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EXPERIMENTS IN REARING SMALL OYSTERS, MALPEQUE AREA, 1937.

by

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Experiments in rearing small oysters in the Malpeque bay area in 1937 were along three lines: the use of gravel flats at extreme low tide level; the use of floating trays with board bottom and wire ends; and the use of board trays suspended from a float. These were explored as they seemed to offer some prospect of cheaper or more effective rearing methods than those already developed and adopted. As will be seen below these expectations were realized in the first two at least although further experiments are desirable to confirm the tentative conclusions from the 1937 results and to explore the possibilities more thoroughly.

Unfortunately the "set" in 1936 was both poor and late and the yearling spat at the beginning of 1937 was, therefore, unusually small. All the experiments described here were started in July - i.e. after a considerable proportion of the season's growth. The results do not, therefore, give a complete picture and this makes repetition specially necessary. It is planned to repeat and expand the 1937 experiments in 1938 starting as soon after open water as possible and using the 1938 spat which is of good size.

The details of the experiments follow. For comparison data are presented for spat reared in a floating, wire-bottomed tray of the type described in Bulletin XLVIII and now extensively used by the industry. The growth data are summarized in the table for all the experiments.

A. Gravel flats at Little Curtain island.

The rearing of small separate oysters on shallow natural grounds was the subject of experiment in 1935 and other years and the conclusion was then reached that the use of natural grounds was not promising when compared with floating trays. A number of factors were responsible among which may be mentioned growth of algae and consequent silting and mortality or distortion, dispersal by wave action sometimes accompanied by burying, penetration of starfish to lowtide level and the very limited area of firm bottom in sheltered situations. Later experience by oyster farmers showed that in certain exceptional situations, such as small runs at the mouths of creeks for example, separate spat could be reared successfully but none of these comprised any considerable area. For an important development of rearing on natural ground, which was obviously desirable to avoid the expense of the trays, it was necessary to find considerable areas of firm bottom not subject to shifting or to severe wave action, not subject to excessive algal growths and silting, and sufficiently high to avoid starfish. This seemed an improbable combination as in sheltered situations the intertidal zone is usually narrow in this area and bottoms relatively soft and subject to silting.

Attention was first drawn to a promising area at the north end of Little Curtain island by Mr. Brenton Clark, of Summerside, an enterprising oyster farmer, and the area was explored early in 1937. In this part of the bay heavy wave action has produced wide flats near the level of an extreme low tide. At the northern end of Little

Curtain island several acres of these flats consist of gravel lying over red clay - a type of bottom in itself resistant to shifting. It lies next to the shore and is protected by a great width of sand flats at about the same level which break heavy seas before they reach the gravel. The level of the gravel flats used in the 1937 experiments is such that they are dry at extreme low tides only - i.e. for only a few hours each month. The depth varies from about one to about three feet during the small tides when the moon is over the equator. Starfish were found to be almost completely absent and the algal growth on the gravel very limited. No fine silt was apparently settling. Thus the flats offered as close an approach as could be found to the combination of firm bottom, freedom from dense algae and silt, protection from severe wave action and freedom from shifting. They also offered salty water conducive to the formation of a strong shell.

Preliminary experiments in the use of these flats were started on July 9. An area about 75 feet by 42 feet was marked off and divided transversely into four plots of approximately 800 square feet each. Spat and small oysters were planted on these as follows:

1. ca. 32,800 large 1935 spat reared on trays in 1936.
2. ca. 35,000 small 1935 spat reared on trays in 1936.
3. ca. 19,400 large 1936 spat selected by screening after removal from the collectors the previous day.
4. 100 cardboard collectors with 1936 spat broken into sections.

Samples of each lot were measured on July 9, August 16 and when the oysters were removed in the autumn. The data are summarized in the table.

It was found that the pieces of collectors planted on Plot 4 were soon widely scattered by wave action. The other lots were not badly enough shifted to affect commercial operations seriously but there was unfortunately some mixture from one plot to another. This was apparently very slight before the taking of samples on August 16 and it is believed that the samples taken from Plots 1 and 2 in September were affected very little. The autumn sample from plot 3 however (October 18) undoubtedly includes some oysters from the other plots. The spat in the pieces of collectors on Plot 4 could, however, be identified with certainty and plenty remained to indicate the rate of growth.

Owing to the necessity of using infrequent and unreliable extreme low tides, removal of the oysters was started on September 17 and oysters were recovered as follows:

Plot 1.	Sept. 22.	8 bbl. of ca. 2800 oysters/bbl.	ca. 22,400
Plot 2.	Sept. 17.	4 bbl. of ca. 4200 oysters/bbl.	ca. 16,800
	Sept. 22.	2½ " " 4200 oysters/bbl.	ca. 10,500
Mixed lots principally of Plot 3 oysters:			
	Oct. 18.	2 bbl. of ca. 5750 oysters/bbl.	ca. 11,500
	Oct. 27.	1 bbl. of ca. 5750 oysters/bbl.	ca. 5,750
		Total	ca. 67,000

The 67,000 oysters recovered amount to about 78% of the 87,000 oysters planted. Owing to the shifting from one plot to another it is difficult to estimate the proportion recovered from each plot but they are probably about the same.

Owing to difficult conditions for recovery many oysters remained some of which will probably survive (as will be apparent in the spring of 1938) while a few were probably stolen by those picking oysters in the vicinity, in spite of the employment of a special guardian by the Department. Both the recovery and the protection could be improved by oysters farmers using the flats. The important question at this stage is that of the mortality. Only about one per cent of the oysters recovered were dead and it seems certain that the mortality was low.

The oysters in plots 1 and 2 were somewhat overcrowded in places, leading to distortion. But the quality of the oysters recovered was very good on the average. Where not overcrowded the shape was good and the shells average considerably stronger than those of oysters reared on trays at the head of Bideford river.

When the measurements of spat taken from plot 4 on September 17 are compared with those of spat from trays at the head of Bideford river on October 19 to 22 it is evident that the growth was more rapid on the flats. Oysters from plot 4 could be identified with certainty and the figures for the growth are not affected by the shifting from plot to plot. The small amount of growth which would occur after September 17 would not affect the picture much but it might have been different if the experiment had been started at the beginning of the open water season. Previous work has shown that much growth occurs before July 9 when these experiments were started and this early growth may be greater at the head of the rivers than at Little Curtain Island. It is planned to repeat and expand the experiments in 1938 so as to give a better comparison of the entire season's growth on the flats and in floating trays at the head of Bideford river.

The capacity of the flats is of great practical importance. It was evident that plots 1 and 2 were slightly overcrowded although this might have been overcome by raking the oysters over to reduce clustering and burying, and to keep the distribution as even as possible. The concentration on those plots may be taken as the approximate upper limit for these flats. Plot 3 was evidently well below the crowding level.

An acre contains 43,560 sq. ft. or 6,272,640 sq. inches. At the concentration of 0.3 oysters per sq. inch, as in plots 1 and 2, this would hold about 1,880,000 oysters. The average lengths in plots 1 and 2 were 6.7 cm. and 5.7 cm. respectively or about 2.7 and 2.3 inches. It seems therefore safe to say that these flats will successfully produce about 1,880,000 oysters $2\frac{1}{2}$ inches long per acre or would rear about 3,000 bbl. of potential marketable oysters to that size. These figures are, however, based on the assumption that the mortality is negligible on the flats. Using the 78% recovery as a basis the figure is reduced to about 2,300 bbl. Allowing also for a 15% mortality from this $2\frac{1}{2}$ " size to marketable size (certainly an ample allowance) the figure is still about 2,000 bbl.

If oysters are disturbed to prevent clustering, crowding is probably a matter of volume rather than length. With this assumption 1,880,000 2 $\frac{1}{2}$ -inch oysters would be the equivalent of about 3,670,000 2-inch oysters which would be well-grown tray oysters. This is the production of about 400 4' x 12' floating trays properly culled during the growing season.

To summarize:

1. Preliminary experiments were made in 1937 in the use for rearing small oysters on gravel flats at Little Curtain island. The flats are at the level of an extreme low tide, protected from severe wave action by wide sand flats at about the same level and free from starfish, dense algal growth or silting.
2. Growth from July 9 to the end of the season compared favourably with that of oysters on floating trays at the head of Bidford river. It is planned to have 1938 experiments cover the whole season.
3. Spat on pieces of cardboard collectors were badly scattered but small separate spat of 1936 and small oysters of 1935 were scattered only short distances. This confused the results of the four lots of oysters used and in 1938 it is planned to separate experimental plots by a safe distance.
4. Only about 78% of the oysters were recovered but some were left and some perhaps stolen. Only about 1% of those recovered were dead and the mortality was apparently very low. The survival of those left over winter will be observed.
5. The shape and shell-thickness of the oysters reared was on the average good although where overcrowding occurred some distortion resulted. The oysters reared on these flats should be raked over to keep clustering and burying at a minimum and distribution as even as possible.
6. Assuming the concentration on two plots where some overcrowding occurred without any raking to be about the maximum, the capacity of the flats for rearing oysters would be sufficient to produce enough 2 $\frac{1}{2}$ -inch oysters per acre to make about 2,000 bbl. of marketable oysters after allowing for a 15% mortality in the interval. It is indicated that the capacity of one acre is equivalent to about 400 4' x 12' floating trays. Even if this capacity is not realized it is evident that these flats have great potentialities.
7. With a 75% survival on the flats (which may be bettered) as compared with a survival of over 90% on floating trays, the cost of producing small oysters for planting (including cost of producing separate spat) would be one half or less that of the floating trays.

B. Board-bottomed floating tray.

The rearing of separate spat, obtained on cardboard collectors, on floating trays with wooden covers and wire-cloth bottoms has been described in Bulletin XLVIII and has been adopted by the industry. Much of the expense of the trays of this sort is the cost of the wire-cloth which at about 7 cents per square foot amounts to about \$3.50 per 4' x 12' tray and which lasts only about three years. With the development of a cheap preservative for wood against shipworms reducing the cost of painting a board-bottomed tray to a small amount

as compared with the great expense of copper paint the relative cheapness of such a tray as compared with a wire-bottomed tray has been increased, and further experiment along this line was carried on in 1937.

Earlier trials of board-bottomed trays had given discouraging results but in them the trays had been made only four inches deep. This depth is satisfactory with wire-cloth bottoms through which circulation occurs but is insufficient for a board-bottomed tray in which all circulation is obtained through wire cloth ends. In 1937 a tray 4 ft. wide, 12 feet long and 1 foot deep with sides, top and bottom of wood and ends of wire cloth was tried and it gave promising results.

12,000 1936 spat, which had been removed from the collectors July 8 to 12 after being held on floats during the spring, were placed on this tray July 20. Measurements of the spat on July 9, August 20 and October 19 are given in the table and may be compared with those for the same quantity of spat on a 4' x 12' tray of the usual type with wire-cloth bottom and wooden sides, cover and ends.

The data indicate that the growth in the experimental board-bottomed tray was more rapid than that in the ordinary wire-bottomed tray and that the shape of the oysters produced was reasonably good. The latter would doubtless have been improved by more frequent raking or culling, the spat in the board-bottomed tray and wire-bottomed tray alike being uncultured throughout the season and being raked over only once.

The following table gives approximate costs of maintaining the board-bottomed tray and the ordinary wire-bottomed tray. The figures are only approximate as costs of both labour and materials vary greatly.

Original cost:

Lumber	50 sup. ft. $\frac{1}{2}$ " boards	0.75	50 sup. ft. $\frac{1}{2}$ " boards	0.75
	36 lin. ft. 2" x 4"	.50	75 sup. ft. 1" boards	1.50
	100 " " 1" x 3"	.50	20 lin. ft. 1" x 3"	.10
Nails, staples	1 lb. galvanized	.10	1 lb. galvanized	.10
Wire cloth	50 sq. ft. at 0.7	3.50	8 sq. ft. at 0.7	.56
Tar-copper	1 gal. (two coats)	.30	1 $\frac{1}{2}$ gal. (two coats)	.45
Labour	6 hrs. at .30	1.80	6 hrs. at .30	1.80
		<u>\$7.45</u>		<u>\$5.26</u>

2nd. year, 4th year, etc.:

Tar-copper	2/3 gal. (two coats)	.20	1 gal. (two coats)	.30
Labour	4 hrs. at 30	1.20	4 hrs. at .30	1.20
Misc.	Nails, wood, etc.	.25	Nails, wood, etc.	.25
		<u>\$1.65</u>		<u>\$1.75</u>

3rd. year, 5th. year, etc.:

Tar-copper	2/3 gal. (two coats)	.20	1 gal. (two coats)	.30
Labour	4 hrs. at 30	1.20	4 hrs. at .30	1.20
New wire cloth	50 sq. ft. at .07	3.50	8 sq. ft. at .07	.56
Misc. nails, wood, etc.		.25	Nails, wood, etc.	.25
		<u>\$5.15</u>		<u>\$2.31</u>

The above figures are for 4' x 12' trays, made of unplanned spruce and painted with the tar-copper oleate mixture. Experience has shown that the wire-cloth will last for at least two years and often three; so that the above estimates based on a life of two years are ample. The wire cloth must be removed and replaced each year for satisfactory painting and tightening. This accounts for the labour of upkeep equalling that for the board-bottomed tray which requires more painting. The use of 1" boards for the cover of the board-bottomed tray is provided for to give greater stability. Some damage by shipworms is to be expected in the slats on the bottoms of the trays where the protective coating is sometimes scraped off when trays are taken ashore for culling. This has been allowed for.

To summarize the estimated costs: The wood-bottomed tray has an original cost of about \$5.25 of which \$1.80 is labour, and an average annual maintenance cost of about \$2.00 of which \$1.20 is labour. The wire-bottomed tray has an original cost of about \$3.50 of which \$1.80 is labour, and an average annual maintenance cost of about \$3.40 of which \$1.20 is labour. Averaging the total cost over five years the average annual cost for the wood-bottomed tray is about \$2.65 of which half is labour and the average annual cost of the wire-bottomed tray is about \$4.22 of which \$1.32 is labour. The labour costs are about the same but the wire-bottomed tray has an average annual cost of materials of about \$2.90 and the wood-bottomed tray only about \$1.33. Some saving may be possible below these estimates.

As the 1937 results indicate that the board-bottomed tray is as satisfactory as the wire-bottomed tray and has about the same capacity the reduction in cost makes it preferable. Considering that the 4' x 12' tray will provide good growing conditions for 10,000 spat if the larger spat are culled out and planted during the summer, the cost of the tray (exclusive of care of spat and tray when in use) is reduced to about .26 per 1,000 spat reared, and of this half is labour.

C. Open board trays suspended from a float.

In the first experiments with rearing separate spat on trays in 1933 a series of open trays suspended from a float were used. (See "Rearing oyster spat protected from starfish" - a manuscript report presented April, 1934). Rapid growth occurred but the shape was very poor on the lower trays which were not disturbed. It was found, too, that suspension from a two-puncheon float was unsafe and that the method of suspension used was very inconvenient.

Late in 1937 a preliminary trial was made of a variation of this method. It was considered that about 30 trays 3 ft. by 8 ft. could be suspended from a large 4-puncheon float in six vertical series of five. The cost would then be relatively low, now that a cheap protection against shipworms is available. There seemed some prospect that the rapid growth might make this method worth while if practical difficulties could be overcome. The greater stability

of the 4-puncheon float, as compared with the 2-puncheon, largely removes the risk of the suspended trays being overturned. In place of the method of suspension used in 1933, each tray was suspended individually with ropes in the 1937 experiment. A single vertical series of 4 4' x 6' trays was used, the trays being suspended at depths of 2', 3', 4' and 5'. As a control a floating 4' x 6' tray with wood cover and wire bottom was moored to the 4-puncheon float from which the trays were suspended. 1936 spat, which had been removed from collectors July 8 to 12 and which had been held in the interval on wire-bottomed trays, were used and 6,000 were placed in each 4' x 6' tray on August 5. This was the same concentration as was used in the board-bottomed floating tray and the control tray.

The results were in agreement with those in 1933. Growth on the suspended trays was more rapid and the shape poor. The oysters in the suspended trays were not disturbed except that the uppermost tipped sideways a little in a storm and the level was readjusted and the spat redistributed. This may account for the better shape in that tray as compared with the lower ones. In the undisturbed trays a certain amount of silt settled.

It was found that the handling of the suspended trays was difficult, and it appears that the extra labour needed for the same care as is given to floating trays may make the method more expensive even if the poor shape can be overcome. It is planned to continue the experiment in 1938 using the suspended trays throughout the season and giving some of them as much cleaning and culling as has been found desirable for floating trays and as will be given "control" floating trays. A detailed record of the labour required for this will be kept as well as records of growth and survival.

D. Table summarizing growth of spat in 1937 rearing experiments.

The measurements of spat in the above rearing experiments, including a "control" 4' x 12' wire-bottomed tray, are summarized in the accompanying table. The table is largely self-explanatory.

Samples were taken wherever possible by cleaning completely more than one small patch of the tray or plot, in this way avoiding selection by picking up individual oysters.

The range in length, median length, average (arithmetic mean) length and concentration have obvious meanings.

The shape is given as judged when the sample was examined. This takes into account factors which were not measured such as shell strength and bluntness of "lips". These judgements were made independently of the figures for length/width. It is obvious, however, that there is close correlation, and it may be stated as a matter of observation that in general a low figure for length/width is almost always accompanied by other good characteristics. This is the only figure indicative of quality which is given, although average weight is also desirable and has sometimes been determined. The latter brings thickness of the animal and shell thickness into the picture although it does not differentiate between them.

The $(\text{length} - \text{width})/2$ is given as a better indication of the growth than the length alone. The data would permit calculation of the relative area as indicated by length X width but this involves a great deal more work. The length is measured as the greatest length from the hinge to the posterior end of the oyster. The "width" is

Table summarizing measurements of small systems in rearing experiments in 1937.

Experiment.	Range in Median Mean Mean				lgt/width.	Shape.	No. per sq.in.	No. in sample.	Date.
	length. (cm.)	length (cm.)	length (cm.)	(1st)/2 (cm.)					
Little Curtain in flats									
1. Large 1935 systems from trays.	2.9-5.8	4.2	4.26	3.97	1.26	Good	ca.0.3	126	July 9
	3.9-6.3	5.2	5.16	4.65	1.26	Good	ca.0.3	80	Aug. 16
	4.5-8.7	6.6	6.66	5.69	1.44	Fair	"	200	Sept. 22
2. Small 1935 systems from trays.	1.8-4.3	3.3	3.20	2.93	1.17	Good	ca.0.3	296	July 9
	2.8-5.4	4.2	4.20	3.88	1.18	Good	"	116	Aug. 16
	3.9-7.6	5.6	5.66	4.88	1.41	Fair	"	215	Sept. 17
3. Large 1936 separate spot.	1.2-3.9	2.2	2.27	2.12	1.09	Good	ca.0.17	216	July 9
(mixed sample)	2.2-4.2	2.9	2.95	2.91	1.10	Good	"	117	Aug. 16
4. 1936 spot on pieces of collectors.	3.3-6.4	5.2	5.01	4.43	1.25	Good	"	131	Oct. 16
	0.6-3.7	1.9	1.95	1.89	1.16	Good	7	126	July 9
	1.6-5.0	3.1	3.19	2.94	1.19	Good though clustered		136	Aug. 16
	2.5-4.4	4.1	4.09	3.66	1.35	Clustered but good		271	Sept. 17
Wood-bottomed tray.									
	0.6-3.7	1.9	1.95	1.89	1.16	Good	ca.1.74	126	July 9
	1.4-4.9	3.0	3.11	2.77	1.26	Good	ca.1.74	146	Aug. 20
	2.5-6.2	4.0	3.98	3.48	1.34	Fairly good	"	266	Oct. 19
Wire-bottomed tray. ("Control")									
	0.6-3.7	1.9	1.95	1.89	1.16	Good	ca.1.74	126	July 9
	2.0-5.0	3.3	3.33	3.06	1.21	Good	"	140	Aug. 20
	2.1-6.2	3.6	3.64	3.20	1.27	Good	"	491	Oct. 22
Trays suspended from float.									
	0.6-3.7	1.9	1.95	1.89	1.16	Good	ca.1.74	126	July 9
1. Control, floating.									
	2.0-4.8	3.4	3.30	3.18	1.18	Good	"	142	Aug. 16
	2.3-6.3	3.6	3.71	3.36	1.24	Good	"	209	Oct. 20
2. Depth 2 feet.									
	2.2-4.4	3.3	3.27	3.08	1.18	Good	"	149	Aug. 16
	2.5-6.2	3.9	4.02	3.58	1.33	Fairly good	"	163	Oct. 20
3. Depth 3 feet.									
	2.1-4.8	3.5	3.39	3.15	1.26	Good	"	149	Aug. 16
	3.3-8.0	5.0	5.19	4.75	1.57	Very poor	"	125	Oct. 20
4. Depth 4 feet.									
	1.7-4.7	3.2	3.16	2.93	1.16	Good	"	145	Aug. 16
	3.3-7.4	5.3	5.24	4.37	1.26	Very poor	"	63	Oct. 20
5. Depth 5 feet.									
	2.2-4.9	3.5	3.38	3.11	1.19	Good	"	123	Aug. 16
	3.5-7.3	5.2	5.24	4.33	1.26	Very poor	"	148	Oct. 20

Summary.

Data are presented on rearing experiments in 1937.

Spat and small oysters planted on gravel flats at low tide level at the north-west end of Little Curtain island grew at a rate which compares favourably with that on trays at the head of Bideford river. About 78% were recovered and some living oysters were left on the flats. It is indicated that enough oysters could be reared on an acre of these flats to produce about 2,000 bushels of marketable oysters, allowing a mortality of 15% between removal from the flats at about 2½" and attainment of marketable size. The experiment was very promising and the flats of great apparent value for rearing purposes. Shape of the reared oysters was good.

Spat on a board-bottomed floating tray, 4' x 12' and 1' deep with wire cloth in the ends, grew at about the same rate as spat on a wire-bottomed tray of the usual type. Shape was somewhat poorer than on the wire bottoms, but it is believed that this could be overcome by handling. A table of costs is presented indicating the much smaller expense of the wood-bottomed tray.

Experiment with open wooden trays suspended from a 4-punchon float gave results similar to those with suspended trays in 1935. The growth on the lower trays of a vertical series was fast but the shape very poor. These trays were not disturbed and it is believed that the shape could be greatly improved by handling. These trays are being tried as a possible prospect for reduced cost or more rapid growth, but are not regarded as very promising.

The 1937 experiments will be repeated in 1938. The 1937 spat is of normal size so that the rearing experiments can be extended to cover the entire season and to give a more complete picture of the results of the various methods.

Rearing Oyster Spat Protected from Starfish.

Report on work during 1933.

A.W.E. Needler.

Scope and significance. In this report are described some experiments in rearing oyster spat on trays, in boxes or in protected enclosures which were initiated in 1933 chiefly as an attack on the starfish problem. Losses caused by starfish from the time of planting spat until they reach a length of $1\frac{1}{2}$ or 2 inches are the most serious obstacle to profitable oyster farming. Although profitable yields have been obtained by planting spat on beds from which starfish had been mopped even in the best cases the loss was large. In some cases almost all the spat were killed, in many over 90% were killed and a survival of 20% would be considered good and would assure a profitable yield. The collection of spat has met with good success each year since the work was commenced at the head of Hidesford river in 1929 and mortality of the oysters has everywhere been low after a size of $1\frac{1}{2}$ inches has been reached. So that the starfish problem is one of the most important facing us.

In another report already submitted by the writer this year ("Starfish and Oysters") an account is given of experiments and investigations attacking the problem including improvement of methods for catching starfish, study of the distribution and life history of starfish and study of the sizes of starfish which can attack oysters of various sizes. The latter experiments showed that oysters could usually resist successfully the attacks of starfish if two-thirds as long as the "diameter" of the starfish, and it was found that the very great majority of our starfish were too small to attack successfully oysters $1\frac{1}{2}$ to 2 inches long. This confirms our previous observations that the mortality of oysters was low

after reaching that size and our explanation of the losses as caused by starfish.

In this report an account is given of another attack on the problem - an attempt to rear the spat out of reach of the starfish to the size at which they are relatively safe. The attempt introduces immediately a number of other problems - factors influencing growth and survival, designing cheap apparatus, crowding and clustering and shape - and offers prospects of a number of beneficial results in addition to protection from starfish - e.g. prevention of smothering, production of single oysters, more rapid growth etc. The experiments during 1933 serve only to introduce the subject and extensions are planned during 1934.

The experiments were carried on at or near the Prince Edward Island Marine Station at the head of Bideford river. Many of the statements made above apply only to the Malpeque bay or similar areas as in other areas, of course, other problems are often much more serious than the starfish problem - e.g. spat collection, losses from drills, etc.

Sources of spat. Methods of spat collection are related to the problems of rearing spat. The spat used in the experiments in 1933 were collected on cement-coated cardboard "egg-crate filler" spat collectors in 1932. These collectors allow easy separation of the individual spat which is, of course, an advantage in the rearing of single oysters. In previous reports on spat collection it has been pointed out that when large pieces of these collectors were planted on the oyster grounds crowding and clustering resulted which was practically as bad as with shell cultch and that they offered little advantage over the latter. On the other hand the singled spat when planted on ordinary or even relatively clean bottoms smothered

easily and heavy losses occurred. Thus to make the cement-coated cardboard collectors worth while special methods of rearing the spat are necessary, and the rearing of spat on trays etc., in addition to its other advantages would bring into usefulness another kind of "cultch" to supplement the shell cultch which has been hitherto the chief satisfactory material for spat collection.

It is planned to extend the experiments to include some trials with spat on shells as it may be found that the rearing methods would be beneficial for them as well as for the singled spat from the cardboard collectors, although special problems of separating the spat would arise. Shells, when available, are more satisfactory than the cardboard collectors in a number of ways depending chiefly on the more fragile nature of the latter, and may be a better "cultch" material when spat are to be reared on trays etc., as well as when the spat are planted directly on the beds.

Holding spat over the winter. Our waters are frozen over for about four months and oysters do not grow for about six. The holding of the spat during this season when no growth occurs offers a special problem. The requirements for a method of holding them include: cheapness, convenience, sufficient circulation to prevent smothering and a method of placing the containers on hard bottom deeper than the bottom of the ice and of recovering them in the spring. As it has been found by several investigators that oysters remain almost continuously closed during the winter (ca. 0°C) it was thought that it would be possible to hold them in bulk piled fairly deeply. This has been found to be the case.

Over the winter of 1932-33 spat were held in trays about 2' x 3' made of $\frac{1}{4}$ " mesh galvanized wire cloth supported by copper painted hardwood strips 2" x 1" in cross-section. Two of these trays

which were originally made for rearing the spat, were tied together face to face leaving a space about 4" deep. In each of two trays about 20,000 spat were placed piled 2" to 3" deep. The spat were mostly 1 cm. to 2.5 cm. in length and many had a small piece of the cardboard collector attached. The trays were placed on a hard bed sufficiently far below the surface to escape the ice. The strips supporting the netting of which the trays were made supported them off the bottom slightly so that circulation was possible from below as well as from above. The spat were kept in the trays until the end of May and at that time between 5% and 10% were found to be dead. A higher proportion of the smaller were dead than of the larger. It is to be noted that a certain small proportion of the spat were doubtless dead when placed in the trays in 1932 and it is safe to estimate the mortality during the winter at about 5%.

To test the effects of holding the spat in bulk at the higher temperatures which were reached after the end of May, a small box of the $\frac{1}{2}$ " wire cloth 6" x 5" was filled with spat and suspended from a float on June 2nd. By July 11th no mortality had occurred, those on the outside were growing well and those inside not at all. Some silt had settled among the spat which must have reduced the circulation greatly. The absence of mortality in this case shows that in holding spat over the winter piled some inches deep there is no need to spread the spat on trays immediately to avoid mortality, i.e. that there is plenty of time to arrange the trays and put out the spat even allowing for bad weather and large quantities to be handled.

Spat put out in the autumn of 1933 were placed in simpler containers made for the purpose. A rectangular frame of 2 x 4 spruce on edge was made, the wire cloth for the bottom nailed directly to it and protected by wooden strips, and a simple cover made with wire

cloth and strips. For use in the winter copper-painting is not necessary and unplanned lumber is satisfactory, as the larvae of Teredo settle only in the summer. Thus one of the chief sources of danger and expense is absent in winter. The containers used in 1933 were filled completely and held about 22,000 spat each of an average length of 2 cm. The cost of the materials in these containers (inside dimensions 20" x 36" x 4") was about 55 cents (7 ft. 2x4 spruce at .02, 6 sq. ft. wire cloth at .06, and nails, etc.).

Details of rearing experiments. The experiments were rather crude attempts along what appeared to be promising lines. They do, however, indicate a number of factors influencing the growth and survival and their action, and in a number of instances met with considerable success. They serve as preliminary trials on which to base more intelligently planned experiments. The methods included (1) enclosure on firm shore at low tide, (2) large open floating tray, (3) trays suspended from floats and (4) shelved boxes of wire cloth suspended from floats.

The spat used in the trials were obtained from cardboard collectors in 1932 and held over the winter as reported above. The size varied between extremes of about 0.5 and 5.0 cm. with most between 1.0 and 2.5 and average and mode about 1.75 cm. Samples set aside for measurement were unfortunately left at the Prince Edward Island Marine Station and the size frequencies cannot now be presented in detail, but the above will serve to indicate the original size which was approximately the same in all the trials.

1. Enclosure on firm shore at low tide level. An area 8'x8' was selected on firm gravel-mud shore in the cove just west of the P.E.I.M.S. at the level of an ordinary low tide. It was surrounded on three sides by small stakes placed about 2" apart

to which wire cloth was attached making an effective barrier keeping out starfish.

Fig. 1. Enclosure for rearing spat. Bideford river, 1933.

The enclosure was prepared on June 2nd and 3rd and 4,500 spat were planted in it on June 5th there being an area of about 1 $\frac{1}{2}$ square inches per spat. A storm from the NE piled many of the spat into the inner western corner of the enclosure on June 25th but apparently few escaped from the enclosure, the force of the waves being broken by the spruce trees which had been anchored as bread-waters. By July 9th there had been little or no mortality, considerable growth and a growth of algae (largely green) without as yet an accumulation of silt. On Aug. 9th silt was accumulating among the algae, the growth appeared to have slackened and a considerable proportion of the spat were dying. A sample was measured and a second sample on Aug. 31st showed little growth in the interval and an increased mortality. By Aug. 31st about 23 of soft silt had accumulated. On Sept. 30th the spat were removed, 2210 being recovered alive and between 1,000 and 1,500 dead (largely as separate valves). The shape was very poor as compared with that of the spat reared on floats - being crooked, long and thin relatively. A few measurements indicate this: in inches 2 $\frac{1}{2}$ x1 1-8, 1 $\frac{1}{2}$ x1 $\frac{1}{2}$, 1 $\frac{1}{2}$ x1, 1 $\frac{1}{2}$ x1, 2x1 $\frac{1}{2}$, 1 $\frac{1}{2}$ x1 $\frac{1}{2}$, 1 $\frac{1}{2}$ x1 $\frac{1}{2}$, 2 $\frac{1}{2}$ x1, 1 $\frac{1}{2}$ x7-8, 1 $\frac{1}{2}$ x7-8. Average length (width = 1.65 (11 indiv.)). Range 1.2 to 2.5.

Table 1. Spat reared in enclosure on shore.

	When planted.	August 2.	August 31.	Sept. 30.
Length (")	Number	Number	Number	Number
$\frac{1}{8}$		1	4	0
$\frac{1}{4}$		3	3	1
$\frac{1}{2}$		24	11	7
$\frac{3}{4}$		33	25	15
1		26	27	15
1 $\frac{1}{4}$		12	22	27
2		1	10	8
2 $\frac{1}{4}$		0	4	4
2 $\frac{1}{2}$		0	0	2
2 $\frac{3}{4}$		0	0	0
3		0	0	1
Av. length.	ca. .75	1.35	1.46	1.63
Number weighed	-----	-----	54	50
Av. weight (gm.)	-----	-----	4.8	6.4

These shapes vary a great deal and some are extremely long and narrow.

The general results of this experiment are not as satisfactory as in many cases of rearing on floats. The spat were not crowded more than on floats (not nearly as much as in some cases) as regards the area per spat, but the circulation was probably more poorer. This is indicated by the accumulation of very soft fine silt which was apparently responsible for most of the mortality and poor shape, and possibly in part at least for the poor growth. On neighbouring unsheltered shore no silt accumulated and the spat occurring there naturally were of excellent shape and somewhat greater average size.

I had imagined, as a possible development, the use of a stretch of shore protected from severe wave action by anchored trees. It may be possible to arrange a second experiment in which more circulation is permitted without sufficiently severe wave action to remove or destroy the spat. On the whole, however, the results of this trial are much less encouraging than those on floats, with poorer shape and growth, and a loss of about 50%.

2. Large floating tray. A tray 15' x 4' was made with 4x6 spruce on edge along the sides and 2x6 spruce on edge across the ends. The floor of the tray was made of galvanized wire cloth nailed to the frame and supported underneath by 2"x1" stripes from side to side of the tray. All the wood was copper-painted after a priming coat of white lead paint. The tray when placed in the water with small spat at the beginning of the season floated with about 3" of the stringers out of water and gradually sank until they were almost covered at the end of the season. The tray was anchored in a very sheltered situation in McKinnon's creek at the head of Bideford river and a bundle of brush was tied to the line by which it was anchored, to form a breakwater.

The tray was prepared on June 6th and 15,000 spat placed in it. The inside area of the tray was about 7,500 square inches and there was about one half of a square inch per spat. Growth, however, was at first fairly rapid and there was an extremely low mortality. Green filamentous algae grew luxuriantly in the tray and large quantities were removed on July 11th and Aug. 30th. The spat overlapped one another almost from the beginning and by Aug. 30th were piled about 2" deep. Few, however, were grown to one another and the mortality remained low.

13,800 were recovered alive from the tray and about 1,100 (less than 10%) dead, a few being lost. The percentage grown to one another was about 5% the remainder being single. The shape, although much better than that of spat from the enclosure on shore, was on the average poorer than best obtained in the experiments which follow.

Measurements in inches (sample taken Nov. 6th):

1.3 x 1.1, 1.6 x 1.1, 1.8 x 1.2, 1.8 x 1.1, 2.1 x 1.3, 1.9 x 1.3,
1.6 x 1.2, 2.1 x 1.2, 1.7 x 1.3, 2.4 x 1.4, 1.4 x 0.8, 1.6 x 0.9,
1.8 x 1.1, 2.0 x 1.4, 2.0 x 1.2, 2.1 x 1.2, 1.3 x 1.1, 1.8 x 1.2,

2.0 x 1.4, 2.4 x 1.3, 1.8 x 1.4, 1.8 x 1.3, 2.2 x 1.3, 1.7 x 1.5,
 1.1 x 0.6, 1.6 x 1.3, 1.9 x 1.5, 1.3 x 1.1, 1.2 x 0.6, 2.3 x 1.8,
 1.9 x 1.7, 2.0 x 1.2, 1.9 x 1.2, 1.7 x 1.1, 1.7 x 1.2, 1.9 x 1.1,
 1.8 x 1.0, 2.4 x 1.4, 1.4 x 1.3, 1.5 x 1.0, 1.8 x 1.0, 1.6 x 1.1,
 1.4 x 1.1, 1.5 x 1.1, 1.7 x 1.2, 1.7 x 1.1, 0.8 x 0.5, 1.6 x 1.1,
 1.6 x 1.2, 1.8 x 1.1, 1.4 x 1.0, 1.3 x 1.0, 2.0 x 1.3, 1.2 x 1.1,
 1.1 x 0.8, 1.2 x 0.8, 2.6 x 1.6, 1.3 x 1.0, 1.0 x 0.7, 2.2 x 1.5,
 1.8 x 1.2, 1.5 x 1.2, 1.6 x 1.1, 1.1 x 0.9, 1.3 x 1.0, 1.8 x 1.2,
 1.6 x 1.1, 1.2 x 0.9, 2.0 x 1.1, 1.3 x 1.0, 1.4 x 0.7, 1.8 x 1.0,
 1.7 x 1.1, 1.3 x 1.2, 1.8 x 1.0, 1.4 x 1.4, 1.2 x 0.8, 1.0 x 0.7,
 2.0 x 1.5, 1.9 x 1.4, 1.7 x 1.2. Average length - width = 1.49.
 (81 indiv.) Range 1.0 to 2.0

Table 2. Growth of spat on large floating tray.

	When planted	August 30	October 17	November 6
Length (")				
1 1/4		---	---	1
1 1/2		---	1	3
1		5	1	19
1 1/4		13	3	48
1 1/2		16	21	83
1 3/4		21	13	68
2		29	17	37
2 1/4		16	11	10
2 1/2		8	4	6
2 3/4		3	---	---
No. measured		111	284	444
Av. length	ca. 0.75	1.84	1.81	1.50
Av. weight (gm)		6.7	10.7	7.5
No. weighed		38	70	80

The above table shows a decrease in the average length of spat in samples taken Aug. 30th to November 6th. The first sample was apparently not representative as my notes show that of 1,000 taken on that date and transferred to floats only 25% were 2" long or longer, as compared with over 50% in the sample in the table. No growth occurred between Oct. 17th and Nov. 6th as the temperature was approaching the lower limit at which feeding occurs. The Nov. 6th

sample was taken because it was suspected that the Oct. 17th sample was not representative. The average for the whole probably lies between the two.

The cost of the tray may be estimated as follows: wood of frame - ca.100 ft. at 2.50, wire cloth - 60 sq.ft. at .06 =3.60, nails, labour and copper paint ca. 2.00. Total original cost about 8.00. The trays would probably last for three years, with repainting, and the annual cost of the tray would be about 4.00 of which nearly half might be labour. This is a cost of ca. .30 per 1,000 oysters if the number reared is about 13,000. As this is apparently too high a number the cost, for best results, would probably be .40 or .50 per 1,000.

To summarise the results with the large floating tray. It was found to rear 13,800 oysters to an average length of close to 1 1/2" with a mortality of about 10% and the production of a reasonably good - though not the best - shape. Only 5% were grown to one another. The tray was moored in a very sheltered place and very little trouble was involved in looking after it. The oysters were apparently not overcrowded early in the season but became very much so later - as is indicated by the small amount of growth after the end of August. Possibly one of the hindrances to growth was the strong growth of algae in the tray.

It is planned to extend the experiments with trays of this type. By covering the trays the effect of exclusion of light and prevention of algal growth will be studied and at the same time more exposed situations can be used without danger of loss. In addition to this it is planned to try various concentrations, the effects of thinning part way through the season, the variations in growth and shape in different situations etc.

3. Trays suspended from floats. A number of trays ca. 2' x 3' made of wire cloth supported by copper-painted hardwood strips (1"x2") were suspended from a float similar to those designed for spat collection. The floats are described and figured in Note #28, Progress Reports, Atlantic Biological Station. The inside dimensions of the trays were 22" by 34" - an area of about 746 sq. inches. The sides were formed by 2"x1" wooden strips on edge.

The suspension of trays from floats offers some practical difficulty. The method employed was briefly as follows: For each set of trays four heavy (40 lb. ⁺ -) concrete weights were suspended by heavy galvanized wire (#9) (the "brace wire" fence) spaced so that they passed the ends of the trays close to the sides. The trays, provided with wires to the corners which could be hooked with a boat-hook, were attached to the large wires with small wire loops and allowed to slide down. The trays were weighed with bricks to make them sink and each tray rested on two pieces of wooden strips nailed on edge on the top of the tray beneath. This method was found to be cumbersome but it is difficult to design a method of suspending a large number of trays one above the other.

Two such series of trays were suspended from one of the two-puncheon floats. In each the lowest tray was about 8 feet below the surface, and six trays were spaced evenly between that depth and a depth of about 3 feet. Trays were not placed nearer the surface as they would then have been in slack water caused by the puncheons and the wire bags of shells which were hung about the float to make it more stable.

Unfortunately a heavy storm on Oct. 29th, after removing many of the bags of shells caused the float to overturn and the loss of much of the material just before the final examination. The data are, therefore, somewhat limited.

In one series the trays were open and in the other they were covered by a second similar tray fastened upside down over each. Let us first consider the open trays.

Six open trays were put out on June 5th to 9th each with 950 spat, leaving just over $\frac{1}{4}$ " sq. in. per spat.

Table 3. Spat reared on uppermost open tray.

Length (")	When planted	Aug. 4th	Aug. 31st	Sept. 29th
$\frac{1}{8}$		1	6	0
1		6	6	16
$1\frac{1}{4}$		17	20	30
$1\frac{1}{2}$		16	42	89
$1\frac{3}{4}$		7	27	115
2		8	17	105
$2\frac{1}{4}$		1	3	22
$2\frac{1}{2}$		0	1	9
$2\frac{3}{4}$		0	0	0
3		0	0	0
Number measured		56	122	388
Av. Length	ca. 0.75	1.47	1.55	1.74
No. weighed			51	
Av. weight (gm.)			7.0	

The growth of the spat in the uppermost open tray is indicated by the data in Table 3. An average length of $1\frac{1}{4}$ inches was reached - slightly higher than in the large floating tray. The shape was excellent and the weight at the end of September was high. No clustering occurred and mortality was only about 5%.

The uppermost tray was examined much more often than the lower trays as it was necessary to remove the upper trays to get at the lower. There was also some thinning in the uppermost - samples preserved etc. The lower trays were all closely similar and in general it may be stated that the growth was greater, the shape poorer and the clustering worse (about 5% grown to one another). The mortality was about 5%.

After the storm on Oct. 29th, 1960 living and 125 dead spat were recovered which had been dumped out of the lower open trays. Tonga especially prepared to catch small material by weaving wires

between the teeth were used. But it must be realized that the spat recovered were probably larger on the average than the spat as a whole on the lower trays. They are of some interest, however.

Table 4. Spat from lower open trays on float, recovered after storm.

<u>Length (")</u>	<u>Number</u>	
1	4	
1 $\frac{1}{2}$	10	
1 $\frac{3}{4}$	30	
1 $\frac{1}{2}$	56	
2	96	
2 $\frac{1}{4}$	36	
2 $\frac{3}{4}$	120	
2 $\frac{1}{2}$	77	
3	24	Average length 2.21"
3 $\frac{1}{4}$	26	
3 $\frac{3}{4}$	0	
3 $\frac{1}{2}$	0	
4	1	

The average weight was 16.8 gm. The largest was 4"x1 $\frac{1}{2}$ "x1". The shape was poor and there was a considerable amount of clustering.

Turning now to the double or covered trays, they were put out at the end of May (27th to 31st) with the same number of spat in each as in the open trays. When examined on July 11th the uppermost tray showed no mortality, not much algae and 2" as the maximum size of the spat. When recovered after the storm of Oct. 29th the order of the trays could not be distinguished as they had broken loose. The three recovered were, however, similar in every way indicating little or no effect of depth on the growth. 6.0% of the 2966 spat in the three trays were dead, and of the living 6.2% were clustered the remainder being single. In shape and proportion clustered these were indistinguishable from those recovered after dumping from the lower open trays. The shapes are indicated by the following measurements: 2.5 x 1.3, 2.3 x 1.0, 3.5 x 2.3, 2.0 x 1.4, 3.0 x 1.6, 3.5 x 2.0, 2.3 x 1.3, 3.0 x 1.3, 1.8 x 1.3, 2.2 x 1.6, 2.0 x 1.0, 2.2 x 1.2, 3.0 x 2.0, 2.5 x 1.5, 3.0 x 1.5, 2.6 x 1.6, 2.7 x 1.9, 2.4 x 1.7, 1.6 x 0.7, 1.5 x 1.0, 2.1 x 1.8, 2.5 x 1.4, 3.4 x 1.6, 2.8 x 1.3, 2.7 x 1.4, 2.7 x 1.6, 2.9 x 1.7, 2.0 x 1.0, 3.4 x 2.0, 1.8 x 1.4,

1.9 x 1.4, 3.0 x 1.8, 2.4 x 1.6, 2.7 x 1.3, 2.6 x 1.3, 2.0 x 1.3, 1.7 x 1.3, 1.7 x 1.2, 1.4 x 1.0, 1.6 x 1.0, 1.3 x 1.0. Average length - width 1.70 (41 indiv.).

Table 5. Length of spat from double trays.

<u>Length (")</u>	<u>Number</u>
1	4
1 $\frac{1}{2}$	13
1 $\frac{3}{4}$	22
1 $\frac{1}{2}$	19
2	20
2 $\frac{1}{4}$	14
2 $\frac{1}{2}$	23
2 $\frac{3}{4}$	16
3	18
3 $\frac{1}{4}$	4
3 $\frac{3}{4}$	7
3 $\frac{1}{2}$	1
4	2

The table shows the length frequencies. The average weight of 40 was 15.9 gm.

When allowing for some influence of selection by the tongs the spat from the covered trays and from the lower open trays are very similar indeed. The former being somewhat longer but the latter slightly heavier for their length. We may summarize these trays as producing the largest growth of any of the experiments both in length and weight, but poor shape (L-W-1.7) and some clustering (ca. 6%). The mortality was low. The shape was inferior to any of the others except those in the enclosure on the shore. This is contrasted with the excellent shape in the uppermost open tray. The latter was handled very often whereas the lower open trays and the covered trays were hardly handled at all.

although the trays suspended from the floats were shown to be capable of producing good growth and shape, the method is not very promising from a practical point of view. The suspension is cumbersome and so few trays can be suspended from a float that it becomes expensive. The cheaper open trays must be ruled out owing

to danger of loss. These difficulties must be overcome if this general scheme is to be made as good as the large floating tray or as the shelved wire-cloth boxes which follow:

4. Shelved boxes of wire cloth. A box of $\frac{1}{2}$ " galvanized wire cloth was made 6" x 12" x 24" (the dimensions being determined largely by the size of the pieces of cloth) and suspended on end with five horizontal partitions or shelves making four compartments about 3" high at the bottom and two about 6" deep at the top. Into these were counted (from bottom to top) 150, 250, 350, 450, 550, 650 spat respectively. They were put out on the float June 15, and on July 11th, had grown well but none of the compartments were yet full. The box was hung with the top about 2' below the surface and few algae or mussels settled on it.

On Aug. 2nd about one half of the spat from each compartment were transferred to the corresponding compartment in another box similar in every way except that it was divided into six equal compartments about 6" x 11 $\frac{1}{2}$ " x 4".

Table 6. Thinning of spat in shelved box.

<u>Comp't</u>	<u>Transferred to new</u>	<u>Left in old</u>	<u>Dead</u>	<u>Lost</u>	
Bottom A	75	71	4	--	
B	125	86	15	24	
C	175	178	27		30 extra
D	225	182	45		2 extra
E	275	234	21	20	
F	325	260	55	10	

It can be seen that some were lost or made their way from one compartment to another. These would be small enough to fall through the meshes and must either have died soon after putting out the box or have fallen through then. It is indicated, however, that there was a smaller loss or mortality in the bottom compartment (about 5%) and more in the upper compartments (up to about 10%).

Table 7. Sizes of spat in shelved boxes, Aug. 2nd.
Compartments.

Size (")	A (new)	A (old)	D (new)	D (old)	E (new)	E (old)
$\frac{3}{8}$	--	--	1	6	--	1
$\frac{7}{8}$	1	--	1	2	1	6
1	2	1	3	3	1	5
1 1-8	1	4	2	3	2	5
$1\frac{1}{8}$	--	1	7	6	5	10
1 3-8	1	5	8	10	3	8
$1\frac{1}{2}$	4	2	4	10	5	4
1 5-8	7	3	3	3	5	1
$1\frac{3}{4}$	3	5	2	5	8	1
1 7-8	5	5	1	1	2	2
2	--	1	1	--	4	--
Av. Lgt.	1.56	1.54	1.36	1.31	1.55	1.24

Table 7 gives the sizes of samples of spat measured. It shows a tendency to select the larger spat in transferring to the new box, but it also indicates that the spat in the lowest compartment grew best, in the "D" compartment least and better in "E". "E" had more spat but was twice as large. "D" was actually bulging and none of the other compartments had much room left. Rough observation indicated a gradation from "A" to "D" (and smaller spat in "F" than in "E"?).

Table 8. Lengths of spat in shelved box, Aug. 31st.
Compartment.

Size	A (new)	D (new)
$\frac{1}{8}$	--	1
$\frac{1}{4}$	--	6
1	3	27
$1\frac{1}{8}$	10	40
$1\frac{1}{4}$	17	40
$1\frac{3}{8}$	20	36
2	17	25
$2\frac{1}{8}$	5	4
$2\frac{1}{4}$	--	1
Av. Lgt.	1.69	1.48

Table 9. Spat reared in shelved box, Nov. 9.

	Compartment.					
	<u>A.</u>	<u>B.</u>	<u>C.</u>	<u>D.</u>	<u>E.</u>	<u>F.</u>
Alive	73	128	162	213	259	304
Dead	1	0	4	11	3	11
Average weight (gm)	14.1	13.2	10.9	9.9	7.7	9.4
Length.	--	1	--	2	4	2
1	1	1	4	3	9	10
1 1/2	8	9	8	11	11	12
1 1/4	19	12	15	13	13	21
1 1/2	21	19	13	19	15	15
2	15	19	13	16	11	19
2 1/4	6	6	5	3	3	6
2 1/2	3	5	7	2	3	4
2 3/4	--	2	--	1	1	1
Av. Lgt. (")	1.74	1.77	1.75	1.70	1.61	1.66

Tables 8 and 9 show the growth of the spat transferred to the new box. It shows that the lowest three compartments produced spat of similar lengths, that the lengths decreased to D and E and increased again slightly to F. The average weight of the spat showed a steady decrease from A to E and a slight increase again to F. F, although with more spat than E, has the advantage of another uncovered side from which to get circulation. The shape of all the spat was good. In the fuller compartments it was evident that the spat in the centre had grown least.

The above results, though somewhat crude, show that there are practical prospects to such a method. The mortality was low, the shape produced was good and the growth fairly good. The method will be used in further experiments in 1934 which will include comparison of effects of crowding independently of depth, and of depth independently of crowding, the effects of handling and jarring in regard to the formation of clusters and other minor points.

The boxes as constructed in 1933 require about 11 sq. ft. of wire cloth (at .06 66 cents) and a considerable amount of labour.

Supposing 125 spat to the compartment or 750 to the whole this represents a cost of 0.80 per 1,000 for materials alone and not including a means of suspension. This indicates that the cost of this method without modifications is double that of the large floating tray. A number of improvements are, however, possible. It was found that the wearing quality depends to a large extent on avoiding racking the wire cloth. Bending cracks the galvanized surface and permits rusting. It was found that the wire suspending the boxes should encircle them woven into the sides, instead of passing through only the upper corners.

General discussion. After the outline of each experiment given above it may be worth while to make what generalizations are possible, or rather to discuss various problems and results in the light of all the experiments combined. At this early stage this is a matter of sketching the problems and putting forward questions or suggested explanations, not one of summarizing results.

Growth. A great variation in the size attained by the spat at the end of their second summer (15 months old) was found, - both in the average sizes attained in the different experiments and in the sizes of the individuals within each experiment. The latter was always very large - e.g. $\frac{1}{2}$ " to 2 $\frac{1}{2}$ " in shelved box, 1" to 4" in covered trays suspended from the float. In fact the minimum size always approached the maximum size of the spat planted and we can say that there were always some which grew very little and some which died without growing at all. This suggests that some were always in very poor situations for growth - often through overcrowding. It seems possible also that some were weakly or injured by the spring and would not have grown or lived in the best conditions. A whole series of problems are raised in this connection. What causes the individual variations and can they be avoided or, rather, reduced by altering the

arrangement of the spat or trays, by thinning etc.? From the practical point of view this is very important and the relation between the increased cost (possible smaller number of spat per container) and increased growth is of interest in deciding what alteration of method pays. The observations hitherto suggest that in many instances spat have been crowded to such a degree that some have been unable to grow more than a very little, and that crowding would be profitably reduced until these extreme conditions were eliminated as such spat are just so much extra trouble with no profit. Experiments on crowding and its effects are planned for next season to supplement the preliminary experiments with the shelved boxes (p. 15) in which overcrowding was indicated as a factor in the reduction of growth. Position in the container - such as in sheltered corners - also appears to play a part in the individual variation superimposed on the effect of crowding. It is expected that more detailed observations in this regard will lead to alteration in the design of the trays, boxes etc.

The average sizes attained by spat reared may be summarized as follows:

	<u>Av.Length (")</u>	<u>Av.Weight (gm.)</u>	
Enclosure on shore	1.65	4.8	v.poor shape.
Large floating tray	ca. 1.6	ca. 8.	good shape.
Uppermost open tray	1.74	?	v. good shape.
Lower open and covered trays.	ca. 2.2	ca.16.	poor shape.
Shelved boxes, -			
most crowded	1.6	7.7	fair shape.
least crowded	1.74	14.0	good shape.

"Poor shape" means long, thin or twisted. It is always accompanied by low weight in relation to length.

Crowding is indicated as one of the chief factors influencing the average as well as the individual growth. It is the chief variant in the wire-cloth shelved boxes. The effects of crowding are more evident in the average weights than in the average lengths owing to its influence on shape. With the exception of the enclosure on the

shore in which siltiness and smothering played a part, the average size attained is roughly in inverse proportion to the crowding - the least crowded being the trays **suspended** from the floats and the most crowded being the large floating trays and the more crowded shelves in the wire boxes. Crowding is, of course, related to circulation and probably is effective through reducing the circulation and, consequently, the food supply. In the large floating tray circulation was possible only from below through the wire and growth may be increased by opening the ends to circulation, or by changing the situation of the tray to places with a stronger current. Experiments are planned to study influence of crowding and of strength of current.

The experiments do not give reliable indication of the influence of depth on the growth. Near the surface algae grow luxuriantly and tend to reduce the circulation, while below a depth of about 2 feet the growth is negligible from that point of view (probably owing to reduction of light). In the large floating tray the algal growth was very pronounced and, it is believed, greatly reduced the circulation. It is proposed to try excluding the light. Changes in depth are also probably correlated with changes in the quantity of food and in this respect very different in different situations. The depth also influences the amount of light, of which the direct effects are not yet indicated.

The influence of the foods supply, as may be seen, enters into crowding, circulation, depth and situation in the inlet; and progress in the study of all these factors needs first of all observations on the food supply and its correlation with growth, and, if possible, experiments on the effects of altering the food. One of the chief fundamental questions is what is the degree and nature of the influence of the food supply on growth and fatness.

The influence of temperature and salinity on growth are not evident from our results hitherto in the rearing of spat. Other studies have indicated that areas of high temperature (usually associated with low salinity and low currents) are favourable to rapid growth, and this probably applies to the rearing of spat. Our experiments in 1933 have not been sufficient to disassociate temperature or salinity from other factors.

Enough has been said to indicate the complexity of the conditions and some lines of attack. As regards the experiments as a whole it is worth mentioning that, except for the enclosure on the shore, the growth appeared to be well above the average occurring in nature when spat are growing on the bottom. If increased by further improvements it will probably be more than double the latter. This is in itself a valuable result, in addition to the reduction in mortality which was the chief object in developing these rearing methods. Survival. The survival was everywhere good and even in the enclosure on the shore the loss (about 50%) was below the average obtained when spat are spread on beds even after an effort has been made to remove the starfish by mopping. In the other experiments the mortality was about 10% or less, and, as has been suggested above, may be considerably reduced by avoiding overcrowding.

Starfish settle on the trays early in the summer but do not reach a large enough size to attack the spat being reared although they are quite large enough to attack the spat of the current year. The avoidance of destruction by starfish is probably the chief factor in the reduction of the mortality. The high proportion of the spat passing a length of $1\frac{1}{2}$ " offers good prospects of avoiding the starfish problem by a single year's rearing.

Shape and clustering. The overcrowding is indicated as the chief factor producing poor shape and clustering. In the enclosure on the

shore siltiness was evidently the chief cause of the very poor shape, but in the floating experiments overcrowding is indicated. In instances in which the experimental trays were not disturbed all season about 5% of the spat grew to other spat - often to a degree making it impossible to separate them without killing one. On the other hand when the spat were frequently handled practically none of this occurred even in the extreme crowding in the shelved boxes. It seems that shaking separates the spat again in the early stages of the clustering. Even 5% is a small proportion in clusters and the production of single oysters is one of the advantages of these rearing methods.

Economic value. The cost of the rearing indicates that the methods when properly developed will be of definite value to the industry.

Thus in the cheapest method tried - large floating tray - the cost of the rearing itself was about .50 per 1,000 and in this experiment 70% had reached or passed lengths of $1\frac{1}{2}$ " and 20% 2" - i.e. were past the greatest danger of loss by destruction by starfish. Thus, by bringing into use another form of cultch (concrete-coated cardboard collectors) and avoiding the great losses in the first year, the rearing of spat by these methods promises to be economically profitable.

Toronto, April, 1934.

