FISHERIES RESEARCH BOARD OF CANADA

MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 174

Title

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MSS Report to the Biological Board of Canada

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Introduction:

The cycle of temperature and salinity, for the inshore waters of the Scotian shelf, may be illustrated by the periodic observations which have been made at station 60, off Halifax, during the past four years (1932-35 inclusive).

Station 60 is located in latitude 44° 23′ 25″N. and longitude 63° 21′ 58″W., off Halifax harbour, in fifty-five fathoms of water. When opportunity offered, the station was occupied for hydrographic observations in this column of water. Although fairly regular observations were made during the spring, summer and autumn months, it was not until 1935 that a representative series of winter observations were obtained. The collected observations of temperature and salinity are furnished in table 1. These data, for depths of 0, 50, and 100 metres are plotted in figures 1 and 2 to illustrate the cycle of temperature and salinity in inshore waters of this area of the Scotian shelf.

At first glance at the plotted results, it will be evident that, insofar as the salinity is concerned, the water

tures are concerned however, conditions at the fifty and one hundred metre level are quite similar except during the autumn. During the winter months, the temperature is fairly uniform throughout the column.

The Cycle of Temperature:

Temperatures as high as 19.8°C. (September 6th, 1932) are reached by the surface waters, falling as low as -1.0°C. (January 19th, 1935) during the winter months. Surface temperatures during 1932 and 1933 reached slightly higher values than in the following years (1934 and 1935). At a depth of 50 m. the temperatures are generally less than 5.0°C. (as low as -1.6°C. on March 15th, 1935). In late summer however, the temperature at 50 m. may increase sharply (In September, 1932 from 1.23°C. to 12.06°C.), and these higher temperatures may then persist for some time. Such a phenomenon hasebeen dealt with in various publications by the writer. It will be noted that such sharp rises in temperature, at a depth of 50 m. do not occur every year. In 1934, for example, the temperature at 50 m was, insofar as our observations indicate, never greater than 5.12° C.

The temperatures at a depth of 100 m. tend to follow those at 50 m., but never reach as high a value nor drop to as low a value. Generally the temperature at a depth of 100 m. is 5.0° C. or less. During the winter of 1934, temperatures as low as -0.4° C. were recorded at a depth of 100 m., while in December, 1935, a temperature of 7.00° C. was noted.

For a short period each year -- early winter -- the temperature of the water column at station 60 is uniform throughout. this is the period of the annual overturn, when the cooling of the surface layer sets up a rapid and effective vertical circulation sometimes throughout the whole column. A uniform temperature is the result. Further cooling of the surface layer throughout the winter months tends to maintain this vertical circulation, with the result that the water column is generally uniform in temperature throughout the winter months. This is probably best illustrated by the regular series of monthly observations during the winter of 1934-35.

The cycle in the surface layer is therefore an increase in temperature from the winter minimum, which usually occurs in February to the late summer maximum, which is usually observed in September. From this time of summer maximum, the surface temperature gradually decreases to the winter minimum. This cycle of events is disturbed somewhat by shoreward movements of surface waters in the late autumn months. It is also interrupted by the removal of the immediate surface waters accompanied by upwelling of deeper and colder waters. At a depth of 50 m., the minimum temperature is usually experienced in February, sometimes March, and the manner of increase in temperature, to the late summer maximum, varies considerably from year to year. The years 1932 and 1933 illustrate a gradual increase in temperature until late August, and then a sharp rise to the maximum which might be reached in September or October. In 1934, a gradual rise from the minimum to the maximum, which was reached in December, is indicated, while in 1935, a somewhat similar progress of events brings the maximum temperature sometime in early December. The sharp changes in temperature,

occurring at a depth of 50 m. in the late summer, are the result of the replacement process in inshore waters at times of the existence of steep atmospheric pressure gradients over the neighboring ocean. These replacement processes have been dealt with in some detail in publications by the writer. At a depth of 100 m., these replacements of waters also disturb the regular sequence of events as the temperature rises from a minimum, occurring during the winter months, to a maximum, which may be attained in any month of the late autumn or early winter.

The Cycle of Salinity:

In 1932, 1933, and 1934, the surface salinity is at its minimum (as low as 30.17 ‰) during the autumn months, but in 1935 comparatively low salinities are in evidence both in the spring and autumn months. The surface salinities, on the whole, were comparatively higher in 1934 than in the other years of observation. The maximum surface salinity of the period, observed in December, 1934, was 31.69 ‰ .

The salinity at 50 m., at times, undergoes sharp changes. These are particulary evident in the autumn of 1932 and 1933. This, is another phase of the same phenomenon mentioned previously in connection with the sharp temperature changes. It will be noted that in the years 1932 and 1933, minimum salinities at a depth of 50 m. were observed in the late autumn, while in spring and early summer the salinities are comparatively high. In 1934 and 1935, minimum salinities at a depth of 50 m. were experienced in early winter -- at the time of the annual overturn, when conditions were comparatively uniform from top to bottom or at least in the upper fifty metres.

The years 1933 and 1934 illustrate quite clearly the effect of the vertical circulation set up by the cooling of the surface waters, and it is quite evident that in some years this "overturn" is effective to a depth of at least one hundred metres. It would seem however, that such was not the case in the winter of 1932-33, for the salinity was uniform (approximately 30.50 ‰) only in the upper fifty metres in December and January, while the salinity of the 100 m. level varied between 32.18 ‰ and 32.47 ‰.

The salinities at a depth of 100 m. show the largest annual variation, sharp changes generally taking place at the time of the annual overturn. It is evident from the plotted results, that the salinities in general, were somewhat higher in 1934 than in the other years of observation.

The Origin of the Intermediate Layer:

The origin of the "intermediate layer" on the Scotian shelf is a matter of considerable interest. The question arises as to how much of it is due to local "after-winter" effects. In other words the annual overturn and subsequent winter cooling would produce a body of water, at considerable depths below the surface, which would conform to the characteristics of the "intermediate layer" were it to remain there. The foregoing discussion of conditions at station 60 has indicated that the annual overturn and subsequent cooling is effective to depths at least as great as 100 m. A study of the plotted variations at station 60 will immediately convince one, that after the influence of winter is past, the waters of the column at all depths are readily replaced. This is indicated by the marked changes in

temperature and salinity which generally follow the advent of spring. Consequently, it would seem that movement, rather than "after winter" effect is the major factor in suppying characteristic waters of the "intermediate layer". This is borne out by evidence from other phases of the investigations of the waters of the Scotian shelf.

Station 60 - 1932 to date.

HYDROGRAPHIC DATA

Sta.	Date 1932	Depth	Sal.	Temp.
60	June 22	0 m.	31.03	10.5
		10	31.01	8.2
		25	31.35	2.0
		50	32.09	0.3
		75	32.45	0.6
		100	32.52	0.7
	June 27	0	31.01	9.5
		10	30.96	8.8
		25	31.78	2.9
		50	32.18	0.1
		75	32.55	0.5
		100	32.59	0.7
	July 6	0	31.29	8.9
		10	31.27	7.4
		25	31.67	1.9
		50	32.08	0.6
		75	32.46	0.6
		100	32.79	1.2
	July 11	0	31.19	9.3
		10	31.16	8.8
		25	31.81	1.4
		50	32.20	0.1
		75	32.37	0.4
		100	32.52	0.5
	July 18	0	31.09	13.1
		10	31.03	12.47
		25	31.62	2.34
		50	32.27	0.93
		75	32.55	0.62
		100	32.75	1.19
	July 25	0	30.83	15.3
		10	31.06	14.11
		25	31.71	1.99
		50	31.98	0.93
		75	32.20	0.63
		100	32.40	0.77
	Aug. 1	0	30.99	15.9
		10	31.01	13.69
		25	31.67	4.41
		50	32.15	1.01
		75	32.50	0.88
		100	32.68	1.07
	Aug. 8	0	30.74	16.5
		10	30.82	14.21
		25	31.56	3.11
		50	31.98	1.22
		75	32.36	1.27
		100	32.68	1.31
	Aug. 10	0	30.74	16.9
		10	30.80	14.61
		25	31.50	3.37
		50	31.92	1.39
		75	32.59	1.24
		100	32.86	1.72
60	Aug. 13	0 m.	31.06	17.4
		10	31.04	17.29
		25	32.20	6.19
		50	32.59	0.82
		75	32.77	0.92
		100	32.84	1.27
	Aug. 15	0	30.84	16.4
		10	30.84	14.20
		25	31.27	6.58
		50	32.36	1.47
		75	32.68	1.07
		100	32.77	1.11
	Aug. 24	0	30.97	19.5
		10	31.08	17.36
		25	31.74	3.60
		50	32.29	1.05
		75	32.65	1.17
		100	33.19	2.54
	Aug. 30	0	30.99	16.3
		10	30.99	14.60
		25	31.82	4.69
		50	32.57	2.41
		75	32.83	1.45
		100	32.95	1.72
	Sept. 6	0	30.97	19.8
		10	30.93	19.70
		25	32.05	8.88
		50	32.59	1.23
		75	32.68	1.07
		100	32.81	1.41
	Sept. 13	0	30.53	16.0
		10	30.53	14.64
		25	30.82	13.46
		50	30.82	12.06
		75	31.51	6.52
		100	31.82	4.98
	Sept. 26	0	30.55	13.8
		10	30.55	13.71
		25	30.93	12.17
		50	31.53	11.18
		75	32.39	3.08
		100	32.70	2.42
	Oct. 10	0	30.82	13.8
		10	30.77	13.01
		25	31.24	11.28
		50	31.98	6.30
		75	32.47	2.33
		100	32.74	1.56
	Nov. 14	0	30.53	8.5
		10	30.50	8.56
		25	30.50	8.56
		50	30.50	8.56
		75	31.53	6.37
		100	31.49	5.38

Station 60 - 1932 to date. (2)

HYDROGRAPHIC DATA

Sta.	Date 1932	Depth	Sal.	Temp.
60	Dec. 21	0 m.	30.48	4.0
		10	30.48	4.39
		25	30.48	4.39
		50	30.64	4.60
		75	31.98	5.40
		100	32.18	5.10
	1933			
	Jan. 19	0	30.84	2.5
		10	30.84	2.57
		25	31.20	3.89
		50	31.64	3.79
		75	32.27	3.69
		100	32.47	3.28
	May 15	0	31.20	4.0
		10	31.22	2.83
		25	31.65	0.64
		50	31.94	0.69
		75	32.16	0.74
		100	32.23	0.78
	May 22	0	31.24	4.7
		10	31.18	4.04
		25	31.60	1.95
		50	31.71	0.58
		75	31.80	0.53
		100	31.98	0158
	May 29	0	31.00	5.7
		10	30.99	3.97
		25	31.11	3.88
		50	31.83	2.45
		75	31.92	0.53
		100	32.07	0.71
	June 5	0	30.61	7.2
		10	30.61	5.04
		25	31.04	1.16
		50	31.64	1.18
		75	32.07	0.99
		100	32.54	1.53
	June 12	0	30.91	9.0
		10	30.82	8.64
		25	31.64	5.22
		50	31.83	2.17
		75	32.25	0.90
		100	32.30	1.09
	June 19	0	30.53	9.2
		10	30.52	7.85
		25	31.24	1.98
		50	31.67	1.23
		75	32.07	0.97
		100	32.25	1.16
	June 26	0	30.48	10.9
		10	30.68	6.73
		25	31.27	1.63
		50	32.01	1.68
		75	32.18	0.70
		100	32.43	1.31
60	July 3	0 m.	30.57	11.1
		10	30.53	9.80
		25	30.93	4.71
		50	31.80	1.15
		75	32.21	0.75
		100	32.47	1.14
	July 10	0	30.55	11.6
		10	30.57	11.05
		25	31.44	1.56
		50	31.76	1.34
		75	31.56	0.95
		100	32.30	1.27
	July 18	0	30.95	15.6
		10	31.00	14.55
		25	30.97	5.49
		50	31.91	1.17
		75	32.09	0.93
		100	32.30	1.39
	July 24	0	30.62	16.9
		10	30.64	11.75
		25	30.99	6.41
		50	31.65	2.52
		75	32.25	1.37
		100	32.48	1.56
	July 31	0	30.97	14.0
		10	30.99	10.34
		25	31.64	5.96
		50	32.07	1.54
		75	32.61	2.00
		100	32.90	2.57
	Aug. 7	0		16.9
		10	30.93	15.51
		25	31.82	8.34
		50	32.16	2.48
		75	32.43	1.72
		100	32.52	1.87
	Aug. 14	0	30.93	17.8
		10	30.99	16.1
		25	31.56	5.40
		50	31.82	1.73
		75	32.39	1.73
		100	32.47	1.72
	Aug. 21	0	30.88	18.3
		10	30.93	17.88
		25	31.44	7.96
		50	31.73	3.49
		75	32.20	1.62
		100	32.61	1.87
	Aug. 28	0	20.52	18.2
		10	30.50	17.58
		25	30.91	8.82
		50	31.51	3.82
		75	32.10	2.78
		100	32.34	1.81

Table I (continued)

Station 60 - 1932 to date. (3)

HYDROGRAPHIC DATA

Sta.	Date	Depth	Sal.	Temp.
	1933			
60	Sept. 4	0 m.	30.26	18.3
		10	30.23	17.85
		25	30.59	14.83
		50	31.73	4.06
		75	32.51	2.62
		100	32.72	2.42
	Nov. 1	0	30.17	10.0
		10	30.14	10.35
		25	30.14	10.25
		50	30.41	10.70
		75	31.47	6.76
		100	32.05	4.87
	1934			
	Jan. 19	0	31.09	-0.5
		10	31.04	-1.0
		25	31.17	-1.0
		50	31.11	-1.0
		75	31.17	-1.0
		100	31.24	-0.4
	May 28	0	31.71	7.9
		10	31.67	5.48
		25	31.91	3.75
		50	32.27	1.96
		75	32.43	2.15
		100		1.76
	June 11	0	31.18	8.1
		10	31.26	7.22
		25	31.91	3.03
		50	32.38	1.16
		75	32.48	1.75
		100	32.72	2.37
	June 25	0	31.35	9.6
		10	31.36	8.96
		25	31.92	7.24
		50	32.36	2.03
		75	32.59	1.80
		100	33.12	3.25
	Aug. 16	0	31.35	15.3
		10	31.26	14.92
		25	31.27	7.18
		50	32.14	2.28
		75	32.75	2.37
		100	32.97	2.99
	Sept. 22	0	30.86	18.0
		10	31.09	18.05
		25	31.46	17.08
		50	32.12	3.65
		75	32.12	3.61
		100	33.31	3.90
	Oct. 3	0	31.62	18.2
		10	31.76	18.16
		25	31.51	12.83
		50	32.43	3.47
		75	33.01	3.40
		100	31.49	4.48

Sta.	Date	Depth	Sal.	Temp.
	1934			
60	Dec. 7	0 m.	31.69	5.40
		10	31.67	6.91
		25	31.71	6.59
		50	32.38	5.12
		75	33.13	4.52
		100	33.26	4.56
	1935			
	Jan. 19	0	31.13	-1.0
		10	31.11	0.40
		25	31.11	0.40
		50	31.18	0.57
		75	31.09	0.52
		100	31.18	0.46
	Feb. 19	0	31.24	0.0
		10	31.18	-1.60
		25	31.18	-1.60
		50	31.73	0.40
		75	31.73	0.40
		100	31.96	1.22
	Mar. 15	0	31.49	0.0
		10	31.47	-1.40
		25	31.46	-1.40
		50	31.69	-1.61
		75	31.92	0.31
		100	31.94	0.41
	Apr. 24	0	31.55	2.3
		10	31.74	0.89
		25		-0.61
		50	31.89	-0.71
		75	32.03	-0.76
		100		0.00
	May 4	0	31.65	3.5
		10	31.60	2.04
		25	31.94	0.74
		50	32.03	-0.01
		75	32.25	0.23
		100	32.88	2.20
	June 3	0	30.86	6.6
		10	31.02	5.85
		25	31.65	-0.07
		50	31.85	-0.53
		75	32.03	-0.69
		100	32.12	-1.04
	July 1	0	30.57	12.9
		10	31.17	7.43
		25	31.55	3.43
		50	32.20	0.45
		75	32.39	0.36
		100	32.63	0.90
	Sept. 2	0	31.08	17.1
		10	31.09	16.71
		25	31.80	6.90
		50	32.12	0.77
		75	32.48	1.08
		100	32.77	1.84

Station 60 - 1932 to date. (4)

HYDROGRAPHIC DATA

Sta.	Date 1935	Depth	Sal.	Temp.
60	Nov. 7	0 m.	30.61	10.5
		10	30.55	10.55
		25	31.11	10.92
		50	31.89	1.72
		75	32.16	2.78
		100	32.52	1.71
	Dec. 7	0	30.86	6.1
		10	30.84	7.61
		25	30.84	7.63
		50	30.84	7.70
		75	31.67	8.68
		100	32.30	7.00

Table I (concluded)