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SUMMARY REPORT ON MARINE BORER SITUATION IN SAINT JOHN HARBOUR, BASED ON TEST BLOCKS FROM THE ATLANTIC SUGAR REFINERIES, SAINT JOHN, N.B. 1937.

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SUMMARY REPORT ON MARINE BORER SITUATION IN SAINT JOHN HARBOUR, BASED ON TEST BLOCKS FROM THE ATLANTIC SUGAR REFINERIES, SAINT JOHN, N. B.

by

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Since December, 1935, blocks have been received at monthly intervals at the laboratory of the Atlantic Biological Station from the Atlantic Sugar Refineries, Saint John, N. B., for the purpose of examination for marine borers. At first, blocks from two locations were sent, one from the north-west corner of the wharf, the other from the Kennedy Slip. This last was discontinued in September, 1936. This summary will deal only with observations from blocks from Board No.1, at the north-west corner.

OBSERVATIONS AND DATA

In addition to maintaining and forwarding the blocks for examination, the Atlantic Sugar Refineries made temperature readings, and salinity observations (made more or less daily from November 1, 1934 to November 1935, and then weekly until November 1936). These were discontinued entirely at the end of October,1936. These hydrographic data serve to interpret the findings of the borer attacks which vary from season to season, and from month to month.

There were two special hydrographic surveys of Saint John harbour, made jointly by the Saint John Harbour Commission (as it then was), the Atlantic Sugar Refineries, and the Biological Board of Canada, with the research vessel "Zoarces", under the direction

of the hydrographer of the Biological Board, Mr. H. B. Hachey. Reports on the observations of these two surveys have already been submitted.

Data on the attack from month to month are shown in the table following (Table I). In this table, the number of burrows found in each block examined is shown in columns for the year and month it was received. In brackets, is also shown the depth (below harbour datum) at which the block was exposed. These blocks have each had approximately six months' exposure, so the date of immersion can easily be worked out. There was a control block fixed at the level -16.55 feet, and which was exposed in each case for one month only. None of the control blocks has ever shown any attack.

TABLE I.

	1934	1935	1936	1937
January		0 (-15.55)	1 (-15.55)	0 (-18.05)
February		0 (-16.05)	0 (-16.05)	1 (-15.05)
March		0 (-17.05)	0 (-17.05)	0 (-15.55)
April		0 (-17.55)		0 (-16.05)
May		0 (-18.05)	0 (-17.55)	
June		0 (-15.05)		0 (-17.05)
July		0 (-15.55)	0 (-18.05)	0 (-17.55)
August		2 (-16.05)	0 (-15.05)	6 (-18.05)
September		2 (-17.05)	1 (-15.55)	0 (-15.05)
October		0 (-17.55)	0 (-16.05)	
November		1 (-18.05)	2 (-17.05)	
December	0 (-15.05)	0 (-15.05)	1 (-17.55)	

Since it has been shown that the depth of exposure has been an important factor in relation to attack by marine borers, another table (Table II) has been prepared to whow what influence, if any, has been exorted by this factor.

TABLE II.

											Totals
-15.05	Dec.'34	0	June '35	0	Dec.'35	0	Aug.'36	0	Feb.'37	1	1
-15.55	Jan.'35	0	July '35	0	Jan.'36	1	Sep.'36	1	Mar.'37	0	2
-16.05	Feb.'35	0	Aug. '35	2	Feb.'36	0	Oct.'36	0	Ap-My'37	0	2
-16.55			Monthly Controls ---------- only.								
-17.05	Mar.'35	0	Sep.'35	2	Mr-Ap'36	0	Nov.'36	2	June'37	0	4
-17.55	Apr.'35	0	Oct. '35	0	May '36	0	Dec.'36	1	July'37	0	1
-18.05	May '35	0	Nov. '35	1	July '36	0	Jan.'37	0	Aug.'37	6	7

Temperature and salinity play probably the most important role in connection with any attack developing by marine borers. In the case of the Gribble (Limnoria lignorum), it is known that salinities of less than 14 parts per thousand are fatal. It is capable of doing damage however over a wide range of temperatures, and occurs from the Arctic through the Tropics.

A table of temperatures and salinities prepared from data compiled by the Atlantic Sugar Refineries has been prepared (Table III). The data from this table, together with other data referred to below, enable one to secure a rather good picture of the salinity changes likely to occur in Saint John harbour, and also the probable durations.

TABLE III.

	Temperature-°F.				Salinity-parts ‰.			
	Surface		Bottom		Surface		Bottom	
1934	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Nov.	49.0	40.0	49.0	42.0	27.3	10.7	32.3	12.2
Dec.	46.0	35.5	48.0	37.0	26.8	7.1	31.2	11.5
1935								
Jan.	38.0	30.5	40.5	38.5	28.1	15.0	30.5	16.3
Feb.	34.5	32.0	34.0	31.0	28.5	19.0	31.2	21.0
Mar.	33.0	31.0	34.0	32.0	26.0	19.5	30.5	20.0
Apr.	36.0	33.0	44.0	33.0	26.3	2.5	30.0	2.5
May	50.5	39.5	48.0	36.0	19.5	0.5	29.5	0.5
June	59.0	48.0	59.0	42.5	21.7	5.0	30.5	8.5
July	66.0	50.0	61.5	48.5	27.8	8.5	30.0	9.5
Aug.	65.0	54.5	59.0	53.0	28.2	16.8	31.0	20.5
Sep.	63.0	51.5	57.0	50.5	27.8	20.0	31.2	26.0
Oct.	54.0	49.0	53.0	50.0	27.5	19.0	31.5	26.0
Nov.	49.0	45.0	51.0	46.0	24.2	20.2	31.5	21.3
Dec.	46.0	35.5	46.0	41.5	25.7	11.2	30.5	21.5
1936								
Jan.	35.5	34.0	37.5	34.0	23.0	16.5	27.5	20.0
Feb.	33.5	32.5	34.0	33.5	22.0	19.0	30.7	23.2
Mar.	36.5	33.0	35.5	33.0	26.3	1.0	29.7	1.7
Apr.	42.0	37.0	39.0	34.5	10.7	5.2	27.7	3.7
May	50.5	39.0	47.0	41.0	5.7	1.5	26.3	1.7
June	59.0	50.5	55.0	46.5	15.3	6.3	23.5	8.0
July	60.0	53.0	53.0	50.5	19.0	17.7	31.5	21.2
Aug.	56.5	54.0	54.0	52.5	23.0	17.5	31.7	24.0
Sep.	57.0	51.5	54.0	51.0	28.5	19.2	28.7	23.7
Oct.	52.0	50.0	51.0	50.0	25.5	22.3	30.5	25.5

Readings in 1936 weekly; previously daily, or nearly so.

It is well known that both salinity and temperature vary with the tide, and with the river discharge. But, it is really the duration of exposure to any particular salinity or temperature which will determine the presence or absence of any animal in a given area, and the extent of its activities. The data in Table III above presents a picture for one point in the harbour, at one moment in the day (or week).

The surveys made by Mr. Hachey show what takes place across a section of the harbour at various phases of the tidal cycle, at two highly contrasting times of the year, namely at the extreme low stage of the river (September) and at a period of high freshet (April).

In addition to these sets of data, there was prepared by the Atlantic Sugar Refineries, a graph to show the relation between the monthly average salinity at the surface and bottom of the harbour (at their sampling point), and the mean daily discharge month by month of the Saint John river, as measured at Pokiok, N.B., by the Dominion Water and Power Bureau. From the data in this graph, it was possible to calculate two straight-line equations (by the method of Least Squares), one for the surface, and one for the bottom, to give a means of calculating the salinity (average monthly) when the average daily discharge for any month is known. These equations are:

Surface: $Y = -0.334 \times +24.3$
Bottom: $Y = -0.244 \times +28.04$

In these equations, x is the discharge in thousands of cubic feet per second, at Pokiok, and Y is the salinity, in parts per thousand (‰). The data in Table IV was taken from this graph, and is that upon which the equations have been calculated (disregarding however

the data for April, 1935).

TABLE IV.

6666	Salinity-‰		Discharge
	Surf.	Bottom	M.cu.ft.per sec.
November, 1934	16.8	24.4	22.4
December, 1934	13.6	22.2	24.2
January, 1935	18.6	23.4	11.5
February, 1935	22.6	28.2	7.5
March, 1935	22.3	28.2	6.6
April, 1935	12.2	18.3	53.5
May, 1935	5.7	14.2	57.0
June, 1935	11.5	19.7	35.3
July, 1935	17.0	22.3	19.5
August, 1935	21.6	22.0	6.2
September, 1935	23.2	27.6	5.0
October, 1935	23.2	27.4	5.0

From the data of Table III, the maximum and minimum salinity measured may be determined, and from the equations, or Table IV, the average salinity for the month may be determined. The reports of Mr. Hachey already referred to, enable one to determine the approximate duration of these lowest and highest salinities during any particular tidal cycle which is the limiting factor with respect to the activities of the gribble or other organisms (test organisms). It will be obvious that May 1935, was a critical month (from Table III and IV), for the average monthly bottom salinity was 14.2, and the minimum was 0.5‰ per mille, but a maximum of 29.5‰ per mille occurred, and the important point is the durarion of each of these extremes. An idea can be secured from Mr. Hachey's report for the following April (1936). In his section, for Station 1 (the Atlantic Sugar Refinery), the salinity was less than 14‰ per mille, for approximately 7½ hours, and for the balance of the total cycle, namely 4½ hours the salinity was between 20 and 30‰ per mille. This was probably repeated each 12 hours. Whether a bath of 7½ hours of water of a salinity of less

than 14‰ per mille is lethal, no experiments have been done to determine, so far as the writer is aware. It is likely however that any Limnoria in shallow burrows would be killed, but those in deep burrows, where the wood of the burrow would likely be saturated with salt from the higher salinities of the rest of the year, enough diffusion at times of low salinity might be expected to occur to enable the animal to survive. Since all burrows examined from the east side of Saint John Harbour have been shallow ones, it is not likely that any of these animals are surviving these periods of low salinity. A quite different result appears across the harbour, on the west side, for there the period of salinity less than 14‰ per mille was only 4½ hours, and salinities of 25 to 30‰ per mille. occurred on the bottom for 7½ hours. In September, 1935, no salinity of less than 26‰ per mille was observed on the bottom at Station 1, and the average monthly salinity was 27.6‰ per mille. This last occurs at the time of minimum run-off.

So by means of these sets of data, a fairly good idea may be obtained of the conditions of temperature and salinity to which marine borers are exposed in Saint John Harbour.

Other factors of importance in determining attack by marine borers seem to be the freshness or newness (period of immersion) of the wood exposed, and also the degree of crowding (population) in the old sites. There are probably still other factors, but these seem likely to be the main ones.

DISCUSSION

Table I, showing the intensity of attack with regard to the time of year shows that blocks received in March, through to July, have always been negative. Since these blocks have been exposed for six months in all cases, we must conclude that conditions favourable for attack do not occur between September and February, whereas suitable conditions for invasion must occur sometime during the other half of the year, that is between March and August.

Information as to the time of year attack occurs cannot be determined from these data more closely than indicated above. However, test boards from another site in Saint John harbour, placed by the Saint John Harbour Commission at West Saint John, at Berth 17, indicate that June is the month when the greatest attack on new wood begins. New attack is considerably less in subsequent months. An attack in June could infest all blocks exposed in that month, which would mean blocks coming in to the laboratory until December. Since, however, in one case, a January block, and in another, a February block have been attacked, some migration also occurs afterward, at least until August. Since the data for Berth 17 have not yet been analyzed, nothing more definite can be stated regarding the time of year of attack than probably not before June, and since no blocks received in July have ever been attacked, it seems likely that whereas borer attack begins on the West side in June, attack (migration) does not reach the eastern side of the harbour until July, and definitely ceases (at the most) in February - probably sooner.

It has been observed that it is usually the lower parts of marine structures which are most severely attached by the gribble,

it was to be expected that some correlation between intensity of attack and depth of exposure would be observed. For the data available, it is apparent that other factors are more important, although some evidence of greater attack with depth seems obvious. In Table II, blocks are shown at the depths immersed, and the data of laboratory examination. When a block is removed after six months exposure, it is replaced by another which is left similarly for a further period of six months.

It will be seen that at -15.05 feet, only one block has been attacked, out of six exposures, but only two have been attacked, in the same period at any other depth. There seems however,(except for the level -17.55 ft.) to be evidence of more suitable conditions with depth for the number of burrows increases at the deeper levels.

The data for level -18.05 seems to show that when favourable depth is associated with favourable time of year, a maximal attack may develop.

The factor of temperature, from the data in Table III, would seem to show that the period most favourable to attack occurs when the water is warmest. Other workers (M.W.Johnston, page 435, Biol. Bull. LXIX(3); 1935) observed that maximum migration (attack) occurred between a temperature range of 7.7°C. to 9.4°C. (45.9°F. to 48.9°F.), occurring between January to July at Friday Harbour, Washington. If one considers the temperatures between June and August, at the bottom, in Saint John harbour, the range is; maximum 54°F. to 55°F., in 1935, 59°F. to 62°F. in 1936, and minimum 47°F. to 53°F. in 1935, and 43°F. to 53°F. in 1936. These values agree rather well as to temperatures at the period of maximum attack, but in the two localities, they occur at quite

widely different times of the year.

The question of the effect of salinity has been discussed above. It has seemed to be the most important in controlling the attacks by this borer, since it is well established that a salinity of less than 14‰ per mille is rapidly fatal. It will be seen from Table III that attack apparently occurs during that period of maximum salinities at which the temperature is also favourable. On the basis of salinity-temperature factors acting together, the period of July, August, September and October appear to be entirely suitable for attack by this organism.

A factor, apparently of considerable importance, which has never been previously referred to (except possibly by M. W. Johnston) is that of the unfavourable influence of newly immersed wood. This is definitely shown by the fact that no control blocks, which were all immersed at -16.55 feet, were ever attacked. It has also been shown by the fact that newly immersed control boards at Berth 17, on the western side of the harbour, while suffering some degree of attack, were never so severely attacked as the boards which had been immersed for longer periods. Some degree of saturation by the sea-water seems to be essential for attack of any severity by this borer.

Another factor, to which attention was first drawn by Johnston, is that the intense spring migration is apparently a spawning migration, due to over-crowding in the original area. The attack in Friday Harbour, in March-April (apparently quite similar to the one in Saint John Harbour in June-July) is

ascribed to "a definite seasonal migration, which is associated with the main breeding season".

CONCLUSION

It seems to be obvious that it is an interplay of many factors which is concerned with an attack by Limnoria lignorum. Provided a suitable breeding place is near, an active migration of adults is to be expected when the water temperature reaches 45° to 50°F., provided the salinity is also favourable (it must be greater than 14‰ per mille, and likely 25‰ per mille or more is better). It would seem, from other work, that the higher the salinity, and the more uniform it is, the greater and more severe will an attack by this borer be.

The unfavourable influence of turbidity has not been referred to, but it is obvious that much turbidity will produce a plugging of the burrows and so act to reduce any attack which might otherwise develop.

These facts indicate rather well the comparative immunity of all structures in Saint John harbour to attack from marine borers, especially those on the east side. These temperatures preclude Teredo attack which requires an optimum temperature of about 70°F. for breeding. The warmest waters reported, about 60°F., are too low for successful Teredo breeding. The point of greatest danger in Saint John harbour so far as attack by the gribble is concerned is Berth 17, due to the influx of cold salt water at that particular point. The age of this structure will serve to illustrate this point also, for it is and has been subject to the greatest danger of attack.

ADDENDUM

For the current year, 1937, certain data on hydrographic conditions have been received, and summarized by Mr. Hachey. He states that "the summer water temperatures in the Bay of Fundy were exceptionally high, with the highest monthly mean of the period 1921-37 recorded for May, June and August". Together with this, we have the report in the Monthly Weather Map of the Meteorological Service of Canada, that "In northern New Brunswick there was a deficiency of (precipitation) about 35%; of about 50% along the middle portion of the Saint John valley; and of 75 to 90% along the north shore of the Bay of Fundy".Temperatures were in excess over the whole of New Brunswick, from 3 to 4 degrees Fahrenheit along the Bay of Fundy, to only 2 degrees along the Maine-New Brunswick border and the eastern coastline. This report is that for July, the latest one on hand.

The combined effect of these conditions seems likely to make the waters of Saint John harbour several degrees warmer than normal, and with the decreased precipitation, the salinity is likely to be higher than normal. With this last effect, there seems every likelihood that attack by the gribble ought to be greater than normal.

St. Andrews, N.B.
1937.