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SUMMARY OF OYSTER FARMING EXPERIMENTS IN SOUTH CAROLINA 1939-1940

R. F. SHUMAN

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Explanatory Note

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SUMMARY OF OYSTER FARMING EXPERIMENTS IN SOUTH CAROLINA 1939-1940

by

R. O. Smith
Aquatic Biologist
Branch of Fishery Biology 1/

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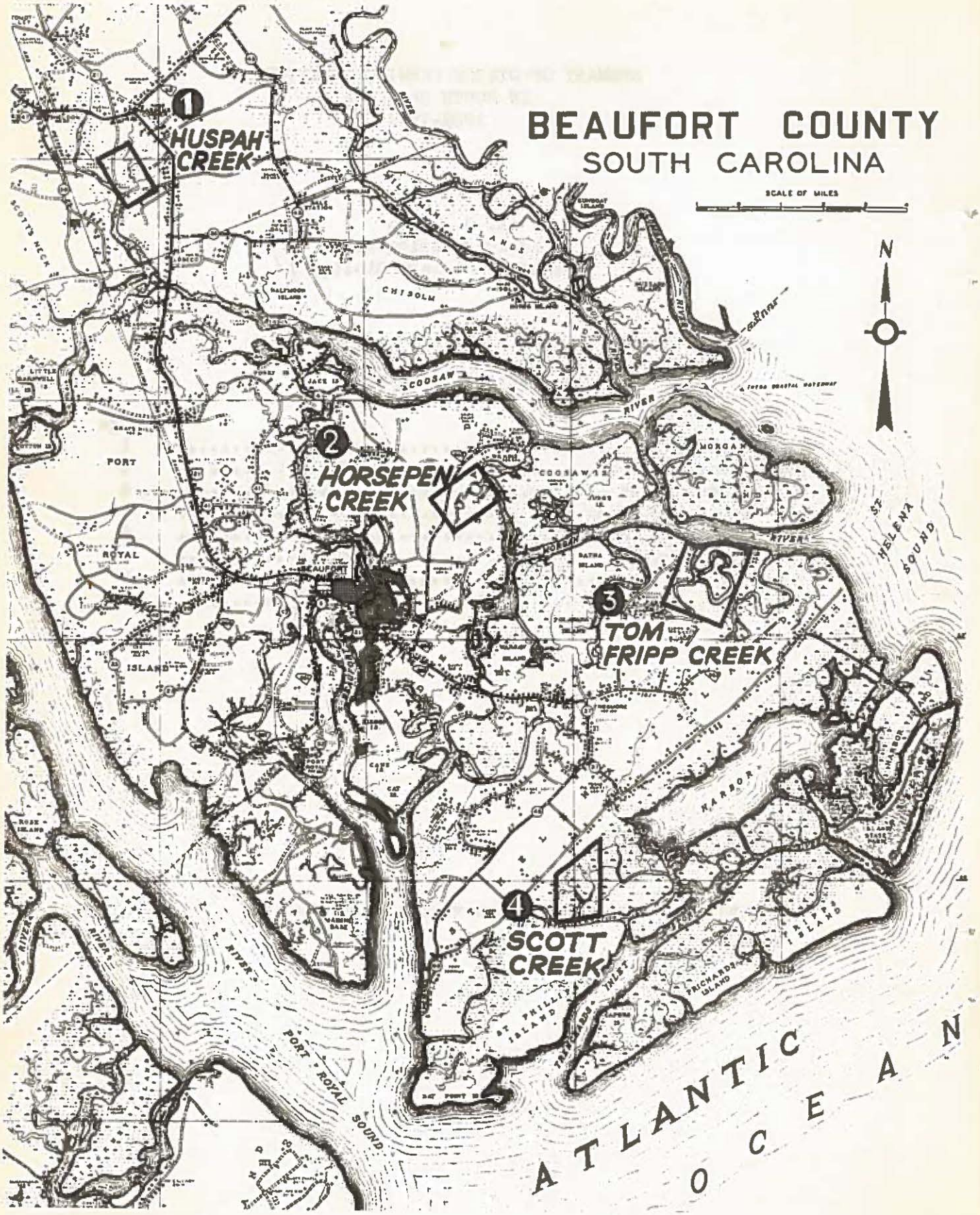
1/ With Office of Foreign Activities since 1946.

FIGURE 1.


BEAUFORT COUNTY
SOUTH CAROLINA
SCALE OF MILES
N
1
HUSPAH CREEK
2
HORSEPEN CREEK
3
TOM FRIPP CREEK
4
SCOTT CREEK
PORT ROYAL ISLAND
CHISOLM ISLAND
COOSAW RIVER
MORGAN ISLAND
ST HELENA SOUND
HARBOR
PRICHARDS ISLAND
ST PHILLIP ISLAND
PORT ROYAL SOUND
ATLANTIC OCEAN

INTRODUCTION

Although the Division of Fishery Biology of the Fish and Wildlife Service, (formerly Division of Scientific Inquiry, Bureau of Fisheries), has made surveys and carried on experimental work relating to oysters since shortly after its organization in 1870, it has never before had the facilities to actually engage in the production of oysters. This report summarizes progress in oyster farming experiments in South Carolina in 1939-40.

The purposes of the present investigations are two fold. First, to develop practical methods for producing a good quality of oyster for raw shucking and second, to improve the quality of the oysters used for canning. In carrying out this program, the following factors have been kept constantly in mind: 1. The results must be of practical value to oyster growers. 2. Since the oyster industry in South Carolina and Georgia is dependent on unskilled colored labor, only the simplest and cheapest tools and materials have been used.

Field work began in Beaufort County in January 1939 with labor supplied by a local W.P.A. project. All of these men were familiar with the local oyster industry and represented the average type of laborer on which the local industry depends.

The environmental conditions affecting oyster culture in South Carolina and Georgia are so different from those of North Carolina and Northward and the Gulf coast as to require considerable study before progress could be made. The most important factors in South Carolina and Georgia are silting and an average rise and fall of tide amounting to 7 feet. This is in contrast to the Gulf coast where the chief problem is change in salinity and the North Atlantic coast where the controlling factors are temperature and depredations of enemies.

By the end of 1940 sufficient information had become available on temperature, salinity, silting, rate of growth, time of spawning, and zones of setting as to make possible the development of a definite program for the future management of certain areas. We are therefore passing from the stage of merely becoming familiar with local conditions, and entering the phase of production management. In its broader aspects this may be described as so planning the utilization of all bars and banks in an area as to provide a constant flow of market oysters of uniform quality, size and appearance from year to year.

Reference to the General Highway and Transportation Map of Beaufort County (Figure 1) shows that it consists chiefly of several hundred small islands separated by creeks and rivers of varying size.

Altogether a very large area is available for the growing of oysters, but under natural conditions practically no oysters are to be found below low water mark, and the distribution between tide lines is not continuous, some portions of the streams being heavily pouplated while other sections are entirely barren.

Since it was obviously impossible to carry on observations througout the entire area it was decided to establish small experimental farms on the basis of differences of salinity. It was not possible to obtain locations entirely satisfactory due to the fact that practically the entire brackish water limits were already leased and some compromise was necessary. However, four small creeks with their tributaries were set aside for experimental use through the co-operation of the State Board of Fisheries and the L. P. Maggioni Company, the latter company controlling considerably more than half of the available oyster growing territory in the County. The experimental creeks are marked on Figure 1.

Approximately one hundred acres are included in the present operations, which requires the employment of from twenty to twenty-four colored oystermen with a white supervisor, all labor as stated above being furnished by the W.P.A. Floating equipment consists of eight oyster batteaus of forty bushels capacity each, one lighter of three hundred and fifty bushels capacity, and two motor boats for towing and survey.

During the calendar year 1939, the work was confined to Horse Pen Creek, where 62,375 bushels of shells were transported from the Sams Point oyster cannery and used as follows: For cultch, 23,780 bushels; for hardening soft bottom, 30,225 bushels; for construction of dams, paths, etc., 8,370 bushels. 1,287 bushels of natural growth oysters were picked elsewhere and brought into Section B. as a spawning reserve, and 1,050 bushels of our own seed oysters for the 1939 set are summarized in Table 4.

During the calendar year 1940 to date (January 1 to December 10) we have planted five acres of brush, 54,860 bushels of shells and transplanted 6,990 bushels of "coon" oysters. During the fiscal year beginning July 1, we have transported 19,060 bushels of shells of which 1,530 were used for cultch, 5,140 for hardening soft bottom, 8,420 for dams and paths and 3,970 for reserve.

When the present work was begun in Beaufort County (January 1939), almost no data relative to local environmental conditions were available so that it became necessary to make plans not only for experimental work, but also to accumulate regular and continuous observations on such fundamental hydrographic conditions as temperatures, salinity, pH and turbidity. These are now available for more than one year. Monthly averages are shown in Table 3.

EXPERIMENTAL AREAS

Descriptions of the several experimental areas, and work in progress, are summarized below:

Huspah Creek, at the upper end of Coosaw River, receives considerable drainage from the land and has the lowest salinity of the four sites. In the course of one mile a variety of growing conditions are available, as depths up to sixteen feet exist in some places and the banks range from shifting sand to soft mud bars and the banks have practically every slope from vertical to relatively flat. Since this creek is some twelve miles from the nearest source of shells to be used for hardening soft bottom or serving as cultch for the attachment of spat, it was impractical to attempt the collection of seed by usual methods as carried out in the other areas. Since a large supply of brush was available it was decided to use this in place of shells. Originally it was my intention to begin brush planting in Huspah Creek not later than the middle of August, but following the storm of August 11, 1940 our W.P.A. workers were placed on emergency duty in clearing up debris and work on the oyster project was not resumed until August 28.

Between September 9 and September 30 of this year a shifting sand flat estimated to be approximately three acres in extent was thickly planted with brush extending from low water mark to above high water mark. Although our experiments elsewhere have shown that early planting of cultch (prior to July 1) give best results due to the longer growing period, data were needed on the relative abundance of late setting and also as to whether or not these late setting spat will, over a period of time, catch up in growth with spat which attached during June and July.

A careful examination of the brush was made on December 9 which showed no spat whatever, although a good set of barnacles was obtained. This proves definitely that setting does not occur on brush in this area after the end of August. Since there is an ample supply of adult oysters to furnish larva the lack of set must be attributed to exhaustion of the gonads or conditions unsuitable for attachment of spat. This result is rather surprising for elsewhere, (lower Beaufort River), seed less than 5 mm. (1/4 inch) in diameter has been found in January, pointing to limited spawning during the late Fall.

Planting of brush in Huspah Creek is illustrated in Figure 3.

Horse Pen Creek is located about three miles off Coosaw River near its mid point. Due to the proximity to a supply of shells at the oyster cannery at Sams Point, (See Figure 4), this creek has, to date, received about ninety per cent of our attention. From its mouth, where it flows into Lucy Point Creek, it extends about a mile and a half inland. There is comparatively little fresh water drainage and the salinity rarely falls below twenty, and during the period of observations it has, for the most part, generally varied between twenty and thirty parts per thousand. At

mean low water, depths to fifteen feet can be found. pH varies between 7.7 and 8.1. The transparency, as measured by a Secchi disk, varies considerably, ranging from one foot to more than twelve feet.

At the time we took it over the oyster population consisted of some scattered clusters of "ceon" oysters on several mud flats, a few bushels of fairly well-shaped single oysters on hard broken shell bars near low water mark, and an unknown number of scattered clusters in the marsh mud. In the main, however, the banks and intertidal flats were barren as shown in Figure 5, which shows Section A. in its natural condition. Figure 6 shows shells being planted on high water, and Figure 7 shows the planted flat at low water.

In order to maintain comparative records of production on varying types of bottom, the creek was divided into eight sections lettered from A. to H. inclusive. Section D. includes an impounded area or claire described in paragraph 15, Table 1. A complete record of the number of bushels of shells planted on each section and the number of seed oysters obtained from it is kept as a daily record. Planting of shells to harden bottom is shown in Figure 8. Planting of shells for cultch is shown in Figure 9. Loading shells on batteaus and lighter are shown in Figures 10 and 11. Records of production by number of bushels has proved to be rather unsatisfactory, for due to the rapid growth of the spat, one bushel taken in July may easily occupy a space of one and one-half to two bushels by December.

In Table 2 an attempt has been made to show the various types of bottom which have been separated into sections and for which we have separate data on the amount of shells planted and the seed produced. As stated in the table, the amount of shells planted for cultch is an arbitrary figure. It does not represent the total amount of shells placed on the individual sections but is merely an approximation of the number of bushels which were not silted over or which were planted for the specific purpose of catching seed. While this division of the shell planting is by no means perfect it was necessary to have some sort of yardstick of the suitability of the various sections for the production of seed and Table 2 summarizes the result as well as may be done at this time. In this connection it should be noted that in several cases, particularly Sections A., E. and G., that the hardening process is a cumulative one. While many of the shells planted on these sections in 1939 were silted over and resulted in a relatively small production of seed oysters, as compared with the number of bushels of shells planted, it has been noted that the 1940 set will be considerably increased as the result of the 1939 shell planting. In other words, the process of bringing naturally soft bottom to a condition suitable for the production of seed oysters may take several years with the relative return of bushels of seed oysters compared with bushels of cultch planted rising slowly as the hardening process continues. It now appears that while certain types of bottom which are natural settling basins may never be brought into production. There are many acres of bottom which, though soft, can eventually be made to yield a good crop of seed by yearly planting of shells.

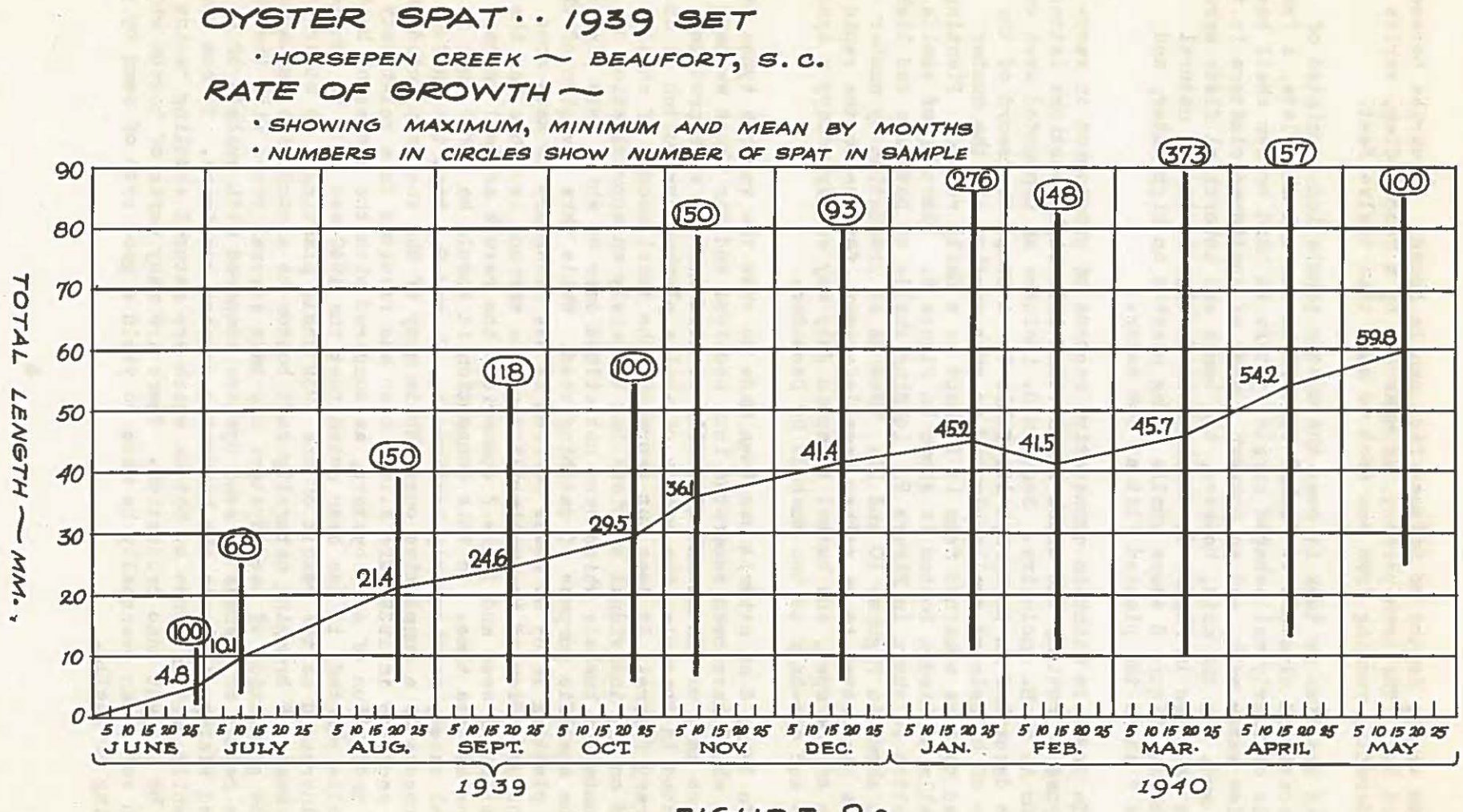

OYSTER SPAT·· 1939 SET
· HORSEPEN CREEK ~ BEAUFORT, S. C.
RATE OF GROWTH ~
· SHOWING MAXIMUM, MINIMUM AND MEAN BY MONTHS
· NUMBERS IN CIRCLES SHOW NUMBER OF SPAT IN SAMPLE
TOTAL LENGTH ~ MM.
0
10
20
30
40
50
60
70
80
90
100
4.8
68
10.1
150
21.4
118
24.6
100
29.5
150
36.1
93
41.4
276
45.2
148
41.5
373
45.7
157
54.2
100
59.8
5 10 15 20 25
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
1939
1940

FIGURE 2a

In addition to the hydrographic data, we now have more than a year's record of the rate of growth based on monthly samples. At the end of one year difficulties are encountered in making measurements for the reason that late spat of one season may be smaller than early spat of the succeeding season attached to it; which tends to confuse the picture, for example, of the rate of growth of the 1939 seed oysters through inclusion of 1940 seed. Graphs showing rate of growth are shown as Figures 2a and 2b. Culling of seed oysters is shown in Figure 12.

Some knowledge of the relationship between size and sex ratio of native oysters in South Carolina was thought to be necessary for a better understanding of the spawning season. In many localities the oysters occur naturally in large, thick clusters representing all sizes and ages of the population. Less common are bars on which single oysters are scattered and not abundant, generally below two hundred bushels per acre. During the late spring (April 24 to June 21, 1939) a total of 281 individuals of all sizes divided between 147 cluster oysters and 134 single oysters, were measured and sexed. In accordance with work of investigators elsewhere it was anticipated that the cluster oysters would comprise a few females surrounded by a considerably larger number of males and that the single oyster would be divided more or less evenly between males and females. An examination of Table 2 will show that this does not appear to have been the case as there is relatively little difference in the percentage of the two sexes, whether occurring in clusters or singly. The only sharp line of distinction is found on a size basis. The oysters below market size (3 inches) were predominantly male as was to be expected, but of oysters of market size and above (3 to 6 inches) the differences are not so great although females do predominate in the proportion of 59% females to 41% males. While these data are interesting they are not known to have any practical value from the standpoint of oyster culture at the present time.

Although we are experimenting with growth of seed in large trays 16 feet long by 30 inches wide with hardware cloth bottom holding about six bushels of oysters, and located at various levels from surface to bottom, both within the impounded area (claire and in Section A. of Horse Pen Creek), they appear to be of no practical value unless some cheap means can be found of duplicating them on a large scale. However, there is no question but that growth is greatly accelerated by maintaining the oysters above the bottom so that silting is avoided. One of these trays is shown in Figure 13.

Tom Fripp Creek. This creek is a tributary of Morgan River, which is merely an arm of St. Helena Sound, and the creek extends two miles inland but with considerable branching which adds greatly to its extent. It had been expected that due to its proximity to the ocean the salinity would be relatively higher than in Horse Pen Creek, but this did not prove to be the case, the salinity varying between twenty and thirty parts per thousand. The pH ranged between 7.8 and 8.0 and transparency, as measured by visibility of the Secchi disk, varied from 12 to 59 inches. The maximum depth is thirty feet.

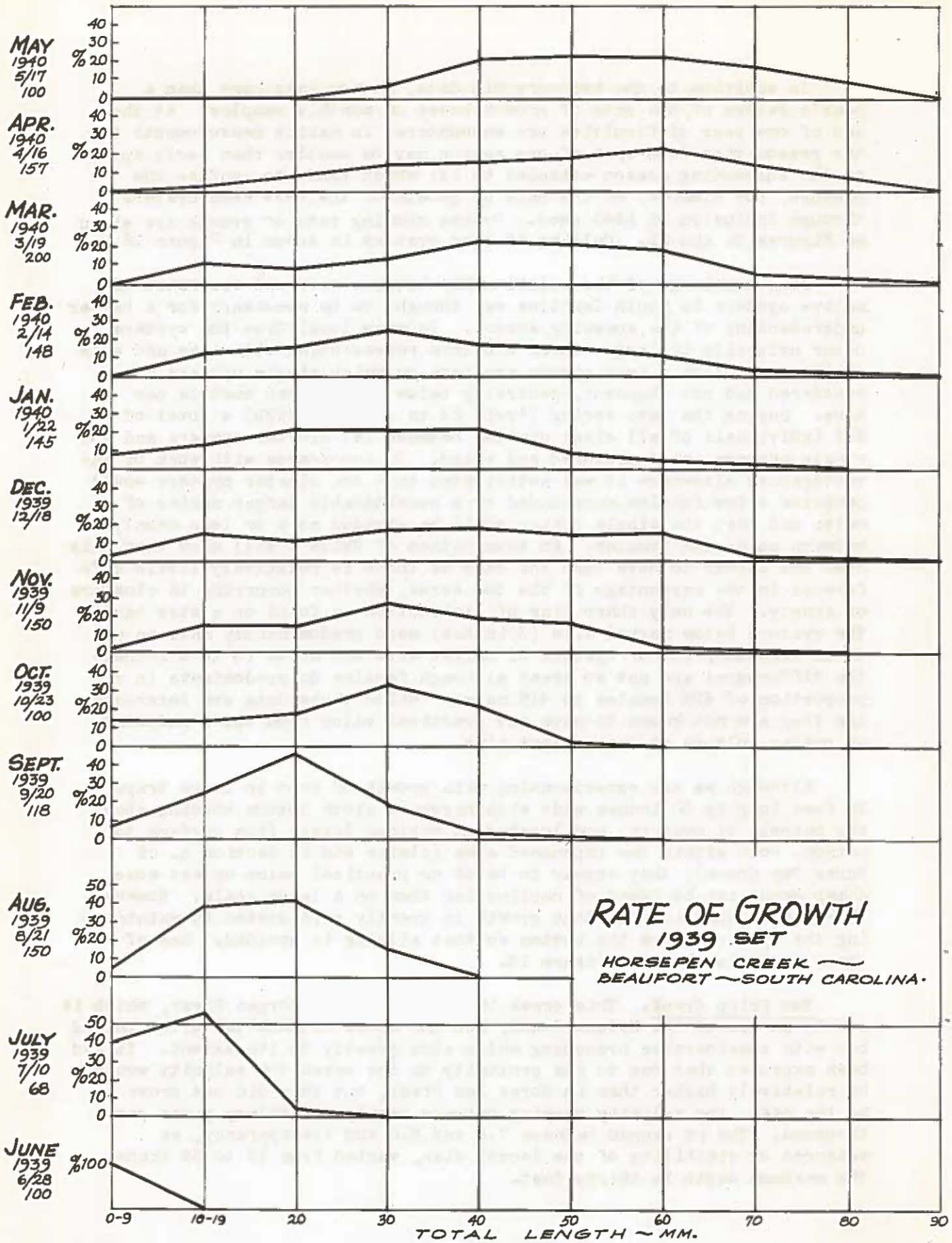

MAY 1940 5/17 100
APR. 1940 4/16 157
MAR. 1940 3/19 200
FEB. 1940 2/14 148
JAN. 1940 1/22 145
DEC. 1939 12/18
NOV. 1939 11/9 150
OCT. 1939 10/23 100
SEPT. 1939 9/20 118
AUG. 1939 8/21 150
JULY 1939 7/10 68
JUNE 1939 6/28 100
%
RATE OF GROWTH
1939 SET
HORSEPEN CREEK —
BEAUFORT — SOUTH CAROLINA.
0-9
10-19
20
30
40
50
60
70
80
90
TOTAL LENGTH ~ MM.

FIGURE 2b

During the period April 18 to May 3, 1940, brush was planted over an area of two and one-half acres of soft mud bottom and extending from below low water mark to above high water mark. Also, during the period, 6,270 bushels of shells were planted between tide lines on firm mud bottom.

On November 25, samples of seed from both shells and brush were measured. The average size of seed on shells was found to be 35 mm. whereas the average size on brush was 57 mm., or an average difference of about 7/8 inch. Two individuals from a sample of 129 on brush exceeded 90 mm.

The set on brush on November 25, 1940, is shown in Figure 14, while a general view of the section showing seed on shells, also taken November 25, 1940, is shown in Figure 15.

Since no supplies of shells are available no additional planting will be made. However, some brush is available and it is hoped to again plant two and one-half acres. One observation of value in future planting of brush is that no setting took place on small twigs or branches under 1/2 inch in diameter and the bulk of seed were located between a point 6 inches above the mud and 30 inches above the mud.

Scott Creek is a tributary of Station Creek and extends a mile and a quarter into the marsh only and therefore is practically unaffected by land drainage. The salinity here ranged between thirty-two and thirty-four parts per thousand. pH was constant at 8.1 while turbidity, as measured by the Secchi disk, ranged between 28 and 52 inches. The maximum depth at low water is about sixteen feet, with firm bottom or broken shells.

This section has never produced oysters of high quality, but hundreds of acres of sharp-billed "coon" oysters are available, of such quality that they are rarely even used for canning. The clusters are so large and thick that the oysters of necessity grow very long and narrow, with a thin, brittle shell which is easily broken. It was realized that if the quality of these oysters could be improved to such an extent as to make them suitable at least for canning purposes that it would relieve the strain on production in creeks where the oysters are of sufficiently good quality for raw shucking.

To test this possibility 6,990 bushels of "coon" oysters were picked, the clusters broken apart and the single oysters planted on firm bottom in Scott Creek in from 6 to 10 feet of water during the period from May 8 to June 21, 1940.

A sample was dredged from the planted area on December 10 and although this is just the beginning of the growing season the oysters dredged show an increased width of from 1/8 to 3/4 inch. It is still too early to state definitely whether or not these oysters will become suitable for market use, but certainly the improvement to date is sufficient so that the experiment will be watched with much interest. Mortality from the time of planting May 8, to December 10, was 44%. It is doubtful if this can be reduced appreciably as it is mainly due to the brittle shells being cracked in breaking the clusters apart.

Picking native "coon" oysters with grabs in Trenchard's Inlet is shown in Figure 16. Culling and breaking the clusters apart is shown in Figure 17.

CONCLUSION

The information briefly presented above now provides a sound basis for future development of the oyster industry in South Carolina and Georgia.

During the first two years ending with December 1940, the chief concern was with quantity: How many shells produced how much seed in how long a time. Future work will be directed as rapidly as possible toward improvement in quality, not only for the greater delectation of the consumer, but also as an economic measure. Production costs can be expected to continue their advance, but it is believed that they can be minimized by improving the quality of the oysters so that more product will be obtained from processing less material.

Also, in view of unsettled world conditions some thought has been given to increasing production, especially of canned oysters, in case it should become necessary. With proper control, and without increasing plant capacity, production of canned oysters in South Carolina could be increased 30% in two years; with necessary expansion of plants and floating equipment, output could be doubled in five years and maintained as long as necessary.

ENVIRONMENTAL CONDITIONS

Approximately 15 records per month of water temperature; salinity; pH; and turbidity, covering 18 months, mostly in Horse Pen Creek, summarized in Table 4. Due to the flatness of the country, run-off of fresh water is fairly slow, and the sandy subsoil can absorb heavy rains quickly, preventing floods. Also, many of the so-called rivers and creeks do not drain a large area of land, but are simply channels for tidal currents. Reference to Table 4 shows that seasonal changes in salinity are relatively unimportant, with a range between 20 and 30 parts per thousand. At the same time there is little difference between surface and bottom salinity. However, since the natural growth is mainly between tide lines, the oysters are subject to whatever salinities may exist between top and bottom.

Ordinarily the minimum winter temperature of the water is close to 10°C (50°F) reached during January. The maximum of 33°C (91°F) generally occurs during the latter part of July. These are bottom temperatures in from 6 to 17 feet of water. Considerably higher and lower readings can be obtained in shallow water over mud flats which are exposed at low tide.

That changes in hydrogen-ion concentration of the water could materially affect oysters in the region seems improbable. The maximum range varies between 7.7 and 8.1, but with one exception the maximum change in any one month was found to be 0.2. It should be pointed out that none of the records show a reaction on the acid side, further indicating that conditions are essentially marine.

Transparence of the water fluctuates widely, and occasionally, rapidly. The maximum change from one day to another was over four feet (144 inches January 18, 1940-96 inches January 19, 1940). Ordinarily the difference from one day to another ranges from a few inches to 2 feet. As there is little or no clay in the region, the changes are mostly due to stirring up of the soft mud by strong winds, rains, and currents, and especially in the spring, (see minimum for April, Table 4) finely divided particles of decaying vegetation, chiefly dead marsh grass.

ENVIRONMENTAL CONDITIONS (Continued)

In spite of the very considerable fluctuations, the monthly averages show an orderly progression from a maximum in January to a low in July. In general, winters are calm, with light winds from the north or northwest, and during this period transparency is greatest. Spring is windy, with frequent rain, and resulting decrease in transparency. The summer months, but mainly July and August, are times of sudden squalls, usually with heavy local showers, and these conditions continue through September, and are reflected in the low average transparency. The latter part of the Fall months show a gradual increase in transparency toward stabilized winter conditions.

The strength of the current itself is at times sufficient to create turbid conditions. It should be noted that normally the water level is changing at the rate of one-quarter inch a minute, representing a tremendous volume of water moving over a large area. This rate is increased during Spring tides immediately following full moon.

RATE OF GROWTH

Monthly measurements of oysters of known age covering the first 15 months, are shown in Figure 2.

SEASON OF GROWTH

Mostly between September 1 and May 30 (Fall, Winter, and Spring). 10 to 25°C (50 to 77°F).

SETTING

Observed not to be identical with spawning season. Some setting takes place throughout the year, spat of 5 mm. (1/4 inch)or less having been found in every month of the year. However, setting is of commercial importance only between May 15 and August 31. There are several waves of setting during this time, of which the earliest, between May 15 and June 30, is most important because this set has the advantage of a headstart over later set.

SEX RATIO

Data summarized in Table No. 3. All individuals from between tide lines. It will be noted that young oysters between 3/4 and 3 inches (20-70 mm.) all less than one year of age, are preponderantly male, while those three inches and above, mostly in their second year or older, are somewhat more than half female. The fact that there are comparatively fewer females under the legal market size of 3 inches may be of great importance under extreme conditions of over fishing, when the stock of spawning females is reduced below the level required for population maintenance.

OBSERVATIONS ON SPAWINING

Repeated attempts have been made to induce spawning of males and females by stimulation with eggs and sperm without success. It appears that there is no mass spawning of both sexes as a result of stimulation by temperature of sexual products, but rather a general, constant release of eggs and sperm in small quantities from maturity of gonads in April, until exhaustion in August or September.

RESULTS OF SHELL BAGS AS COLLECTORS

The above observations are borne out by experience with shell bags. If left out for one week, less than one spat per shell can be found. If left for one month several spat per shell are present, and if left for three months the shells are thickly covered. Also, whichever side of the shell is down will have more and larger spat than the upper surface. Shell bag collectors shown in Figures 18 and 19.

SUITABILITY OF VARIOUS TYPES OF BOTTOM FOR:

A-SETTING. Every type of bottom from shifting sand, through soft mud to hard broken shell has been tested by planting with shells. Shifting sand can be used if sufficient shells are planted to cover. Very soft mud usually indicates a natural settling basin and cannot be used. In one case, Section A, Horse Pen Creek, a generally flat soft mud bank from 12 to 30 inches above low water and on the eddy side, was hardened by application of oyster shells a foot thick, making a surface firm enough to support a man's weight. These shells acted as baffles, with the result that in six weeks mud had filled all crevices and lay smoothly level with the tops of the shells. As shown in Table No. 1, only 190 bushels of seed oysters were produced. Section B is adjacent to Section A, and similar to it.

Relatively steep mud banks on stable side of stream are best for seed catching due to minimum silting. However, there is a slow cutting away of banks on the channel side of most creeks, especially if marshy, and this is manifested, customarily during February to May, by a cracking of the mud along a cleavage line from 4 to 12 feet back from the edge of the bank. This crack slowly widens and finally the whole section of bank mud gradually slides into the channel and is swept away. Some creeks undergo this process annually, others only every two or three years, but wherever tell-tale cracks are observed, it is useless to plant shells, as they will be lost.

Setting also has been observed on shells down to 25 feet below the surface, but survival was limited to about 6 weeks, due to borers (Eupleura), silting, etc.

B-GROWTH. For maximum growth, planting should be limited to the zone from 6 inches above low water mark to 30 inches above low water. In this zone the seed are out of water sufficiently to prevent infestation of boring sponge, attachment of barnacles or smothering by moss, but nevertheless are covered with water for about 18 hours a day so that feeding is not seriously limited.

C-FATTENING FOR MARKET. Almost without exception, oysters for raw shucking are obtained from broken shell bars naturally formed a few inches above low water level in the beds of small sloughs. If not naturally present, such bars can be made as described in paragraph 11, Developing New Bottom.

COMPARISON OF SHELLS WITH BRUSH AS CULTCH

At 6 months of age seed caught on brush average 20 mm. longer than seed caught on shells. However, due to the bark pulling off and letting the seed drop in mud, the seed caught on brush must be watched and transplanted before loss occurs, while seed caught on shells may be left without attention for around 18 months. Also, setting evidently occurs during a changing tide, and not at either high or low water slack. For this reason, brush or poles at least 3/4 inch in diameter should be used where the current is rapid, as is usually the case, for the smaller twigs and branches catch no set. This is doubtless due both to whipping about in the current, and also to the small area where the current is blocked sufficiently for the larvae to attach. No difference can be seen between the number spat on the up or down stream sides, so it is concluded that setting takes place equally on flood and ebb tide.

Although seed on brush grow faster than set on shells, and are longer and wider at the same age, the former has a very light shell, and the oyster is much thinner. Experiments are under way to determine how long it takes these seed to thicken up and make a heavy bodied oyster.

OPTIMUM TIME TO PLANT CULTCH

Shells may be planted on suitable bottom in the lower half of the intertidal zone beginning in January. All cultch should be planted by July 1 to obtain maximum growth. Equally abundant set was obtained in Horse Pen Creek on shells planted between January 16 and July 1.

AGE AND SEASON FOR TRANSPLANTING SEED OYSTERS

If seed is to be planted below low water mark it should be at least 2" long to avoid serious mortality from borers (Urosalpinx), boring sponge, smothering by silt, moss and Bryozoa. Maximum growth is obtained by leaving the seed undisturbed during its first year, but better shape results from transplanting at 6 months of age. Since growth is most rapid during the late fall, winter, and spring, breaking clusters apart and transplanting should not be done at this time if it can be avoided, as the shells are thin, brittle and easily broken. Even in midsummer, oysters taken from between tide lines may be held out of water and exposed to direct sunlight for at least 24 hours without opening up. Following our experience in Scott Creek, it is recommended that transplanting be done as far as possible between July 1 and September 30.

DEVELOPING NEW BOTTOM

The chief limiting factor in bringing barren ground into production is silting. The second factor is availability of shell or other material for hardening. Our Section D., is a small drain about 20 feet average width and 300 yards long. It is beginning to develop single oysters of excellent shape from our 1939 seed, but some 5000 bushels of shells were used to harden the bottom. Measurements and counts have been made to determine the quantities of shells required for cultch and hardening surfaces. Since our shells are from cannery stocks, the figures probably are not directly applicable to other sections of the country, where larger oysters are produced, and fewer bushels of shells will cover the same area. Here, however, in order to cover one acre with a single layer of shells, edge to edge, but not overlapping, approximately 1900 bushels of shells are required. Seven hundred is the maximum which should be planted for cultch. For hardening, as much as five times as many may be needed. Hardening cannot be done indiscriminately, however, as will be evident below.

CHANGES IN NATURAL BOTTOM RESULTING FROM PLANTING OPERATIONS

Planted shells act as baffles and promote silting. In order to avoid waste of shells due to silting over, care must be taken not to form artificial baffles and settling basins. On experimental Section E., Horse Pen Creek, windrows of shells of 20 feet apart and two feet high were placed across the current on mud bottom. This was done during the summer of 1939. At the present time (December 1940), mud has completely filled the spaces between the rows, so that the whole area is again level.

Brush planted for cultch has a similar effect. In Huspah Creek, brush was planted on a hard sand bar during the period September 9 to 26, 1940. On December 9, 1940 from four to eight inches of soft mud had covered the sand.

USE OF CLAIRES TO PROMOTE FATTENING OF MARKET OYSTERS

An area of about 10 acres has been inclosed to form a claire by putting mud and shell dams across the five outlet sloughs. The claire consists of five acres of high marsh unfit for use, and five acres divided between mud flats and drainage sloughs. Most of the flats and sloughs have been hardened with shells, and 1,485 bushels of 1939 seed oysters have been planted in depths varying from one to five feet. Results show that very large quantities of shells are necessary to properly harden the bottom. Although over 10,000 bushels of shells were scattered over the mud, much of the seed was not properly supported and did not survive. Also, it is evident that claires should not be used for growing purposes, but only for fattening, as the constant submersion results in heavy infestation with boring sponge, reducing the rate of growth. In the future we intend to plant only seed longer than two inches in length. Since hardening of bottom and planting of seed has not been completed, no conclusions can be drawn as to the value of claires.

ENEMIES

Practically every oyster enemy except the conch, Thais, and the leech, stylochus, has been observed in this area. They include: starfish; borers (Euplerua); the conch; Busycon; boring sponge, boring clam (not common); Polydora; Bucephalus; and presumably the protozoan parasite discovered by Dr. Prytherch. However, these enemies have been largely outwitted by the oyster's habit of attaching itself between tide lines. In the two seasons during which observations have been made on our own set, little or no mortality has been found between tide lines.

ENEMIES (cont'd)

Realtively little mortality occurs if seed are transplanted from the intertidal zone to below water mark when they are two inches long or larger (1 year old), but spat up to one inch in length are destroyed within a few weeks. In July 1939 one hundred and twenty bushels of spat up to about 15 mm. (3/5 inch) in length, and not over 6 weeks of age, were transplanted from between tide lines to hard bottom about 2 feet below low water mark, and were all killed within a month, many showing drill holes. Transplanted oysters of market size are quickly infested with boring sponge, which makes its appearance within six months, but does not begin to penetrate to the inner surface of shells for more than a year. The exact time required to break through to the interior is not known, as our 1939 set was only put under water in 1940, and in the course of a year has not penetrated to the shell interior.

TABLE 1
PRODUCTION AND DISTRIBUTION OF SEED OYSTERS
1939 SET
HORSE PEN CREEK
By Sections

	A Very Soft Mud Flat	B Soft Mud Flat	C Soft Mud Flat	D Banks or Channel Firm	E Behind Dams Soft	F Firm Mud Sand	G Firm to Hard Below low tide	H Soft to Firm	I Soft Mud Shifting Sand Flats	Totals
Shells Planted For Cultch (1) Bushels	2790	0	1960	5000	0	1000 Windrows 5020	1260	3430	8540	23,780
Seed Produced (2)	190	0	140	(3) 2000	0	250	50	670	20	3,220
Seed Planted November 1939 to March 1940	0	0	0	140	1485	125	470	0	0	2,220

(1) Estimated. Actually, no sharp division can be made between shells used for hardening and those used for cultch as all will catch seed if not silted over. Production is inveresely proportional to silting.

(2) It is doubtful if more than 80% of the seed oysters are picked, due mostly to carelessness of the negro oystermen, but in part to the rapid change in tide levels.

(3) 900 bushels were picked from one bank, the other being left for measurement of rate of growth and future use. The bank not picked has greater area than the one picked.

TABLE 2
SIZE AND SEX RATIO OF NATIVE OYSTERS
BEAUFORT, SOUTH CAROLINA
April 24-June 21, 1939
Between Tide Lines

Total Length mm.		In Clusters No. Individuals ♀	In Clusters No. Individuals ♂	In Singles No. Individuals ♀	In Singles No. Individuals ♂
Below Market Size					
20-29)		0	3	0	0
30-39)	0.75	0	6	0	1
40-49)	to	0	19	1	4
50-59)	2.75	3	11	0	6
60-69)	inches	4	13	2	11
Total		7	52	3	22
Per Cent of Group		12.0	88.0	12.0	88.0
Market Size					
70-79)		6	12	9	9
80-89)		13	9	10	9
90-99)		5	9	19	12
100-109)	3.0	6	5	19	9
110-119)	to	10	2	5	1
120-129)	6 inches	3	0	2	1
130-139)		3	1	3	0
140-149)		1	0	0	1
150-159)		3	0		
Total		50	38	67	42
Per Cent of Group		57.0	43.0	61.0	39.0
		No. Individuals		No. Individuals	
Sub-Totals		57	90	70	64
Total		147		134	
Per Cent		39.0	61.0	52.0	48.0
Combined Total (All Groups)		281			
%♀s		45.0			
%♂s		55.0			

Market Size Oysters Only Clusters and Singles		Below Market Size Oysters Clusters and Singles		
%♀s	59.0	%♀s	12.0	
%♂s	41.0	%♂s	88.0	

	Clusters ♀	Clusters ♂	Singles ♀	Singles ♂
	Per Cent		Per Cent	
Below Market Size	12.0	58.0	4.0	34.0
Market Size	88.0	42.0	96.0	66.0
	100.0	100.0	100.0	100.0

TABLE 3

SUMMARY OF ENVIROMENTAL DATA, BEAUFORT, SOUTH CAROLINA

Temperature °C	Average		Maximum		Minimum	
	1939	1940	1939	1940	1939	1940
January	12.2	7.2	15.6	10.0	9.7	3.3
February	15.2	10.4	17.8	13.1	12.8	5.6
March	18.0	14.6	21.4	16.7	12.2	12.8
April	21.8	19.0	25.0	22.8	18.9	17.2
May	25.2	22.6	29.4	26.1	20.6	18.9
June	30.6	27.8	31.6	29.4	30.0	26.1
July	30.6	30.6	32.0	33.1	29.2	29.4
August	29.8	30.2	30.0	31.7	29.4	29.4
September	----	----	----	----	----	----
October	23.7		27.8		19.7	
November	16.2		19.4		11.7	
December	12.6		13.9		11.7	
Salinity °/00 at 17.5°						
January	30.03	30.32	30.42	32.07	29.67	28.59
February	28.57	26.67	29.99	29.47	25.34	24.32
March	20.57	23.99	24.79	25.05	17.72	22.72
April	22.79	24.20	24.34	26.64	21.96	22.45
May	25.48	26.29	27.09	28.99	24.43	25.21
June	26.49	29.63	27.98	30.46	25.33	28.80
July	27.21	29.50	28.51	30.68	26.19	27.79
August	27.35		27.50		27.25	
September	-----		-----		-----	
October	29.99		30.41		29.49	
November	30.47		31.43		28.96	
December	31.70		31.98		31.42	
pH						
January	8.1	8.0	8.1	8.1	8.1	
February	8.1	8.1	8.1	8.1	8.1	
March	7.9	8.0	8.1	8.1	7.7	
April	7.9	7.9	7.9	8.1	7.8	
May	7.9	7.9	7.9	7.9	7.7	
June	7.8	8.0	7.9	8.1	7.7	
July	7.8	7.9	7.9	8.1	7.7	
August	7.8		7.9		7.8	
September	---		---		---	
October	7.9		8.0		7.9	
November	7.95		8.0		7.9	
December	7.9		8.0		7.9	

Table 3
Summary of Environmental Data, Beaufort, South Carolina
(cont'd)

Transparency Secchi Disk	Average		Maximum		Minimum	
	1939	1940	1939	1940	1939	1940
	Inches		Inches		Inches	
January	----	91	----	144+	----	33
February	----	72	----	109	----	48
March	----	58	----	77	----	44
April	----	42	----	62	----	12
May	----	43	----	59	----	34
June	35	34	44	38	28	26
July	32	31	48	33	18	24
August	34		40		30	
September	----	----	----	----	----	----
October	33		50		20	
November	50		71		34	
December	61		77		48	

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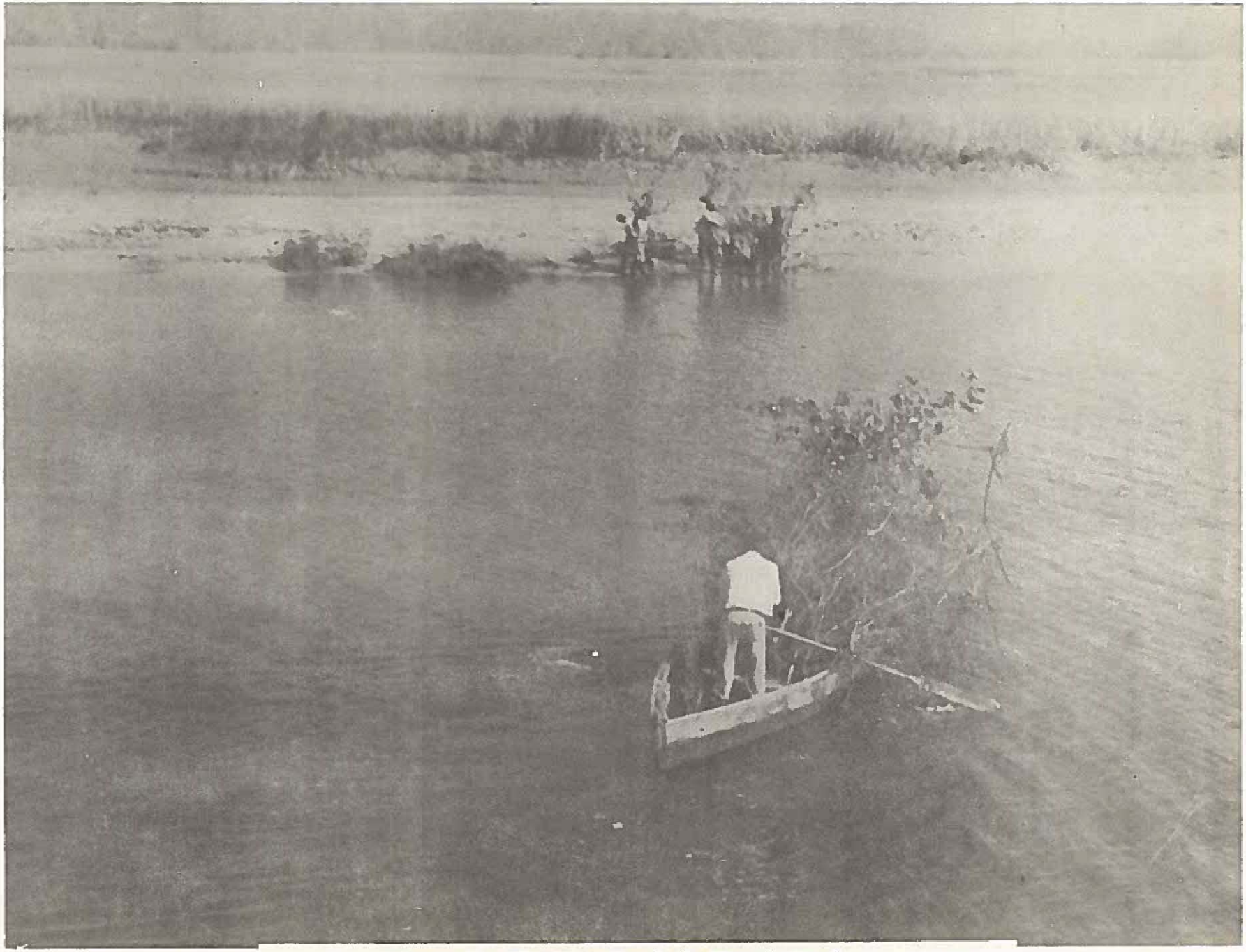

Figure 3. Planting Brush in Huspah Creek

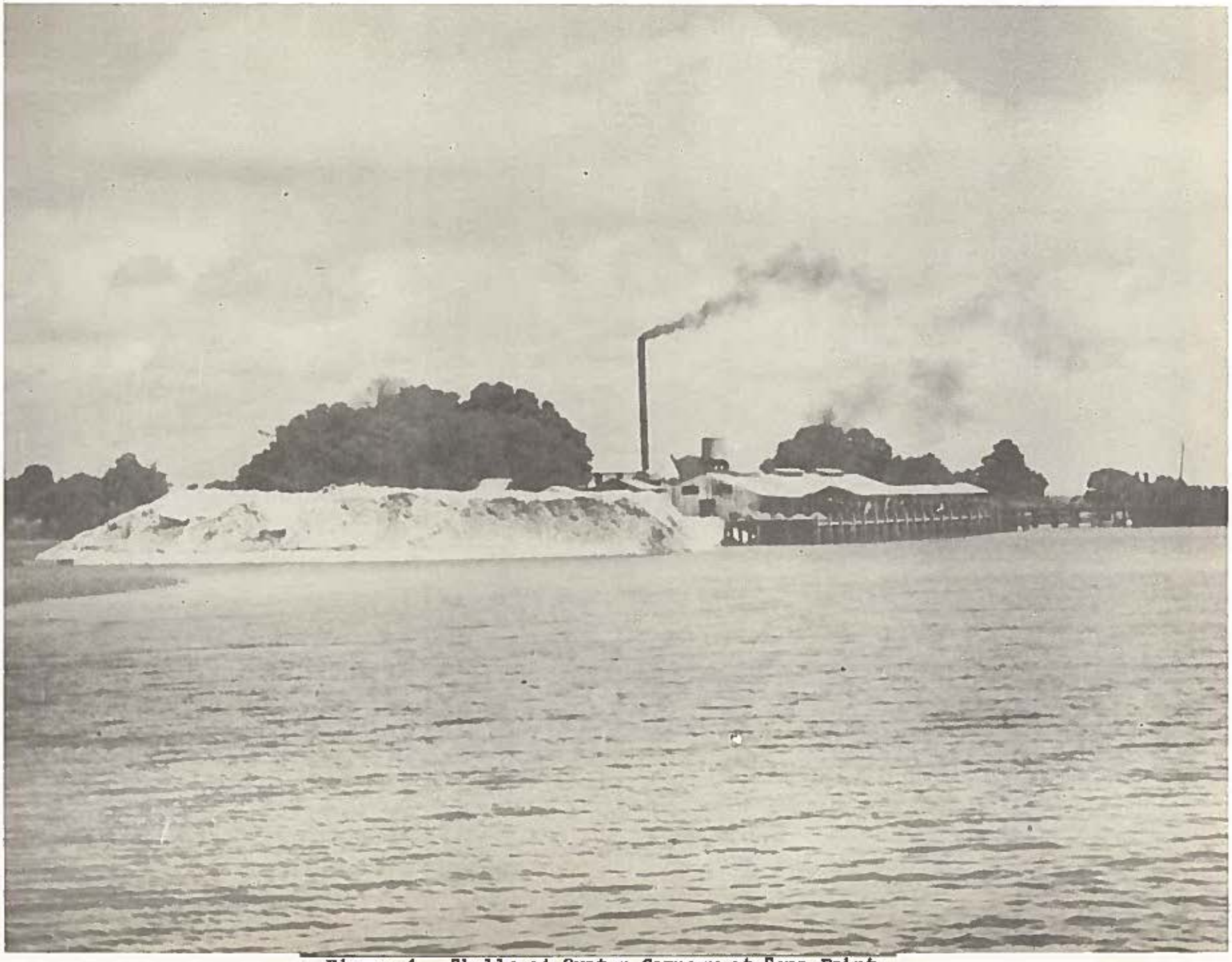

Figure 4. Shells at Oyster Cannery at Sams Point

Figure 5. Horse Pen Creek. Banks and Intertidal Flats.
Natural Condition. Low Tide

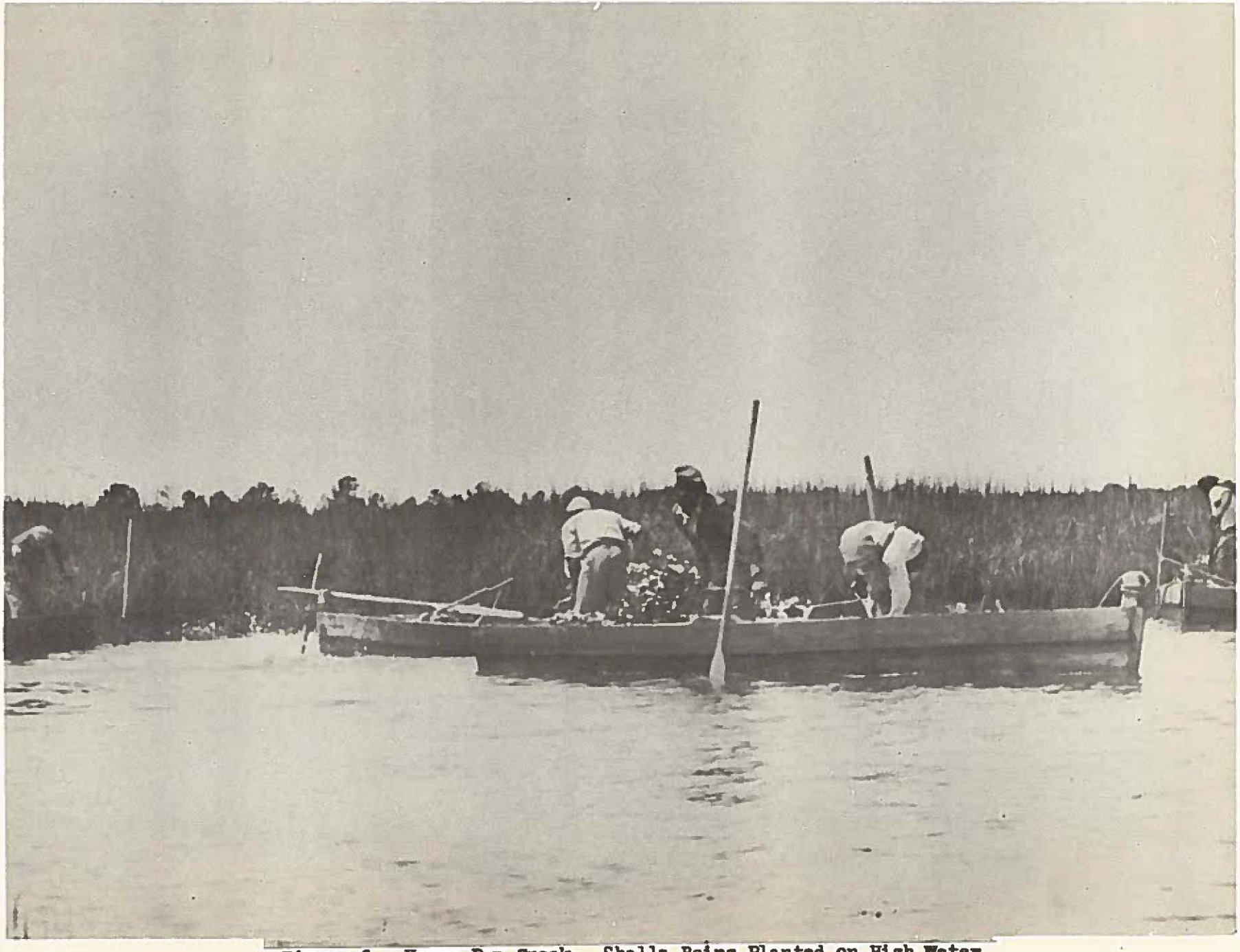

Figure 6. Horse Pen Creek. Shells Being Planted on High Water

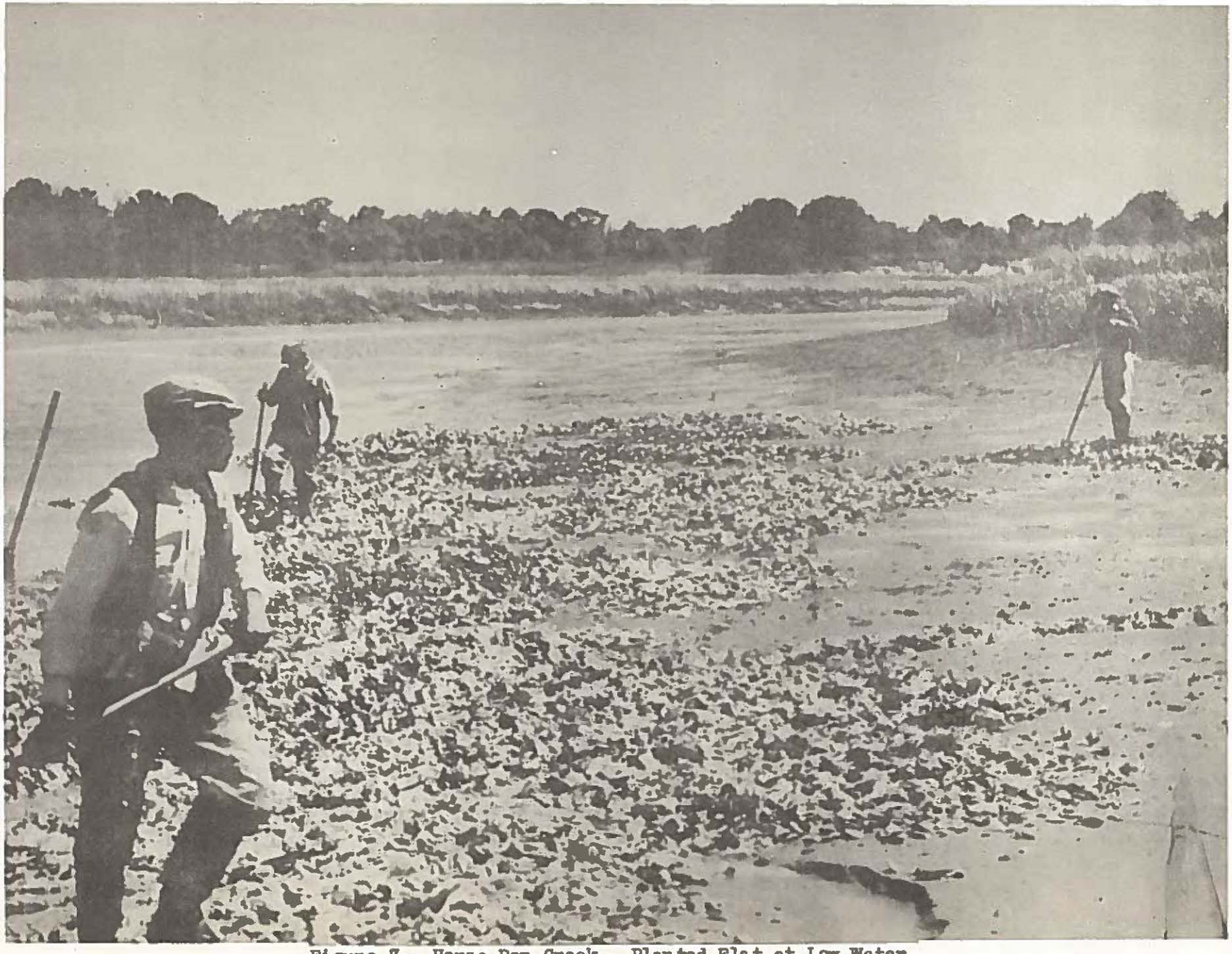

Figure 7. Horse Pen Creek. Planted Flat at Low Water

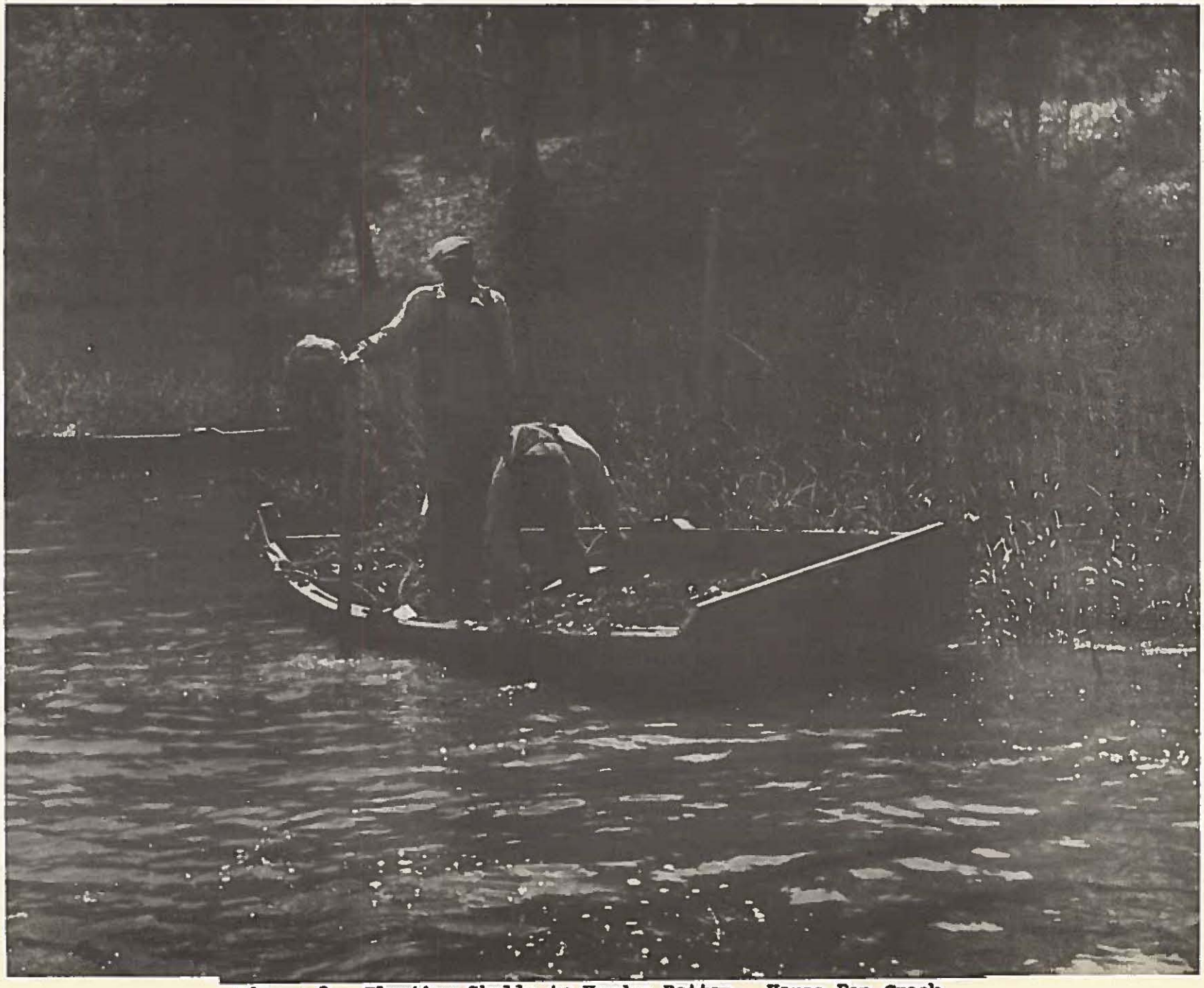

Figure 8. Planting Shells to Harden Bottom. Horse Pen Creek

Figure 9. Planting Shells for Cultch. Horse Pen Creek

Figure 10. Loading Shells on Batteaus. Horse Pen Creek

Figure 11. Loading Shells on Lighter. Horse Pen Creek

Figure 12. Culling of Seed Oysters. Section F. Horse Pen Creek

Figure 13. Tray. Section A. Horse Pen Creek

Figure 14. Set on Brush. Tom Fripp Creek

Figure 15. Seed on Shells. Tom Fripp Creek

Figure 16. Picking Native "Coon" Oysters. Trenchard's Inlet

Figure 17. Culling and Breaking Clusters Apart. Trenchard's Inlet

Figure 18. Location of Shell-bag Collector. Horse Pen Creek

Figure 19. Close-up View of Shell-bag Collector