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Oyster Larvae in the Biddeford river,

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Author

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OYSTER LARVAE IN THE BIDEFORD RIVER,
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by
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1. Introduction.

The work described below formed part of the investigations which accompanied efforts to restore to productivity the depleted oyster beds in the Bideford River. It is possible for good sets of spat to be secured by experience gained through trial cultchings applied in conjunction with examination of oysters, but the best possible results are unlikely to be obtained unless such experience is supplemented by knowledge of the numbers and distribution of oyster larvae in the area in question and the factors concerned in their rate of growth and movements. Recent investigations by Thurlow Nelson in Delaware Bay, and Prytherch in Milford Harbour (Connecticut) serve to illustrate the differences which may be found dependent on local conditions, and the accuracy with which predictions of setting may be made. The present paper deals with little more than a preliminary investigation from which as such, few, if any, conclusions may be expected. The data recorded should, however, be of value as a basis for comparing progress in subsequent seasons, and for suggesting further investigations.

Acknowledgment is made to Dr. A. W. H. Needler, on whose experience during the previous summer the stations were selected, and who organized the taking of the samples, and to those at the Biological Station who took part in collecting them.

2. Methods.

Plankton and water samples were taken almost daily in

the Bideford river at the highest and lowest points where oysters are known to occur in any concentration. These were:

1. Upper Station. Over Paugh's bed at the head of the main creek.
2. Lower Station. About $1\frac{1}{4}$ miles below Station 1, $\frac{1}{4}$ mile seaward of Bideford wharf, over the "Pulpit" bed (so named from the erection which supported a thermograph and a tide recorder. At Paugh's bed a thermograph was installed in a boat).

Samples of fifty gallons of water from the surface and fifty from the bottom at each of these stations were drawn by a rotary hand pump through a 1 inch diameter hose attached to a funnel, and delivered into a small No. 18 townet, the catches being bottled separately. This method follows the essentials of that described by Thurlow Nelson, 1921, (1). Surface and bottom temperatures were recorded.

A preliminary inspection of each catch under the microscope was made at once for information on the progress of spawning and guidance as to the placing of collectors. For this purpose any mollusc larvae in the samples were readily concentrated at the centre of a shallow dish by agitating it with a circular movement, after adding a drop of formalin.

Later, as time permitted, the larvae were again separated from the samples and spread on a ruled slide, where those of the oyster in the umbo stages were counted in a very large proportion of the samples and the length(anteroposteriorly) recorded. Such larvae never formed more than a small proportion of the young bivalves present, and were often outnumbered by larvae of a gastropod, probably *Nassa*. No attempt was made to

identify, count, and measure the small straight hinged oyster larvae. On account of their resemblance to early larvae of other bivalves, it was thought that results would be misleading without undue expenditure of time in measuring them all for length, height, and length of hinge line. Such larvae can be recognized at sight only after prolonged experience of the species in question. Measurements were made with an ocular scale of which each division represented 19 microns. The largest larvae measured .36 mm. (19 divisions); the smallest .076 (4 divisions). Those over .1 mm. (6 divisions) could be identified with confidence in the preserved condition, and they have been included in the counts as the smallest umbo stage.

In addition to the daily routine sampling, an investigation of conditions over a 24-hour period was made at each station. Hourly samples were taken at the upper station on July 16th and 17th, at the surface, mid-depth, and bottom, and similar but two-hourly samples at the lower station on July 28th and 29th, in order to ascertain what effect, if any, on distribution of larvae, could be attributed to temperature and tidal variations, light and darkness, or other factors. Alternate samples from the upper station were first examined, and the result did not call for examination of the remainder.

3. The Observations.

In order to simplify a study of the results, the fourteen sizes of umbo larvae (6 to 19 scale units) have been grouped arbitrarily as follows:

- I .11 to .20 mm. (6 to 10 scale units).
- II .21 to .29 " (11 to 15 " ").
- III .30 to .36 " (16 to 19 " ").

Several of the earlier bottom samples taken during June contained much mud and fine sand, which made the work of separating and counting the larvae most difficult. A few larvae may have been overlooked in consequence.

Daily Samples.

Table 1 shows the distribution of umbo larvae in groups for each day, and Fig. 1 shows graphically the total umbo larvae for each sample, together with the water temperature recorded by the thermograph at approximately the time of sampling.

A few umbo larvae appeared late in June, corresponding to an early partial spawning which produced the first straight hinged larvae present on June 17th in the sample from the upper bed, and a few days later on the lower bed. According to the rate of development recorded by the earlier investigators (Stafford, Julius Nelson), spawning began on about June 12th within a day or two of the temperature exceeding 20 C. The main spawning evidently took place in July, up to the middle of the month; the maximum number of larvae being taken on the lower bed on July 24th. A third spawning in the second half of July, probably about July 25th, is suggested by the figures for August 6th, when larvae of Groups I and II were present. Single larvae were seen in samples as late as August 25th and 26th. Larvae were present therefore for a period of about ten weeks from the time spawning began.

Samples from the surface at the lower station yielded most larvae. Next in order came bottom samples from the upper bed. The percentage of the total contributed by each series is as follows:

| | | | |
|-------------------|------------|-----------|-----------------|
| 1. Lower Station. | Surface. | 37.5 | (511 larvae) |
| 2. Upper | " Bottom. | 23.5 | (316 ") |
| 3. " | " Surface. | 22 | (298 ") |
| 4. Lower | " Bottom. | <u>17</u> | <u>(231</u> ") |

106 1,356

Thus, while at the upper station the numbers at the surface and bottom were practically equal, at the lower station there were more than twice as many at the surface as at the bottom. The maximum catch, 140 in 50 gallons, or barely 3 per gallon, occurred on July 12th in the lower surface sample, and consisted almost entirely of larvae not larger than .2 mm. Percentages of each group are given at the foot of Table 1. The highest proportion of older stages (over .3 mm.) which included larvae ready to set occurred in the bottom samples from the upper bed, where they formed nearly a quarter of the umbo stages taken. Such larvae contributed only seven per cent. to surface samples from the lower station, where two-thirds of the catch, both at the surface and at the bottom, consisted of smaller larvae up to .2 mm. in length.

Special 24-hour Samples.

Upper bed, July 16th and 17th.

The numbers of larvae are shown in Table 2 and Fig. 2, and are very small, the catches consisting of little more than a few of the older stages. The average corresponds to one larvae in 19 gallons. The most caught was 15 at noon in the mid-depth sample. The numbers fell off during the period, and do not show any obvious correlation with tidal, temperature, or light variations.

Lower Bed, July 28th and 29th.

Tables 3 - 6 show respectively the catches at the surface, mid-depth, bottom, and all three combined. It will be seen that larvae though less scarce than during sampling of the upper bed were by no means numerous, averaging only one in ca. three gallons. Roughly twice as many were caught at the surface as at the bottom. The total catch varied from hour to hour, and showed a progressive diminution, as at the upper station. All stages are included from .095 (5 divisions). Those of group II formed nearly half of the catch. Tidal and temperature conditions are shown in Fig. 3, together with the numbers of larvae of all stages. Here again no correlation is in evidence.

4. Discussion of the Observations.

Certain errors of sampling, due to the nature of the apparatus used, and to lack of uniformity arising from different individuals operating the pump, and other causes, have doubtless occurred. For subsequent investigations it would be desirable to test the consistency of sampling by comparing several samples taken in the same place in rapid succession.

A phenomenon of interest is the greater proportion for the whole season of larger larvae (over .3 mm.) at the upper station. The percentages there of larger larvae at the surface and bottom are two and a half times and twice as great respectively as at the lower station. Although the total number of larvae taken at the upper station was only 83% of those taken at the lower, the density of setting was distinctly greater at the upper station where the best collectors were found. The cause of this is a matter for further investigation. There was no evidence of any movement such as that described by Thurlow Nelson (2) in Delaware Bay where larvae are lifted and carried

shorewards on the upper surface of a well defined wedge of denser water entering the bay at the flood tide, and mixing by the end of the flood, leaving the larvae on the bottom during the ebb. Any such movement would presumably result in a greater concentration of larvae at the upper station. Nor do the samples taken over 24 hour periods indicate any response to tidal movement such as Prytherch (3) found in Milford Harbour. It is doubtful if, with a maximum range of little more than four feet, tidal currents in the Bideford river approached in velocity those in Milford Harbour with a maximum range of nine feet. Further, a marked ebb and flow occurs only once in each 24 hour period in the Bideford river. Where currents are concerned, speculation is unprofitable, and a series of observations preferably with a current meter would be valuable.

During this exceptionally dry summer any seaward movement due to entry of fresh water at the head of the creek can only have been negligible; in fact the salinity remained almost constant at about 28 parts per mille, and was even slightly higher in the bay than certain samples of Gulf water taken outside.

Presumable this was due to evaporation in the extensive shallow area of the bay. Such differences as occurred between surface and bottom salinities in the creek were extremely small, and altogether negligible.

The largest larvae observed were 0.36 mm. in length, (disregarding two or three specimens of "unset spat," which had begun to grow dissoconsh shell, and were found in the plankton samples). This is interesting in view of the observation recorded by Julius Nelson (4) who worked in Malpeque Bay in 1915: "the Canadian oyster spat at the time of fixation to culch is a fourth

larger than the spat in the corresponding stage of development in New Jersey waters." It was the general opinion of local residents that the summer of 1930 was one of exceptional warmth. Possible therefore development proceeded more rapidly and setting took place earlier than in 1915, but the temperatures then noted by Julius Nelson in the Bideford creek do not indicate a much cooler season, though the spring was late that year. The foregoing observations suggest that the size of setting is not inherent with the Canadian oyster, but is subject to variation. Further observations during subsequent seasons should be of great interest.

As regards temperatures, the thermograph records at the upper station showed well marked diurnal variations. Here the instrument bulb was only about a foot from the surface. When late in the season, the instrument was transferred from the boat to a platform similar to that at the lower station and the bulb placed one foot from the bottom, a smooth line was obtained, very similar to that traced at the lower station, where the steadiness of the pen at about 21°C. for many weeks was remarkable. The highest temperatures recorded in the mornings at the time of plankton sampling, as shown in Fig. 1, occurred at the new moon both in June and July. At the full moon in July there was a marked drop, and at the same time larvae practically disappeared from the samples. The minimum temperature given by Stafford (5) and Julius Nelson (4) at which the Eastern oyster begins to spawn, viz. 20°C. (68°F.), was reached on June 11th at the upper station, and six days later at the lower station, on which dates larvae were first found at the upper station.

The number of larvae taken in the samples is interesting as a measure of the concentration of spawning oysters, provided the minimum spawning temperature is reached. At the maximum on July 24th there were 140 in the sample from the surface at the lower station; barely three per gallon. With both surface or bottom samples taken together, the figure becomes 2 per gallon. Turning to Julius Nelson's record, we find figures of the same order for Bideford river, viz. one to four larvae per 20 quarts. His highest number in the whole Malpeque area was two per quart. These figures contrast very markedly with those found in such well-stocked areas as Great South Bay, Long Island, and Delaware Bay, where over 1,000 per gallon may be present, followed by an extremely dense set of spat. The prospect of a very satisfactory yield from the Bideford river should, however, be indicated by a much lower figure.

5. References.

- (1) Nelson, Thurlow C. Aids to Successful Oyster Culture. Bulletin 351, New Jersey Agric. Exp. Sta. New Brunswick, N. J. 1921.
- (2) Nelson, Thurlow C. Ann. Repts., Dept. of Biology, New Jersey Agric. Exp. Sta., New Brunswick, N. J.
- (3) Prytherch, Herbert F. Investigation of the physical conditions controlling spawning of oysters and the occurrence distribution, and setting of oyster larvae in Milford Harbor, Connecticut. Bull. of Bureau of Fisheries, XLIV, 1928. Doc. No. 1054.
- (4) Nelson, Julius. An investigation of oyster propagation in Richmond Bay, P. E. I., during 1915. Contr. Canad. Biol. 1915-16.
- (5) Stafford, Joseph. The Canadian Oyster. 1912. Cons. Comm. Ottawa.

Table No. 1. Number of oyster larvae in umbo stages found in 50 gallon samples, grouped thus:

I. .11 to .20 mm. II. .21 to .29 mm. III. .30 to .36 mm.

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| Date | Upper Station | | | | | | | | Lower Station | | | | | | | |
|------|---------------|----|-----|-------|--------|----|-----|-------|---------------|----|-----|-------|--------|----|-----|-------|
| | Surface | | | | Bottom | | | | Surface | | | | Bottom | | | |
| | I | II | III | Total | I | II | III | Total | I | II | III | Total | I | II | III | Total |
| June | | | | | | | | | | | | | | | | |
| 21 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 5 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 11 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 1 | 9 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 1 | 3 | 8 | 12 | 0 | 0 | 1 | 1 | 2 | 3 | 6 | 11 | 0 | 1 | 1 | 2 |
| July | | | | | | | | | | | | | | | | |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 2 | 0 | 0 | 2 | 3 | 2 | 0 | 5 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 3 | 3 | 0 | 0 | 6 | 6 | 0 | 0 | 1 | 1 | 1 | 2 | 4 | 7 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 4 | 13 | 0 | 0 | 0 | 0 |
| 22 | 8 | 0 | 1 | 9 | 5 | 3 | 24 | 32 | 44 | 1 | 2 | 47 | 0 | 0 | 0 | 0 |
| 24 | 15 | 0 | 0 | 15 | 48 | 7 | 9 | 64 | 132 | 7 | 1 | 140 | 69 | 3 | 3 | 75 |
| 26 | 11 | 14 | 2 | 27 | 2 | 4 | 1 | 7 | 5 | 7 | 0 | 12 | 17 | 33 | 2 | 52 |
| 28 | 14 | 47 | 26 | 87 | 7 | 15 | 12 | 34 | 34 | 32 | 5 | 71 | 5 | 4 | 0 | 9 |
| 30 | 12 | 7 | 6 | 25 | 29 | 6 | 5 | 40 | 18 | 3 | 10 | 31 | 15 | 6 | 8 | 29 |
| Aug. | | | | | | | | | | | | | | | | |
| 1 | 7 | 4 | 1 | 12 | 18 | 6 | 0 | 24 | 22 | 10 | 1 | 33 | 10 | 0 | 0 | 10 |
| 4 | 0 | 6 | 0 | 6 | 2 | 0 | 0 | 2 | 19 | 24 | 1 | 44 | 3 | 1 | 1 | 5 |
| 5 | 1 | 2 | 0 | 3 | 2 | 13 | 2 | 17 | 1 | 4 | 1 | 6 | 1 | 6 | 1 | 8 |
| 6 | 23 | 20 | 1 | 44 | 19 | 21 | 1 | 41 | 45 | 30 | 2 | 77 | 5 | 5 | 0 | 10 |
| 7 | 0 | 1 | 0 | 1 | 6 | 2 | 1 | 9 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 1 |
| 8 | 2 | 12 | 0 | 3 | 6 | 7 | 2 | 15 | 6 | 1 | 0 | 7 | 9 | 5 | 2 | 16 |
| 9 | 0 | 3 | 0 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 3 | 1 | 4 | 0 | 5 | 2 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 1 | 1 | 2 |
| 13 | 0 | 3 | 1 | 4 | 1 | 0 | 5 | 6 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 14 | 1 | 2 | 2 | 5 | 0 | 0 | 1 | 1 | 1 | 4 | 1 | 6 | 0 | 1 | 1 | 2 |
| 15 | 1 | 3 | 1 | 5 | 1 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | | |
|------------|-----|------|------|-----|-----|----|----|-----|-----|-----|----|-----|------|----|------|-----|
| Total | 116 | 129 | 53 | 298 | 149 | 94 | 73 | 316 | 337 | 138 | 38 | 511 | 135 | 70 | 26 | 231 |
| Percentage | 39 | 43.5 | 17.5 | 100 | 47 | 30 | 23 | 100 | 66 | 27 | 7 | 100 | 58.5 | 30 | 11.5 | 100 |

TABLE NO. 2.

Upper Station. (Paugh's Bed).

| Sizes of | July 16th | | | | | | July 17th | | | | | | Total |
|--------------------------|------------|-----------|-----------|-----------|-----------|------------|----------------|-----------|-----------|-----------|-----------|------------|-------|
| | 12 noon | 2 p.m. | 4 p.m. | 6 p.m. | 8 p.m. | 10 p.m. | 12 midnight | 2 a.m. | 4 a.m. | 6 a.m. | 8 a.m. | 10 a.m. | |
| <u>Surface Samples</u> | | | | | | | | | | | | | |
| mm. | | | | | | | | | | | | | |
| .17 | | | | | | | | | | | 1 | | 1 |
| .30 | | 1 | | 1 | | | | | | | | | 2 |
| .32 | 2 | 1 | 1 | 2 | | | 3 | | 1 | 1 | 1 | | 12 |
| .34 | 1 | 1 | 2 | | | | 3 | 1 | | | | 1 | 9 |
| Total | 3 | 3 | 3 | 3 | 0 | 0 | 6 | 1 | 1 | 1 | 2 | 1 | 24 |
| <u>Mid-depth Samples</u> | | | | | | | | | | | | | |
| mm. | | | | | | | | | | | | | |
| .30 | | 1 | | | | | | 1 | 1 | | | | 3 |
| .32 | 8 | 3 | 1 | | | | | 1 | 2 | | | | 15 |
| .34 | 7 | 1 | | 1 | | | 4 | 1 | | | | | 14 |
| .36 | | | | | | | | | | 2 | | | 2 |
| Total | 15 | 5 | 1 | 1 | 0 | 0 | 4 | 3 | 3 | 2 | 0 | 0 | 34 |
| <u>Bottom Samples</u> | | | | | | | | | | | | | |
| mm. | | | | | | | | | | | | | |
| .17 | | | | | | | | | | | 3 | | 3 |
| .25 | | | | 1 | | 1 | | | | | | | 2 |
| .28 | | | | | 1 | | | | | 1 | | | 2 |
| .30 | | | | | | | | 1 | | | | | 1 |
| .32 | 4 | 7 | | 1 | | | 3 | | 1 | | | 1 | 17 |
| .34 | 2 | 4 | 1 | | | 1 | 2 | | 1 | | | 2 | 13 |
| Total | 6 | 11 | 1 | 2 | 1 | 2 | 5 | 1 | 2 | 1 | 3 | 3 | 38 |
| <u>All Depths</u> | | | | | | | | | | | | | |
| Total | 24 | 19 | 5 | 6 | 1 | 2 | 15 | 5 | 6 | 4 | 5 | 4 | 96 |

TABLE NO. 3.

Lower Station. ("Pulpit" Bed).

Surface Samples

| Sizes of Larvae mm. | July 28th | | | | | | | | July 29th | | | | | Total |
|------------------------------|-----------|------|------|------|------|------|------|------|-----------|------|------|------|------|-------|
| | 9 | 11 | 1 | 3 | 5 | 7 | 9 | 11 | 1 | 3 | 5 | 7 | 9 | |
| | a.m. | a.m. | p.m. | p.m. | p.m. | p.m. | p.m. | p.m. | a.m. | a.m. | a.m. | a.m. | a.m. | |
| I (.09) | 7 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| (.11) | 2 | 3 | 4 | 1 | 2 | 0 | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 17 |
| (.13) | 5 | 10 | 2 | 4 | 7 | 2 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 34 |
| (.15) | 3 | 2 | 0 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 14 |
| (.17) | 1 | 5 | 1 | 4 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 1 | 0 | 17 |
| (.19) | 0 | 11 | 1 | 3 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 20 |
| II (.21) | 1 | 2 | 1 | 5 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 15 |
| (.23) | 6 | 8 | 3 | 4 | 3 | 0 | 6 | 0 | 0 | 0 | 0 | 2 | 0 | 32 |
| (.25) | 6 | 5 | 4 | 6 | 0 | 4 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 28 |
| (.27) | 3 | 10 | 4 | 7 | 1 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 31 |
| (.285) | 6 | 7 | 5 | 4 | 2 | 1 | 0 | 1 | 0 | 1 | 2 | 6 | 2 | 37 |
| III (.30) | 1 | 3 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 1 | 14 |
| (.32) | 1 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 3 | 2 | 0 | 11 |
| (.34) | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| (.36) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 42 | 71 | 28 | 44 | 23 | 14 | 14 | 9 | 5 | 2 | 11 | 20 | 3 | 286 |
| I .09 to .20 | 18 | 34 | 11 | 15 | 13 | 4 | 5 | 6 | 1 | 1 | 4 | 4 | 0 | 116 |
| II .21 to .29 | 22 | 32 | 17 | 26 | 9 | 7 | 9 | 3 | 1 | 1 | 3 | 11 | 2 | 143 |
| III .30 to .36 | 2 | 5 | 0 | 3 | 1 | 3 | 0 | 0 | 3 | 0 | 4 | 5 | 1 | 27 |

TABLE NO. 4.
Lower Station. ("Pulpit" Bed).

Mid-depth Samples

| Sizes of Larvae | July 28th | | | | | | | July 29th | | | | | Total | |
|-----------------------|-----------|------|------|------|------|------|------|-----------|------|------|------|------|-------|------|
| | 9 | 11 | 1 | 3 | 5 | 7 | 9 | 11 | 1 | 3 | 5 | 7 | | 9 |
| | a.m. | a.m. | p.m. | p.m. | p.m. | p.m. | p.m. | p.m. | a.m. | a.m. | a.m. | a.m. | | a.m. |
| mm. | | | | | | | | | | | | | | |
| I (.09 | 14 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 |
| (.11 | 7 | 4 | 1 | 3 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 20 |
| (.13 | 2 | 0 | 4 | 6 | 5 | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 25 |
| (.15 | 0 | 1 | 0 | 1 | 1 | 4 | 0 | 2 | 0 | 0 | 2 | 2 | 0 | 13 |
| (.17 | 3 | 1 | 4 | 1 | 1 | 4 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 18 |
| (.19 | 2 | 3 | 4 | 3 | 1 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 17 |
| II (.21 | 1 | 0 | 5 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 12 |
| (.23 | 5 | 3 | 2 | 1 | 0 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 17 |
| (.25 | 9 | 3 | 8 | 3 | 2 | 4 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 31 |
| (.27 | 3 | 0 | 2 | 1 | 2 | 3 | 2 | 3 | 0 | 0 | 0 | 2 | 0 | 18 |
| (.285 | 7 | 3 | 2 | 3 | 3 | 6 | 2 | 6 | 0 | 1 | 1 | 2 | 0 | 36 |
| III (.30 | 1 | 0 | 2 | 2 | 6 | 5 | 1 | 1 | 0 | 0 | 3 | 2 | 0 | 23 |
| (.32 | 2 | 0 | 0 | 0 | 1 | 5 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 10 |
| (.34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 3 |
| (.36 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 57 | 21 | 35 | 26 | 25 | 46 | 7 | 20 | 1 | 2 | 11 | 12 | 0 | 263 |
| I .09 to .20 | 28 | 12 | 14 | 15 | 9 | 17 | 1 | 6 | 1 | 1 | 3 | 5 | 0 | 112 |
| II .21 to .29 | 25 | 9 | 19 | 9 | 9 | 19 | 5 | 12 | 0 | 1 | 2 | 4 | 0 | 114 |
| III .30 to .36 | 4 | 0 | 2 | 2 | 7 | 10 | 1 | 2 | 0 | 0 | 6 | 3 | 0 | 37 |

TABLE NO.5.

Lower Station. ("Pulpit" Bed).

Bottom Samples

| Sizes of Larvae | July 28th | | | | | | | July 29th | | | | | Total | |
|-----------------------|-----------|------------|-----------|-----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|-----------|-------|-----------|
| | 9 a.m. | 11 a.m. | 1 p.m. | 3 p.m. | 5 p.m. | 7 p.m. | 9 p.m. | 11 p.m. | 1 a.m. | 3 a.m. | 5 a.m. | 7 a.m. | | 9 a.m. |
| mm. | | | | | | | | | | | | | | |
| (.09 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| (.11 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 4 |
| (.13 | 0 | 2 | 1 | 3 | 4 | 0 | 4 | 1 | 0 | 0 | 0 | 1 | 0 | 16 |
| (.15 | 1 | 1 | 0 | 2 | 3 | 1 | 3 | 4 | 0 | 1 | 1 | 0 | 0 | 17 |
| (.17 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| (.19 | 2 | 0 | 1 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 10 |
| (.21 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 11 |
| (.23 | 0 | 1 | 1 | 3 | 4 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 13 |
| (.25 | 0 | 0 | 4 | 3 | 0 | 1 | 3 | 0 | 1 | 1 | 0 | 0 | 1 | 14 |
| (.27 | 0 | 0 | 3 | 2 | 1 | 1 | 0 | 2 | 0 | 1 | 3 | 1 | 0 | 14 |
| (.285 | 0 | 3 | 2 | 7 | 1 | 3 | 0 | 1 | 0 | 1 | 4 | 0 | 1 | 23 |
| (.30 | 0 | 0 | 2 | 2 | 2 | 0 | 5 | 0 | 0 | 0 | 3 | 0 | 1 | 15 |
| (.32 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 6 |
| (.34 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 4 |
| (.36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 4 | 9 | 17 | 33 | 19 | 8 | 19 | 13 | 1 | 8 | 15 | 4 | 3 | 153 |
| I .09 to .20 | 4 | 5 | 2 | 8 | 11 | 3 | 8 | 7 | 0 | 1 | 1 | 3 | 0 | 53 |
| II .21 to .29 | 0 | 4 | 13 | 18 | 6 | 5 | 5 | 6 | 1 | 5 | 9 | 1 | 2 | 75 |
| III .30 to .36 | 0 | 0 | 2 | 7 | 2 | 0 | 6 | 0 | 0 | 2 | 5 | 0 | 1 | 25 |

TABLE NO. 6.

Lower Station. ("Pulpit" Bed).

Totals of Surface, Middle and Bottom Samples.

| Sizes of Larvae | July 28th | | | | | | | | July 29th | | | | | Total |
|-----------------------|-----------|------------|-----------|-----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|-----------|-----------|-------|
| | 9 a.m. | 11 a.m. | 1 p.m. | 3 p.m. | 5 p.m. | 7 p.m. | 9 p.m. | 11 p.m. | 1 a.m. | 3 a.m. | 5 a.m. | 7 a.m. | 9 a.m. | |
| mm. | | | | | | | | | | | | | | |
| (.09 | 21 | 7 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 |
| (.11 | 9 | 7 | 5 | 4 | 3 | 1 | 3 | 3 | 1 | 1 | 0 | 4 | 0 | 41 |
| (.13 | 7 | 12 | 7 | 13 | 16 | 7 | 4 | 5 | 1 | 0 | 1 | 2 | 0 | 75 |
| (.15 | 4 | 4 | 0 | 5 | 6 | 7 | 5 | 6 | 0 | 1 | 3 | 3 | 0 | 44 |
| (.17 | 5 | 7 | 5 | 6 | 2 | 4 | 1 | 4 | 0 | 0 | 3 | 2 | 0 | 39 |
| (.19 | 4 | 14 | 6 | 8 | 5 | 5 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 47 |
| (.21 | 2 | 2 | 9 | 9 | 5 | 3 | 0 | 2 | 1 | 1 | 3 | 1 | 0 | 38 |
| (.23 | 11 | 12 | 6 | 8 | 7 | 4 | 8 | 3 | 0 | 1 | 0 | 2 | 0 | 62 |
| (.25 | 15 | 8 | 16 | 12 | 2 | 9 | 5 | 2 | 1 | 1 | 0 | 1 | 1 | 73 |
| (.27 | 6 | 10 | 9 | 10 | 4 | 5 | 4 | 6 | 0 | 1 | 4 | 4 | 0 | 63 |
| (.285 | 13 | 13 | 9 | 14 | 6 | 10 | 2 | 8 | 0 | 3 | 7 | 8 | 3 | 96 |
| (.30 | 2 | 3 | 4 | 6 | 9 | 6 | 6 | 1 | 1 | 0 | 7 | 5 | 2 | 52 |
| (.32 | 3 | 2 | 0 | 3 | 1 | 7 | 1 | 1 | 1 | 1 | 5 | 2 | 0 | 27 |
| (.34 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 1 | 0 | 9 |
| (.36 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 103 | 101 | 80 | 103 | 67 | 68 | 40 | 42 | 7 | 12 | 37 | 36 | 6 | 702 |
| I .09 to .20 | 50 | 51 | 27 | 38 | 33 | 24 | 14 | 19 | 2 | 3 | 8 | 12 | 0 | 281 |
| II .21 to .29 | 47 | 45 | 49 | 53 | 24 | 31 | 19 | 21 | 2 | 7 | 14 | 16 | 4 | 332 |
| III .30 to .36 | 6 | 5 | 4 | 12 | 10 | 13 | 7 | 2 | 3 | 2 | 15 | 8 | 2 | 89 |