DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF FISHERIES
GEORGE M. BOWERS, Commissioner

CONDITION AND EXTENT OF THE NATURAL OYSTER BEDS OF DELAWARE

Bureau of Fisheries Document No. 745

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By H. F. Moore,
Assistant, United States Bureau of Fisheries.

INTRODUCTION.

At the solicitation of the Delaware Oyster Survey Commission the Bureau of Fisheries during the summer of 1910 undertook a survey of the natural oyster beds of Delaware Bay within the jurisdiction of the State of Delaware. The State, which was making a survey of the planted beds under the supervision of Mr. C. C. Yates, of the United States Coast and Geodetic Survey, furnished the triangulation and made a small appropriation for the payment of two temporary employees during part of the work, but the Bureau of Fisheries furnished all other personnel, in addition to launches, boats, and equipment.

The steamer *Fish Hawk* was detailed for the work from June 1 to July 10, though, owing to unexpected delays in securing a launch able enough for the execution of hydrography in the open waters of the bay, she did not actually reach the field of operations until June 18. Part of the civilian personnel was ordered to the ship on May 26, in order to have the equipment in readiness for the anticipated commencement of work on June 1, on which date the entire party was assembled.

The purpose of the survey was the accurate location and charting of the natural oyster beds and the investigation of their present condition and productiveness. No previous survey or investigation of the beds of this region has been made, and although their approximate location is known to the local oystermen with reference to certain more or less indefinable natural landmarks, it is difficult for them to indicate, even roughly, their general position on the charts. Concerning some of the beds, and especially the southern extension of Flogger bed, the information obtained from the various sources was extremely contradictory.

METHODS OF THE SURVEY.

The methods employed were those pursued in former surveys of like character, and are explained in detail in a description of the beds of the James River,[1] from which some of the following is repeated:

A "boat sheet" was prepared, on which were accurately platted the positions, as determined by triangulation, of lighthouses and the towers erected as shore signals. These data were furnished by the State and were based on a development of the triangulation employed in the survey of the planted or leased beds.

The oyster beds were discovered by soundings with a lead line, but principally by means of a length of chain dragged over the bottom at the end of a copper wire running from the sounding boat. The wire was wound on a reel and its unwound length was adjusted to the depth of water and the speed of the launch, so that the chain was always on the bottom. Whenever the chain touched a shell or an oyster the shock or vibration was transmitted up the wire to the hand of a man whose sole duty it was to give heed to such signals and report them to the recorder.

The launches from which the soundings were made were run at a speed of between 3 and 4 miles per hour, usually on ranges ashore to insure the rectitude of the lines. At intervals of three minutes—in some cases two minutes—the position of the boat was determined by two simultaneous sextant observations of the angles between a set of three signals, the middle one of which was common to the two angles, the position being immediately platted on the boat sheet. At regular intervals of twenty seconds, as measured by a clock under the observation of the recorder, the leadsman made a sounding and reported to the recorder the depth of water and the character of the bottom, immediately after which the man at the wire reported the character of the chain indications since the last sounding—that is, whether they showed barren bottom or dense, scattering, or very scattering growths of oysters.

With the boat running at 3 miles per hour the soundings were between 80 and 90 feet apart, and, as the speed of the boat was uniform, the location of each was determinable within a yard or two by dividing the platted distance between the positions determined by the sextant by the number of soundings. The chain, of course, gave a continuous indication of the character of the bottom, but the record was made at the regular twenty-second intervals observed in sounding.

The chain, while indicating the absence or the relative abundance of objects on the bottom, gives no information as to whether they are shells or oysters, nor, if the latter, their size and condition. To obtain these data it was necessary to supplement the observations

[1] Moore, H. F.: Condition and extent of the oyster beds of James River, Virginia. Bureau of Fisheries Document No. 729.

already described by others more definite in respect to the desired particulars. Whenever, in the opinion of the officer in charge of the sounding boat, such information was required, a numbered buoy was dropped, the time and number being entered in the sounding book. Another launch, following the sounding boat, anchored alongside the buoy, and a quantity of the oysters and shells were tonged up, separated by sizes, and counted.

This boat at each station made a known number of "grabs" with the oyster tongs, exercising care to clean the bottom of oysters as thoroughly as possible at each grab. In a given depth of water and using the same boat and tongs, an oysterman will cover practically the same area of the bottom at each grab, but, other factors remaining the same, the area of the grab will decrease with an increase in the depth.

Careful measurements were made and tabulated showing the area per grab covered by the tonger employed on the work at each foot of depth of water and for each pair of tongs and boat used. With these data, and knowing the number of "grabs," the number of oysters of each size per square yard of bottom was readily obtainable by simple calculation. The following example will illustrate the data obtained and the form of the record:

DEPARTMENT OF COMMERCE AND LABOR.

BUREAU OF FISHERIES.

FIELD RECORD OF EXAMINATIONS OF OYSTER BEDS.

General locality, *Delaware Bay, Delaware.*
Local name of oyster ground, *Over-the-Bar.*
Date, *July 9, 1910.* Time, *8.50 a. m.*
Angle, *B 146–B 147.* Buoy *No. 6.*
Depth, *18 feet.* Bottom, *soft.*
Condition of water, *clear.*
Density, *1.008.* Temperature, *25° C.*
Current, ... Stage of tide, *one hour flood.*
Tongman, *M. A. Duffield.*
No grabs made, *8.* Tongs, *20 feet.*
Total area covered, *2.5* sq. yds.
No oysters taken { *1 in., 13. 1 in.–3 in., 129.* / *3 in.–4 in., 59. 4 in., 11.*
Quantity shells, *14.*
Result { Spat per square yard, *5.2.* / Culls per square yard, *51.6.* / Counts per square yard, *28.0.*

This furnishes an exact statement of the condition of the bed at a spot which can be platted on the chart with error in position of not more than a few yards. From the data obtained a close estimate may be formed of the number of bushels of oysters and shells per acre in the vicinity of the examination and, by multiplying the observations, for the bed as a whole. In the course of the survey 590 observations were made at various places, principally on the natural rocks, but some on the barren bottoms also.

In estimating the relative productiveness of the bottoms it appeared advisable to depart from the methods employed in the James River survey on account of the difference in the conditions under which the industry is prosecuted. Where tongs are used exclusively, a bed with a given quantity of oysters lying in shoal water is more valuable, commercially, than one with the same quantity of oysters in deep water, owing to the fact that the labor of the tonger is more efficient on the former. As has been pointed out, the area covered by a "grab" decreases with the depth, other factors being the same, and moreover the deeper the water the greater is the labor involved in making the grab and the smaller is the number of grabs which can be made in a given time.

In Delaware Bay, while there is a certain amount of tonging during the fall and at such times as the weather will permit in winter and early spring, the most important and productive fishing is by means of dredges, the use of which is permitted from April 15 to June 30, inclusive. In dredging, the effects of varying depths of water, within reasonable limits, are practically negligible so far as the catch is concerned. The time required for winding in from deep water is greater than from shallow water, but as the dredge is approximately equally efficient whatever the depth, and as the difference in the time required in winding is small as compared with the period during which the dredge is on the bottom, the factor of depth, so important in tonging, is practically inconsiderable.

The classification adopted in this report is as follows:

Depleted bottom	Less than 25 bushels per acre.
Very scattering growth	Between 25 and 75 bushels per acre.
Scattering growth	Between 75 and 150 bushels per acre.
Dense growth	Over 150 bushels per acre.

As the region is important for the production of seed rather than market oysters, all sizes are included in the estimates of the density of oyster growth, but all loose shells and other debris commonly dredged are excluded. "Depleted bottom" is not necessarily that which was formerly productive but now practically barren, but is merely an expression of the present impoverishment of the bed without respect to its past. In some cases it may be a formerly barren area slowly coming into productiveness.

The bottom rated as bearing a "very scattering growth" is the least productive bottom capable of furnishing a livelihood to the dredgers.

In the course of the survey 16,435 acres, or over 25 square miles, were explored with sounding lines and chains. Of this area 2,144 acres were found to be included in oyster beds of varying degrees of productiveness. In the survey the chain was dragged over 124 miles of the bottom, soundings were made at 5,772 places, and the position of the boat was instrumentally determined at 819 points.

DESCRIPTION OF OYSTER GROUNDS.

BOMBAY BED.

This is the northernmost public oyster bed within the confines of Delaware. Its northern limit is opposite the upper pier at Woodland Beach, and its southern end is a little below the small creek known locally as Tombstone. Its inner or southwestern edge is from 200 to 400 yards from shore, the average width of the bed is about one-fourth mile, and the total length slightly in excess of 1 mile.

The estimated area, density of growth, and contents of the bed are as follows:

OYSTER GROWTH ON BOMBAY BED.

Character of oyster growth.	Area.	Oysters per acre.			Estimated content of oysters.
		Under 3 inches.	Over 3 inches.	Total.	
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	111	250	115	365	40,515
Scattering	12	103	23	126	2,512
Very scattering	6	22	5	27	162
Depleted	26	0	0	0	0
Total	155				43,189

The dense area comprises a broad strip running along the entire inshore edge of the bed. The scattering areas are two, the larger lying near the middle of the outer edge of the bed and the smaller, a very narrow strip, on the offshore edge of the lower end. Both merge more or less gradually into the dense area with which they are continuous. The area of very scattering growth is a small patch situated near the offshore part of the upper end of the bed, in the midst of the depleted bottom. The latter appears to be a formerly moderately productive area which has become covered by a deposit of mud and now produces no oysters, although there are numerous buried shells lying on a hard bottom about 6 inches beneath the present surface. This bed differs from all others of the region treated in this report in being founded on a stony bottom, a considerable proportion of the oysters taken being attached to rock fragments. The oysters are in small clusters, with thin, sharp shells. Small oysters predominate, not only numerically but by measure. No drills were found and, reasoning from the low salinity of the water, probably do not occur. The specific gravity of the water at the time of examination, July 10, 1910, was about 1.005, and it is likely that the bed suffers periodically during freshets. The average depth of water is about 8 to 10 feet.

It was reported that there were oysters between the piers, but none were found, although there were a few attached to the piling and lying on the bottom in its vicinity.

The details of the examination of this bed are shown in the following table:

DETAILS OF EXAMINATIONS OF BOMBAY BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
183	July 10	10	Dense	1.6	35.2	2.6	129	26	155
184	do	10	do	10.5	42.0	12.6	184	126	310
189	do	10	do	11.0	65.8	19.5	269	195	464
191	do	11	do	15.8	34.2	3.2	175	32	207
192	do	10	do	28.4	54.2	20.5	299	205	504
195	do	12	do	9.5	17.9	9.5	96	95	191
197	do	12	do	52.0	58.4	13.7	387	137	524
199	do	11	do	74.2	57.4	10.0	461	100	561
194	do	12	Scattering	11.0	12.6	3.7	83	37	120
198	do	12	do	35.2	0.0	1.0	123	10	133
186	do	10	Very scattering	0.0	6.3	0.5	22	5	27
185	do	11	Depleted	0.0	0.0	0.0	0	0	0
187	do	10	do	0.0	0.0	0.0	0	0	0
188	do	10	do	0.0	0.0	0.0	0	0	0
190	do	11	do	0.0	0.0	0.0	0	0	0

THRUM-CAP BED.

For a distance of about 5 miles below Bombay bed the bottom is reported to be barren, with the possible exception of a few patches of insignificant size, and it was not deemed warrantable to incur the expense of an examination.

Thrum-cap bed is a somewhat triangular area lying about 1 mile offshore opposite the small stream known to the oystermen as Hay Ditch. It covers an area of about 78 acres, of which it is estimated 6 are covered by a dense growth, 14 by scattering, and 55 by very scattering, and 3 acres are characterized by a total absence of oysters, but with scattered shells buried in the mud.

The areas of dense and scattering growth form a narrow strip on the inshore edge of the bed, with the denser area at the upper end. The bottom covered with very scattering growth stretches in gradually decreasing productiveness from the outer edge of this strip toward the deeper water. The depleted area is a small patch where the dense growth shades off into the surrounding barren bottom. The depth of water on the bed varies from about 18 feet at the inshore edge to 22 feet on the outer border.

It is estimated that the bed contained at the time of examination 4,195 bushels of oysters of all sizes, of which the dense area bore 1,164 bushels, the scattering 1,106 bushels, and the very scattering 1,925 bushels.

There were comparatively few dead oysters, and no indications of the presence of drills were observed. In July the specific gravity of the water varied from about 1.003 at low water to 1.011 at high tide.

The results of the examinations of this bed are shown in the following table:

DETAILS OF EXAMINATIONS OF THRUM-CAP BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
179	July 9	19	Dense	4.4	28.4	8.0	114	80	194
181	do	20	Scattering	5.5	12.2	1.7	62	17	79
178	do	22	Very scattering	1.7	3.3	1.7	18	17	35
180	do	19	Depleted	0.0	0.0	0.0	0	0	0

OVER-THE-BAR BED.

This bed, like the preceding, from which it is separated by a distance of a little over one-eighth of a mile, lies just beyond the edge of the shifting sands, which extend to about the 12-foot curve. It is about 1½ miles from shore, and takes its name from its position some distance outside of a long sand bar, which, according to the navigational charts, is covered by about 4 feet of water at low tide, but on which the present survey found water a little deeper. The depth on the bed itself varies from 15 to 20 feet.

The extent and general condition of the bed in July, 1910, is shown in the following table:

OYSTER GROWTH ON OVER-THE-BAR BED.

Character of oyster growth.	Area.	Oysters per acre.			Estimated content of oysters.
		Under 3 inches.	Over 3 inches.	Total.	
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	109	103	162	275	29,975
Very scattering	15	41	0	41	615
Depleted	39	0	0	0	0
Total	163				30,590

The dense growth is found on two areas, 41 and 68 acres in extent, respectively, separated by a depleted area containing nothing but buried shells. The upper area is long and narrow and contains a large preponderance of oysters over 3 inches long. The northern end of the lower area is similar, with four or five times as many large oysters as small ones, but in the southern the two are in approximately equal quantity, and the average of both sizes is about 335 bushels per acre. The area of very scattering growth is found at the inshore edge of the southern part of the bed, and was apparently formed by a recent strike on a previously depleted area. The three depleted areas lie at the ends and the middle of the bed, the latter in reality separating the rock into two distinct parts. The depleted

bottom bears no oysters and but few exposed shells and, apparently, has been formed either by the silting of sparsely productive bottom or by shells dragged by dredging from the rock on to the adjacent muddy bottom.

The oysters throughout the entire bed are long, narrow, sharp-edged, and inferior in quality, and are almost invariably in clusters, whose bases are buried in soft mud. The bottom throughout is soft, and there is apparent nowhere any depth of shell deposits such as are found on Silver bed and the Ridge.

The details of the examinations made on this bed are shown in the following table:

DETAILS OF EXAMINATIONS OF OVER-THE-BAR BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
169	July 9	18	Dense	15.2	28.8	14.8	154	148	302
170	do	18	do	12.0	28.0	8.4	140	84	224
171	do	18	do	5.2	51.6	28.0	198	280	478
172	do	20	do	9.2	5.6	10.4	52	104	156
174	do	19	do	0.8	9.2	15.6	35	156	191
177	do	21	do	5.6	6.1	26.1	41	261	302
167	do	17	Very scattering	0.8	10.8	0.0	41	0	41
168	do	18	Depleted	0.0	0.0	0.0	0	0	0
173	do	20	do	0.0	0.0	0.0	0	0	0
176	do	20	do	0.0	0.0	0.0	0	0	0
182	do	21	do	0.0	0.0	0.0	0	0	0

PATCHES BETWEEN OVER-THE-BAR AND SAND BEDS.

In the area between these beds are several small scattered patches of oysters, but two of which were examined to determine their character. One of these has an area of about 16 acres and is estimated to contain about 1,000 or 1,200 bushels of oysters. The other is about 5 acres in extent and contains probably about 200 bushels of oysters. On both beds and probably on other small patches in the vicinity the oysters are long, thin, and narrow, and are found in scattered clusters.

The following table exhibits the data obtained from the examinations:

DETAILS OF EXAMINATIONS OF PATCHES BETWEEN OVER-THE-BAR BED AND SAND BEDS.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
160	July 8	19	Very scattering	0	2.8	3.2	10	32	42
162	do	15	do	0	3.0	6.3	11	63	74

SAND BED.

Sand bed lies nearly north of the Ridge and northeast of Silver bed, being separated from the latter by a distance of about one-third of a mile. It covers an area of about 54 acres, of which 16 acres are covered by a dense growth of oysters and 11 acres by a scattering growth, the remaining 27 acres being depleted.

The productive bottom forms a zone along the inner edge of the bed, the southern and middle portions bearing the denser growth. The depleted bottom occupies the outer half of the bed. It is estimated that the bed contained about 4,600 bushels of oysters of all sizes at the time of examination, and that of these 3,700 bushels were on the area of dense growth, 700 bushels on the very scattered growth, and 200 bushels on the depleted bottom. Oysters over 3 inches long preponderated on the productive portions of the bed, but were inferior in quantity on the depleted area.

The oysters are superior in shape to those found on the bars north of this, being in smaller clusters and rounder. Dead oysters were comparatively few, and no indications of the drill were noted.

Several boats were observed working on Sand bed during the latter part of June, and it is reported that the bed was dredged to some extent earlier in the season.

The following examinations were made:

DETAILS OF EXAMINATIONS OF SAND BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
154	July 8	20	Dense	1.2	24.4	14.4	90	144	234
159	do	19	Very scattering	4.0	1.2	4.8	18	48	66
155	do	18	Depleted	0.0	0.0	0.0	0	0	0
156	do	19	do	0.4	2.4	0.4	10	4	14
157	do	19	do	1.6		0.4	6	4	10

LEIPSIC ROCK.

This is a small but exceedingly prolific bed lying in the mouth of Leipsic Creek within one-eighth of a mile of the shore. It is approximately circular in outline and consists of about 4 acres of very dense growth. It is estimated that the bed bears nearly 3,000 bushels of oysters, practically none of which is over 3 inches in length, and it is probable that it represents a recent rejuvenescence of an old bed. There is a deep deposit of shells forming the core of the bed, but around the edges this is covered by a deposit of mud which appears to be encroaching on and causing a gradual contraction of the productive area. It is probable that the oysters are subject to periodical destruction from fresh water and mud carried by freshets.

So far as could be learned the rock has not been worked for several years.

The following examinations were made:

DETAILS OF EXAMINATIONS OF LEIPSIC ROCK.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
140	July 7	11	Dense	41.0	114.5	1.4	544	14	558
144	do	12	do	0.0	14.8	0.4	52	4	56
145	do	10	do	118.0	300.0	1.6	1,460	16	1,476

BED NORTH OF SILVER BED.

North of the western end of Silver bed and separated from it by about one-eighth of a mile of soft bottom in which scattering shells are buried is a nameless bed covering about 25 acres. There are about 8 acres covered by scattering growth estimated to contain about 900 bushels of oysters and about 17 acres of very scattering oysters containing about 750 bushels. The northern part of the bed, which bears the heaviest growth, has a substratum of shells, but the southern edge lies on sandy bottom. The proportion of large oysters is greater than on Silver bed.

The following observations were made:

DETAILS OF EXAMINATIONS OF BED NORTH OF SILVER BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
158	July 8	14	Scattering	4.5	6.7	7.8	39	78	117
152	do	13	Very scattering	4.0	2.2	2.2	22	22	44

BETWEEN SILVER BED AND SIMONS CREEK.

Almost continuous with Silver bed and stretching for a distance of nearly one-half of a mile toward the mouth of Simons Creek is a bed of about 17 acres lying on the mud and sand. Its most productive area is nearest Silver bed, and the opposite end is bare except of scattered shells. The best part, about 5 acres in extent, bears a scattering growth of oysters estimated to contain about 375 bushels, and the area of very scattering growth which adjoins it bears about the same quantity on its 7 acres. The depleted bottom is practically bare at present, but is in a condition to catch a small set under favorable conditions.

The following table shows the results of examinations:

DETAILS OF EXAMINATIONS OF BED BETWEEN SILVER BED AND SIMONS CREEK.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
166	July 8	9	Scattering	2.9	3.4	5.4	22	54	76
165	..do....	9	Very scattering	0.0	4.3	3.7	15	37	52
111	June 29	14	Depleted	0.0	0.0	0.0	0	0	0

SILVER BED.

This bed, which is said to derive its name from the silvery color of the shells found on the hard rock, is, excepting the Ridge, the largest and most important natural bed in Delaware. It lies about 1 mile east of the mouth of Dona River, locally known as Simons Creek. The bed has a maximum extent of about a mile east and west and slightly over a half mile north and south, and it lies in a depth of water varying from 8 to 12 feet.

The following table shows its general extent and condition in July, 1910:

OYSTER GROWTH ON SILVER BED.

Character of oyster growth.	Area.	Oysters per acre.			Estimated content of oysters.
		Under 3 inches.	Over 3 inches.	Total.	
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	65	171	74	245	15,925
Scattering	20	82	27	109	2,180
Very scattering	45	25	21	46	2,070
Depleted	140	8	2	10	1,400
Total	270				21,575

The most productive parts of the bed lie in its northeast half and include a belt of dense and scattering growth about one-half mile long and varying from one-eighth to one-third mile in width.

A considerable part of the bottom covered by the bed is macadamized with a dense accumulation of shells, or probably two such areas separated by a belt of muddy bottom. In places the bottom was so hard with compacted shells and so smooth that a boat anchor would not take hold. Although this bed is not now raised above the surrounding barren bottom, it is probable that it originally formed a knoll, the crest of which has been cut away by dredging and tonging.

The area of dense growth lies in a compact body occupying the middle of the eastern half of the bed, gradually merging with two

small areas of scattering growth at the northwest and southeast ends, respectively. There is a third area of scattering growth near the western end of the bed. The very scattering growth forms a zone around the western and part of the southern side of the more prolific bottom, lying on a substratum of compacted shells. Most of the western half of the bed is composed of depleted bottom, which also extends as a narrow strip around practically the entire circumference of the rest of the bed, the bottom being generally hard and shelly with occasional patches of mud.

In general the present condition of the bed indicates a former greater extent of productive bottom. There is every indication that it has been closely dredged during the past season, and the present content of oysters is probably but a small proportion of the quantity on the bottom at the beginning of the season. The shells are in excellent condition to receive a set of spat, and under favorable circumstances the bed should speedily recuperate. There were comparatively few dead oysters, and drills or borers do not appear to be troublesome.

The following observations were made:

DETAILS OF EXAMINATIONS OF SILVER BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
58	June 25	14	Dense	23.7	65.0	12.2	310	122	432
110	June 29	14	do	5.9	21.1	6.7	94	67	161
149	July 8	13	do	1.5	29.6	7.8	109	78	187
163	do	10	do	8.7	40.0	2.9	170	29	199
55	June 25	14	Scattering	12.2	7.4	1.9	69	19	88
147	July 8	14	do	1.4	22.2	3.3	83	33	116
164	do	9	do	4.3	22.9	2.9	95	29	124
59	June 25	13	Very scattering	0.4	3.3	1.2	13	12	25
100	June 27	11	do	2.4	7.9	1.7	36	17	53
150	July 8	13	do	2.6	4.5	3.3	25	33	58
52	June 25		Depleted						
53	do	13	do	0.3	4.5	0.0	17	0	17
60	do	13	do	0.0	0.0	0.0	0	0	0
98	June 27	11	do	0.0	2.8	0.3	10	3	13
99	do	11	do	1.4	1.0	0.7	8	7	15
109	June 29	14	do	0.0	0.0	0.0	0	0	0
148	July 8	13	do	1.1	2.2	0.0	11	0	11

LUMPS BETWEEN SILVER AND RIDGE BEDS.

Lying between Sand and Silver beds on the north and Ridge and Drum beds on the south are a number of small lumps and patches surrounded by a considerable area of barren bottom. Eight of these areas were located by the survey, most of them covering areas of 3 or 4 acres, and there are probably a number of others, as on account of their small size and irregular distribution but little time was spent in

looking for them. But three of these places were examined in detail, and their location may be determined by an inspection of the chart. One of them was about 3 acres in extent and was estimated to contain about 2,500 bushels of long, sharp-edged oysters in large clusters, growing on a soft, muddy bottom. The other two spots examined bore a very scattering growth. The largest of these, about one-fourth mile inshore of the upper end of Drum bed, was estimated to be about 8 acres in extent and to contain about 300 bushels of oysters. The other, just south of the middle of Silver bed, has an area of about 4 acres and contained at the time of examination about 120 bushels of oysters.

The five areas located but not examined varied in extent from about 1 to 14 acres, and are situated variously. They are shown on the chart as unshaded places surrounded by red lines. Judging from the chain readings none of them is particularly productive.

The following observations were made in this region:

DETAILS OF EXAMINATIONS OF LUMPS BETWEEN SILVER AND RIDGE BEDS.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
96	June 27	18	Dense	1.4	28.0	75.2	103	752	855
86	do	15	Very scattering	0.7	4.1	1.9	17	19	36
97	do	13	do	0.0	2.2	2.2	8	22	30

DRUM BED.

Drum bed lies west of and very close to the depleted edge of the ridge and about 1 mile from shore. It has a length of over one-half mile, a width of about one-fourth mile, and a total area of approximately 68 acres. Its condition and the relative extent of oyster growths of the several degrees of productiveness are shown in the following table:

OYSTER GROWTH ON DRUM BED.

Character of oyster growth.	Area.	Oysters per acre.			Estimated content of oysters.
		Under 3 inches.	Over 3 inches.	Total.	
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	16	139	83	222	3,552
Scattering	21	30	65	95	1,995
Very scattering	19	32	18	50	950
Depleted	12	1	6	7	84
Total	68				6,581

The most prolific part of the bed is an area about one-fourth mile square extending across its middle, consisting of an area of dense growth flanked on each side by one bearing a scattering growth. The northern end of the bed is composed of a gradually narrowing area of very scattering growth, and there is a small patch of similar character at the inside corner of the southern end.

The depleted bottom is in two patches, one adjoining the scattering and very scattering growths at the lower end and the other interposed between the dense scattering and very scattering oyster deposits just above the middle. The bottom is soft on the areas of very scattering growth and on part of the northernmost depleted area, but is elsewhere hard and shelly.

Small oysters exceed in quantity those over 3 inches long, excepting on the area of scattering growth, where there are about twice as many large as small ones. Loose shells are in fair abundance and of a character to catch a good set under favorable conditions.

The following observations were made:

DETAILS OF EXAMINATIONS OF DRUM BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
47	June 25	16	Dense	27.2	18.8	3.6	161	36	197
48	do	16½	do	16.0	30.0	7.6	161	76	237
107	June 29	17	do	4.0	23.2	13.6	95	136	231
51	June 25	17	Scattering	7.2	13.2	3.2	71	32	103
84	June 27	17	do	1.4	10.0	8.2	4	82	86
106	June 29	18	do	1.6	2.8	8.2	15	82	97
105	do	18	Very scattering	1.6	9.2	1.6	37	16	53
108	do	17	do	0.0	7.6	2.0	27	20	47
73	June 27	15	Depleted	0.0	0.4	0.4	1	4	5
85	do	17	do	0.0	0.0	0.8	0	8	8

RIDGE BED.

The Ridge bed, known to the oystermen as "The Ridge," is at present the most important natural bed in Delaware, and during the period of the present survey it sustained by far the heaviest dredging. During the latter half of June numerous vessels were at work daily and until the end of the month, when the dredging season closed, there appeared to be a fair catch.

The Ridge lies about 1½ miles from the nearest shore, midway between Dona River and Mahon River. It is triangular in shape, with a deep indentation or slough of muddy bottom projecting deeply into its base at the southern end. It has an extent of slightly over 1 mile north and south and its southern end is almost of equal extent east and west. It has a total area of 371 acres and the most productive bottom, that which is rated in this report as bearing dense and

scattering growths, stretches from the northern apex to about the middle of the bed, where it divides into two limbs astride the slough before alluded to.

It is evident that this bed, like Silver bed, is an old one, and without doubt its central portions, those which now bear the heaviest growth of oysters, were formerly elevated above the surrounding bottom to form a shoal or ridge which has been pulled down and in large part carried away by the oystermen, particularly the dredgers, until at present the water over it shoals but little as compared with the surrounding barren areas. The great deposit of shells which originally existed has been taken up and the bottom so denuded that in places the originally underlying mud has been brought to the surface. Many little patches of bare mud were found where there was every reason to expect a deposit of shells and oysters and it was apparent that the bed was being overworked.

The general condition and extent of the bed at the end of June, 1910, is shown in the following table:

OYSTER GROWTH ON RIDGE BED.

Character of oyster growth.	Area.	Oysters per acre.			Estimated content of oysters.
		Under 3 inches.	Over 3 inches.	Total.	
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	49	160	23	183	8,967
Scattering	86	96	25	121	10,406
Very scattering	65	36	21	57	3,705
Depleted	171	4	1	5	855
Total	371				23,933

The dense areas are two in number, separated by an area of scattered growth. The smaller of these areas lies at the northern apex of the bed and the larger one is a long belt along most of its eastern side. More or less soft mud is to be found in the former, especially near its upper edge, but the latter rests on a solid substratum of shells.

The lower end of the larger dense area gradually verges into a small spot of scattering growth, but most of the bottom bearing a growth of this character is embraced in a long, somewhat S-shaped strip running from near the northern end of the bed almost to its southwest corner. The northern end, especially between and adjacent to the dense growths, is most productive.

The very scattering growth is all confined to the southern edge of the bed, most of it being between the mud slough and the dense and scattering growth. Excepting close to the more productive areas there is much muddy bottom in this area. Most of the depleted

bottom lies on the west side of the bed, but there is a narrow strip along the eastern edge and embracing the southern end of the dense and scattering growth. Much of the depleted area is in reality denuded or barren, and although most of it lies on hard bottom there are numerous muddy spots, especially near the southern edge.

On this bed as a whole and especially on the more productive areas small oysters are in great preponderance. In many cases there were quantities of oysters so small that they fell between the teeth of the tongs.

The following observations were made on this bed:

DETAILS OF EXAMINATIONS OF RIDGE BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
67	June 26	17	Dense	20.0	20.0	3.9	140	39	179
91	June 27	18	do	31.2	21.2	1.6	183	16	199
93	do	16	do	29.1	16.0	1.6	158	16	174
62	June 26	16	Scattering	19.2	7.6	2.0	94	20	114
65	do	16	do	16.0	12.0	4.0	98	40	138
69	do	18	do	17.2	13.6	2.8	108	28	136
92	June 27	16	do	28.8	4.4	2.0	116	20	136
101	do	15	do	7.4	10.7	1.9	63	19	82
61	June 26	14	Very scattering	4.8	1.1	0.7	21	7	28
63	do	15	do	2.2	3.7	5.2	21	52	73
79	June 27	16	do	0.8	10.4	2.4	39	24	63
90	do	17	do	12.4	5.2	0.0	62	0	62
64	June 26	16	Depleted	0.0	0.0	0.0	0	0	0
66	do	16	do	1.2	2.0	0.0	11	0	11
70	do	17	do	2.0	2.4	0.0	15	0	15
80	June 27	15	do	0.0	0.0	0.0	0	0	0
81	do	14	do	2.6	0.7	0.4	12	4	16
82	do	16	do	0.0	0.0	0.0	0	0	0
83	do	17	do	0.4	0.4	0.0	3	0	3
87	do	16	do	0.0	0.0	0.0	0	0	0
88	do	16	do	0.0	0.0	0.0	0	0	0
89	do	16	do	0.0	0.0	0.0	0	0	0
102	do	13	do	0.0	0.0	0.0	0	0	0
103	do	13	do	0.0	0.4	1.1	1	11	12

SMALL BEDS NORTHEAST OF RIDGE BED.

Northeast of the Ridge is a small patch of about 7 acres of very scattering growth which is estimated to contain about 200 bushels of oysters, most of them over 3 inches in length.

The following results were obtained from an examination of this area:

DETAILS OF EXAMINATIONS OF SMALL BEDS NORTHEAST OF RIDGE BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
94	June 27	18	Very scattering	0	1.4	2.4	5	24	29

OLD BED.

Old bed lies close to the southeastern edge of the Ridge, from which it is separated by a narrow strip of mud with many buried shells. It is stated that the dredgers sometimes haul across the barren bottom from one bed to the other.

The condition and extent of the bed as determined by the survey were as follows:

OYSTER GROWTH ON OLD BED.

Character of oyster growth.	Area.	Oysters per acre.			Estimated content of oysters.
		Under 3 inches.	Over 3 inches.	Total.	
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Very scattering	20	40	2	42	840
Depleted	17	10	3	13	221
Total	37				1,061

Although the bed is at present not very productive it has the appearance of former greater value. It lies on a dense bed of shells and is undoubtedly the remnant of an old accumulation. There are very few large oysters to be found, but the young growth is fair in places and the conditions for a new set are good. The bed evidently has been subjected to severe dredging.

The following observations were made:

DETAILS OF EXAMINATIONS OF OLD BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
76	June 27	16	Very scattering	10.4	2.8	0.0	46	0	46
130	June 30	17	do	6.0	1.4	0.0	26	0	26
131	do	19	do	0.8	5.6	0.8	22	8	30
132	do	19	do	10.4	11.6	0.0	77	0	77
133	do	19	do	4.8	4.4	0.0	32	0	32
74	June 27	17	Depleted	0.0	2.0	0.0	7	0	7
75	do	18	do	1.2	2.0	0.8	11	8	19
78	do	17	do	0.0	1.2	0.4	4	4	8
134	June 30	20	do	0.6	4.4	0.0	18	0	18

OUTSIDE OF OLD BED.

Immediately outside of Old bed is an area of about 16 acres, surrounded by sand, for which the oystermen appear to have no name, if, even, they are aware of its existence. But one observation was made at this place, where a dense growth of young oysters was found. If the other parts of the bed are equally productive this patch contains about 6,800 bushels of oysters, practically all of them under 3 inches in length. The present growth is apparently of recent origin.

The following results were obtained from the examination:

DETAILS OF EXAMINATIONS OF BEDS OUTSIDE OF OLD BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
77.....	June 27	15	Dense.....	35.0	83.4	15.0	414	15	429

SCATTERED PATCHES BETWEEN RIDGE AND SOUTHWEST BEDS.

On the soft bottom lying between these two beds are a number of little patches of oyster growth, of which five were located with the chain and three were examined by tonging. The latter were all highly productive, and they probably represent the possibilities of oyster production in this vicinity on beds not frequented by the dredgers.

The three beds examined covered a total of 11 acres, and it is estimated that they contained about 5,300 bushels of oysters, of which nearly three-fourths were over 3 inches long. Based on the results of the examination, and assuming that the other beds found are equally productive, the five beds probably contain about 11,000 bushels, and it is probable that at least 20,000 bushels are scattered in little 2 to 5 acre patches in the vicinity.

The following table shows the data obtained from examinations:

DETAILS OF EXAMINATIONS OF SMALL SCATTERED PATCHES BETWEEN RIDGE AND SOUTHWEST BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
40.....	June 22	12	Dense.....	20.3	21.1	21.1	145	211	356
42.....	...do.....	14	.....do.....	15.2	30.4	20.7	159	207	366
71.....	June 27	14	.....do.....	15.2	14.4	71.5	104	715	819

SOUTHWEST BED.

Southwest bed lies in the southeastern part of the present productive natural oyster grounds of the State and its southern edge is about one-fourth mile north of the "east line" which separates the private beds from the public ones. It has a north and south extent of upward of one-half mile and a maximum width of about one-third mile, containing all told about 106 acres.

The extent and relative productiveness of the bottoms, as classified in this report, are shown in the table following.

OYSTER GROWTH ON SOUTHWEST BED.

Character of oyster growth.	Area.	Oysters per acre.			Estimated content of oysters.
		Under 3 inches.	Over 3 inches.	Total.	
	Acres.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Dense	11	40	744	784	8,624
Scattering	8	99	48	147	1,376
Very scattering	31	18	13	31	961
Depleted	56	4	1	5	280
Total	106				11,241

The area of dense growth is near the southern end of the bed and is flanked on the east and west sides by a very scattering growth, and on the north and south by depleted bottom. Most of the oysters are over 3 inches long and they appear to be in numerous small patches on the soft mud. The place has the appearance of bottom which has been overlooked by the oystermen and may as a whole be somewhat smaller in area than is indicated in the preceding table.

The bottom bearing scattering growth lies at the northeast edge of the bed and at its southwestern limits merges into a strip of very scattering growth running along the western edge of the bed as far as the densely covered bottom first described. There is another small patch of very scattering growth near the southeast corner of the bed.

The depleted bottom lies in three patches, one at each end of the bed and the other at the middle of the eastern edge.

Although it is not known whether Southwest bed was dredged during the past season, it bears every evidence that it has been overworked. Excepting on the small area of dense growth there are few marketable oysters, and bare or almost bare muddy spots are of frequent occurrence. Many oysters had been killed by drills and many of these animals and their egg cases were found.

The following table shows the results of examinations:

DETAILS OF EXAMINATIONS OF SOUTHWEST BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
126	June 30	14	Dense	1.5	10.0	74.4	40	744	784
31	June 22	13	Scattering	5.6	22.7	4.8	99	48	147
121	June 30	13	Very scattering	0.4	5.6	0.4	21	4	25
122	...do	12	...do	1.5	7.5	0.4	31	4	35
128	...do	15	...do	0.0	1.4	3.0	5	30	35
129	...do	14	...do	0.0	4.4	1.5	15	15	30
32	June 22	13	Depleted	0.0	0.0	0.0	0	0	0
120	June 30	14	...do	0.4	4.4	0.0	17	0	17
123	...do	12	...do	0.0	1.4	0.4	5	4	9
124	...do	13	...do	0.0	0.0	0.4	0	4	4
125	...do	15	...do	0.0	0.0	0.0	0	0	0
127	...do	15	...do	0.0	0.0	0.0	0	0	0

STONE BED.

This bed possibly takes its name from the quantity of hard, sandy worm tubes, known to the oystermen as "stone coral," which are found attached to and overgrowing the oysters. It is probable that a good many of the latter are stifled and killed by this growth, which is even more abundant on a small depleted patch lying between the Stone bed and the mouth of Mahon River.

The bed covers an area of about 33 acres of very scattering growth, on which there is an average of about 53 bushels of oysters per acre. It is estimated that about July 1, 1910, there were on the entire bed about 1,750 bushels of oysters, the large and small being in about equal quantities.

The following observations were made:

DETAILS OF EXAMINATION OF STONE BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
36.....	June 22	13	Very scattering.....	0.7	4.8	2.6	19	26	45
104.....	June 29	18	.....do.....	.....	10.0	2.4	35	24	59

EAST LINE BED.

This bed lies just at the line which marks the southern limits of the public grounds, and it appears that for that reason it has a sentimental interest to the oystermen. It has a diameter not much greater than the length of a boat and is too small to plot on the chart, on which its position is indicated by a circle.

Numerous examinations were made in its vicinity over an area of 6 or 8 acres, but at only one place were oysters found, and there they were very dense and mostly of marketable size.

The data obtained at this station are shown in the following table:

DETAILS OF EXAMINATIONS OF EAST LINE BED.

Station number.	Date of examination.	Depth of water.	Character of growth.	Oysters caught per square yard.			Estimated quantity oysters per acre.		
				Spat.	Culls.	Counts.	Seed.	Market.	Total.
	1910.	*Feet.*		*No.*	*No.*	*No.*	*Bu.*	*Bu.*	*Bu.*
118.....	June 30	13	Dense.....	0.0	10.0	77.8	35	778	813

FLOGGER BED.

Flogger bed lies along Joe Flogger Shoal, which separates Blake Channel from the ship channel. As developed by the survey, it is the largest bed in Delaware, having a length of over 3 miles, an average width of about one-third mile, and an area of about 660 acres. Owing to its exposed situation and the depth of water, as well as to the contradictory information received as to its approximate location and extent, it was the most troublesome bed encountered by the survey. Lines were run across Joe Flogger Shoal from its extreme southern end, but no indications of shells or oysters were encountered until within about one-half mile of east line. From this point scattering shells were found, but when the bottom was examined with the tongs these were discovered to be more or less submerged in the sand.

The bed as outlined on the chart was located almost entirely by means of the chain. At its upper end it lies on the eastern or ship-channel side of Joe Flogger Shoal, but about a mile from its upper end it expands to the westward over an area of somewhat deeper water, and thence, to its southern end, continues on the western or Blake Channel side of the shoal. It was at this point of expansion only that oysters were found, in one small patch of very scattering growth and two or three areas of depleted bottom. The results were not of sufficient importance to exhibit in detail on the chart. It is possible that oysters are to be found in limited quantities in some of the deeper water, but the chain readings did not indicate patches of sufficient importance to warrant the expense of making dredgings. It is reported that there are oysters in some of the deep water of the ship channel, but no indications were found in such places as were examined.

It is understood that Flogger bed has not been dredged for several years, and the survey indicated that while formerly it may have been of importance commensurate with its area, it has become covered with sand throughout practically its whole extent. It may again become productive, but there is no present indication of this probability.

Oysters were reported around the buoy at the head of Flogger Shoal and at another buoy on the opposite side of Blake Channel, but a careful examination, expecially in the latter place, failed to disclose them.

THE BEDS IN SUMMARY.

The oyster bottoms of Delaware all lie between Woodland Beach and the vicinity of Bowers Beach, covering an area about 21 miles long and with an average width of about 3 miles. South and west of a line running east from the old Mahon River Lighthouse and thence approximately southeasterly along Blake Channel, the bottoms are excluded from the common oyster fishery and a considerable proportion of the area is leased to private persons and firms for purposes of oyster culture.

With this area this report will not deal, as it was examined by the writer in but the most cursory manner and the survey of the private beds was being made solely as a State undertaking. It may be stated, however, that the private beds are planted partly with shells, mostly brought from points on Chesapeake Bay, but generally with seed oysters taken from the natural beds. The grounds are in large part leased or controlled by residents of Philadelphia and New Jersey, and the product is consumed principally in Philadelphia, being marketed through Maurice River Cove in New Jersey.

The natural rocks, with which alone this report is concerned, lie in a narrow strip between Blake Channel and the main ship channel on what is known as Joe Flogger Shoal, and between these channels and the Delaware shore in a belt which stretches from the east line above mentioned to about abreast of the upper pier at Woodland Beach, a distance of about 13 miles.

At its southeastern end, where it adjoins the planted area, this zone is about 3 miles in width, but it gradually narrows to the northward until at its upper extremity it is hardly one-half mile wide. The most extensive beds lie in the lower half of the zone and the most intense fishery is carried on in that region. During the time of the survey this was practically the only place in which the dredgers were operating, and we were informed that but little had been done elsewhere earlier in the season.

The following tables summarize the data of the extent, condition, and general distribution of oyster growth on the several beds previously discussed in more detail:

AREAS OF OYSTER BEDS.

Name of bed.	Character of oyster growth.					Total.
	Dense.	Scattering.	Very scattering.	Depleted.	Not determined.	
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Bombay	111	12	6	26	.....	155
Thrum-cap	6	14	55	3	.....	78
Over-the-Bar	109	.....	15	39	.....	163
Between Over-the-Bar and Sand	.....	.....	21	.....	.....	21
Sand	16	.....	11	27	.....	54
Leipsic Rock	4	.....	.....	.....	.....	4
North of Silver	.....	8	17	.....	.....	25
Between Silver and Simons Creek	.....	5	7	5	.....	17
Silver	65	20	45	140	.....	270
Between Silver and Ridge	3	.....	12	.....	21	36
Drum	16	21	19	12	.....	68
Ridge	49	86	65	171	.....	371
Northeast of Ridge	.....	.....	7	.....	.....	7
Old	.....	.....	20	17	.....	37
Outside of Old	16	.....	.....	.....	.....	16
Between Ridge and Southwest	11	.....	.....	.....	12	23
Southwest	11	8	31	56	.....	106
Stone	.....	.....	33	.....	.....	33
East Line	[1]	.....	.....	.....	.....	[1]
Flogger	.....	.....	.....	.....	[2] 660	660
Total	417	174	364	496	693	2,144

[1] Less than 1 acre.

[2] Practically all depleted.

ESTIMATED OYSTER CONTENT OF NATURAL BEDS, JULY 1, 1910.

Name of bed.	Character of oyster growth.					Total.
	Dense.	Scattering.	Very scattering.	Depleted.	Not determined.	
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Bombay	40,515	2,512	162	.....	.....	43,189
Thrum-cap	1,164	1,106	1,925	.....	.....	4,195
Over-the-Bar	29,975	.....	615	.....	.....	30,590
Between Over-the-Bar and Sand	.....	.....	1,200	.....	.....	1,200
Sand	3,700	.....	700	200	.....	4,600
Leipsic Rock	3,000	.....	.....	.....	.....	3,000
North of Silver	.....	900	750	.....	.....	1,650
Between Sand and Simons Creek	.....	375	375	.....	.....	750
Silver	15,925	2,180	2,070	1,400	.....	21,575
Between Silver and Ridge	2,500	.....	420	.....	[1] 3,000	5,920
Drum	3,552	1,995	950	84	.....	6,581
Ridge	8,967	10,406	3,705	855	.....	23,933
Patch northeast of Ridge	.....	.....	200	.....	.....	200
Old	.....	.....	840	221	.....	1,061
Outside of Old	6,800	.....	.....	.....	.....	6,800
Between Ridge and Southwest	5,300	.....	.....	.....	[1] 15,000	20,300
Southwest	8,624	1,376	961	280	.....	11,241
Stone	.....	.....	1,750	.....	.....	1,750
East Line	[1] 500	.....	.....	.....	.....	[1] 500
Flogger	.....	.....	.....	.....	[2]	[2]
Total	130,522	20,850	16,623	3,040	18,000	189,035

[1] Estimated from chain indications.

[2] Practically all depleted.

Combining the foregoing data, an interesting comparison may be instituted between the beds sustaining a heavy fishery with dredges and those which recently have been worked but little. According to the best information, supported by our own observations in the latter part of the season, practically all of the dredging in 1910 was on the beds south of Over-the-Bar, although a few vessels were observed apparently working on Thrum-cap. These beds, excluding Flogger, had a total area of 1,088 acres and a total estimated oyster content of 111,061 bushels, or an average of 102 bushels per acre, at the end of the season. On the beds which were reported or observed to be most severely worked the oyster content averaged considerably less than this. On the Ridge the average for the whole bed was about 60 bushels per acre, on Drum bed about 97 bushels, on Silver bed about 80 bushels, on Old bed 30 bushels, and on Southwest bed about 106 bushels, and for the five beds taken as a whole the average was about 75 bushels per acre.

The beds above and including Over-the Bar have an area of 396 acres and a total estimated content of 77,984 bushels of oysters of all sizes, or an average of 197 bushels per acre. These beds, owing to their position, are probably more subject than the lower beds to damage from freshets and are probably naturally less productive, yet they had at the time of examination an oyster growth over 2½ times as dense. If we consider the various small patches surrounding the five beds enumerated above, which are in general too small to dredge or which, if large enough, have been overlooked during the season

recently closed, the disparity is still greater. Those which were examined by tonging had an area of 46 acres and an estimated content of 18,000 bushels of oysters, an average of nearly 390 bushels per acre, over five times the density of growth on the large beds in the vicinity.

The number of bushels taken from the beds of Delaware during the past season is not known but it was probably several hundred thousand bushels, and from the conditions found in the survey and the data just deduced it probably can be safely assumed that oysters were from three to five times as abundant at the beginning of the season as they were in its closing days when the survey was made.

This heavy draft on the beds would be less serious were it not accompanied by an abuse for which there is no excuse. In a region devoted mainly to planting and where a comparatively small quantity of oysters is marketed directly from the natural beds it is economically advisable to permit the taking of small oysters as well as large. So long as there is an abundance of shells on the bottom and a reasonable quantity of oysters is left to furnish spawn there will be, under favorable conditions of water and temperature, a more or less regular set of spat and the oyster population of the beds will be fairly maintained, although, of course, the proportion of oysters of marketable size will diminish. When, however, the beds are stripped of shells, as appears to be the case in Delaware, they will surely become depleted.

During the survey, although a number of vessels were actively dredging, no member of the party observed a boat engaged in culling. Inquiry among the oystermen elicited the information that while the boats catching seed oysters for sale generally cull their catch because the planters will not pay oyster prices for shells, the vessels owned or operated by planters when dredging on the public beds rarely do so. They are charged with carrying away everything which the dredge picks up, the shells being valuable for hardening the bottoms on their planting grounds and as cultch for catching a set of spat.

That some vessels are guilty of such behavior is within the knowledge of the writer, and moreover the charge is supported by the condition of the beds. One of the most noteworthy of the facts disclosed by the tong examinations was the small quantity of shells found as compared with similar examinations of beds in other States. On the five important beds in the vicinity of the Ridge there are less than 2 per cent as many shells per square yard as are found on the seed beds of James River, Va., where culling is strictly enforced. In places the deep pavement of shells which must have existed formerly has been completely removed and the underlying mud now shows itself in patches in the midst of the beds. A hard-worked bed to be in a healthy condition should contain an abundance of shells. The ultimate result of the continuance of this state of affairs is not difficult

to foresee. Oysters can not set on the mud. They must have some hard, clean object to which to attach when they settle down from their infantile free-swimming habit, and on the beds the old shells and the oysters themselves offer the only possibilities. If there be few or no shells the recuperation of exhausted beds is correspondingly retarded. If both shells and oysters are persistently removed, the most productive bed eventually will be hopelessly depleted.

PHYSICAL AND BIOLOGICAL CONDITIONS.

TIDES AND CURRENTS.

A staff tide gauge was established at the wharf at Mahon River Light-house and readings were taken hourly from 8 a. m. until 5 p. m. during the period of the survey. This does not furnish a very accurate plane of reference, but as the location of the gauge was central with respect to the more important beds it is sufficiently accurate for the purposes of this report. The average rise and fall of the tide between June 19 and July 10 was 5.4 feet, the minimum being 4.5 feet on July 10 and the maximum 6.3 on July 2.

No measurements of the velocity of currents were made, but in general it may be stated that they are strong throughout the region embraced in this report.

SALINITY OF THE WATER.

The salinity of the water exhibited a very considerable range within the limits covered by the survey. From June 18 to July 10 observations were made three times daily at the anchorage of the *Fish Hawk* and several times each day on the oyster beds undergoing examination. Most of the observations on the *Fish Hawk* were made at a point about 1 mile south of the east line and about 3 miles offshore, but others, fewer in number, were made near the southern limit of the planted beds, near the middle of the north and south extent of the public beds, and at the upper limit of oyster growth opposite Woodland Beach.

The data obtained are shown in the following table:

SALINITY OF WATER OVER OYSTER BEDS, JUNE 18 TO JULY 10.

Locality.	Number of observations.	Specific gravity of water corrected.			Average temperature of water.
		Maximum.	Minimum.	Average.	
					°F.
Opposite Woodland Beach	3	1.0074	1.0032	1.0057	79
Midway between Ship John and Elbow Light-house	3	1.0121	1.0100	1.0107	77
3¼ miles southeast by east of Mahon River Light	33	1.0149	1.0103	1.0136	77
6 miles east-northeast of Bowers Beach	6	1.0178	1.0158	1.0164	68

At the upper limit of oyster growth the salinity of the water was low at a time when there had been comparatively little rainfall, and it is probable that it may become practically fresh at this point during periods of freshet. This is without much doubt the cause inhibiting the growth of oysters at places higher up the river.

At the southern end of the planting grounds the salinity is comparatively high and in consequence it is to be expected that the drill or borer would be destructive. On the more important of the public beds, those lying between the east line and the mouth of Leipsic Creek, the density is favorable for the welfare of the oysters. It probably never falls so low as seriously to threaten the beds, and, on the other hand, it is hardly high enough, excepting close to the east line, to favor an abundance of drills.

ENEMIES OF THE OYSTER.

It is stated that schools of drumfish occasionally appear on the oyster beds of Delaware Bay and cause much damage, but none were observed during the survey. This enemy of the oyster is usually more destructive on planted beds than on the public rocks, probably because the single-culled oysters on the former are easier to crush than are the clustered, sharp-edged specimens more common on the natural beds. The inroads of the drumfish are sporadic and unexpected in most places, although on the coasts of some of the Southern States they are frequent enough to warrant the inclosure of the planted beds with wire fences. This appears to be the only really adequate protection, though if the presence of a school on the beds or in their vicinity is discovered in time it can often be driven from the neighborhood by the use of explosives.

The principal enemy to the oyster on the Delaware beds is the drill or borer, a small marine snail which drills a hole through the oyster's shell and thus gains access to the contents, which it consumes. The perforation is made by actual drilling with a rasplike organ protruded from the mouth, and so far as is known no acid or other solvent is employed to soften the shell. The drill breeds during late spring and summer, laying its eggs in vase-shaped, leathery capsules attached in clusters to shells and other hard bodies on the bottom. These capsules, each containing several eggs, are readily recognizable, being about one-fourth inch long and usually yellow in color.

In the few places examined on the planted beds there were considerable numbers of drills and many small oysters killed by them. On the public beds near the east line some drills and killed oysters were found, but over most of the area surveyed the salinity of the water is somewhat too low to permit these pests ever to become a serious factor. Below a salinity represented approximately by a mixture of equal parts of salt and fresh water, having a specific gravity of about 1.012 or 1.013, the drill will not thrive.

Although in the absence of other food the drill will attach and sometimes kill oysters of marketable size, it invariably attacks smaller ones by preference. Seed oysters 2 or 2½ inches in diameter are comparatively immune, and in places where the drills are particularly troublesome such seed should be planted in preference to smaller. Although such is not known to be the case in Delaware, there are localities in which it is useless to plant shells or other cultch, as the spat is drilled before its shell has lost its first paperlike thinness.

The drill is a difficult enemy to combat. Where it is sufficiently abundant to be a menace on private beds the oysters are usually dredged up and the drills removed by hand and destroyed, after which the oysters are again laid down. Much can be done by destroying the drills and their egg capsules wherever found. The common practice of some Delaware planters of depositing rough seed on their beds undoubtedly helps to maintain the abundance of the drill.

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Bombay Bed
Woodland Beach
Tombstone
Bombay Hook Point
Bombay
Roy Dieck
Thorn Cap Bed
Johnsons Creek
Johnsons Light
Ship John Shoal Light
Note
Natural Oyster Beds shown in red.
Area of dense growth of oysters
" " scattered " " "
" " very scattered " " "
" " depleted " " "
Soundings
Depth at mean low water expressed in feet.
Bottom symbols
h. for hard - s. for soft.

NATURAL OYSTER BEDS

DELAWARE

SURVEYED BY

UNITED STATES BUREAU OF FISHERIES

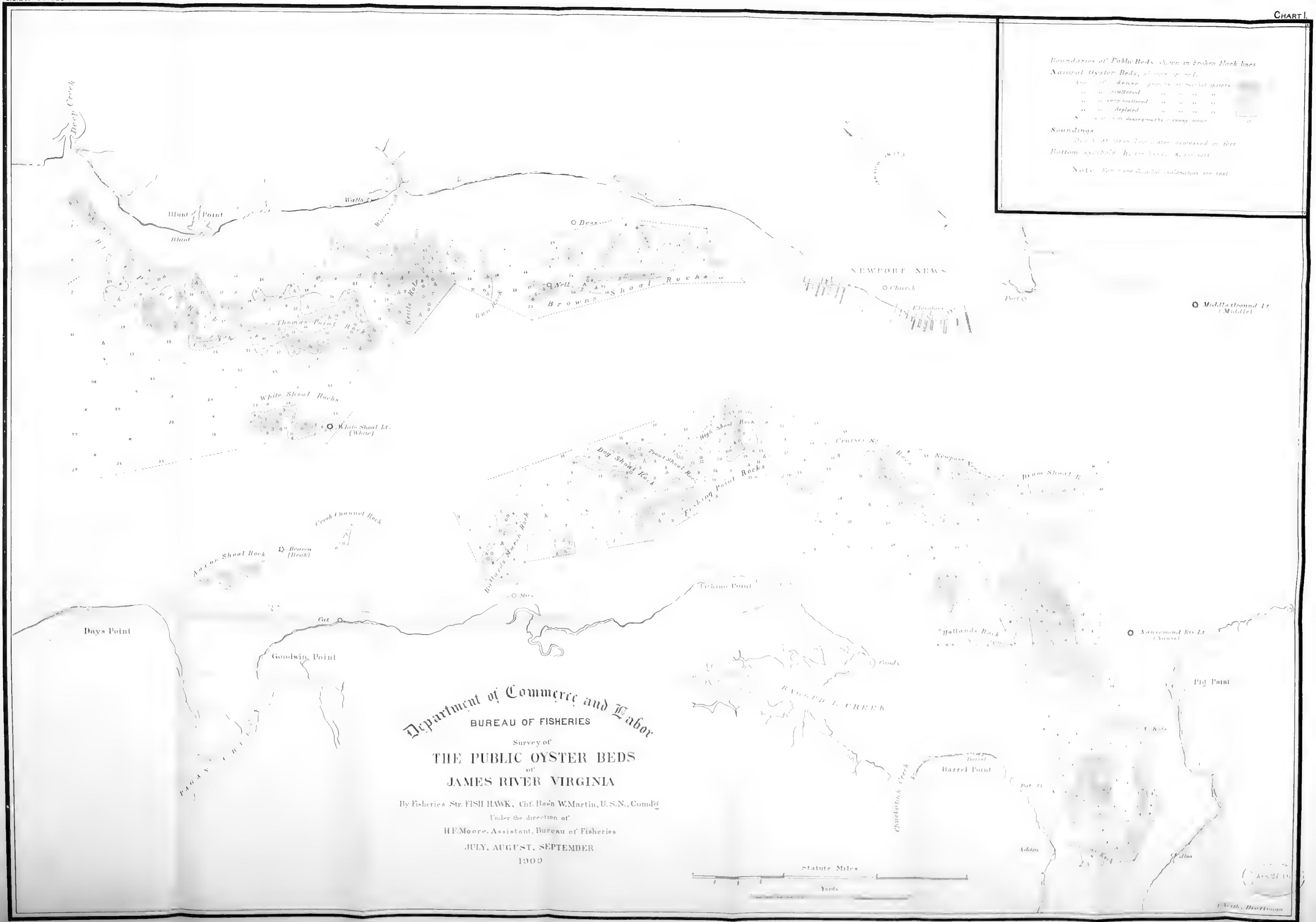
AND

DELAWARE OYSTER SURVEY COMMISSION

Under the direction of

H.F. Moore, Assistant, Bureau of Fisheries

June and July 1910


Boundaries of Public Beds shown in broken black lines
Natural Oyster Beds
dense
scattered
very scattered
depleted
Soundings
Bottom symbols
Note
Deep Creek
Blunt Point
Bess
Nell
Browns Shoal Rocks
Thomas Point Rock
Kettle Hole
Gun Rock
NEWPORT NEWS
Church
Middle Ground Lt. (Middle)
White Shoal Rocks
White Shoal Lt. (White)
Dog Shoal Rock
Trout Shoal Rock
High Shoal Rock
Fishing Point Rocks
Drum Shoal R.
Creek Channel Rock
Beacon (Black)
Days Point
Goodwin Point
Tobins Point
Hollands Rock
Nansemond Rv. Lt. (Nansel)
Pig Point
Barrel Point
Chuckatuck Creek
Statute Miles
Yards
Department of Commerce and Labor
BUREAU OF FISHERIES
Survey of
THE PUBLIC OYSTER BEDS
of
JAMES RIVER VIRGINIA
By Fisheries Str. FISH HAWK, Chf. Bos'n W. Martin, U.S.N., Comd'g
Under the direction of
H.F. Moore, Assistant, Bureau of Fisheries
JULY, AUGUST, SEPTEMBER
1909