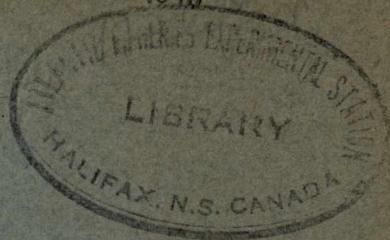


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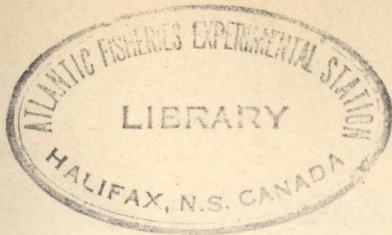
MANUSCRIPT REPORTS OF THE BIOLOGICAL STATIONS

No. 265

REPORT ON PREDICTIONS OF SETS IN MALPEQUE BAY AREA  
AND  
INVESTIGATION OF THE SOFT-SHELLED CLAM; MYA ARENARIA.

by

C. M. Sullivan.



F I S H E R I E S   R E S E A R C H   B O A R D  
O F   C A N A D A

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1942.

## 1. Prediction of Sets in Malpeque Bay Area.

### A. Introduction

The spawning history of oysters in the Malpeque bay area during the summer of 1942 was unique due to unusual water temperature conditions.

Through the month of May up to the middle of June, the average water temperature, calculated from surface and bottom readings taken at the landing stage, rose slowly but steadily to 17.9°C. on June 10th. On June 11th the average temperature was 19.2°, and on the 12th, 13th, and 14th, ranged from 20.7°C. to 22.4°C. Following this peak the temperature dropped to averages of 17 - 18°C., not rising to 20°C. again until June 28th. From June 28th onward, to September 3rd the average water temperature remained consistently above 21°C.

The high temperatures on June 12th, 13th, and 14th, caused some spawning but apparently most oysters were not then ripe for a full-scale spawning did not occur. It was not until the second rise of temperature to averages of over 20°C. that large broods of oyster larvae began to appear in the water.

### B. Prediction of Sets.

Method.-The routine method for spat-fall predictions was employed.

It might be noted here that oyster larvae of the earliest brood showed, to the untrained eye, variations in colour, not noticeable later when the eye became accustomed to selecting larvae by recognition of shape rather than colour. To the uninitiated colour is the most striking feature of the oyster larva, but colours ranging from dull or dark grayish brown to the characteristic rose to red-brown were observed in the larvae of this first brood.

#### Bideford River Predictions

All plankton tows were taken with a #18 net for 20 minutes. No measurements of oyster larvae were made after the collectors went out on July 13th and 14th.

From the data given in Table 1, size frequency distribution polygons were constructed and by correlation with temperature date the following spat settlement dates were predicted:

Brood 1.- spawned on June 13th and 14th. Should begin to settle on July 5th. Peak settlement on July 7th.

It was predicted that the set would be very light and commercial collectors were not put out for this group.

Two experimental collectors were hung on the landing stage on July 7th but daily microscopic examination of squares during the



following week revealed no oyster spat.

Brood 2.-spawned on June 28th. Should begin to settle on July 15th. Peak settlement on July 18th.

Examination of squares of the two collectors on the landing stage showed, on July 16th, a few oyster spat and on July 19th, a very heavy set.

Brood 3.- spawned July 4th. Peak settlement on July 23rd.

An experimental collector was put out on July 26th. Examination on July 26th gave a count of 2,000 spat per collector.

Examination on the same date of the squares from one of the collectors put in the water on July 7th, gave a count of 95,000 spat per collector.

Microscopic examination of station collectors in Williams' cove gave a count of 44,000 spat per collector but it was noted that the upper sides of the squares on these collectors were heavily silted and caught few oysters, while the heavy set occurred on the under sides of the squares. On the silted side of the same square as used in the above count the estimated set was 2,800 spat per collector.

Therefore, a more accurate calculation of spat on the collectors on these floats would be 25,000 spat per collector.

Squares from station collectors in Claude Williams' creek gave counts as follows:

From the float just outside the creek, 21,000 spat per collector.

From the float just inside the creek, 3,000 spat per collector.

This last float was blown up on the shore where it stayed for several days during the settlement period.

#### Paugh's Creek Predictions

Measurements of larvae in tows taken on July 6th, 7th, and 11th, gave the same picture of size frequency distribution as seen in Bidford river except that there were no larvae of the June 13th and 14th group. Prediction dates were:

Brood 1. - Peak settlement on July 16th.

Brood 2. - Peak settlement on July 19th.

• Brood 3. - Peak settlement on July 22nd.

On July 24th squares from each of the three groups of collectors put out in Paugh's creek were examined.

Otto Murphy, - collectors put out on July 7th. 10,500 spat per collector.

Edgar McKinnon, - collectors put out July 13th, 18,000 spat per collector.

Station floats, - put out July 14th and 15th. 24,500 spat per collector.

### Trout River Predictions

Table II shows the size frequency distribution of larvae in Trout river. No measurements of larvae were made after July 10th because the data obtained by that date were sufficient.

Settlement dates in Trout river were predicted as follows:

Brood 1.- spawned on June 13th and 14th. Should begin to settle on July 8th. Peak settlement on July 9th and 10th.

Brood 2.- spawned on June 27th. Should begin to settle on July 16th. Peak settlement on July 17th.

Brood 3.- spawned on June 30th. Should begin to settle on July 19th. Peak settlement on July 21st.

Brood 4.- spawned on July 4th. Peak settlement on July 25th.

In Trout river there was an unfortunate set-up. One hundred and one floats, as well as a number of rows of stakes, were crowded into a small area of the river. The accompanying map gives some idea of the outlay. Most of the collectors were put out from a week to ten days too early. The majority of them were hung close up against the floats, with the long axes of the bundles horizontal so that the lowest squares were not in more than one foot of water.

On July 24th squares from collectors of each group were brought to the laboratory. Microscopic counts of spat gave the following results:

Foster Sharp - Collectors put out July 6th and 7th. They were very crowded; The count varied from 350 to 500 spat per collector. Some squares had no set.

David Smith - On stakes. Put out July 7th and 8th. The tops of many of the collectors were out of water at low tide. Squares from about the middle of a bundle gave 1300 spat per collector.

S. S. Beaton - Put out on July 8th. 800 to 1500 spat per collector.

E. Hardy - On stakes. Put out July 8th and 9th. 1300 per collector.

TABLE 2 TROUT RIVER

Date	Note on No. of larvae of all kinds in tow	Frequency of larvae of given heights, measured in micra.																																		
		63	70	77	84	91	98	105	112	119	126	133	140	147	154	161	168	175	182	189	196	203	210	217	224	231	238	245	252	259	266	273	280			
June 26	Oysters not plentiful, only 76 in whole tow					1	1	3	7	4	21	5	8	8	9	5	0	0	1	0																
June 29	Oysters Fair	17	36	2	0	0	0	0	0	1	2	6	5	7	8	2	4	1	1	2	2	1	0	0												
July 2	Counted 100 oysters in 1/2 tow	10	5	18	40	9	1	0	0	0	0	0	0	0	1	2	1	4	2	1	4	0	1	1												
July 4	Very poor tow. No larvae																																			
July 6	Larvae, especially oysters, very plentiful	50	16	1	14	21	15	4	11	13	16	16	14	2	2	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	2				
July 8	Good	4	22	14	7	11	9	0	2	1	5	0	5	2	5	1	0	2	6	0	2	0	0	2												
July 10	Good	4	18	7	19	8	9	12	1	0	2	2	3	3	1	0	0	2	1	1	0	1	1	4	0	0	0	0	1							

- Brenton Clark - Put out July 10th and 11th. Counts on different squares varied from 1,000 to 3,000 spat per collector.
- Travers-Johnson. - Put out July 10th and 11th. Counts ranged from 900 to 1,500 spat per collector.
- MacLean. - Put out July 10th and 11th. 2,000 spat per collector.
- Ray Tanton. - Put out July 13th and 14th. 6,700 spat per collector.

On August 27th the collectors in Trout river were again examined. By then the spat were visible to the naked eye. A few examples will serve to indicate the trend of the observations.

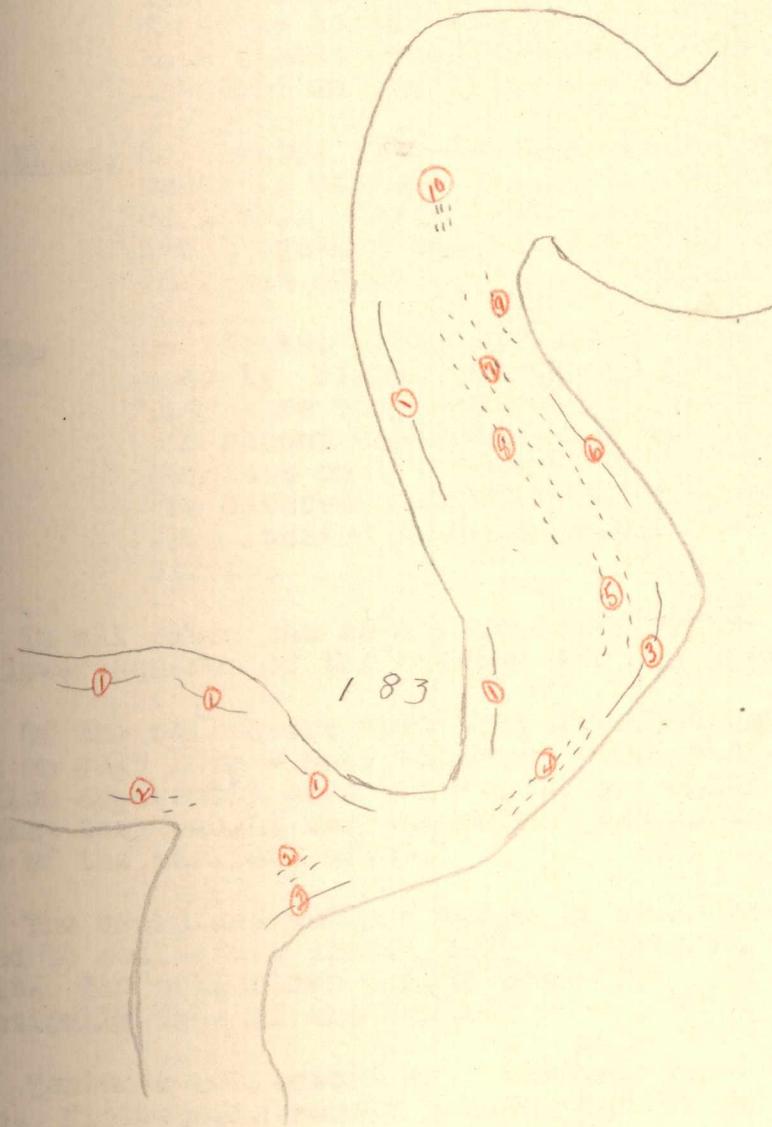
Of the collectors put out in time to catch the earliest set, -

- Sharp. Collectors on floats. Put in water July 6th and 7th. Very poor set. Floats well in from the channel on the right bank of the river. Bundles very crowded and hung close up to the floats. Extremely dirty. None of the earliest brood of oysters settled on these collectors. There were a few of the later broods.
- Smith. Collectors on stakes strung along the edge of the channel on the left side of the river, that is, on the opposite side of the channel from the rest of the floats. There was a good set, particularly on the lower parts of the bundles. The collectors were reasonably clean and the catch consisted of a number of large oysters of the early set as well as many of the later sets. There were no ascidians. Apparently there was good water circulation in this position which kept the collectors clean.
- Beaton. Collectors on floats. Put out on July 8th. Poor set consisting of a few spat of the earliest brood and a slightly heavier catch of later broods. There were a few ascidians on the collectors.

The collectors which were put out during or just after settlement of the early brood showed the following:

- MacLean. On stakes. Put out on July 10th and 11th. The catch averaged one to two large oysters per side with the greater percentage of spat belonging to the second and succeeding broods. The set was light.

Map Showing Approximate Arrangement of Collectors  
in  
Trout River



33 31  
——— Stakes  
- - - Floats

- (1) Smith
- (2) MacLean
- (3) Sharp
- (4) Travers-Johnson
- (5) Beaton
- (6) Hardy
- (7) Clark
- (8) Tanton
- (9) Ellis
- (10) Williams & Grigg

Clark. On floats. Put out July 10th and 11th. The catch was poor. The upper sides of the squares were covered with ascidians. Collectors were crowded badly and hung close up to the floats in shallow water so that they were almost on the bottom at low tide. The best set occurred on the lower parts of the bundles.

Reg. Ellis. On floats. The date on which they were put in the water is unknown but it was probably around the 10th or 11th. The set was poor, consisting of a few large oysters and a few small. Ascidians had settled in great numbers.

Tanton. On floats. Put out 13th and 14th. The collectors were poorly dipped and were hung close up to the floats. They were very crowded. There was a good set of spat of the second and succeeding broods. Settlement was heaviest on the lower parts of the bundles. The spat was covered completely with ascidians. These floats were located next the channel of the right side of the stream.

In all cases the sets were much heavier on the upper sides of the lower squares of the bundles with no spat on the upper squares.

Of the collectors that went out in time for the earliest set - peak on July 10th - only those of Smith had a good catch. His bundles apparently were kept clean by better water circulation so that they caught the second and succeeding sets as well as some spat of the earliest brood.

The ascidians which settled in such large numbers were confined to collectors placed next the channel and on the right side of it. The collectors inside the first line of floats were practically free of the squirts.

Tanton's collectors were the only ones put out at the proper time. Microscopic counts showed that he had the best set, but, due to his position next the channel the spat were covered with a solid mass of ascidians.

#### Bentinck Cove Predictions

Settlement dates in Bentinck cove were predicted as follows:

Brood 1.- spawned on June 13th and 14th. Should start to settle on July 8th. Peak settlement on July 9th.

Brood 2.- should start to settle on July 15th. Peak settlement on July 18th.

Brood 3.- should begin to settle on July 22nd. Peak settlement on July 25th.



In the series of tows taken at Bentinck cove, larvae of Brood 1 were more numerous than they were in tows taken in other places. It was thought that this first brood was worth catching and accordingly it was advised that collectors going into Bentinck cove should be put in the water on July 6th and 7th.

Results of microscopic examinations of squares from Bentinck cove collectors:

1. From a float put out on July 10th. 4,500 spat per collector. Many of these were of the early set.
2. From a float put out on July 17th. 3,400 spat per collector. All of these were of the second and succeeding sets.

#### Frederick Cove Predictions

For Frederick cove it was predicted that there would be no good set of oysters. Examination of collectors in the cove justified this prediction.

Investigation of the Soft-shell Clam

Mya arenaria

A. Aims

Work on the soft-shell clam, Mya arenaria, during the summer of 1942, was done with two main objectives.

- I. To discover as much as possible of the larval life history. Investigations and results along this line fall into four groups:
  - (a). Attempts to induce spawning and to produce larvae by artificial fertilization.
  - (b). Recognition of larvae in plankton tows.
  - (c) Determination of length of free-swimming period.
  - (d). Determination of factors influencing spawning.
- II. To devise methods for the collection of clam spat.

1. Larval life History

- (a) Attempts to induce spawning and to produce larvae by artificial fertilization.

Numerous attempts were made between June 6th and August 1st to induce spawning in clam. On June 5th, clams and sand were brought in from the shore above the Station and from the clam bed at Shipyard point. Each group of animals was placed in a separate aquarium tank in the laboratory. The tanks were daily emptied and filled with new salt water.

Time after time, on day after day active sperm from freshly dug clams was liberated into the water of the tanks or pipetted directly into the incurrent siphons of the clams. But spawning could not be induced.

Liberation of fresh mature clam ova into the tanks also failed to produce any result.

Two female oysters were induced to spawn in one of the tanks but this produced no effect in the clams.

Several attempts were also made to artificially fertilize clam ova and rear larvae to the straight hinge stage in the laboratory. The larvae died at the trocophore stage.

(b) Recognition of clam larvae in plankton tows.

At the beginning of the summer it was believed that clam larvae could be easily recognized and identified in plankton tows and that there was little danger of confusion with other larvae. Accordingly stage tows were examined, larvae measured, and size frequency distribution polygons constructed on the results. These polygons, however, failed to show definite broods and no growth curves could be drawn.

It was not until after the oyster prediction work was finished that a really close and careful study of all larvae in the tows was made. It was then discovered that what had formerly been taken for the straight hinge stage of clam was the corresponding stage of Teredo, and that this stage of Mya could not be positively identified.

In more advanced stages there were distinguished two types of larvae which close scrutiny showed to be different, but which both satisfied the measurements given by Stafford (1906) for Clam. Both larvae are transparent but one has a darker visceral mass with brown pigment spots around the edge of the mantle. This pigmentation begins to appear when the larvae is about 98u high at which time it is noticeable chiefly in the mantle just under the shoulders. As size increases the pigment spreads around the edge of the mantle and finally becomes scattered through it. These brown spots are best seen by passing as much light as possible through the larva.

The other larva, which shall be called "Larva B" from now on, is pictured at various stages of development in Series 2, further on in this report.

It was at last decided that the larva with the brown pigment spots was that of Mya. In shape and appearance it more closely corresponds to Stafford's description of the clam larva. The drawings of the group marked "Clam Series", show larvae of various sizes.

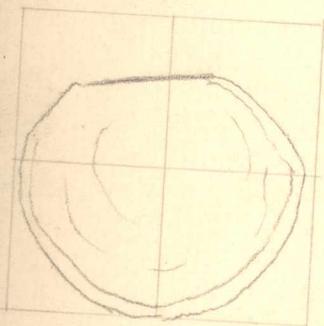
The points of difference between Larva B and the larva selected as that of Mya are:

1. Larva B by reflected light is smooth and has a silvery sheen. Clam larvae by reflected light are silvery but the brown spots show up through the shell.
2. Larva B by transmitted light has a very light, greenish brown visceral mass with no brown pigmentation such as is found in the clam larva.
3. The slope of the shoulders of Larva B is perhaps a little less steep than in Mya.
4. The point of the posterior end is higher and sharper in Larva B than in Mya.

Clam Series

July 21st, 1942. 7:00 P.M. Surface Tow, St. Andrews, N.B.

I.



Measurements

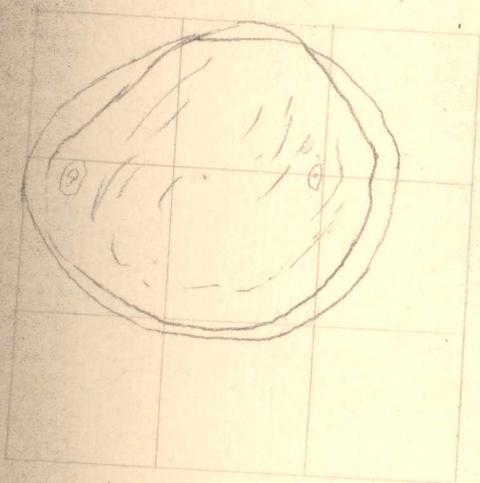
H. = 15 oc. divs. = 105u

L = 17 " " = 179u

Hinge = 8 oc. divs. = 56 u.

What may be a straight hinge stage of clam (Mya). With lots of light, it is light brown and very transparent. When light is cut down, visceral mass looks greenish

II



July 24th, 1942. St. Andrews.

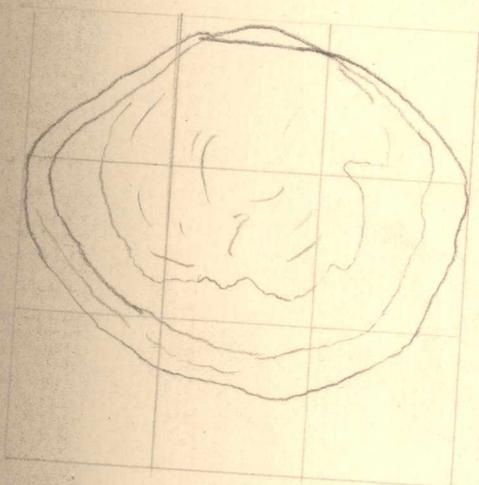
Clam. Brown spots on mantle. Not certain of adductors.

Measurements

H = 23 oc. divs. = 161u

L = 26 " " = 182u.

III



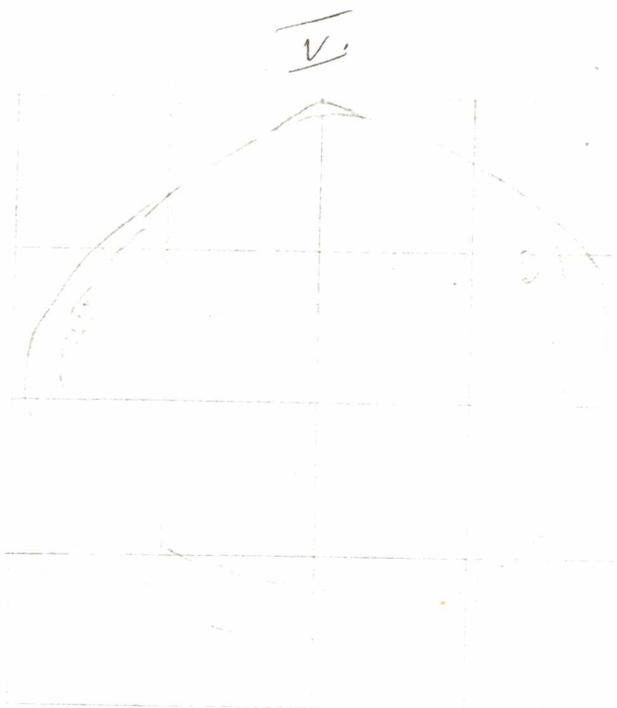
July 24th, 1942. St. Andrews.

Clam. Brown spots are present. Cannot see adductors.

Measurements

H = 26 oc. divs. = 182u

L = 30 " " = 210u.



Clam.

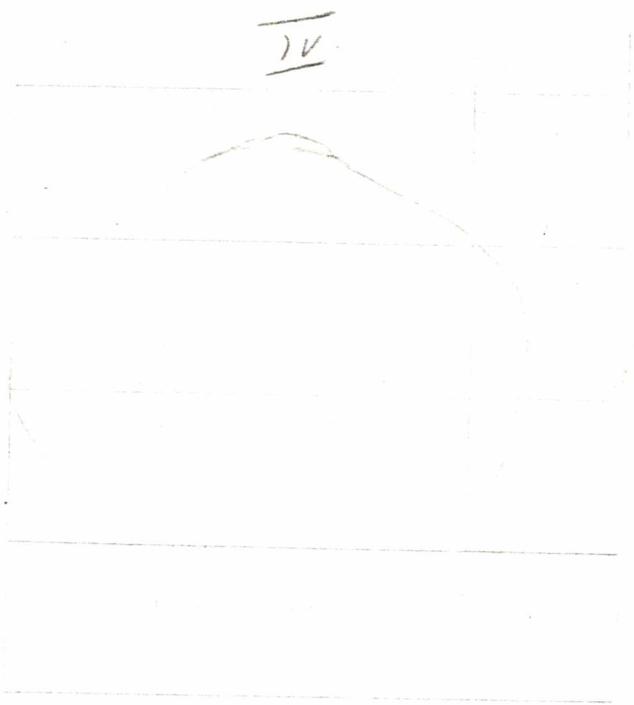
July 24-42. St. Andrews - pelagic same size as found in Bideford river tows.

Measurements

H = 34 cc. Dors = 238μ  
L = 37 " " = 259μ

St. Andrews  
July 24-42

Size:  
H = 31 cc. Dors = 217μ  
L = 34 " " = 238μ



5. The umbos of the two larvae which are characteristically different. In Larva B the umbo develops more quickly than in the clam. It rises above the hinge and shoulder line, whereas in the clam the umbo forms a continuous line with the slope of the shoulders throughout development.
6. The anterior end of Larva B is rounded rather than flattened as it is in the clam larva.

(c) Determination of the duration of the free-swimming period.

As stated before it has, so far, been impossible to identify the straight hinge stage of the clam larva. *Mya* larvae can be distinguished as such only when the brown pigment spots have appeared, at which time they are at least 90  $\mu$ . high.

Measurements were made of such larvae and size frequency distribution polygons constructed.

Table I gives the size frequency distributions.

Figures I and II show the size frequency distribution curves.

From the growth curves the length of the free-swimming period can be tentatively set as two weeks, assuming that the earliest straight hinge stage is, as Stafford (1906) says, about 70 $\mu$  high.

The size at which the larvae settled this year in Bideford river was between 210 $\mu$  and 252 $\mu$ , with maximum settlement occurring at 217 $\mu$  and 224 $\mu$ .

Stafford, (1906), found that the settlement size of clam larvae was about 420 $\mu$ . In tows taken this year at Brandy cove St. Andrews, N. B., clam larvae were found of very great size, some being almost twice as large as the largest found in Bideford river tows. This may be due to differences in water temperatures in the two places.

(d) Determination of factors influencing spawning.

An attempt was made to correlate spawning bursts with water and air temperature data and with tidal cycles.

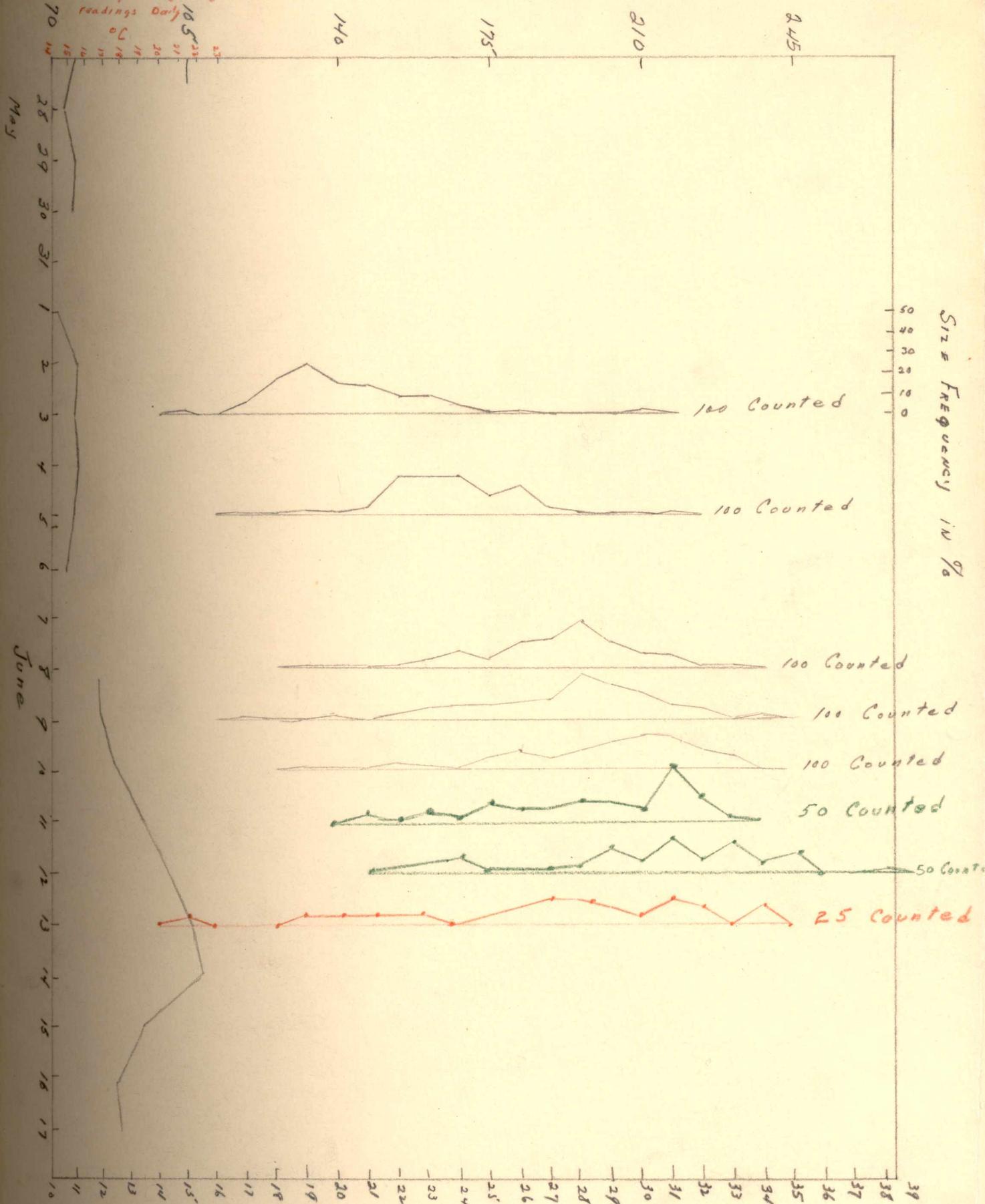
In figure 3 tidal amplitudes, as taken from the tide tables for St. Paul's Island, N. S., computed for Richmond bay, P.E.I., are plotted in lead pencil; average water temperatures calculated each day from two surface and two bottom readings taken at the landing stage are plotted in red pencil; and maximum air temperatures, read from a maximum-minimum thermometer at the Station are marked in green.



Figure 1

LARVAL HEIGHT IN MICRA

Average Water Temps.  
calculated from 4 landing stage  
readings Daily



LARVAL HEIGHT IN OCULAR DIVISIONS.

Figure 2

Larval Height in Micra

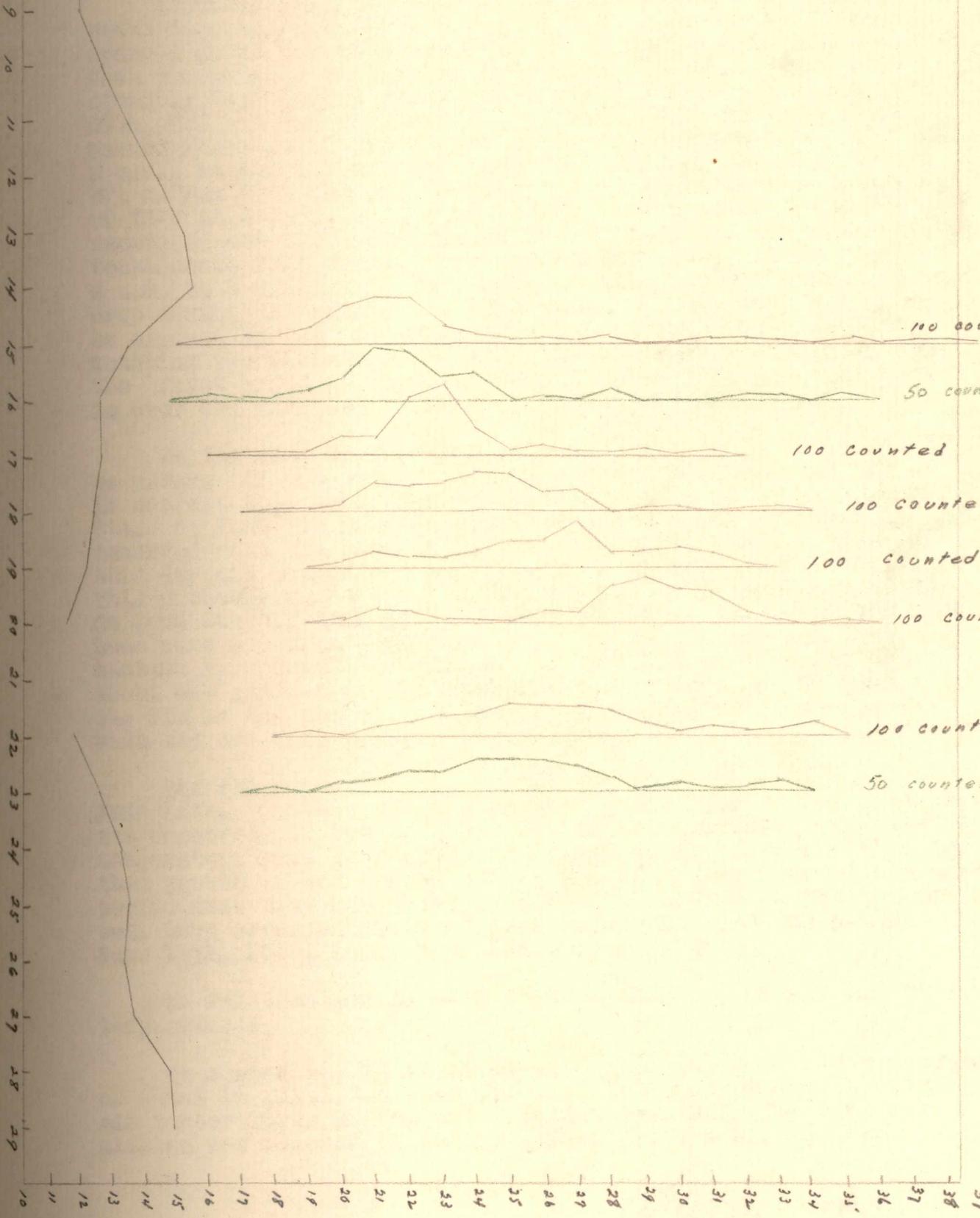
Average water Temperatures  
calculated from 4 landing  
stage readings

daily

70  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39

June

140  
175  
210  
245



Larval Height in Ocular Divisions

Size Frequency in %

Assuming that the pelagic period of clam larvae is of two weeks duration the first brood of larvae should have been spawned about May 28th or 29th. From figure 2 it will be seen that the heights of the low tide levels on these days were steadily decreasing, being, on the afternoon of the 28th and 29th, 0.6 and 0.3 respectively. On May 28th there was no marked increase in air temperature, the maximum being 59°F at 9 a.m., at which hour the tide still covered the clam flats; but on May 29th the air temperature rose steadily to a maximum of 70°F at 4 p.m., and, during the rise the clam flats were uncovered and therefore heated by the sun. On May 30th, the air temperature fell during the day from a maximum of 70°F at 8 a.m. to a minimum of 54°F by noon and probably continued to drop during the afternoon. The clam belt was just beginning to be exposed by the receding tide as the air temperature was reaching the minimum recorded. It may then be concluded that the first brood of clam larvae was spawned as the tide came in over the clam beds on the afternoon of May 29th.

In the case of the second brood the picture is not quite so clear. If the supposition of a two week free-swimming period is correct this brood should have been spawned about June 8th or 9th. On June 7th maximum air temperature was 72°F but it occurred when the clam flats were covered since the tide on this day did not go out far enough to expose the clam belt. This probably rules out the 7th as a probable spawning date. On June 8th air temperatures were 10° lower and again the clam beds were not uncovered during the day. On June 9th the maximum air temperature was again 72°F but on this day only about one quarter of the clam flats was exposed. To take the 9th as the probable spawning date would be in conformity with the two week pelagic period theory.

The other possibility is that spawning occurred about June 11th. On this day approximately one half of the clam belt was uncovered at low tide and during the exposure period the air temperature rose to 84.5°F. If spawning did occur on this day then growth of the larvae during the first few days of their pelagic period must have been rapid. Such an increase in growth rate may well have occurred since average water temperatures during June 12th, 13th, 14th, and 15th were over 20°C.

No relation can be seen between spawning bursts and water temperatures.

To summarize, it seems evident from the facts that spawning of clams is initiated when the clam flats are heated by high air temperatures during the exposure periods. The same conclusion was reached by Battle (1931) for the St. Andrews region.

## II. Collection of Spat

The second object of the clam investigation was to try to devise a method for the collection of spat.

Two types of collectors were arranged. The first consisted of a wooden box one foot square and four inches deep painted to protect it against shipworms. In this tray, three inches of sand which had been washed through a #0 netting, were placed.

The second type was a ten inch cube, wire basket, open at the top.

Six of the Type I boxes were prepared. The sand was brought from the clam bed at Shipyard point. It was washed with fresh water through #0 plankton netting and left standing over night in fresh water with the hope of killing any small bivalves which might have passed through the netting. The boxes were filled with the sand and placed in the following places:

On June 17th.

Sandbox #1. Hung from the landing stage in deep water and raised about one foot off the bottom. It was covered by at least one foot of water even at the lowest tides.

Sandbox #2. Placed at about the 3/4 tide mark on the beach at Shipyard point. The sand was soon washed out of this box by wave action and as a collector it was a total failure.

On June 18th.

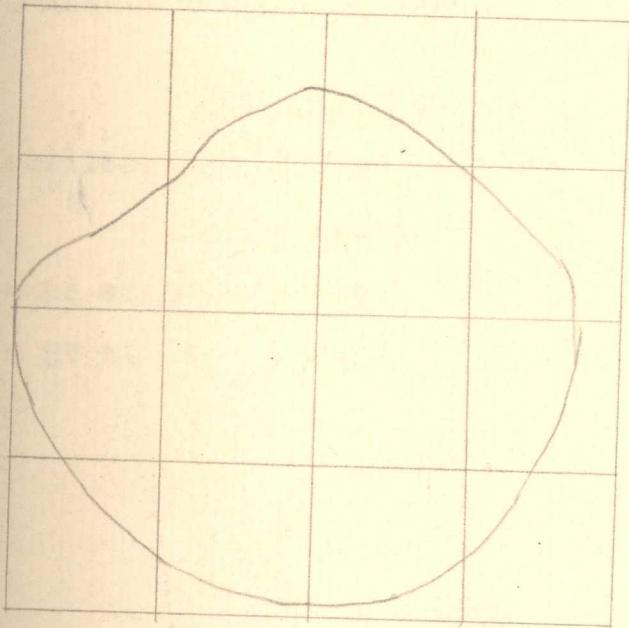
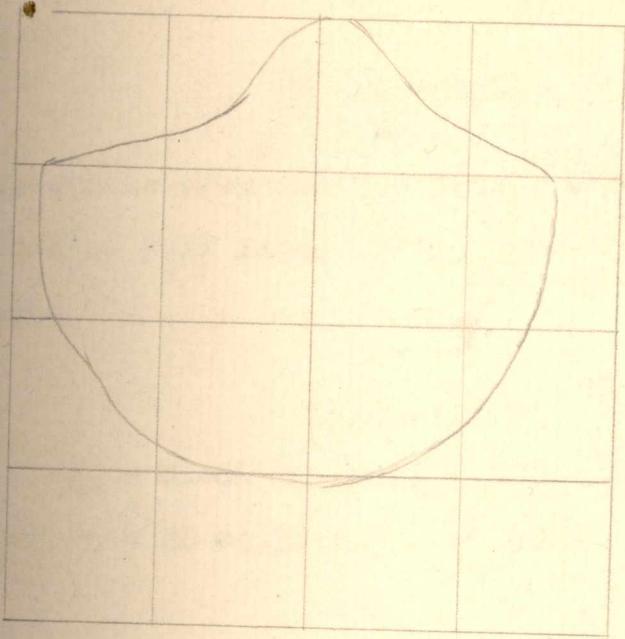
Sandbox #3. Hung one foot off the bottom in the channel about 150 yards above the landing stage.

On June 19th.

Sandbox #4. Hung in deep water just off Shipyard point. It was raised about one foot off the bottom and was covered by about five feet of water at low tide.

Sandbox #5. Placed at the outer edge of the clam belt, on the beach in front of the Station. It was uncovered when the water level went below the 1.8 mark on the tide gauge.

Sandbox #6. Placed at the outer edge of the clam belt at Shipyard point. Wave action washed the sand out of this box.



## Figure 4.

Specimens from which drawings were made, taken from No. 1 box on July 22nd, 1942. This is the prodissoconch of Type 4.

### Measurements

H = 31-32 oc.Divs. = 217-224u

L = 35 oc.Divs. = 345u.

A normal one came from #1 sandbox and at the same time as the clam below. The prodissoconch is white and transparent. The dissoconch is yellow with ridges radiating from the prodissoconch outward to ventral edge of shell. On many of the ridges are little projecting knobs.

### 2nd. Drawing.

Right prodissoconch of clam from No. 1 sandbox.

### Measurements

H = 34 oc.Divs. = 238u

L = 37 " " = 259u.

Six of the Type 2 collectors were made. One was placed beside each of the sandbox collectors. Periodic examination of these baskets failed to reveal bivalves of any kind.

It was thought, when these collectors were put out on June 17th, 18th, and 19th, that there were many clam larvae in the water ready to settle. Subsequent studies of tows showed that clam larvae and larva B had been confused and that actually the first and largest brood of clams had settled and the second brood was due to settle about June 20th and 21st.

It was hoped that by picking small clams out of these collectors the prodissoconchs would be studied and the identification of clam larvae confirmed. The boxes were examined periodically but nothing could be seen with the unaided eye. It was not until July 22nd that a sample of top sand from Sandbox #1 was brought into the laboratory. This sample stood in salt water in a covered dish until July 31st. Examination then showed that many small bivalves, which formerly were concealed in the sand, had died and the gaping shells were lying exposed.

At present only two types of these bivalves will be noted. One was a very small Mya in which the prodissoconch was plainly defined. The other was the bivalve referred to later in this report as Type #, and whose identity is as yet unknown. The prodissoconchs in both these animals are colourless and transparent. The dissoconch in clam is also white, but opaque, with very faint and irregular circular striations. In type 4 on the other hand, the dissoconch is dark brown, with heavy radiating ridges.

The prodissoconchs, as drawn from the shells of each animal, are shown in figure 4.

Examination of the prodissoconchs of Type 4 in this and many other animals leads one to suspect that Larva B develops into this type of Bivalve, although there is, as yet, no really sound basis for this belief.

On July 31st a sample of sand from Sandbox #3, collected in the same way as on July 22nd, was brought in and on August 6th similar samples were taken from sandboxes #4 and #5. Very few soft-shell clams were taken from any of these samples but many very small specimens of various other bivalves were found. They have all been preserved.

On September 8th, 11th, and 12th, the sand from boxes #5 #4 and #3 respectively, was again washed through #0 netting and all the bivalves collected.

The results in number of clams found were:

Sandbox #5 - 55 clams. All were very small, the largest being about 7 mm. long.

Sandbox #4 - 14 large clams, maximum length about 30 mm.  
5 small clams.

Sandbox #3 - 1 small clam.

Sandbox #1 - was not taken up. It is to be sunk in deep water at a marked spot and left until the fall of 1948.

Around July 1st, a number of small clams was noticed on the lids and wire ends of an oyster tray which had been in the water since early spring. A particularly heavy set was observed on the shells of large oysters lying in this tray. The shells of the oysters were very dirty, heavily silted and had also a heavy set of mussels. Among the dirt and mussels, young clams had settled. Such a tray might be used as a collector of clam spat another year.

### III. Information Concerning Bivalves Other Than Clam.

(Note: In all drawings 1 square = 71.4u x 71.4u)

The sandboxes which were put out for the collection of clam spat caught a large variety of other bivalves. Since plankton tows were being studied for clam larvae, other free-swimming bivalve larvae were also noted and drawings were made, using a squared ocular piece, of various stages of development of some of these. Only those larvae are included whose development could be followed with certainty.

An attempt was then made to link up the different kinds of larvae with the types of bivalves which settled in the sandboxes.

In the following pages, brief notes on each larva, and when it appeared in the water will be made. In cases where there is some evidence that a particular larva is the pelagic stage of a bivalve type found in the boxes, drawings of the two will be coupled, but this does not mean that the identities of the larvae thus linked with settled types, are indisputably determined.

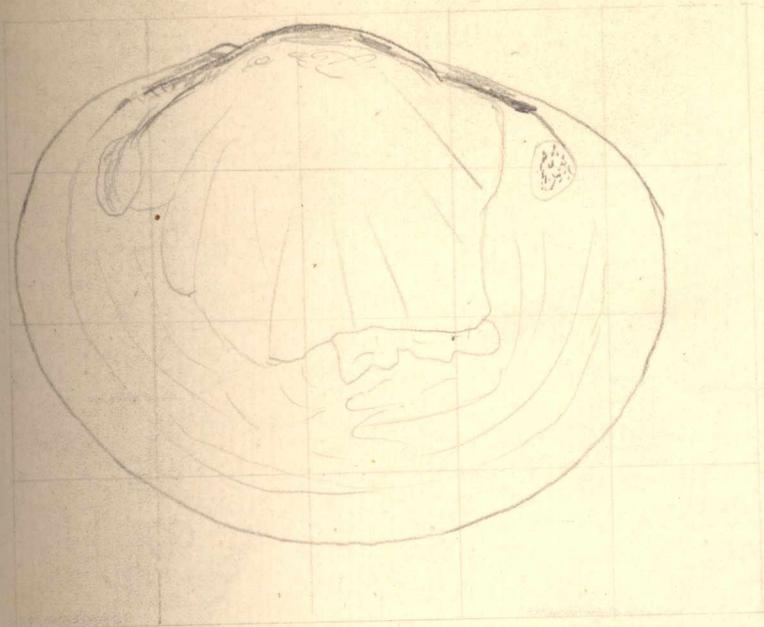
Drawings of the inside configurations of the hinge lines of the different types of bivalves are also included. The arrangement of the teeth was found to be a very valuable aid to the classification of the specimens.

Note: In all drawings of bivalves types, the pictures were made of the outsides of the shells.



Larva A. Series 1.

This series was not completed because there was no difficulty in picking the larva out in tows. It was present in the earliest tows taken on May 20th. It might be the larva referred to M. Miller (1939) as Larva "C" but this is not certain. Larva A had practically disappeared from the water by July 3rd.



Taken in May 28th, 1942 tow.

This is not a really typical specimen of the type.

Larvae is not as yellow as Mytilus but is almost white.

Internal organs are brownish (colours may have faded).

As far as I can make out, Mytilus has circular markings on the shell whereas this larvae has none. Note toothlike projections on hinge line, not seen in Mytilus.

Measurements

H = 39 oc.Divs. = 273 $\mu$

L = 45 " " = 315 $\mu$

Larva B. Series 2.

The distinguishing features of this larva have already been pointed out.

It was first picked out on May 22nd, but may have been present in the water before this. It continued in very large numbers until July 3rd.

It is possible that these larvae give rise to Type 4 bivalve. The large numbers of these larvae, found in tows corresponds with the numbers of Type 4 bivalves taken from sand box samples.

Larva B. Series 2.

II



This larva is wrong side up in relation to the rest of the drawings in the series.

Measurements

$$H = 16 \text{ oc.Divs.} = 112 \mu$$

$$L = 18 \text{ " " } = 126 \mu$$

III

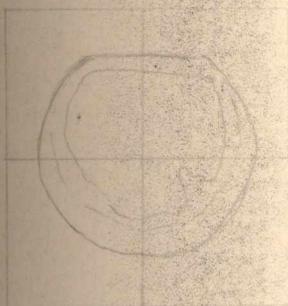


Measurements

$$H = 18 \text{ oc.Divs.} = 126 \mu$$

$$L = 20 \text{ oc.Divs.} = 140 \mu$$

I



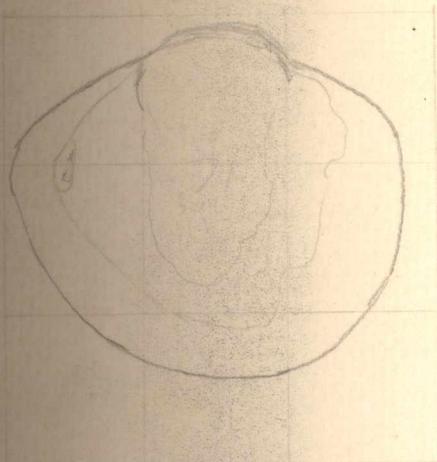
This is thought to be a straight-hinge stage of Larva B, Series 2. Visceral mass is greenish brown. Space between visceral mass and edge of shell is green, like young shipworms. Note heavy shoulders.

Measurements

$$L = 16 \text{ oc.Divs.} = 112 \mu$$

$$H = 14 \text{ " " } = 98 \mu$$

V



Taken from May 30 Stage tow.

Measurements

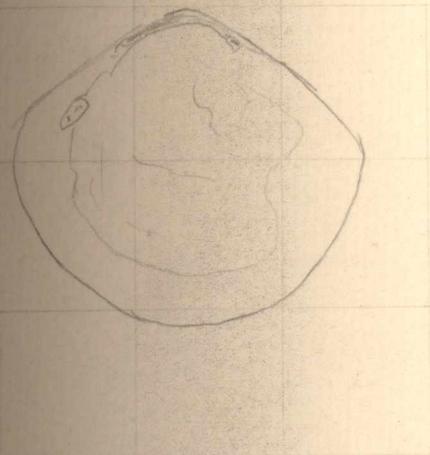
$$H = 26 \text{ oc.Divs.} = 182\mu$$

$$L = 28 \text{ " " } = 196\mu$$

This larva has shape and proportions very like those of clam (*Mya*). The shell, by reflected light, is silvery, shiny, and smooth

By transmitted light, the visceral mass is light greenish brown. There are no brown pigment spots. The slope of the shoulders is perhaps less steep than in the clam, and the most characteristic feature of this stage is the umbo, which is rounded and projected above the hinge and shoulder lines. Could distinguish only one adductor with certainty.

IV



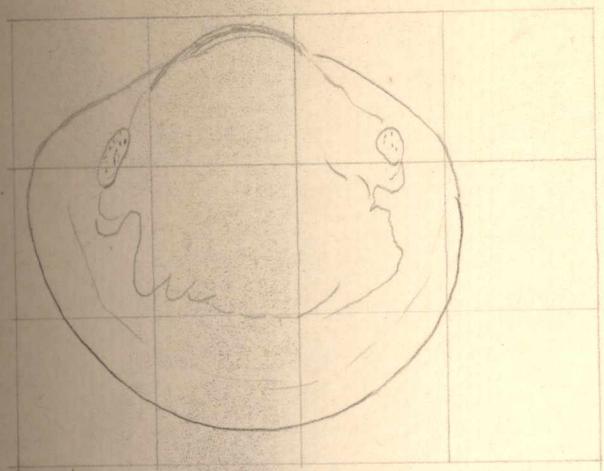
Taken from May 30th stage tow.

Measurements

$$H = 22 \text{ oc.Divs.} = 154\mu$$

$$L = 24 \text{ " " } = 168\mu$$

VI



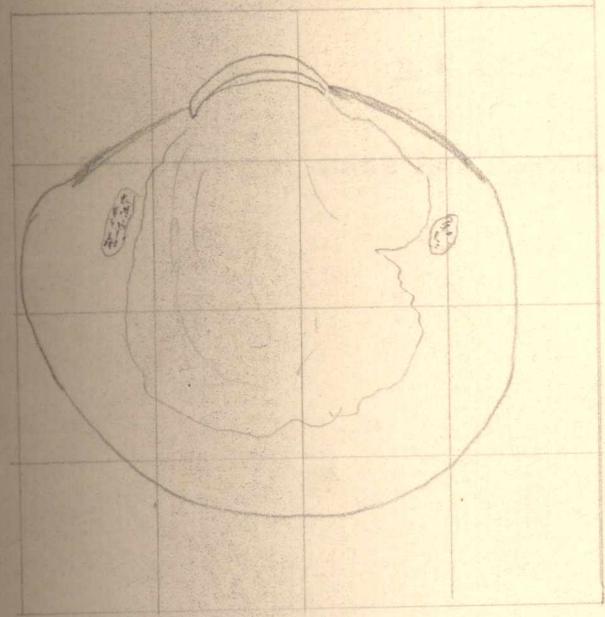
Measurements

H = 29 oc.Divs. = 203 $\mu$

L = 32 " " = 224 $\mu$

Colour of visceral mass is still greenish brown, possibly a bit darker than in earlier stages.

VII



Measurements

H = 33 oc.Divs. = 231 $\mu$

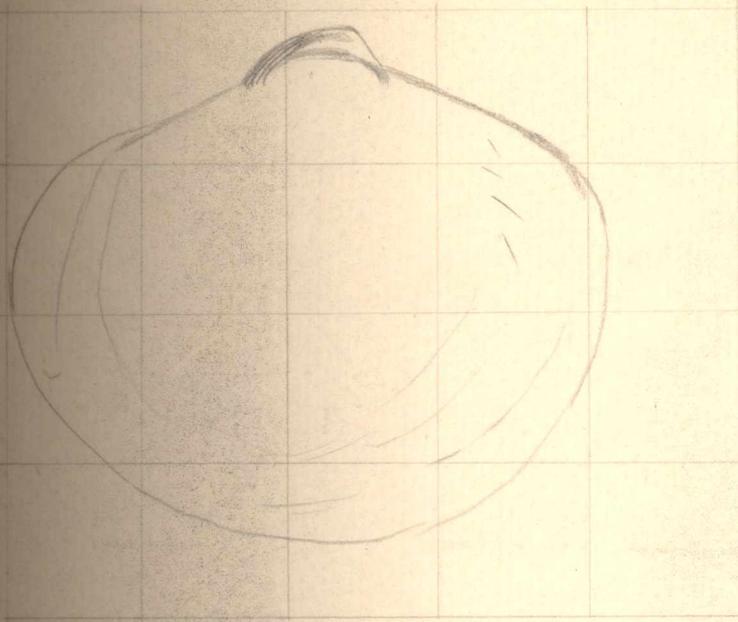
L = 37 " " = 259 $\mu$

(H is measured from top of highest umbo). Both adductors are plainly seen.

The umbo in this animal comes up before it does in the clam and it rises above the hinge and shoulders line whereas in clam

the shoulders are continuous with the umbo. Also the point in this larva is higher up and sharper than in clam.

VIII



Measurements

$$H = 36 \text{ oc. Divs.} = 252\mu$$

$$L = 42 \text{ " " } = 294\mu.$$

The visceral mass has darkened a good deal.

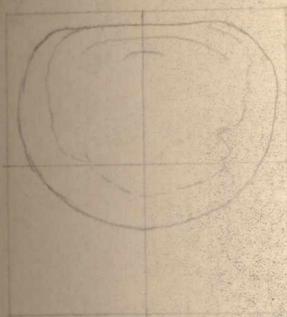
Larva C. Series 3.

This larva is M. Miller's Larva "B".

This year it first appeared in the water on June 8th, disappearing around August 3rd. It was present during this period in large numbers.

It is thought possible that Larva C gives rise to Type 1 bivalve which settled in the sand boxes in considerable numbers.

I



This is M. Miller's Larva "B". Has a grayish white visceral mass and the space between visceral mass and edge of shell is yellow.

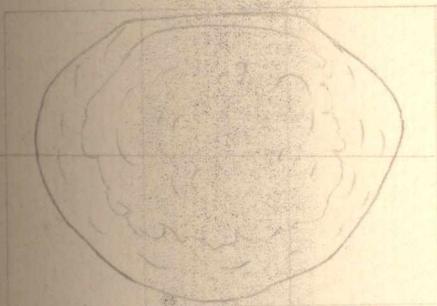
Measurements

$$H = 15 \text{ oc.Divs.} = 105\mu$$

$$L = 19 \text{ " " } = 133\mu.$$

The yellow bank is very faint in earlier stages but can be seen in one measuring:  $\frac{H}{L} = \frac{12}{16} = \frac{84\mu}{112\mu}$ . As the larva grows the colour becomes brighter.

II



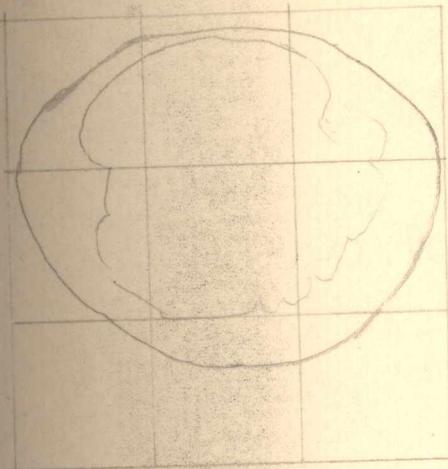
The yellow strip has broadened somewhat, taking in the outside edge of the visceral mass. Umbo is beginning to be seen.

Measurements.

$$H = 20 \text{ oc.Divs.} = 140\mu$$

$$L = 25 \text{ " " } = 175\mu$$

III

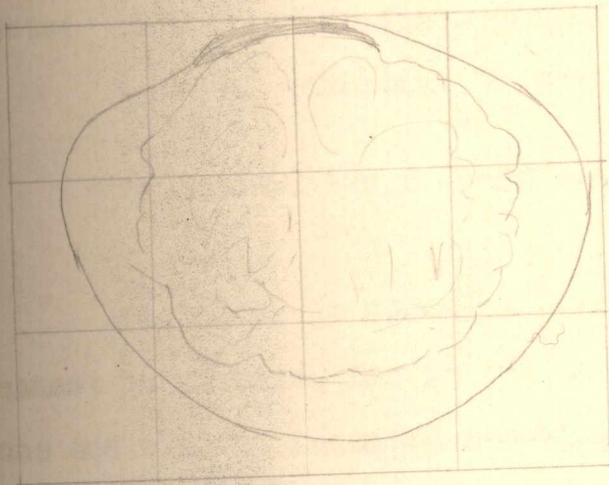
Measurements

$$H = 24 \text{ oc.Divs.} = 168\mu$$

$$L = 30 \text{ " " } = 210\mu$$

$$L. \text{ of hinge line} = 10 = 70\mu$$

IV



The yellow colour is very intense.  
 Colour of visceral mass deepening  
 somewhat so that now it is a  
 brownish gray colour.

Measurements

$$H = 28 \text{ oc.Divs.} = 196\mu$$

$$L = 35 \text{ " " } = 245\mu$$

$$L \text{ of straight part of umbo} = 10 \text{ oc.Divs.} = 70\mu$$

VI



Measurements

$$H = 35 \text{ oc.Divs.} = 245\mu$$

$$L = 43 \text{ " " } = 301\mu$$

$$L \text{ of straight side of umbo} = 10 \text{ oc.Divs.} = 70\mu$$

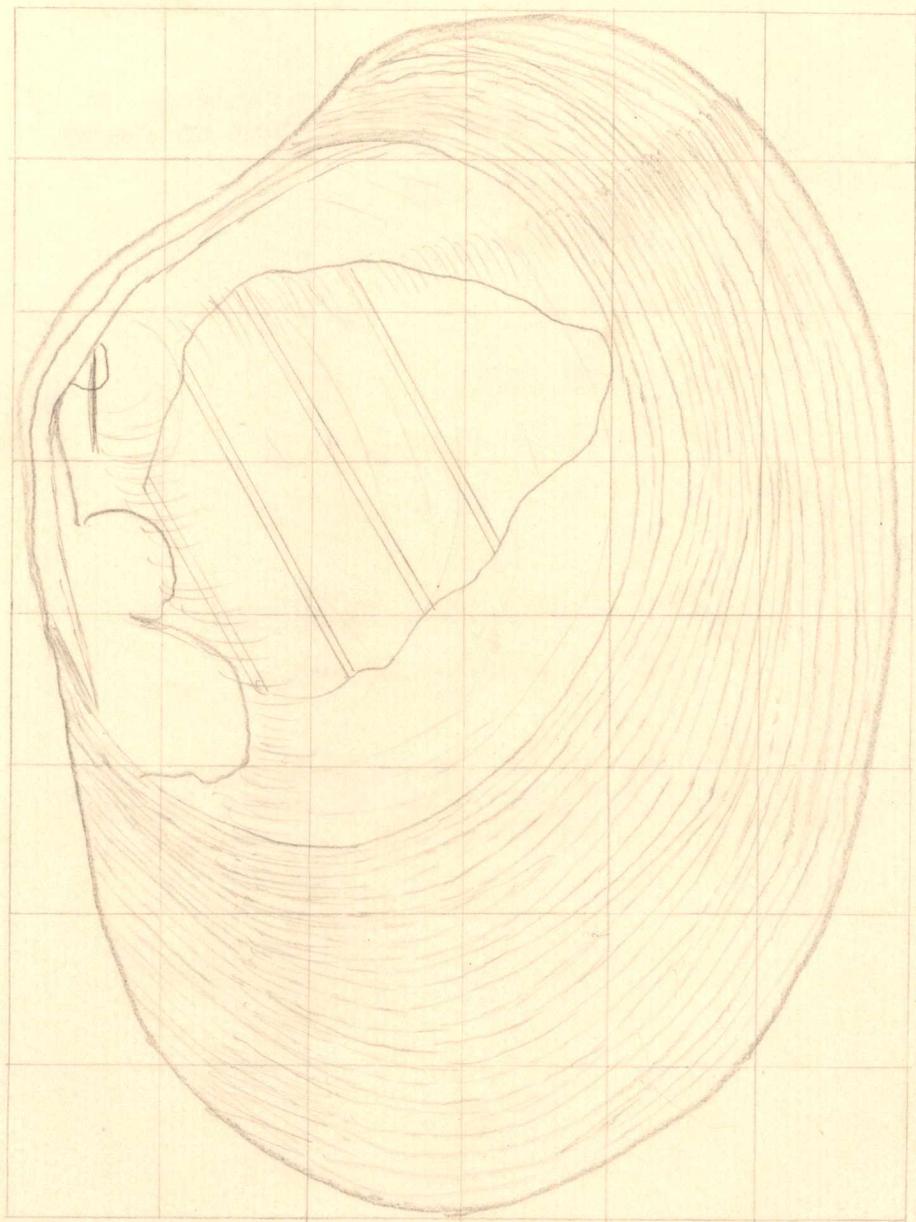
Note: In the larger specimens of this series there seems to be quite a bit of variation in the relationship of L. to H.

In June 26 tow I found one measuring:  $H = 41 \text{ oc.Divs.} = 287\mu$

$L = 49 \text{ " } = 343\mu$

Its shape is becoming more like that of Mytilus but cannot be mistaken for it has the very high, quite sharp point at one end with an indented shoulder at the same end., and the other shoulder slants up almost to the same height as the umbo forming a continuous line with it. The umbo itself is still square and not high. The flat part of it still measures  $70\mu$ .

Type 1.



## Type I

This animal seems to have a squared off umbo and very heavy shoulders. The dissoconch appears to be humped up and doubled over the shoulders. Prodissoconch is yellow. Dissoconch is white and not very transparent.

Taken from stage sand box on July 22nd, 1942.  
Drawn on August 3rd, 1942.

### Prodissoconch measurements

$$H = 42 \text{ oc.Divs} = 294\mu$$

$$L = 49 \quad " \quad = 343\mu$$

### Total measurements

$$H(\text{at } x) = 72 \text{ oc.Divs.} \approx 504\mu$$

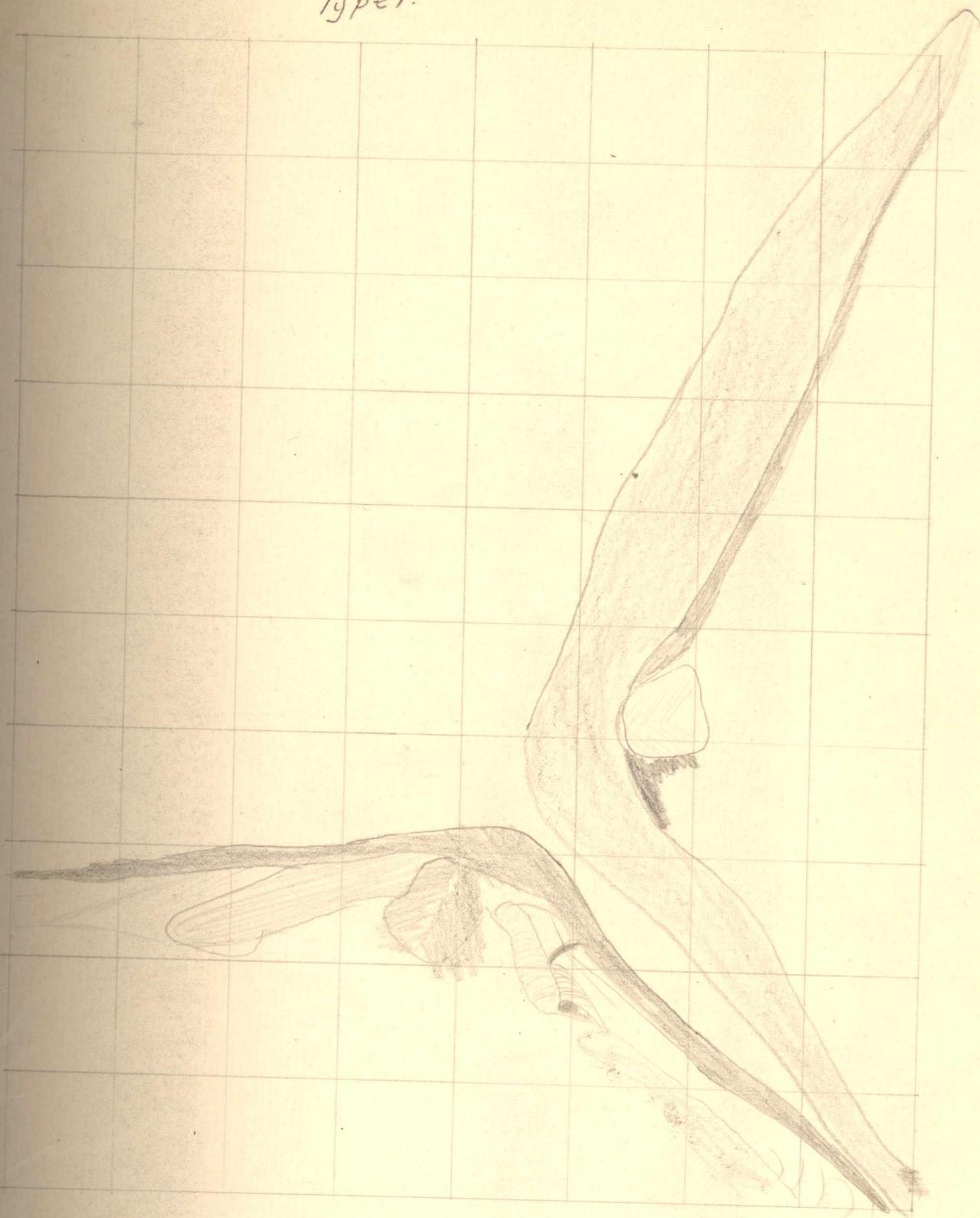
$$L \quad \approx 82 \quad " \quad = 574\mu$$

### Length of flat top of umbo

$$\text{about } 11 \text{ oc.Divs} = 77\mu.$$

This bivalve as it grows, becomes the little brown animal found in large numbers in Boxes #3 and 5 screened in September. The teeth on the hinge line are typical.

Type 1.



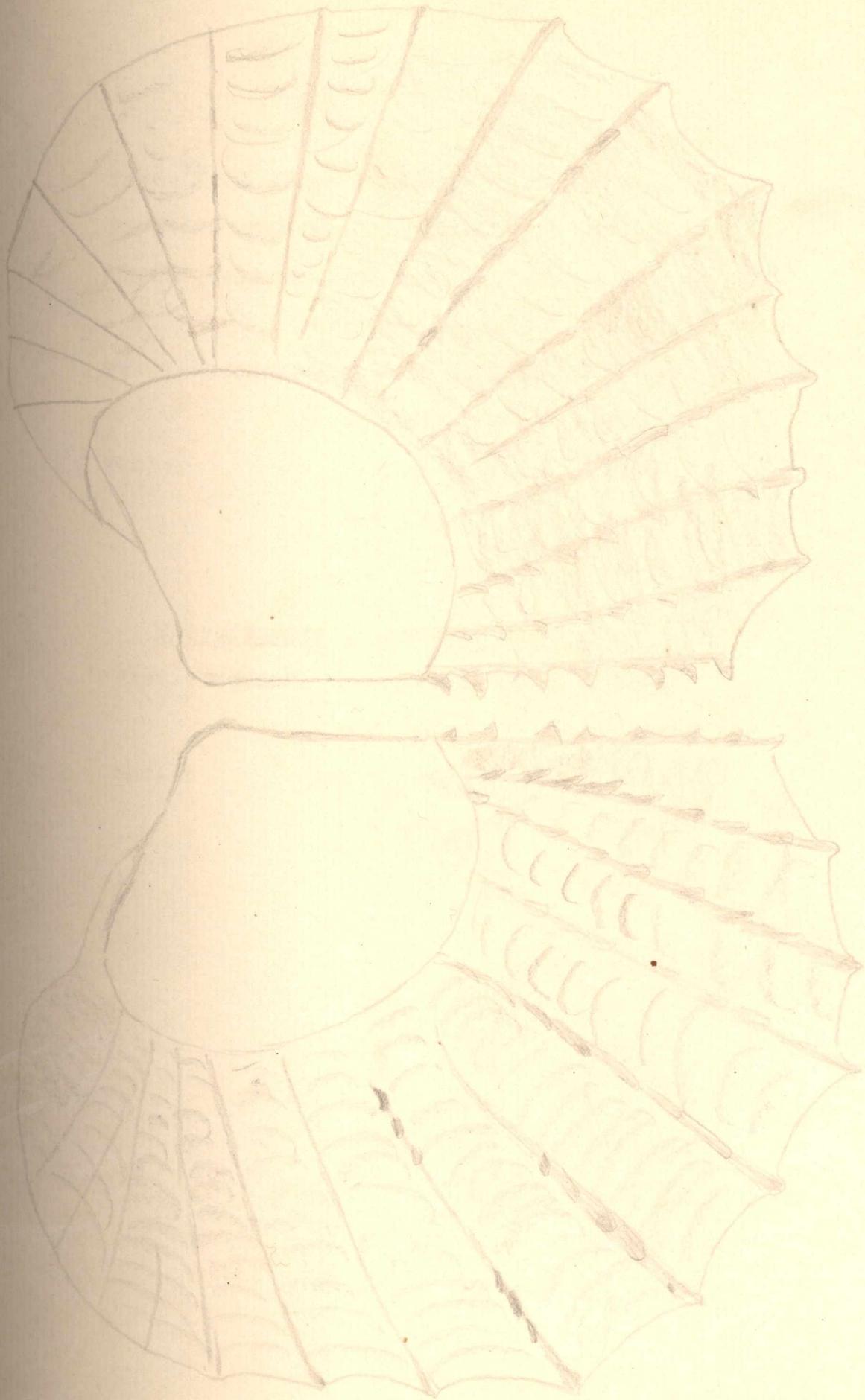
An attempt to picture the inside of the umbo and hinge line of Type 1. Shells lying open with inside up. The large projecting structure in each valve is dark brown and cartilaginous.

Sample was taken from #3 sandbox on July 31st, 1942.

Specimen was large: H = 110 oc. Divs. = 770 $\mu$

L = 137 " = 973 $\mu$

Type 4



Type 4.

Taken from stage sandbox (#1) July 22nd, 1942.

Prodissoconch white, Dissoconch yellow.

There were many of these in the sample taken.

Measurements

Prodissoconchs: H = 28 oc.Divs. = 196 $\mu$

L = 38 " = 266 $\mu$

Whole: H = 68 oc.Divs. = 476 $\mu$

L = 80 " = 560 $\mu$

Measurements of another specimen.

Prodissoconch: H = 27 oc. Divs. = 189 $\mu$

L = 34 " = 238 $\mu$

Whole: H = 106 oc.Divs. = 712 $\mu$

L = 125 " = 875 $\mu$

Larva D. Series 4.

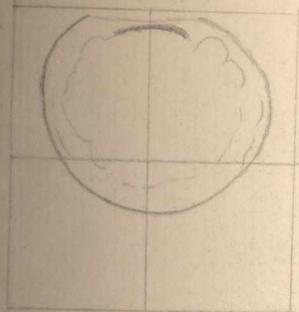
It was noted first on June 15th and was present in increasing numbers until August 1st when it began to grow scarcer disappearing by August 15th. Probably it is the same as M. Miller's larva "E".

Its most characteristic feature is the purple colour of the umbo seen with strong transmitted lighting. In small specimens of Type 2 bivalve, the same colour could be seen around the umbo.

Type 2 bivalve is thought to be Cumingia. It was found in large numbers in all sandboxes and the sizes of the specimens ranged from very small to about 5 mm. long. This fact corresponds to the distribution of Larva D in tows.

Larva D. Series 4

I



This is the larva with umbo outlined in purple. If all available light be passed through it the purple colour is distinguishable even at this early stage. The rest of the larva is a light yellow colour. One shoulder is slightly higher than other, umbo is becoming visible at this stage.

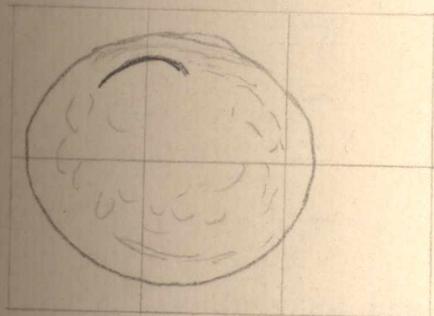
Measurements

H = 13 oc.Divs. = 91 $\mu$

L = 15 " = 105 $\mu$

L of hinge = 70 oc.Divs. = 29 $\mu$

II



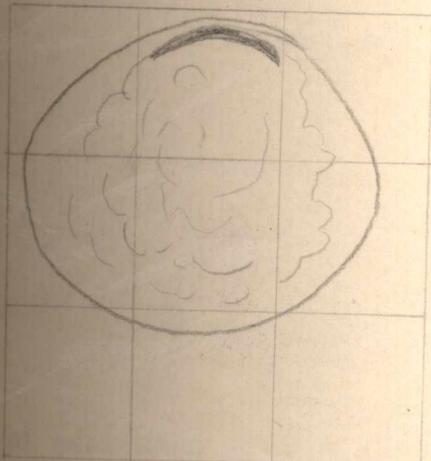
If light is increased, purple colour is very marked around umbo. Umbo is heavy. Umbones about equal in size.

Measurements

H = 18 oc.Divs. = 126 $\mu$

L = 20 " = 140 $\mu$

III



Measurements

H = 23 oc.Divs. = 161 $\mu$

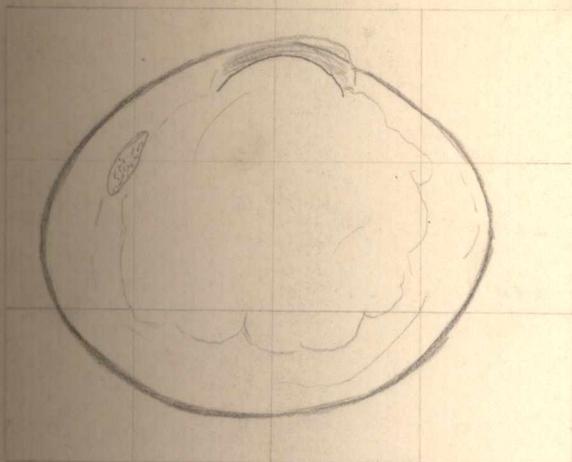
L = 26 " = 182 $\mu$

Measurements

H = 27 oc.Divs. = 189 $\mu$

L = 31 " = 217 $\mu$

Requires full light to see the purple colour which is still confined to the umbo. The shape of this larva is characteristic. Shell appears to be very thick and heavy. Can make out only one adductor. Umbo is prominent.



In June 24 tow. One measuring:

H = 29 oc.Divs. = 203 $\mu$

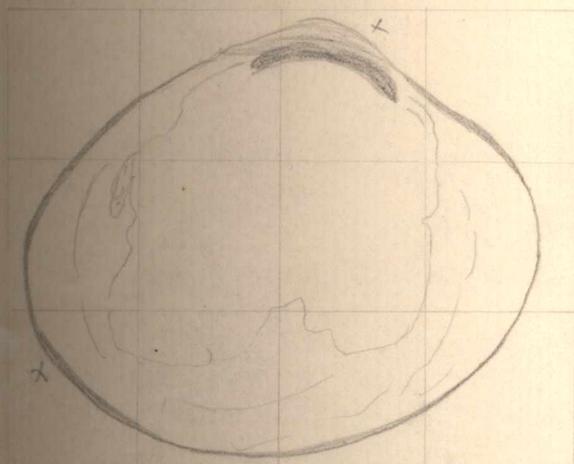
L = 34 " = 238 $\mu$

one measuring:

H = 26 oc.Divs. = 182 $\mu$

L = 32 " = 224 $\mu$

June 24 tow



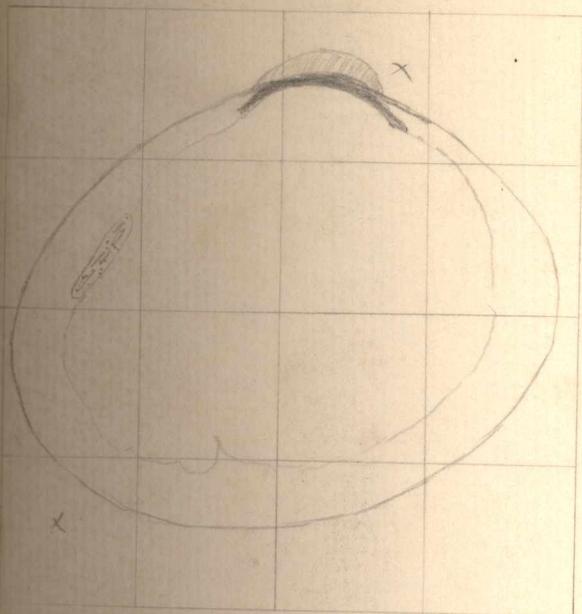
Measurements

H = 30 (at x) = 210 $\mu$

L = 34 = 228 $\mu$

The sudden decrease in difference between H and L is partly due to the increased size of the umbo which causes the larva to be propped up on it and therefore brings the umbo on opposite valve into measurement. H. is measured from top

of near umbo = 28 = 196 $\mu$ . Purple colour is still distinct but not so intense as in younger stages.

Measurements

$$H = 35 \text{ ( at x )} = 245\mu$$

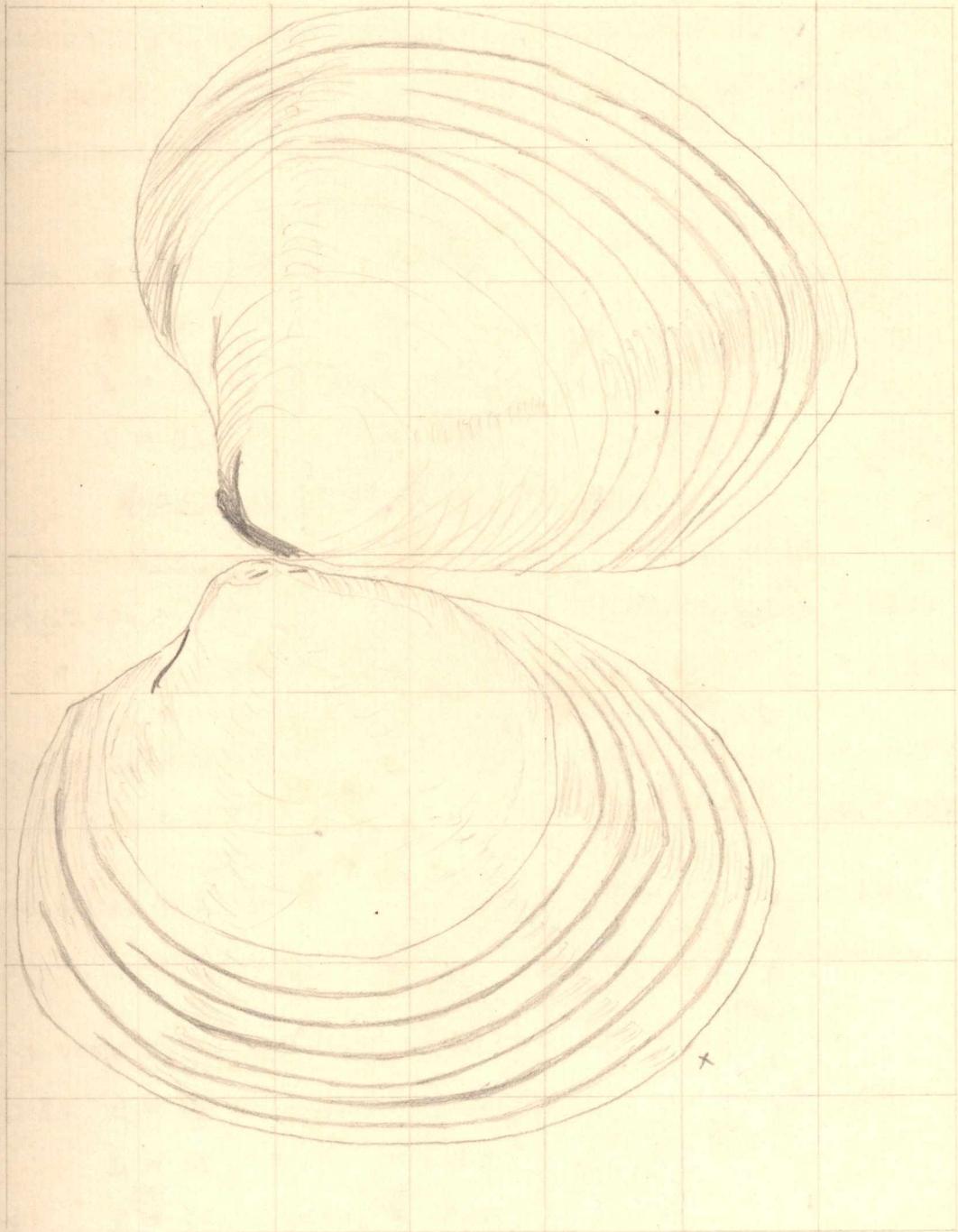
$$L = 39 = 273\mu$$

Purple colour faint with lots of light.

Colour of whole is deep yellow.

Proportions of L to H are changing.

Type 2 Cumingia



Type 2 -- Cumingia

Taken from stage sandbox on July 22nd, 1942.

Prodissoconch yellow and unridged. Dissoconch white, heavy, and heavily ridged. Equivalved. May be mactra or callocardia. Not quahaug probably. Drawn to scale.

Measurements

Prodissoconch: H = 35 oc.Divs. = 245 $\mu$   
H = 30 " = 210 $\mu$   
Total size: L = 58 oc.Divs. = 406 $\mu$   
H = 51 " = 357 $\mu$

Measurements of other specimens

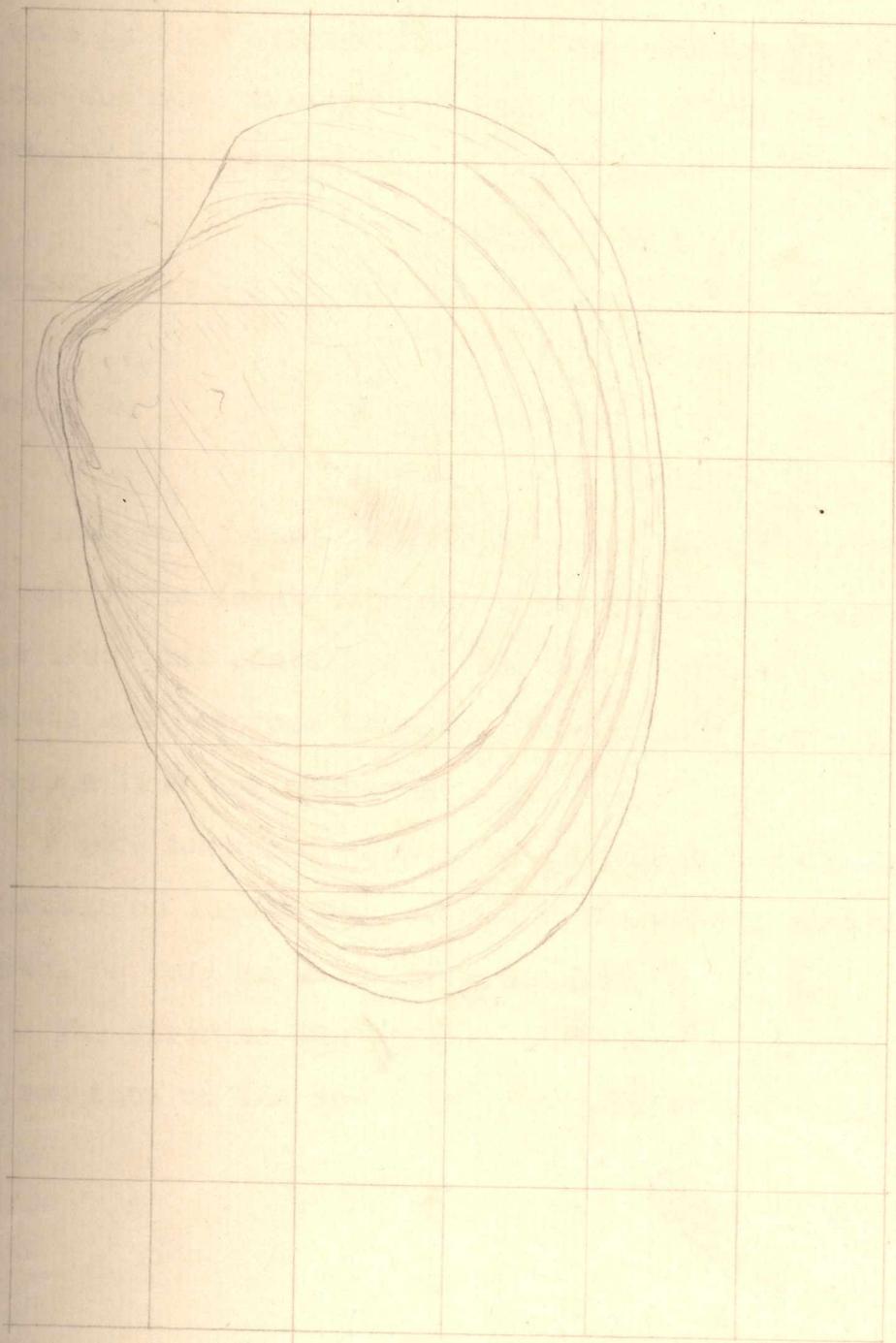
<u>Prodissoconch</u>	<u>Total size</u>
H = 32 oc.Divs. = 224 $\mu$	H = 130 oc.Divs. = 910 $\mu$
L = 37 " = 259 $\mu$	L = 150 " = 1050 $\mu$
H = 34 oc.Divs. = 238 $\mu$	H = 130 oc.Divs. = 910 $\mu$
L = 39 " = 273 $\mu$	L = 156 " = 1092 $\mu$
H = 31 oc.Divs. = 217 $\mu$	H = 76 oc.Divs. = 532 $\mu$
L = 36 " = 252 $\mu$	L = 86 " = 602 $\mu$

Found a very small specimen of this type:

Prodissoconch: H = 34 oc.Divs. = 238 $\mu$   
L = 38 " = 266 $\mu$   
Total size: H = 44 oc.Divs. = 308 $\mu$   
L = 49 " = 343 $\mu$

Prodissoconch had the shape of Larva D, No. 6 of series and the umbo, by strong transmitted light, had a definite purple colouration.

Type 2



Type 2.

Taken from stage sandbox on July 22nd, 1942. Drawn from living specimen. Is a slight suggestion of purple colouration on umbo in very strong light. Prodissoconch is yellow. Dissoconch whiter and more transparent than that of Type 1. Adductors are difficult to distinguish.

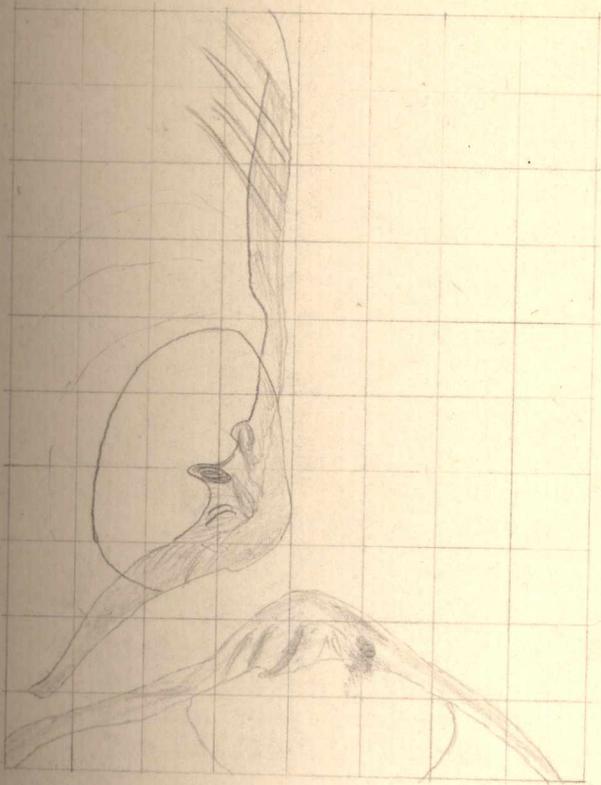
Measurements

Prodissoconch:	H = 34 oc.Divs. = 238 $\mu$	(not including far umbo)
	L = 38 "	= 266 $\mu$
Total size:	H = 56 oc.Divs. = 392 $\mu$	
	L = 64 "	= 448 $\mu$

This one cannot be mistaken for anything else. As growth proceeds a prominent external brown ligament appears over the hinge line just posterior to the umbo. The siphons are long and separate and protrude from the shorter, thicker end. The teeth on the hinge line are characteristic.

A good number of these, of fair size were found in sample from #4 sandbox on August 6th, 1942 and there were also a number in #5 sandbox, as well as many in #3 sandbox.

The circular striations stop after a certain size is reached and from then on the shell is smooth below the striations



Hinge line and teeth, seen from inside of Type 2.  
The teeth get larger and heavier as growth proceeds.

Larva E. Series 5.

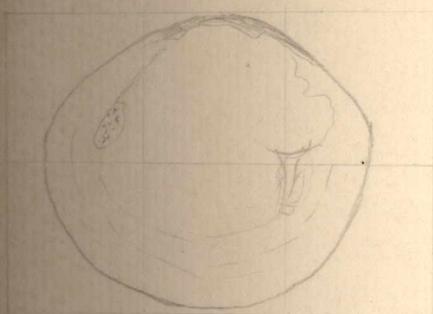
It first occurred in the June 16th tow when it was easily picked out. In later tows its history became more confused, other larvae appearing that were so similar to Larva E that it was very hard to tell whether one or two kinds were present. The difficulty has not yet been cleared up.

In its early stages this larva is shaped like Mya, but it is yellow. Later on it has an outline similar to that of Larva B but there is no danger of confusing these three types.

Larva E could not be linked with any of the bivalve types.

Larva E, Series 5<sup>-</sup>

Ⅷ.



June 22nd tow.

Measurements

H = 20 oc. Divs. = 140 $\mu$

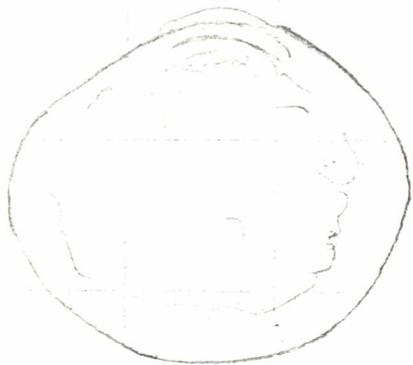
L = 22 " = 154 $\mu$

June 16th and 17th tows

Measurements

H = 25 oc.Divs. = 175 $\mu$   
L = 27 " = 189 $\mu$

This is probably the larva that M. Miller at first thought was a clam but afterwards classed as unknown. In earlier stages it seems to have the shape of a clam (*Lya*) larva, but as growth proceeds the umbones come up above the hinge and shoulder line and larva then looks most like later stages of Larva B, Series 2. This larva is yellowish green. Liver is darker.

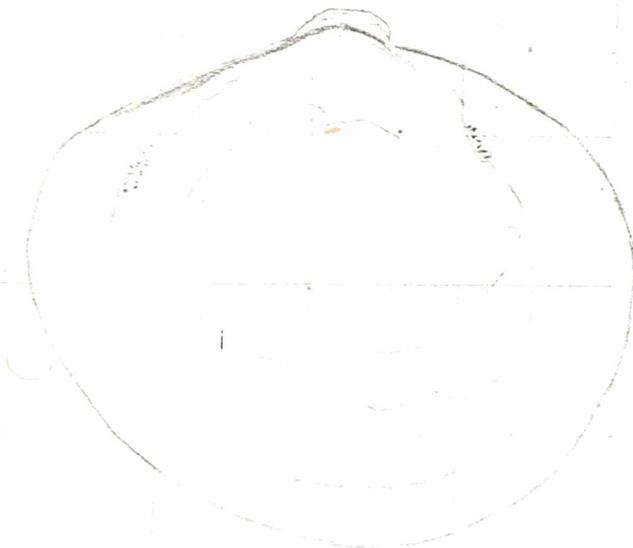
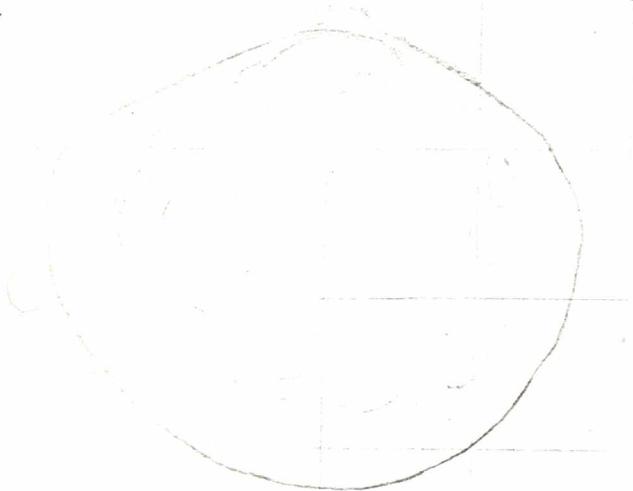


Measurements

H = 32 oc.Divs. = 224 $\mu$   
L = 35 " = 245 $\mu$

Measurements

H = 37 oc.Divs. = 259 $\mu$   
L = 41 " = 287 $\mu$



Other Bivalves Found in Sandboxes

Besides the bivalves already included five other types were found in the sand box collectors.

They were:

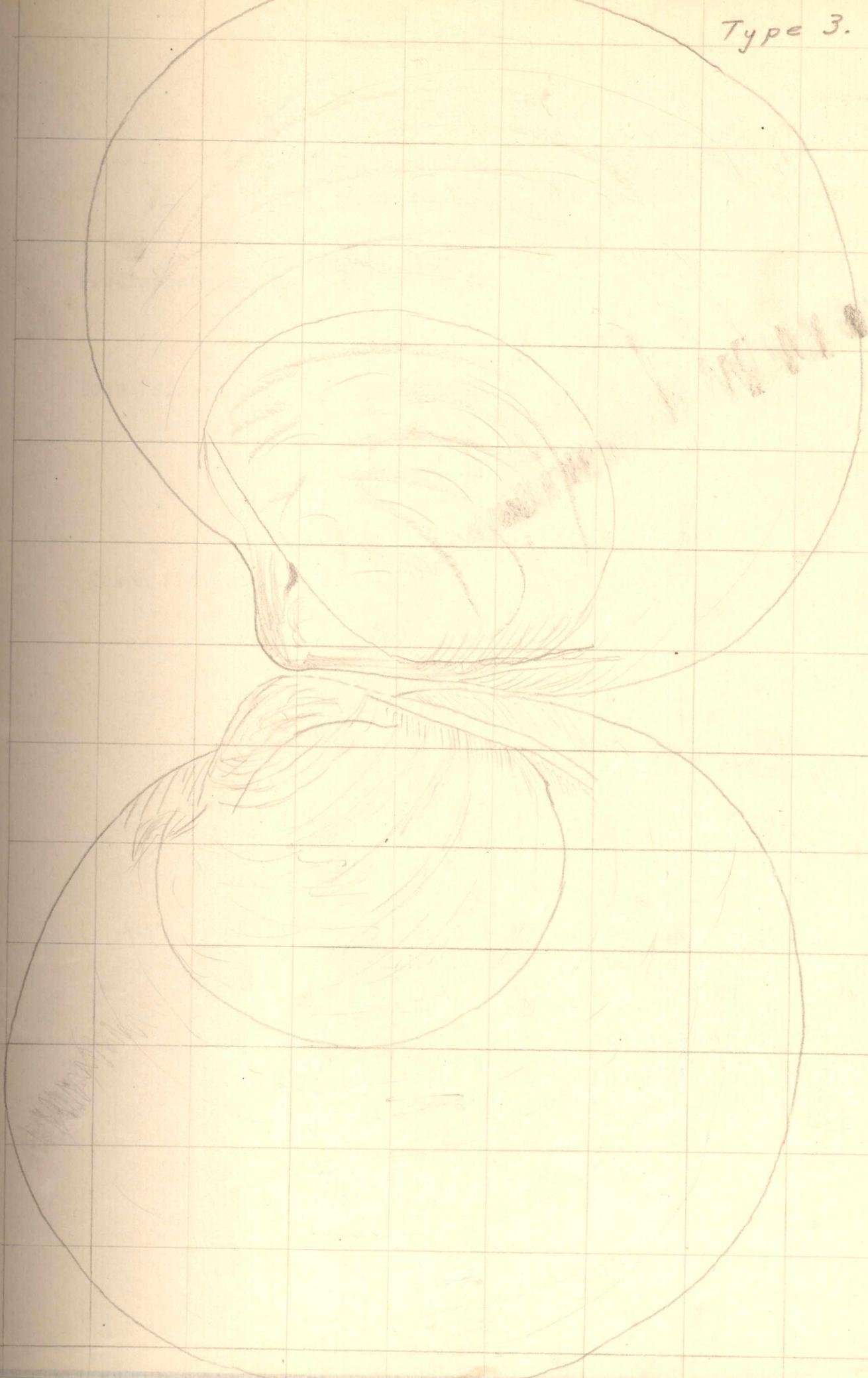
1. Type 3.
2. Quahaug.
3. Razor Clam (No drawing made)
4. Petricola
5. Tellina (No drawing made)

Type 3

Only one specimen of this type was found, in the sample taken from #1 box on July 22nd.

At first it was thought to be the same as Type 1, but it has a more pointed umbo and has not the regular markings on the dissoconch. The prodissoconch is yellow. The dissoconch is white and smooth with a few markings near the bottom of the shell.

Type 3.



Type 3

Measurements

Prodissoconch:

H = 38 oc.Divs. = 268 $\mu$

L = 44 " = 308 $\mu$

Total size:

H = 76 oc.Divs. = 532 $\mu$

L = 86 " = 602 $\mu$

Taken from stage sandbox #1, July 22nd, 1942.

Quahaug

A small number of quahaugs settled in #3 sandbox, the count totalling 25 in all. Neither sampling nor screening revealed any set of quahaugs in the other boxes.

# Quahaug

One valve of young quahaug.

## Measurements

Total: H = 115 oc.Divs. = 805 $\mu$

L = 130 " = 910 $\mu$

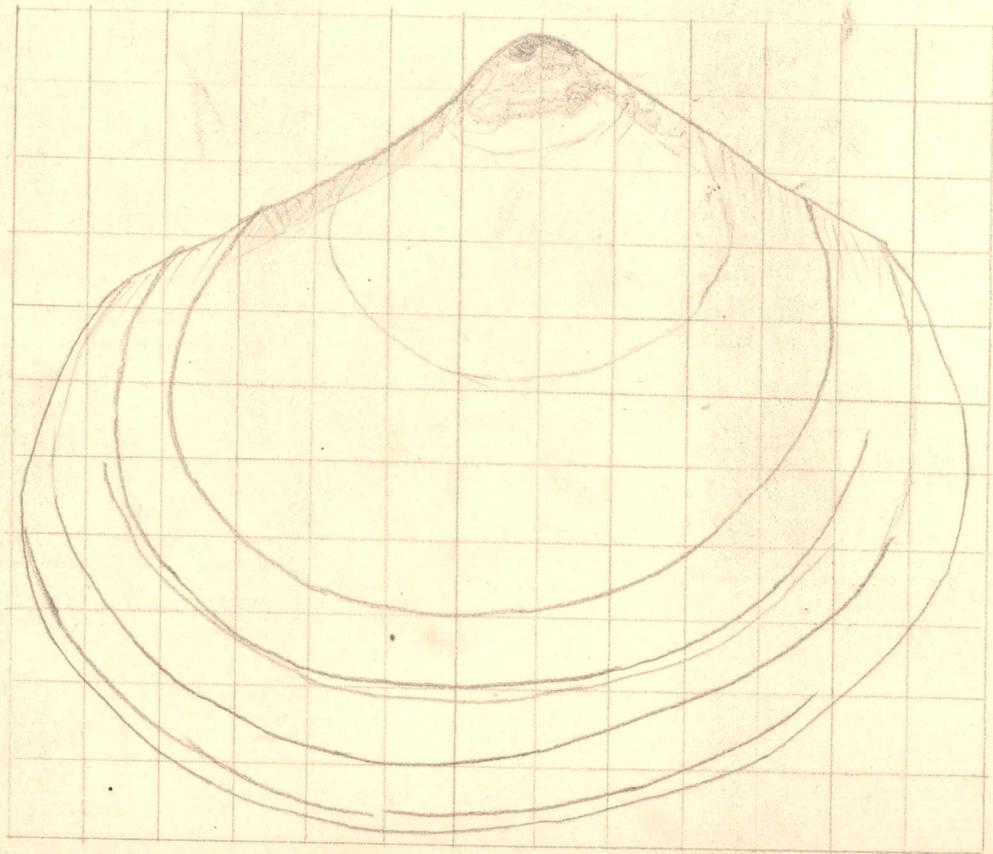
The whole is white. It is impossible to say definitely where prodissoconch ends, but it may be marked off by the first circular ridge.

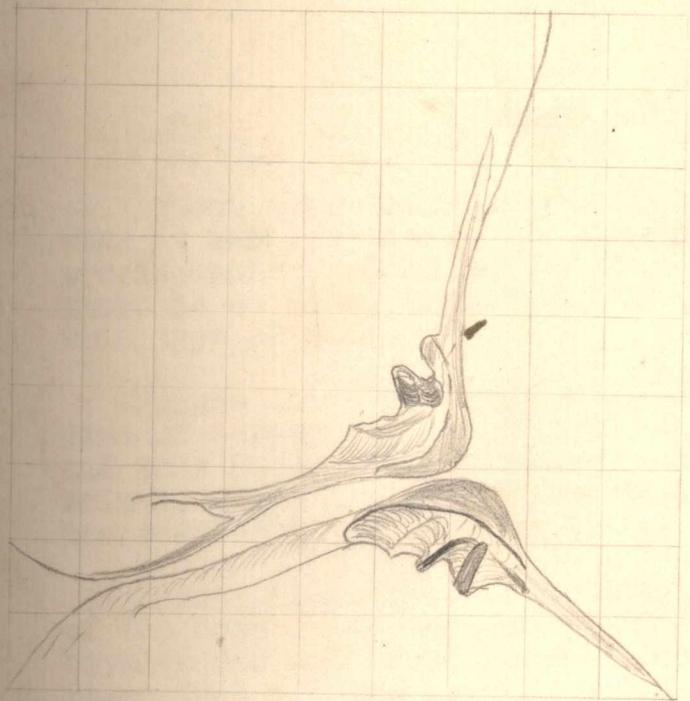
## Measurements to the ridge

H = 49 oc.Divs. = 343 $\mu$

L = 55 " = 385 $\mu$

But there is no difference in colour. Umbo is dimpled but this feature is not outstanding. Ridges are not yet raised.





HINGE LINE OF QUANAUG

### Razor Clams

These were found in considerable numbers in Sandbox #4 when it was screened. The specimens were all so large that prodissoconchs could not be distinguished in any of them. There is no clue, therefore, to the larval life history of this type of clam.

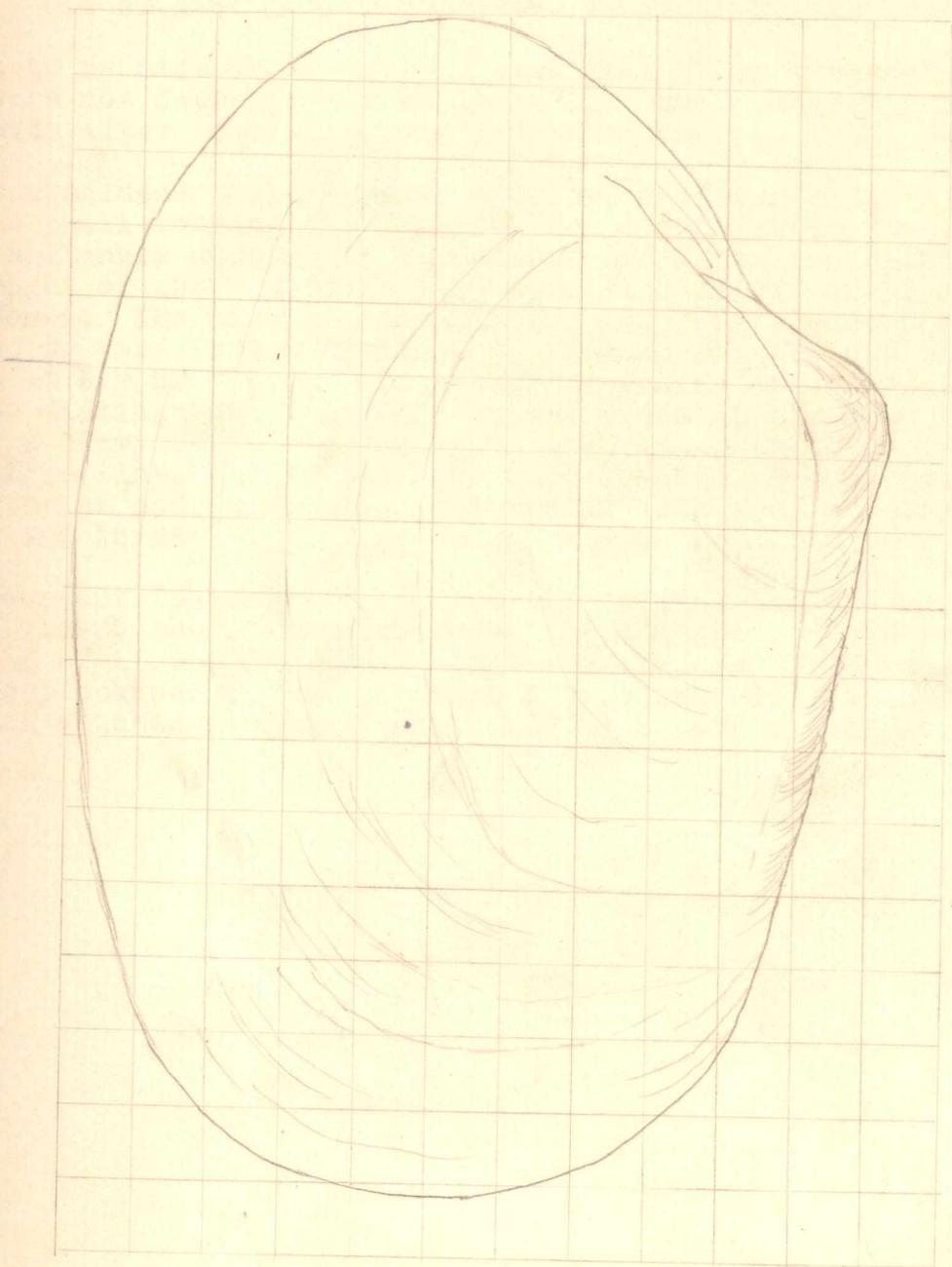
Since these bivalves had reached a large size at the time of screening, it is probable that they settled very early, and this fact, along with the swift burrowing habit of the animal, might explain why no small specimens were obtained in the samples taken earlier in the summer.

Razor Clams were found only in Sandbox #4 when the contents of the boxes were screened. It may be that the larvae of this bivalve did not occur in any number in the tows which were taken just off the landing stage.

### Petricola

Very small specimens of this animal were found in the early samples taken from the boxes. At that time they were thought to be young soft-shell clams, but a study of the hinge line showed the presence and characteristic arrangement of teeth. This feature served, on comparison with larger, recognizable Petricolae, to identify the younger forms.

No specimens were found that were small enough to give an indication of the shape and size of the prodissoconch.



*Petricola*

## Petricola

Taken from stage sandbox #1 on July 22nd, 1942.

One valve drawn on a smaller scale than preceding specimens. Each square has the same value, namely about 71u, Whoel valve is pale yellow to white in colour and prodissoconch cannot be distinguished, but is yellow. The umbo is quite sharp and points forward.

### Measurements

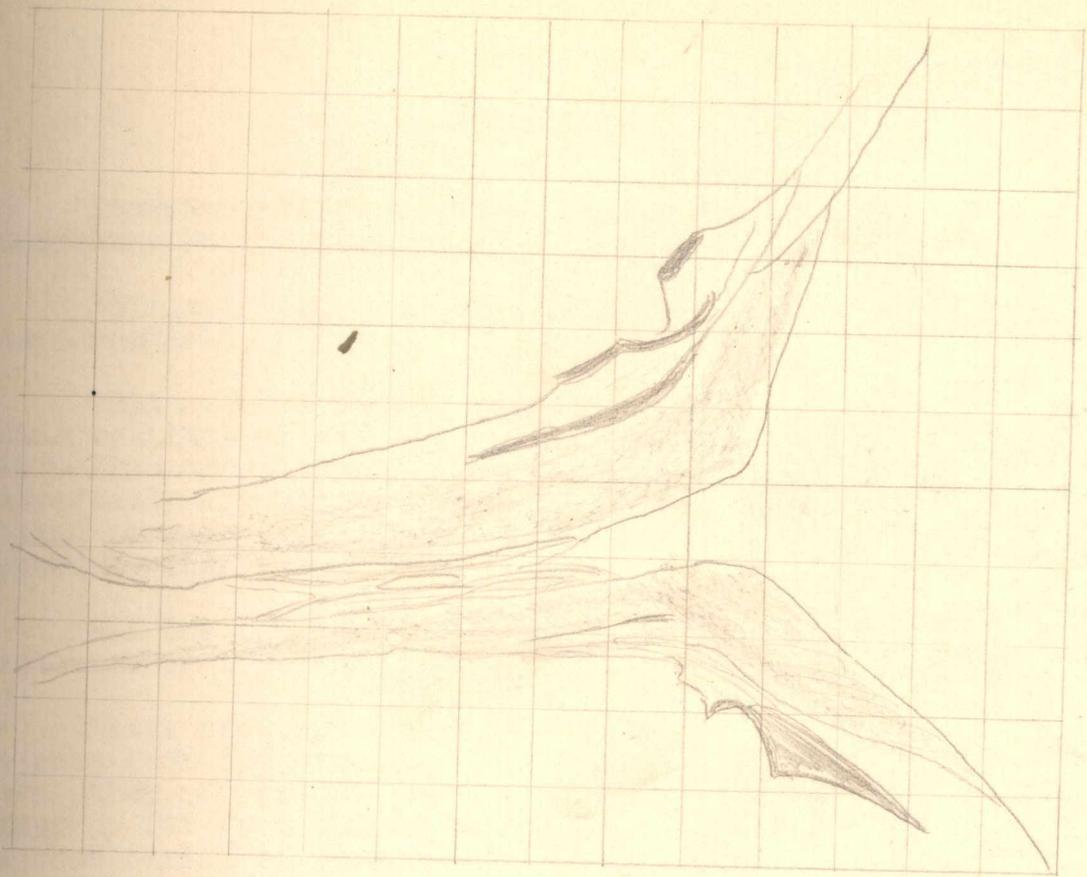
H = about 140 oc.Divs. = 980u  
L = " 165 " = 1155u

There are circular markings around the shell following the shape of the shell, but they are not prominent and valve seems to be quite smooth. Not as numerous as types two and four in the boxes.

They seem to be much less easily killed than other types since empty shells were not found in the early sample until August 29th, more than a month after being removed from the sandbox.

In larger specimens there appears a colour difference in the dissoconch, the shell looking dirty white, contrasting with the yellow colour. This whiteness appears in the dissoconch after the animal has reached the height of about 980u so that specimens after reaching that size are two-toned. The size at which this colour difference becomes evident, seems to vary from individual to individual. In one the change appears at H = 65 = 455u. In a third the line of demarcation is difficult to distinguish. As this animal grows it comes to look very much like a clam, being distinct from the clam only in possessing teeth on the hinge line, and in having a more rounded rather than square cut posterior end, than Mya. The teeth, with age, of course, become heavier and larger.

Another constant feature is the ligament joining the two valves. As the animal grows, the ligament becomes thickened and brown near the umbo while  $\frac{1}{2}$  -  $\frac{3}{4}$  of it remains transparent and fibrous. The outward, radiating ridges, characteristic of adult Petricolae, do not appear until the animal reaches a size of about 1400 = 1.4mm. in height.



An attempt to show the hinge line of *Petricola* from within.

Tellina

Representatives of this species were found in all sandboxes but no very small specimens were obtained.

In connection with this animal a very interesting development occurred.

When sandbox #4 was screened on September 11th, eighty-nine tellinae of all sizes were procured. These were all left in a dish of salt water in the laboratory over the dinner hour. Apparently stimulated by the sudden rise in temperature they began to spawn. When they were next observed the water was crowded with eggs.

All the tellinae were removed to a dish of clear water at room temperature and the spawning reaction was observed.

Sexes are separate. In the act of spawning the female ejects from the excurrent siphon a swift steady thin stream of ova which shoots out to a distance of six inches. The stream is kept up for from thirty seconds to a full minute. Then there is a rest period of several minutes after which spawning may begin again.

The spawning action of the male is the same, except that the current is not as swift and the sperm is not carried as great a distance.

In both sexes the siphons are extended during the procedure and are not withdrawn after the spawning burst.

Spawning was observed to occur even in the smallest specimens which were not over 1.5 mm. in length.

The unfertilized eggs are irregular in shape. As soon as an egg is fertilized it begins to round up and in from fifteen to thirty minutes it is perfectly spherical. The egg then starts to divide.

Newly fertilized eggs were collected for culture. The greatest portion of them were placed in a large battery jar of salt water, the water having first been strained through #18 plankton netting. Straight hinge stages had developed by the following day. Drawings, together with observations and a few measurements, are included. Samples of one day and two day old larvae were preserved on September 12th and 13th, respectively.

The occurrence of spawning of all sizes of tellinae in the laboratory would indicate that several generations mature and spawn in the same summer.

## *Tellina*



A very young straight hinge stage of *Tellina*, spawned and reared in the laboratory. Many of them seem to have the concave hinge line but this is probably a characteristic of extremely young stages only.



Another very young stage. Indentation is lost. The shell outline is not heavy. Between the shell line and the visceral mass the colour is light green with a few dark specks through it.

The visceral mass is more of a grayish green colour and at this stage its outline is not very definite. It is noted that at this stage, when the velum is extended the whole visceral mass moves down leaving a vacant space under the hinge line.

Tellina

Measurements

Height		Length		Hinge line	
oc.Divs.	Micra	oc.Divs.	Micra	oc.Divs.	Micra
8	56	9	63	5	35
7	49	8	56	5	35
8	56	9	63	5	35
8	56	9	63	5	35
9	63	10	70	5	35
8	56	9	63	4	45
8	56	9	63	5	35
8	56	9	63	4	49
8	56	9	63	5	35
8	56	9	63	5	35
8	56	9	63	5	35
8	56	9	63	5	35
9	63	10	70	5	35
9	63	10	70	5	35
8	56	9.5	66.5	5	35
8	56	9.5	66.5	5	35
9	63	10.5	73.5	5	35
9	63	10.5	73.5	5	35
9	63	11	77	5.5	38.5
8	56	9.5	66.5	5	35
9	63	10	70	5	35
9	63	10	70	5	35

Appearance September 13/42

The larvae look much the same as they did yesterday, as far as shape is concerned. Most of them have the slight indentation of the hinge line. They have not so much of a green tint as they had, but rather a pale gray to pale pinkish gray colour. The visceral mass being only slightly darker - more granulated, than the space between the visceral mass and shell.

They look more like young oyster larvae than anything else. The above observations were made on larvae in a sample taken from the small culture dish. Larvae taken from the large battery jar were more uniform in appearance and most had very little or no indentation of the hinge line. They were still a pale gray green colour.

Records of the numbers of various types of bivalves occurring in some of the samples taken from the sand box collectors follow:

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1. Sandbox #3. Sample collected on July 31st.

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Cumingia (Type 2)	39
Type 1	25
Type 4	15
Clam (mya)	7
Mussel	7
Quahaug	7
Petricola	7
Razor Clam	2 (dead)
Oyster	<u>1</u>
Total	110

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2. Sandbox #4. Sample collected on August 6th

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Tellina	55
Cumingia (Type 2)	17
Clam (Mya)	1
Petricola	1
Type 4	<u>1</u>
Total	55

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The result of screenings were:

1. Sandbox #4.

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Cumingia (Type 2)	257
Tellina	89 (roughly divided into
Petricola	80 (45 size groups) 80 (all sizes)

Sandbox #4 (Continued)

Razor Clams	25	(5 were dead)
Clams (Mya)	19	(15 large and 5 small)
Quahaug	<u>1</u>	
-	Total	466

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2. Sandbox #5

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Clam (Mya	55	
Type 1	31	
Cumingia (Type 2)	17	
Tellina	10	
Gemma	10	(Probably washed in)
Unknown (not seen before)	3	
Quahaug	<u>1</u>	
	Total	128

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3. Sandbox #3.

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Cumingia (Type 2)	95	
Type 1	88	
Quahaug	18	
Tellina	13	
Type 4	4	
Petricola	3	
Unknown (same as one above	<u>2</u>	
	Total	224

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Type 4, which was found in large numbers in early samples (on which counts were not made), is very scarce in the final stock taking. This would be explained if Type 4 were a bivalve which did not burrow deeply into the sand, for, in letting the boxes down into the water after taking samples, the top layer of sand was always washed out.

Considerable variation in the bivalve population of different boxes occurs. Examination of the specimens found reveals too that in box #4 soft-shell clams, razor clams, and petricolae grew to large sizes, while in boxes #5 and #3 all bivalves were quite small. Apparently growing conditions differ a great deal from place to place but there is no adequate explanation for the facts.

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- Stafford (1906) On the Recognition of bivalve larvae in plankton collections. Contributions to Canadian Biology. (1906 - 1910).
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