7:00P	84	62	79	" clear
26	8:00A	74	64	74	" "
	9:45P	84	73	77	" , pt. cldy.
27	7:30A	76	64	70	Light SW, bright
	9:45P	90	70	74	" clear
28	8:30A	74	55	64	Light S, bright
	7:00P	86	64	80	" SW, "
29	8:30A	80	54	68	Light SW, "
	6:30P	89	68	70	Light E, clear
30	9:00A	72	60	73	Light SW, cloudy
	5:30P	76	63	62	Light SW, cldy.,raining
31	8:30A	65	63	50	Light N, cldy.,vy.rain last nt.
	6:30P	80	63	67	Fresh SW, cloudy
Aug. 1	9:00a	72	52	63	Strong NE,cldy,rained last nt.
	9:45P	84	60	60	Fresh SW, rainy
2	7:15a	60	54	57	Light NE, clear
	6:30P	77	56	70	Light SW, "
3	5:30a	70	50	50	Clear, calm
	7:00P	94	50	73	Light S, clear
4	7:30a	72	60	64	Light N, clear
	6:15P	80	64	66	Light SW,cldy.,shr.last nt.
5	7:30a	75	50	59	Light SW, "
	6:30P	81	56	78	Fresh E, "
9	8:30a	78	55	68	Fresh NW, clear
	5:30P	93	68	81	" "

DATE	TIME	MAX.	MIN.	PRES.	WEATHER
Aug.10	8:30A	91°F	62°F	68°T	Fresh NE, clear;abrs.last nt.
	7:00P	76	63	63	Light SE, "
11	9:00A	64	44	51	Light NE, bright
12	8:30A	76	64	58	63	Fresh SW, bright
	8:20P	68	55	73	Light SW, cldy
13	9:00A	73	57	63	Light SW, 51, cldy
	5:45P	87	63	79	Fresh SW, cloudy
14	8:30A	77	55	61	Light W,bright, rain last nt.
	3:30P	74	63	68	Light fresh E, bright
15	9:00A	68	52	62	Fresh N, bright
	6:30P	74	62	58	Light SE, "
15	8:30A	68	48	44	Light SE, "
	all day rain on Aug.20 - other days clear & moderately warm.
23	10:00A	55	44	72	Light E, bright
	6:00P	74	47	68	Light E, "
24	8:15A	48	42	44	Fresh SW, "
	6:00P	74	60	62	Light E, showers
25	8:30A	62	42	40	Fresh strong SW, cloudy
26	8:15A	64	44	49	Light fresh SW, clear
	6:30P	70	49	60	Light NW, cloudy
27	8:30A	60	39	50	Light fresh NE, clear
	5:30P	74	50	60	Light SW, clear
28	9:00A	55	40	44	Light SW, "
	7:30P	76	56	60	Light SW, "
29	9:00A	62	43	52	Light SE, "
	7:00P	75	54	77	Light NE, "
30	9:00A	72	44	44	Light SW, clear
	7:30P	79	44	52	Light SE, "
31	8:30A	70	58	70	Light fresh SW, clear
	7:00P	82	54	79	"
Sep. 1	8:30A	76	64	74	Fresh SW, cloudy
	2	8:30A	70	63	63	Light SW, "
	7:30P	70	64	68	Light SW, "
3	9:00A	68	58	64	Fresh SW,cldy;E.gale and abrs.last night.
4	8:00A	78	57	59	Light fresh SW, clear
	7:30P	78	56	68	Light SE, clear
5	8:30A	68	57	57	Light NE, raining
					Strong NE
6	9:00A	64	54	54	Light NE, "
7	10:00A	65	48	50	Calm, cloudy
	7:45P	70	56	60	Light SE, cloudy
8	10:00A	60	50	50	Light NW,heavy rain day & nt.
9	8:30A	64	48	59	Fresh SW, clear
	7:30P	75	54	62	Light W, clear
10	9:15P	73	42	72	Light NE, "
11	8:30A	72	62	63	Light fr.W,cldy.mh.last nt.
12	8:15A	64	50	50	Light E,cldy.abrs.last nt
	6:30P	60	51	44	Light NE,raining.br.rain nt.
13	9:30A	56	54	54	Light fresh N, raining
					Rainy most of day
14	8:30A	58	45	55	Med.SE.clear - at all day
15	7:15A	73	47	60	Mod.E, clear
16	8:30A	60	47	59	58	Light fresh E, cldy.
	P starting at 8:30 the gale and wind of Sep.3; wrecked everything everywhere; E by S; heavy rain.

DATE	TIME	MAX.	MIN.	PRES.	WEATHER
Sep.17	11:00A	54°F	reset thermometer		Fresh S, raining
	2:00P				" NW, "
18	9:00A	58	51	57	Mod.NW,bright-all day
19	7:30A	46	42	42	Light NW, fog " "
20	8:30A	74	42	58	Light SW, " "
	11:00P	60	55	55	Light NE,
	heavy rain p.m. of 21st and night of 21st and 22nd.				
22	8:00A	64	49	59	Light NW, cloudy
23	9:00A	64	41	56	Fresh NW, clear
24	8:00A	65	39	57	Light mod. SE, clear
	5:30P	70	57	54	Near pale SW, cloudy
25	8:15A	64	54	62	Mod. SE, cloudy
	very heavy rain during evening and night of 25th				
26	8:30A	46	38	43	Light mod. SE, clear
	P				Light fresh NE
27					Mod.to fr.SW breezes,clear
28	8:45A	60	44	56	Clear all day,mod.SW to NW
29	9:00A	70	40	56	Light NW,clear,am.nld.aft.
30	8:30A	67	36	48	Light NW,clear all day
Oct. 1	8:00A	64	52	40	Light SE,clear all day
2	8:15A	65	43	50	Light mod.NE,clear all day
3	9:15A	60	44	48	Mod.fresh NE,sldy. "
4	9:00A	54	44	48	Strong NE cldy.clr.in even
5	8:00A	54	30	39	Light NW,clear all day
6	10:00A	41	33	37	mod. W, bright
	P light until late with mod.W to SW light shr.in evening				
7	8:00A	60	30	52	Light SW, pt. cldy.
	P day mostly clear, mod. SW winds				
8	8:30A	72	52	63	Mod. SE, bright
	P day fair until late p.m.,breeze fresh,rain from SE				
9	8:45A	73	57	58	Light SW,raining hard
	P day fair with light breeze from west				
10	7:30A	62	36	53	Mod.fresh NW,clear all day
11	8:30A	64	30	41	Light NW,bright(cl.all day
12	10:00A	47	41	38	Light SW, clear all day
13	12:30P	69	46	55	Mod.fresh SW, pt.cldy.
	clear till p.m. then cloudy with light shower				
14	8:30A	66	42	51	Fresh SW, clear all day
16	8:30A	55	31	55	Mod.fresh SW,clear all day
15	8:30A	42	47	57	Mod.fresh SE, cldy.
	Clear with fr.SW breeze during day;heavy rain from NW at night and light snow fall.				
17	9:00A	49	22	59	Clear, calm
	Clear all day with mod. winds; rain at night				
18	8:30A	56	36	44	Fresh SE, light with rain away
19-20					
21	heavy snow during night about 5 to 6" from NW				
22	9:00A	44	18	29	Mod.NW,clear all day
23	11:00A	38	18	32	Light S,cldy.snowing
	P cloudy all day; light rain from S in evening				

DATE	TIME	MAX.	MIN.	PRES.	WEATHER
Oct.24	7:00A	42°F	32°F		Light SW, fog, clearing
	P				Day cloudy, sond. winds
25	6:00P			43	Light winds, clear all day
26	9:00A			51	Light NE rain; day cloudy
27	8:30A	54	28	54	Mod.NW,snowing,cldy.all day
28	8:45A	54	26	50	Mod.NW,cloudy all day
29	8:00A	38	30	54	Mod. N, bright
30	7:45A	44	20	53	Light SW,clear all day
31	9:00A	55	25	43	Mod.fresh NE, clear all day
Nov.1	8:30A	43	28	36	Mod. NW, bright
					Clear all day, light winds shifting to SW
2	9:00A	52	23	34	Light SW, pt. cldy.
3					day cloudy with light rain in p.m.;fresh to strong SW
4	9:00A	55	41		Strong NW, bright
					partly cloudy with strong NW all day
5	8:30A	44	50	37	Mod.NW, bright all day
6	7:30A	55	38		Light SE, pt. cldy.
					cldy. all day,light rain at night,mod.fresh SW
7	7:30A	47	37	40	Mod.NW, cldy. all day
8	9:00A	44	36	38	Mod.SW,cldy. all day
9	7:00A	48	31		Light NW, clear all day
					with mod. breezes
10	7:00A	48	22	40	Light NE, bright
					cloudy all day, light rain in evening
11	7:15A	45	31		Mod.NW, cloudy
12	8:00A	55	34		Fresh NW, cloudy
					Light rain in p.m. cloudy all day
13	7:00A	38	28	28	Mod.NW, clear all day
15	7:15A	24	44	30	Mod.NW, clear all day
16	9:00A	24	44	44	Strong SW, pt. cldy.
					fresh strong winds all day, rained off and on all p.m.
21	9:15A	48	37	43	Mod. NW, bright
					clear all day, light shower during night
22	8:45A	48	34	38	Light SW, cloudy
					light winds with mists all day; rain at night
23	12:00 noon	47	29	51	Fresh strong NE;cldy.all day
24	8:30A	31	29	28	Light SE, clear
					cloudy all day, light snow in p.m.
25	6:20A	34	29		Mod. NW, cldy.
					cldy. all day, light snow in p.m. mod.NW.
26	7:45A	17	18		Fresh NW, clear
					cloudy all day with fresh NW
27	8:30A	19	-7	30	Light NW,cldy.ice on bay this a.m.
28	8:30A	12		30	Light SE, snowing
					snowed most of day,light NE, clearing in evening
29	8:45A	30	17	43	Mod.fresh NW,bright all day
					4 to 5 inches of snow yesterday
30	8:45A	30	7	23	Mod.SE, snowing heavily,
					cldy. all day.

DATE	TIME	MAX.	MIN.	PRES.	WEATHER
Dec.1	9:00A	30°F	10°F	20°F	Mod. E., snowing
2	8:30A	4	-10	4	Mod. NE., raining
4	8:30A	-10	-18	-8	Light W., clear
6	8:30A	20	2	20	Mod. N., clear
	4:00P	35	20	32	

(the above five readings were made at Buctouche, N.B.)

Introduction

       With the exception discussed below the writer himself made all the observations listed here. The same procedure and equipment was used as described earlier (Medcof 1939a) in making the determinations.

       Mr. Robert Gillis of Orangedale, N.S., made the temperature records for Gillis cove and collected the water samples. The salinity determinations on these were made by the writer. They were carried out on three dates; the first two lots in Cape Breton in August and November; the third lot at Ellerslie where the samples were shipped by Mr. Gillis.

       Mr. Gillis used only a laboratory thermometer for his determinations. The five-foot-depth readings were made by taking the temperature of the water in an open bottle that was kept suspended at the five-foot depth from a stake. This bottle was raised to the surface at the time of each reading and lowered again immediately.

       The writer made the earlier observations on the Buctouche river himself. After September 17th temperature observations were made by Mr. A. G. Campbell of the Department of Pensions and National Health. He likewise collected the water samples after this date. The writer carried out all the salinity determinations. Mr. Campbell had only a fisherman's reversing thermometer for all his temperature readings including surface readings.

Gillis Cove, N. S.

Date	Time	Depth	Temp.	Hydrometer Reading (T)	(T)	Sal.	Remarks
May 10	2.00 p.m.	Sur.	8.2°C.	7.2	16.0	9.0	Water very dirty.
		5'	-	16.1	16.0	20.7	
		5'	4.0	16.9	15.9	21.5	
" 13	5.25 "	Sur.	7.0				
		5'	9.0				
" 15	5.25 "	Sur.	8.3				
		5'	6.8				
" 17	5.35 "	Sur.	14.0	10.1	15.7	12.8	
		5'	10.0	10.9	15.9	13.8	
" 19	5.25 "	Sur.	9.0				
		5'	6.0				
" 21	5.25 "	Sur.	10.9				
		5'	10.2				
" 23	5.25 "	Sur.	12.0	12.8	15.8	16.3	
		5'	12.2	13.0	15.7	16.6	
" 25	5.25 "	Sur.	14.5				
		5'	12.5				
" 27	5.25 "	Sur.	16.1				
		5'	9.2				
" 29	5.25 "	Sur.	12.0				
		5'	10.0				
" 31	5.25 "	Sur.	15.0	14.2	15.8	18.2	
		5'	15.8	17.6	15.8	22.6	
June 1	5.25 "	Sur.	15.5				
		5'	15.2				
" 2	5.25 "	Sur.	18.0				
		5'	13.0				
" 3	5.25 "	Sur.	17.8				
		5'	17.2				
" 4	5.25 "	Sur.	13.0				
		5'	10.0				
" 5	5.25 "	Sur.	16.0				
		5'	15.1				
" 6	5.20 "	Sur.	15.0				
		5'	14.5				
" 7	5.25 "	Sur.	13.3	15.5	15.8	19.9	
		5'	13.0	16.0	15.8	20.5	
" 8	5.25 "	Sur.	14.0				
		5'	13.4				
" 9	5.25 "	Sur.	14.0				
		5'	13.4				
" 10	5.25 "	Sur.	15.7				
		5'	14.5				
" 11	5.25 "	Sur.	17.7				
		5'	13.0				
" 12	6.10 "	Sur.	16.9				
		5'	12.1				
" 13	5.25 "	Sur.	14.0				
		5'	14.3				

Gillis Cove, N. B.

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
June 14	5.20 p.m.	Sur.	16.0	13.0	23.5	18.7	
"		5'	16.9	15.2	23.0	21.5	
" 15	5.25 "	Sur.	16.0				
"		5'	15.0				
" 16	5.25 "	Sur.	15.0				
"		5'	14.0				
" 17	5.25 "	Sur.	16.0				
"		5'	16.0				
" 18	6.35 "	Sur.	17.0				
"		5'	17.2				
" 19	5.40 "	Sur.	17.0				
"		5'	16.8				
" 20	5.40 "	Sur.	15.0				
"		5'	16.1				
" 21	5.30 "	Sur.	14.5	0.5	23.5	2.2	
"		5'	15.8	13.5	23.1	19.2	
" 22	5.30 "	Sur.	14.0				
"		5'	13.0				
" 23	5.30 "	Sur.	14.0				
"		5'	14.0				
" 24	5.30 "	Sur.	16.2				
"		5'	15.0				
" 25	5.30 "	Sur.	18.0				
"		5'	16.0				
" 26	5.25 "	Sur.	18.0				
"		5'	16.1				
" 27	5.30 "	Sur.	19.5				
"		5'	18.0				
" 28	6.15 "	Sur.	21.2	8.0	23.2	8.0	
"		5'	19.0	11.1	23.1	11.1	
" 29	5.30 "	Sur.	18.2				
"		5'	18.8				
" 30	5.40 "	Sur.	21.0				
"		5'	21.0				
July 1	5.30 "	Sur.	21.3				
"		5'	21.2				
" 2	9.00 a.m.	Sur.	19.3				
"		5'	16.8				
" 3	5.50 p.m.	Sur.	21.9				
"		5'	20.8				
" 3	5.30 "	Sur.	22.0				
"		5'	22.0				
" 4	5.30 "	Sur.	20.0				
"		5'	19.0				
" 5	5.30 "	Sur.	19.0	5.9	23.2	8.2	
"		5'	16.0	13.0	23.8	18.8	
" 6	5.25 "	Sur.	19.0				
"		5'	14.0				
" 7	5.30 "	Sur.	21.5	spawning peak			
"		5'	21.8				

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
July 8	5.30 p.m.	Sur	22.0				
"	"	5'	21.0				
" 9	5.30 "	Sur.	24.5				
"	"	5'	21.3				
" 10	5.25 "	Sur.	24.0				
"	"	5'	20.5				
" 11	5.30 "	Sur.	23.0				
"	"	5'	15.0				
" 12	5.25 "	Sur.	22.0	11.5	23.2	16.6	
"	"	5'	18.0	15.1	23.3	21.5	
" 13	5.30 "	Sur.	20.0				
"	"	5'	20.5				
" 14	5.30 "	Sur.	23.0				
"	"	5'	20.5				
" 15	5.30 "	Sur.	22.0				
"	"	5'	23.0				
" 16	5.30 "	Sur.	22.0				
"	"	5'	20.5				
" 17	5.30 "	Sur.	22.0				
"	"	5'	20.8				
" 18	5.30 "	Sur.	24.0				
"	"	5'	22.0				
" 19	5.30 "	Sur.	23.0	11.7	23.7	17.1	
"	"	5'	19.0	13.2	23.7	21.7	
" 20	5.30 "	Sur.	23.0				
"	"	5'	22.8				
" 21	5.25 "	Sur.	23.0				
"	"	5'	21.9				
" 22	5.25 "	Sur.	23.0				
"	"	5'	22.7				
" 23	5.25 "	Sur.	23.3				
"	"	5'	23.4				
" 24	5.30 "	Sur.	23.0				
"	"	5'	21.5				
" 25	5.25 "	Sur.	23.0				
"	"	5'	24.0				
" 26	5.30 "	Sur.	24.0	13.2	23.8	19.1	
"	"	5'	24.5	13.2	23.7	17.8	
" 27	5.30 "	Sur.	24.0				These readings were taken with an alcohol thermometer and converted.
"	"	5'	21.5				
" 28	5.30 "	Sur.	23.5				
"	"	5'	21.5				
" 29	5.25 "	Sur.	23.0				
"	"	5'	21.0				
" 30	5.40 "	Sur.	22.0				
"	"	5'	22.0				
" 31	6.00 "	Sur.	23.8				
"	"	5'	21.8				
Aug. 1	6.00 "	Sur.	23.0				
"	"	5'	19.5				
" 2	5.35 "	Sur.	20.5	15.0	23.8	21.5	
"	"	5'	20.3	14.8	24.0	21.3	

Gillis Cove, N. S.

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
Aug. 3	5.25 p.m.	Sur.	21.5				
		5'	21.0				
" 5	5.25 "	Sur.	23.5				
		5'	23.0				
" 7	6.00 "	Sur.	23.0				
		5'	21.9				
" 9	6.00 "	Sur.	24.3	15.0	24.0	21.6	
		5'	24.5	14.7	24.2	21.2	
" 11	6.15 "	Sur.	22.0				
		5'	21.8				
" 13	5.3. "	Sur.	22.0				
		5'	22.6				
" 15	7.00 "	Sur.	20.0	15.5	23.7	21.1	
		5'	18.9	14.5	24.0	20.9	
" 17	6.00 "	Sur.	22.0				
		5'	21.5				
" 19	6.00 "	Sur.	23.7				
		5'	23.5				
" 21	5.45 "	Sur.	22.0				
		5'	21.0				
" 23	6.00 "	Sur.	20.5	17.1	11.8	21.1	
		5'	17.6	17.6	11.8	21.7	
" 25	6.00 "	Sur.	19.5				
		5'	19.5				
" 27	6.00 "	Sur.	17.0				
		5'	18.0				
" 29	6.00 "	Sur.	18.5	18.2	11.2	22.5	
		5'	18.5	18.2	11.4	22.5	
" 31	5.40 "	Sur.	20.3				
		5'	19.9				
Sep. 2	6.00 "	Sur.	20.0				
		5'	19.8				
" 4	6.00 "	Sur.	21.3				
		5'	20.6				
" 6	6.15 "	Sur.	19.8	18.2	11.8	22.5	
		5'	19.6	17.5	11.5	21.6	
" 8	6.00 "	Sur.	17.8				
		5'	17.5				
" 10	5.50 "	Sur.	17.0				
		5'	18.4				
" 13	6.00 "	Sur.	17.7	9.5	11.8	11.3	
		5'	16.2	16.2	11.8	20.0	
" 15	6.00 "	Sur.	18.9				
		5'	18.5				
" 17	6.00 "	Sur.	15.0				
		5'	16.1				
" 19	6.00 "	Sur.	17.0				
		5'	17.0				
" 21	6.00 "	Sur.	17.0	7.0	12.0	8.1	
		5'	16.9	15.0	12.1	18.4	

Gillis Cove, N. S.

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
Sep.23	5.30 p.m.	Sur.	15.7				
" "	"	5'	15.9				
" 25	5.50 "	Sur.	16.7				
" "	"	5'	16.7				
			16.5				
" 27	6.00 "	Sur.	16.5	8.5	11.6	9.9	
" "	"	5'	15.0	13.6	11.8	15.2	
" 29	5.45 "	Sur.	16.8				
" "	"	5'	16.1				
Oct. 1	6.00 "	Sur.	14.0				
" "	"	5'	13.1				
" 4	5.30 "	Sur.	13.8	16.7	11.4	20.5	
" "	"	5'	13.5	18.0	12.0	22.3	
" 6	5.30 "	Sur.	12.6				
" "	"	5'	12.6				
" 8	5.35 "	Sur.	15.0				
" "	"	5'	15.0				
" 10	5.30 "	Sur.	15.0				
" "	"	5'	14.0				
" 12	5.30 "	Sur.	13.9	16.3	12.4	20.1	
" "	"	5'	11.2	16.7	13.0	20.8	
" 14	5.30 "	Sur.	13.8				
" "	"	5'	13.9				
" 16	5.35	L	Sur.	12.8				
" "	"	5'	12.8				
" 19	5.10 "	Sur.	10.8	17.0	13.0	21.2	
" "	"	5'	10.5	18.2	13.1	22.8	
" 21	5.30 "	Sur.	9.5				
" "	"	5'	9.8				
" 23	5.15 "	Sur.	5.4				
" "	"	5'	8.3				
" 25	5.30 "	Sur.	8.0	13.0	12.5	15.9	
" "	"	5'	8.5	18.2	12.5	22.6	
" 27	5.15 "	Sur.	6.3				
" "	"	5'	8.6				
" 29	5.15 "	Sur.	7.8				
" "	"	5'	8.2				
" 31	5.00 "	Sur.	6.0				
" "	"	5'	7.4				
Nov. 2	5.15 "	Sur.	5.4	16.1	12.9	20.0	
" "	"	5'	5.8	17.0	12.8	21.2	
" 5	4.40 "	Sur.	4.6				
" "	"	5'	7.5				
" 7	5.30 "	Sur.	7.6				
" "	"	5'	7.2				
" 9	4.40 "	Sur.	7.6	16.0	12.8	19.8	
" "	"	5'	7.6	17.1	13.0	21.3	
" 11	5.00 "	Sur.	5.8				
" "	"	5'	5.9				
" 13	4.45 "	Sur.	6.2				
" "	"	5'	7.1				

Gillis Cove, N. S.

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
Nov.16	4.15 p.m.	Sur.	8.5	14.0	8.7	16.7	
"	"	5'	8.1	14.8	7.4	20.1	
" 19	4.15 "	Sur.	5.2				
		5'	5.9				
" 22	5.10 "	Sur.	5.2	11.0	8.7	12.8	
		5'	5.9	15.8	8.8	19.0	
" 25	5.00 "	Sur.	5.9				
		5'	4.2				
" 28	4.15 "	Sur.	2.8				
		5'	2.8				
				Cove covered with ice			
Dec. 9	3.30 "	Sur.	0.5	2.4	9.0	1.9	
		5'	0.8	16.5	9.5	20.0	

South Out, St. Anne's Bay, N.S.

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
May 10	4.00 p.m.	Sur.	7.5	5.0	16.4	6.2	Temp.reading and water sample made by W. A. McIntyre.
June 25	11.15 a.m.	Sur.	13.1	12.9	25.4	19.2	
		5'	10.0	18.4	25.5	26.6	
Aug. 6	12.00 noon	Sur.	18.8	20.5	24.9	29.6	
		5'	17.5	20.6	25.2	29.7	
" 28	1.30 p.m.	Sur.	17.7	23.2	12.8	27.2	
		5'	17.8	23.3	13.3	29.5	
Sept.12	4.30 "	Sur.	17.5	20.0	12.8	25.1	
		5'	15.0	22.0	13.0	27.7	
" 25	2.30 "	Sur.	13.8	22.9	14.2	26.7	
		5'	13.4	23.1	14.6	28.6	
Oct. 17	--	Sur.	10.5	23.0	12.8	28.9	
		5'	10.5	23.0	13.0	29.1	
Nov. 1	12.15 p.m.	Sur.	8.4	23.0	14.1	29.3	
		5'	8.0	22.3	14.3	28.4	
" 15	12.00 noon	Sur.	7.3	18.5	9.6	23.1	
		5'	7.2	21.2	7.1	25.7	
Dec. 9	---	Sur.	--	23.1	7.2	28.1	
		5'	23.2	23.2	8.0	28.4	

Miscellaneous N. S.
HYDROGRAPHY

Samples by R. P. Morrison

June 2		Sur.	15.7	22.3	21.8	"Bog Pond"
		6'	16.0	22.4	22.2	
Aug. 27		Sur.	18.2	14.0	23.0	Oyster Pond
		5'	18.1	14.0	22.9	Jamesville,N.S.
Sept. 23		Sur.	5.6	14.0	4.0	Baddeck Bay
		5'	17.5	14.1	22.1	

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
May 10	4.00 p.m.	Sur.	6.2	16.0	16.0	20.5	
		3'	-	16.5	16.0	21.2	
		6'	4.2	-	-	-	
		9'	-	16.9	15.9	21.7	
" 31		Sur.	13.0				
		5'	11.0				
June 3	12.30 "	Sur.	13.0				
		5'	15.0				
" 14	1.30 "	Sur.	11.0	16.5	21.8	22.8	
" 28	3.30 "	Sur.	17.0				
		5'	17.5				
July 2	10.00 a.m.	Sur.	19.8				
		5'	13.9				
" 12	3.20 p.m.	Sur.	21.0				
		5'	19.0				
" 16	8.30 "	Sur.	20.0				
		5'	20.7				
Aug. 5	10.15 a.m.	Sur.	21.0	14.5	25.2	21.3	
		5'	20.5	14.2	25.2	20.9	
" 23	12.50 p.m.	Sur.	20.7	18.3	14.3	23.2	
		5'	20.3	18.0	14.3	22.8	
Oct. 5	3.30 p.m.	Sur.	19.9	18.6	13.3	23.3	
		5'	19.4	18.4	14.0	23.5	

Date	Time	Depth	Temp.	Hydrometer reading	(T)	Sal.	Remarks
May 11		Sur.	5.9	16.5	17.5	21.5	
		6'	5.9	16.9	16.9	21.8	
June 12	5.10 p.m.	Sur.	14.2				
		6'	11.8				
14		Sur.	9.5	17.5	18.7	23.3	
		6'	10.2	17.7	18.4	23.4	
July 5	12.00 noon	Sur.	14.5		25.0	21.2	
		6'	15.0	15.2	25.0	22.1	
17	7.40 a.m.	Sur.	15.0	15.5	24.5	22.8	
		5'	17.9	15.7	24.8	22.2	
Aug. 5	7.00 p.m.	Sur.	22.3	15.3	24.8	22.2	
		5'	20.5	15.1	25.2	22.0	
23	11.15 a.m.	Sur.	19.8	18.5	14.5	23.0	
		5'	19.8	19.0	14.0	24.1	
Sept. 5	5.00 p.m.	Sur.	19.0	19.0	14.0	24.1	
		5'	19.8	15.5	13.9	23.4	
20	7.15 "	Sur.	19.1	17.7	13.4	22.2	
		5'	16.0	18.5	13.3	23.2	
Oct. 3	5.00 "	Sur.	14.0	18.8	13.8	23.7	
		5'	13.7	19.0	14.0	24.1	
18	5.00 "	Sur.	11.9	18.8	13.2	24.1	
	bt	5'	11.7	19.0	14.3	24.1	
Nov. 4	4.50 "	Sur.	7.8	19.0	14.0	4.1	
		5'	7.5	18.5	14.1	23.4	
15	5.30 "	Sur.	6.0	19.0	10.0	23.5	
		5'	8.2	19.0	9.9	23.5	
Dec.10	2.15 "	Sur.	5.9	18.8	9.8	23.0	
		5'	5.9	19.2	10.0	23.6	

Buctouche, N. B.

Date	Time	Depth	Tide	Weather	Temp. read.	Hydr.	(T)	Sal.	Remarks
May 15	10:30 a.m.	Sur.		Bright (blow yesterday)	8.7	20.1	10.0	24.7	Buctouche bay over area proposed for relaying
		3'							
		8'				20.2	9.7	24.7	
					8.7	20.5	9.7	25.1	
June 27	2:30 p.m.	Sur.	HF	Fresh S	16.3	19.8	20.5	24.8	Buctouche relaying area
		8'			16.1	20.4	19.8	26.6	
27	3:00 "	Sur.	HF	Fresh S	17.3	19.2	20.0	25.8	Black E.
		6'			17.3	19.2	19.7	25.8	Buctouche wharf just above bridge
27	12:00 noon	Sur.	HF	Fresh S	16.2	18.5	21.0	25.3	Buctouche wharf
		10'				18.4	20.4	25.1	
		28'			15.8	19.1	20.7	25.9	
27	10:00 A.m.	Sur.	HF	Fresh S	16.5	15.1	21.1	20.8	Buctouche R.
		3'				15.5	21.0	21.1	1?miles below
		6'				15.7	20.8	21.4	St. Marys
		15'			16.7	16.1	21.1	22.1	bridge
July 11	4:00 p.m.	Sur.	HR	Bright fresh SW	23.4	20.3	20.6	27.5	Buctouche relaying area
11	2:30 "	Sur.	HR	Bright fresh SW	23.5	19.5	20.8	26.5	Buctouche R. at bridge
		10'				19.5	21.0	25.6	
		20'			22.3	20.9	21.0	27.2	
22	6:00 "	Sur.	?F	Clear fresh SW	21.7	18.3	21.2	25.3	Buctouche wharf,tide
		10'				18.0	20.8	24.5	was too sti-
		24'				18.5	21.0	25.3	cng to get depth temperatures
30	3:00 "	Sur.	L,slack	Cloudy fresh SW	22.9	18.0	20.8	24.5	Buctouche wharf
						18.5	20.7	24.9	
		24'			22.0	18.5	20.9	24.9	
Aug.15	2:10 "	Sur.	LF		20.3	19.2	20.0	27.0	Buctouche at tripod
		10'			--	20.1	22.0	27.6	
29	10:30 a.m.	Sur.	?F	Bright still	16.3	20.1	22.0	27.6	Buctouche wharf
		10'			--	20.1	22.0	27.6	
					--	20.1	22.0	27.6	

Date	Time	Depth	Tide	Weather	Temp.	Hydr.	(T) read.	Sal.	Remarks
Sept.14	5:30 p.m.	Sur.	½R	calm,clear	16.4		20.2	20.2	At Buctouche
					15.2		20.5	20.1	transplant
20	4:00 "	Sur.	HF	calm,clear	18.5	6.1	15.0	8.1	buctouche
		10'			16.0	15.2	17.7	19.9	wharf water
		28'			15.4	17.5	18.0	23.7	level 3' 10"
22	10:15 a.m.	Sur.	L.	clear	14.4	9.6	11.1 1.1		buctouche
		10'	#	light N W	14.7	16.5	11.0	20.3	wharf
		28'	2½"		15.0	17.7	11.0	21.7	"
27	9:00 "	Sur.	F.	Clear	9.8	4.2	11.2	4.4	"
		10'		light	10.2	4.1	11.1	4.3	"
		20'	2'	breeze	10.0	6.3	11.0	7.0	"
30	9:00 "	Sur.	F	Bright	11.0	9.0	11.7	10.6	"
				Light NW					
		8'			12.3	16.8	11.5	20.4	
		18'	3½'		13.0	19.4	13.5	24.1	
Oct. 1	4:30 p.m.	Sur.	½	Light W			17.6	17.0	Buctouche
							17.5	18.0	Transplant
2		Sur.	R	Bright	12.0	16.0	11.7	19.6	Buctouche
		4'6"		light N					wharf
		8'			11.8	17.5	10.5	21.5	
		25'			11.8	19.0	11.5	23.6	
4	9:00 a.m.	Sur.	R	Dull	10.3	16.2	11.3	15.9	"
		8'	3'9"	Mod.N	10.5	16.8	10.2	19.6	"
		25'			10.5	15.8	11.2	11.4	"
7	9:00 "	Sur.	2'7"	Light S	11.0	14.5	4.6	17.0	"
		8'			10.5	18.0	4.0	21.5	"
		22'			10.5	19.3	3.9	23.0	"
9	9:00 "	Sur.	2'7"	Light N	14.2	15.5	4.9	18.2	2 "
		8'	LF	raining	14.0	13.7	4.6	18.4	"
		20'		hard	14.0	16.0	5.0	18.8	"
	4:30 p.m.	Sur.	½R	Raised in	--	17.0	16.5	22.0	At area
		6'		a.m.	--	17.5	15.5	22.1	chosen from
									Buctouche R.
									transplant &
									Shediac oyst
11		Sur.	3'1"	Clear	11.9	15.7	4.4	18.6	Buctouche
		8'	HF	light W,	11.9	15.5	4.5	18.6	wharf
		20'		calm	11.9	15.6	4.9	18.5	
14		Sur.	2'9"	calm	11.2	16.2	5.3	19.2	
			LR						

Date	Time	Depth	Tide	Weather	Temp.	Sp.Gr.	(T)	Sal.	Remarks
Oct.14		8'			11.1	16.6	4.9	19.2	Buctouche
		20'			11.8	19.2	5.0	22.5	" wharf
	4:30 p.m.	Sur.	BR	Rain		16.0	5.3	18.0	Buctouche R.
				this a.m.		1.5			at time of
		6'				13.4	4.4	19.2	refinding the
									checdice trans-
									plant.
15	10:30 a.m.	Sur.	HR.	Bright	11.3	19.5	4.9	23.3	at Buctouche
		6'		fresh SE			1.7		bay transplant
						22.3	4.1	24.3	
							1.7		
16	9:00 "	Sur.4'6"		Calm,light	9.4	17.2	7.0	23.2	Buctouche N.
		8'	HF	N.heavy rain	9.8	18.2	6.8	22.6	
		20'		last night.	9.9	19.4	6.8	23.6	
18	9:00 "	Sur.4'6"		Light SW,	8.3	18.5	7.2	22.6	"
			HR	calm bright			1.5		
		8'			9.1	20.4	6.0	24.6	"
		20'			9.6		1.6		
		20'			9.6	21.1	6.8	25.7	"
							1.4		
21	9:00 "	Sur. RB		8" snow	4.5	18.5	10.1	22.6	"
				last night.	4.3	19.2	10.0	23.6	
23	9:00 "	Sur. LR		Calm,	2.6	15.0	9.4	18.3	"
				cloudy	2.2	15.9	9.1	18.7	
		20'		light W	3.5	18.5	9.3	22.5	
25	9:00 "	Sur. HF		Bright,	3.5	14.2	9.0	17.0	"
				light W			1.2		
		8'			4.0	18.3	8.2	22.1	
							1.4		
		20'			9.0	21.1	9.5	25.9	
28	9:00 "	Sur. HF		Cloudy,	1.8	13.1	8.3	15.3	
				light WW			1.2		
		8'			4.3	21.0	7.8	24.5	
							1.5		
		20'			3.5	21.7	7.8	26.6	
30	9:00 "	Sur. HR		Cloudy,	1.4	14.1	6.4	16.6	
				light W			1.3		
		8'			3.9	21.1	6.3	25.5	
							1.5		
		20'			4.2	22.1	6.7	26.8	
							1.6		

Date	Time	Depth	Tide	Weather	Temp.	Hydr. (T)	Sal.	Remarks
Oct.31	9:00	"	Sur.	HR	Clear, fresh E	3.0	15.5	7.2	18.4	Buctouche whf
							1.4			
		8'				3.4	21.1	6.2	25.5	
		20'				3.6	21.4	6.7	25.9	
Nov.4	9:00	"	Sur.	LR	Cloudy, light breeze	5.3	15.1	13.7	18.8	"
							.7			
		8'				4.2	19.2	12.7	19.9	
		20'				4.2	18.1	11.8	22.2	
6	9:00	"	Sur.	LR	Cloudy, light SE	--	16.5	11.0	20.7	"
							1.1			
		8'				--	18.1	9.4	22.0	
		20'				--	21.1	9.3	25.9	
							1.3			
8	9:00	"	Sur.	HF	Cloudy, light W, rained last night	4.9	15.4	11.9	19.0	"
							.9			
		8'				4.9	17.7	12.1	22.0	
							.8			
		20'				4.9	19.1	13.4	24.1	
11	9:00	"	Sur.	HR	Cloudy, light N	3.5	15.5	8.3	18.6	"
							2.3			
		8'				4.2	20.2	7.8	24.5	
							1.5			
		20'				4.2	21.1	7.8	25.7	
							1.5			
13	9:00	"	Sur.	LR		7.0	17.6	8.1	21.3	"
							1.3			
		8'				6.1	19.0	7.8	23.0	
							1.3			
		20'				6.0	20.0	8.0	24.2	
							1.3			
15	9:00	"	Sur.	HR	Strong NE raining	5.0	9.6	9.4	11.1	"
							1.1			
		8'				5.1	11.4	8.8	13.3	
							1.2			
		20'				5.2	13.2	8.5	18.2	
18	9:00	"	Sur.	HR	Clear, mod.W	3.5	15.9	10.0	16.7	"
							1.1			
		8'				4.5	17.4	9.6	21.2	
							1.2			
		20'				4.9	19.5	9.6	23.8	

Date	Time	Depth	Tide	Weather	Temp.	Hydr. (T)		Sal.	Remarks
Nov.11	9:00 a.m.	Sur.	L	Cloudy, very fresh W.	3.5	8.2	9.3	9.3	Buctouche wharf
		8'			3.0 / 1.0	1.0		9.3	12.9	
		20'			3.2 / 1.1	14.0	9.3	16.7	
					1.2				
22	9:00 "	Sur.	LF	Cloudy light S	4.0	9.7	9.7	11.2	"
					1.2				
		8'			3.2	16.1	9.5	19.5	
					1.4				
		20'			4.0	15.0	9.3	18.0	
25	9:00 "	Sur.	HS	------	2.0	9.5	12.5	11.9	Ice formed
		8'			--	15.0	12.0	22.0	Nov. 26.
		20'			--	18.1	12.0	22.5	
Dec. 2	9:00 "	Sur.	HR	Snowing, Mod.NE	below zero	16.0	12.2	19.7	
						16.5	11.7	22.9	
		20'				16.8	12.0	22.9	
4	9:00 "	Sur.	LF	Clear mod.W	"	12.0	13.0	14.7	
		8'				12.5	12.3	15.3	
		20'				13.2	12.1	14.7	
6	9:00 "	Sur.	HR	Clear, mod.E	"	13.2	13.0	16.3	
		8'				16.0	12.9	19.9	
		20'				16.6	12.9	25.3	
9	9:00 "	Sur.			"	14.7	13.0	18.2	Buctouche wharf
		8'				13.2	12.7	18.8	
		20'				17.3	12.6	21.6	
Jan.16	10:30 "	Sur.	LF		-1.3	5.0	9.0°C	5.2	Station 4: 150 yds W.of high-way bridge on Buctouche R. (Taken through the ice)
		10'			-1.3	1.0			
		10'			-1.3	17.7	9.0	21.5	
					1.3				
20	9:45 "	Sur.	LR		-1.3	20.2	3.7	24.5	
						1.5			
		10'			-1.3	22.5	7.5	27.5	

Shediac Bay

Date	Time	Depth	Tide	Weather	Temp.	R.	Hydr. (T)	Sal.	Remarks
May 22	10:30 a.m.	Sur.			7.2	23.0	9.2	28.3	Shediac whf.
		3'				23.1	9.2	28.4	inside Quad-
		6'			9.1	23.0	9.5	28.3	rangle.
	4:30 p.m.	Sur.	Low	Pt.cldy.	10.0	21.1	9.8	23.9	
		5'	F	Light NE	9.4	21.0	9.8	25.6	
27	11:00 a.m.	Sur.	High	Bright	13.5	21.5	14.2	27.7	Off Poirier
		6'		Light W	14.5	21.1	14.0	27.2	property
	1:45 p.m.	Sur.	High	Light W	18.8	-	-	-	At point S. of entrance to Shediac river
31	5:30 p.m.	Sur.	High	Bright	15.3	19.3	20.5	26.5	Poirter bed.
		4'		Fresh S	15.2	-	-	-	
June 3	1:30 p.m.	Sur.	Low	Bright	16.3	19.2	24.5	27.4	
		4½	F	Light SW	16.3	19.0	25.1	27.2	
	3:30 p.m.	Sur.	Low		16.9	-	-	-	Wither bed
		5'	F		16.7	-	-	-	
5	6:00 p.m.	Sur.	Low	Bright	19.0	-	-	-	Poirier bed
			F	fresh E					"
6	8:00 p.m.	Sur.	½R	Cloudy	15.1				"
9	6:00 p.m.	Sur.	L	Fresh NE rain	15.5				"
10	5:00 p.m.			Hot bright day,fresh SW					"
11	2:15 p.m.	Sur.	High	Fresh SW	17.2	19.2	25.7	27.7	"
12	day cloudy and cold								
13	heavy rain								
14	cold								
15	strong SW wind, warm								
16	5:00 p.m.		½F	Light NE bright	18.9				
17	12:00 noon	Sur.	½F	Light SW	16.9	22.1	(15.2)	28.3	Páirier bed
	12:00	Sur.	½F	Light SW	17.8	22.1		28.5	Close to shore where water

Date	Time	Depth	Tide	Weather	Temp.	Hydr. (T) R.	Sal.	Remarks
June 18	5:00 p.m.	Sur.	Low slack	Fresh SW bright	20.5			waded out as far as could go on N.side of bar at Poirier bed.
					21.5			waded out as far as could go on S.side of bar at Poirier b
19	10:00 a.m.	Sur.	High slack	Fresh SW cloudy	15.3			waded out as far as possible
		5'			15.0			
20	5:30 p.m.	Sur.	Low slack	Light NE foggy	17.3			
23	2:00 p.m.	Sur.	High slack	Light W.cloudy	15.3			waded out as far as possible at Poirier bed.
24	10:00 a.m.	Sur.	HE	bright light NE	14.9	21.9 18.9 28.9		Poirier bed.
		6'			14.7	22.2 18.3 29.3		"
25	6:30 p.m.	Sur.			16.9			by wading out as far as possible from shore at Poir.bed.
26	5:00 "	Sur.	HE	Still pt.cldy.	16.4			"
28	6:15 a.m.	Sur.	HF		16.0			
		5'			15.5			
	6:30 p.m.	Sur.	H	fresh SW	17.5			
		5'			17.6			
		Sur.			22.1			obtained by wading out as far as possible at Poirier bed.
July 1	12:15 p.m.	Sur.	LF	fresh SW	17.3			Poirier bed.
		5'			17.5			
3	11:45 a.m.	Sur.	½F	fresh SW	18.4			"
		5'			17.5			
	4:00 p.m.	Sur.	L	Fresh SW	20.7			"
		4'			20.7			
5	11:00 a.m.	Sur.	H	Pt.cldy.	16.7	21.2 21.0 28.8		Poirier bed.
		5'			16.3	21.2 20.9 28.8		"
6	10:45 a.m.	Sur.	HF	Bright light NE	18.6			Wilbur bed.
		6'			18.0			
	7:30 p.m.	Sur.	LF	--	21.0			Poirier bed.
		5'			21.0			
7	5:30 "	Sur.	LF	Bright light SW	21.9			"
		4'			21.8			"

Date	Time	Depth	Tide	Weather	Temp. R.	Hydr. (T)	Sal.	Remarks
July 8	4:00 p.m.	Sur.	½F	Hot day	23.7	21.2 21.8	28.9	Poirier bed.
		4'			23.4			"
10	9:45 a.m.	Sur.	LR	Pt.cldy. light NW	21.0	21.2 20.1	28.5	"
		5'			20.5	21.5 20.2	28.9	"
12	4:00 p.m.	Sur.	HF	Bright fresh NE	21.8			"
		6'			21.7			"
15	2:00 "	Sur.	LF	---	22.5			"
		5'			21.4			"
16	5:45 "	Sur.	LF	Fresh SW	21.6	21.8 19.7	29.2	"
	8:55 "	Sur.	HR	Light SW	20.0	21.9 20.1	29.5	"
					20.2			
17	4:50 "	Sur.	L. slack		19.7	21.3 20.1	28.7	Middle of Shediac bay
		8'	R		19.8	21.7 20.0	29.2	off Point du chene.
23	10:30 a.m.	Sur.	½F	bright light SW	20.7	21.7 20.0	29.2	Poirier bed.
		7'			20.7	21.7 19.8	29.1	"
25	3:10 p.m.	Sur.	LR	Bright fresh SW	21.2			Wilbur bed.
		7'			21.2			"
28	1:15 "	Sur.	½F	bright light NE	23.7	21.5 18.8	28.5	Poirier bed.
		4'			23.4	- - -		"
31	10:00 a.m.	Sur.	½F	bright light SW	21.3	21.5 19.5	28.8	"
		7'			21.2	21.6 19.3	28.8	"
Aug. 8	3:30 p.m.	Sur.		Fresh E	23.3			"
15	10:00 a.m.	Sur.	LR.		20.8	21.5 21.9	29.5	"
23					20.4	21.5 22.0	29.5	"
		5'			21.2	21.5 22.0	29.5	"
26	5:00 p.m.		H.	Fresh SW cloudy	16.5			"

Date	Time	Depth	Tide	Weather	Temp. Hydr. R.	(T)	Sal.	Remarks
Aug.27		Sur.	H.	Bright	16.3	21.5	22.0	29.5	Poirier bed
	5'				16.5	-	-	-	"
29		Sur.	L.	bright light N	16.5	18.5			"
31		Sur.	L.	bright black light SW	22.0				"
	at							
Oct.1	6:45 p.m.	Sur.	L.	bright light SW	20.5				"
	4'				20.6				"
6		Sur.	L.	Still cloudy	15.0	21.7	18.0	28.5	"
	1'					21.9	17.7	28.8	"
	4'				14.8	21.9	17.8	28.8	"
10	3:00 "	Sur.	½R.	cloudy	17.0				"
	4'				17.0				"
12	11:30 a.m.	Sur.	LF	cloudy	14.4	21.6	18.0	28.4	"
	4'				14.4	21.5	18.2	28.5	"
18	3:00 p.m.	Sur.		warm day	14.8				"
20									"
22	10:00 a.m.	Sur.	LS.	cloudy light NW	16.1				"
27	3:00 p.m.	Sur.	½	cloudy light breeze SW	12.3	20.5	11.0		Wilbur bed.
Nov.3	12:00 noon	Sur.	½R.	bright light SW	9.8	22.2	4.4	24.7	"
						1.8			
	9'				10.2	22.0	5.0	24.5	"
						1.8			
5	5:30 p.m.	Sur.	H.	clear, light SW	13	3 20.8	5.0	25.0	Poirier bed.
	5'				13.3	22.1	4.4	24.6	"
17	9:30 a.m.	Sur.	H.	bright, mod.SW.	3.9				"
23	11:00 "	Sur.	LR.	cloudy, snowing light S	1.8	21.3	2.7	25.5	"
	4'				1.8	-	-	-	"
28	11:00 "	Sur.	LR.	cloudy,	1≥8	4			"
						20.4	3.3	24.5	
	5'					20.9	2.0	24.5	
Nov.4		Sur.			--	22.3	9.0	27.4	

HYDROGRAPHY

Shediac River, N. B.

Date	Time	Depth		Tide	Weather	Temp.	Hydr. (T) R.	Sal.	Remarks
May 27	2:00 p.m.	Sur. 3' 9'		High R.	bright fresh to light NE	15.4 16.3 16.0	17.4 18.0 19.1 18.0 19.9 18.2	22.6 24.6 25.7	At bridge over Shediac river.
June 3	3:00 "	Sur. 3' 12'	½F			19.2 19.2	14.2 18.0 14.5 18.0 14.7 18.0	18.7 19.1 19.4	At highway bridge over Shediac R.
3	3:00 "	Sur. 3' 7'	2F			19.3 18.5	10.2 18.4 10.3 18.0 11.5 18.0	13.6 13.6 15.1	At wooden bridge over Shediac R.

HYDROGRAPHY

Scoudouc River, N.B.

Date	Time	Depth	Tide	Weather	Temp. Hydr. (T) R.			Sal.	Remarks
July 22	10:45 p.m.	Sur.			9.6	20.1	19.1	24.7	Soudouc R.at
		3'				21.5	20.4	26.5	Shediac high-
		6'			9.2	21.1	19.1	29.9	way bridge.
June 4	10:15 a.m.	Sur.	High slack	Bright fresh NW	17.1	15.0	18.4	19.9	at Smith's mill on Soudouc R.
		5'				17.7	17.7	23.2	
		6.7'			16.7	17.7	17.8	25.3	
4	11:00 "	Sur.	HF.		17.3	18.0	17.7	23.2	In cove off
		4'				15.3	17.6	23.9	the Webster's
		10'			16.7	15.3	17.8	25.8	property, Soudouc R.
9	6:00 p.m.	18'	Low F.	bright light N.	19.6	0.2	23.0	1.5	Soudouc R.at A.Caisnie's camp where oysters were taken.
July 13	11:00 a.m.	Sur.	LF.	Still clear	22.2	15.1	25.0	22.0	Dr.Webster's cove
		3'				18.3	25.1	26.6	
		10'			21.5	19.4	23.3	27.9	
16	10:00 "	Sur.	HF.		20.2	19.3	20.2	27.6	Dr.Webster's cove
		10'			17.7	21.5	20.2	28.9	
Aug. 2	9:00 "	Sur.	HF.	Fresh SW bright	16.0	5.0	21.2	4.8	Caisnie's camp.
		2'				17.8	21.1	24.1	
		7'			23.0	16.3	21.2	25.0	
6	10:00 "	Sur.	H.	Light SW bright	22.0	4.3	21.3	6.5	"
		1'			23.8	18.3	21.7	25.1	
		5'			23.5	18.3	20.2	25.1	
Sept.12	3:30 p.m.	Sur.	L.	Clear, slack still.	16.0	1.6	20.5	2.8	"
		2'				17.8	20.7	24.2	
		5'			17.3	18.5	20.6	25.1	
12	4:15 "	Sur.	LH.	"	17.1	5.9	20.2	13.6	Tripod at
		2'				19.0	20.2	25.7	Webster's.
		5'			17.6	19.2	20.3	25.9	

Northumberland Strait, N.B.

Date	Time	Weather	Tide	Depth	Temp.	Hydr.(T) R.	Sal.	Remarks.
May 22	11:00 a.m.	Fog light E.	RF.	Sur. 3' 8.3	22.3 23.2 23.6	9.5 9.1 9.3	27.4 28.3 29.1	Point du chene at wharf.
June 19	2:30 p.m.	Raining, fresh SW.	½F	Sur. 6' 12'(Bo-ttom)	15.0 14.8	22.2 14.3 22.5 14.2 22.9 14.3	28.3 29.2 29.3	Point du Chene at wharf in channel.
July 17	4:10 "	Cloudy, fresh SW.	LS	Sur. 20'	19.8 19.7			In channel at Point du Chene
17	3:45 "	"	"	Sur. 5' 10'	19.2 19.2	21.9 20.6 21.5 20.4 21.5 20.3	29.6 29.7 28.8	½ mile of Point du Chene at edge of channel
17	4:15 "	"	"	Sur. 10' 21'	18.6 18.5	22.0 20.8 22.1 20.4 22.1 20.3	29.7 29.7 29.7	At Block House off Pt.du chene
17	5:00 "	"	"	Sur. 20'	19.5 19.3			½ mile off Point du Chene in
Aug.30	1:00 "	Bright fresh SW	LF.	Sur. 10' 20'	17.8 17.8	21.5 22.0 21.5 22.0 21.5 22.0	28.1 28.1 28.1	channel. At second red buoy off Point du Chene.
Sept.10	10:00 a.m.	Bright mod.SW.	½F.	Sur. 10' 20'	16.0 16.0	20.5 20.8 20.7 20.3 20.5 20.4	27.9 27.9 27.7	5 miles off Outside Cape in Strait; water very brown.

Kouchibouguac River, N. B.

Date	Time	Weather	Tide	Depth	Temp.	Hydr. (T) R.	Sal.	Remarks
May 30	1:00 p.m.	Bright LF light N		Sur. 6'	14.7 14.3	19.4 20.2	17.0 19.2	25.5 26.3	at highway bridge.
June 3	11:00 a.m.	Light SW bright		Sur. 6'	18.0 13.3	20.5 21.1	18.2 18.3	27.1 27.9	at transplant 2 mile below bridge.
28	8:20 p.m.	Clear, RF. light SW		Sur. 6'	15.3 18.2	20.9 21.0	22.0 21.7	28.7 28.8	at transplant
July 19	8:30 "		LR.	Sur. 6'	21.3 21.2	21.3 21.3	21.0 21.0	28.9 28.8	at transplant
24	2:30 "	Cloudy 1R. fresh SW		Sur. 6'	21.1 21.1	21.6 21.3	21.0 21.0	29.3 28.9	1 mile below bridge
29	2:15 "	Light NE LS bright		Sur. 7'	24.0 25.3	21.3 21.5	20.1 20.2	28.7 28.9	"
Aug. 7	7:30 "	---	---	Sur. 7'	23.9 23.8	21.4 21.5	22.0 22.0	29.3 28.1	"
27	---	---	---	Sur.	--	20.5	11.6	23.4	"

Aboujogan River, Hydrography

May 30	3:30 p.m.	Bright LR. light N		Sur. 6'	16.3 16.2	16.0 16.4	17.6 16.4	20.9 21.2	1 mile below highway brg.

Barachois at Benet Beach (Natural's)

Nov. 6	2:00 p.m.	Pt.cldy. LR.	3mrl'	--	19.5	12.7	24.7	A) Stations 1
			1'	--	21.3	12.0	26.6	B) Western pa
			1'	--	21.4	10.3	26.3	C) pond
7	3:00 "		LS	1' 1'	--	19.0 19.4	14.2 15.0	24.1 24.7	at centre of pond
			1'	--	19.6			At eastern e

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