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Final Report on the Study and Appraisal of Mussel Resources in Selected Areas of the Upper Mississippi River.*

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I. INTRODUCTION.

During the months of July and August, 1920, the U. S. Bureau of Fisheries made a study and appraisal of the mussel resources of the Mississippi River in and between the areas commencing at a point about five miles above Red Wing, Minnesota, extending thence through Lake Pepin, and ending nearly 80 miles down stream at La Moille, Minn. More exact boundaries for the areas will be indicated hereafter. The work carried on was with reference to recent administrative action on the part of the states of Wisconsin and Minnesota, which provided for the closure of certain of these areas for the protection of the fresh water mussels, as well as for areas to remain subject to fishery. From the data acquired in this investigation, it is expected to establish a basis for comparison of conditions in the present and after a period of protection.

II. GENERAL CONDITIONS IN THE AREAS.

While usually attaining a depth of from 5-20 ft. within the limits of the state of Minnesota, the river at the time of this investigation was in a flood stage of from 2-9 ft. One apparent effect of the latter condition was to [illegible] of the mussels shoreward, as in general the [illegible] of the shell beds are often determined by the depth and [illegible] of the channel. The fall of the river is greatest [illegible] Lake Pepin there

* Published with the [illegible] of the U. S. Bureau of [illegible] which is from the Fairs of [illegible] Act.

† During this investigation, Messrs. J. P. Mueller and W. [illegible] as assistants.

above it, resulting in a more rapid current in the former region, which is accelerated by the pressure of the impounded waters of the Lake. Where snags are abundant on the bottom, this current is strong enough to make mussel fishing with crowfoot bars somewhat dangerous.

The bottom of the river within the areas is for the most part composed of fairly coarse gravel mixed with varying proportions of mud and sand. The latter increase perceptibly in the vicinity of the tributary streams of the region, the principal entering streams being the Cannon River at Red Wing, the Chippewa at Read's Landing, the Zumbro near Wabasha, Minn., and the Trempealeau below Winona, Minn. The Chippewa is principally responsible for the enormous quantities of sand brought into these areas discussed below Lake Pepin. Only through the construction of wing dams have the Government engineers been able to preserve a navigable channel. These dams are designed to catch the sand near mid-stream, deflecting it toward the shore where it ultimately forms sand bars or islands, but unfortunately smothering at the same time the valuable clam beds which formerly existed in the Mississippi below Lake Pepin, with the consequent discouragement of the clamming industry. In the opinion of some engineers, it appears practicable to terrace the banks of the Chippewa near Lake Pepin in such a way as to divert the sand to fill up the low lying country nearby, but a better preventative would be the reforestation of the Chippewa drainage basin. The conservation of the national mussel resources in thus seen to be closely related to other problems of national economy.

III. STATUS OF THE MUSSEL FISHERIES IN RELATION TO THE PRECEDING.

That stretch of the river about five miles northwest of Red Wing in the vicinity of Diamond Island, and which is known to old-time clammers as the Trenton Bed, is apparently but little worked, although our observations indicate that such might be profitably undertaken as it is in an area subject to fishery. At Red Wing itself the summer of the survey, three clammers were observed. They reported that their returns seemed to be diminishing, although in past years this immediate section was considered one of the best on the river.

As will be observed in the accompanying tables, certain species, commercial as well as non-commercial, have been clammed out of this as well as other localities, some trace of them always being found in the piles of shells observed along the bank, or old clammers remembered collecting them in the vicinity.

Within the area studied, the clamming center of the river is in that part of Lake Pepin between Lake City and Pepin, as in late years the profitable downstream limit of the mussel fishery in these areas has been found to be the outlet of Lake Pepin about 1½ miles northwest of Read's Landing in an area which has since been closed to clamming. Lake Pepin furnishes most of the shells from the areas considered, but its clam resources appear to be attracting but few fishermen. Where in 1914, 100 rigs were observed in operation on the lake, hardly more than 15 were working in the summer of 1920. However, it is stated on good authority, (a), that about 200 tons of mussel shells, with an average valuation of from $50 to $55 per ton had their source in this region. The best pearl found sold for $750, a half dozen others brought from $100 to $175.

South of Lake Pepin during August, 1920, but two other clammers were seen, one rig at Winona, Minn., and a solitary clammer working with a fork in the nearby Straight Slough, obtaining only scanty returns. Piles of dead shells on the banks of the latter indicated the former abundance of the mussel fauna. At one time there existed extensive mussel beds at or near Wabasha, Minn., Teepeeota Point, (about 4 miles downstream from the former); near Alma and Fountain City, Wis.; Minneiska and Winona, Minn. The party found greater or smaller remnants of these formerly worked beds. They appear to be composed of old and sometimes gigantic shells, with an absolute dearth of younger ones. This would indicate that the beds are not being maintained, even if bottom conditions generally are favorable for mussel life. If it were found practicable to restock such beds with juvenile shells, such beds might readily regenerate. Reasons commonly assigned within the last mentioned regions for the de-

(a) A well informed manufacturer writes "As near as we are able to estimate there have been between 200-250 tons of shells collected on the Mississippi River between St. Paul and Winona during 1920, and inasmuch as Lake Pepin is the center of the clamming industry, we believe [illegible] of the total amount would [illegible] the quantity taken from Lake Pepin and close vicinity.

pletion of the mussels resources, and the consequent decline of the clamming industry may be given:

1. The smothering of the mussel beds by sand deflected by the dams has been previously indicated. Additionally it may be stated that the increased current thereby insured has the probable effect of sweeping juveniles just dropped from fish long distances down stream, or to lodge them upon the sand bars, where later they may be covered up.

Within the limitations of the apparatus used in this investigation, it was not found practicable to estimate quantitatively the extent of the mussel beds smothered in this fashion. Under such circumstances, the dead shells were difficult to collect by the prevalent method of clamming. To indicate that such beds were formerly extensive are the statements of fishermen as corroborated by the observation of government engineers. Mention is made further on of those beds which came under the party's observation.

2. Destructive fishing methods formerly in use, such as taking very young shells, deliberately clamming out beds, or fishing with the shoulder rake, are also responsible. The party found evidence of the latter in most of the beds last mentioned. However, favorable sentiment toward respecting this part of the protective laws is widely prevalent.

3. The growth of formerly extensive mussel beds near communities situated along the river has been inhibited by the pernicious practice of dumping rubbish of somewhat indestructible nature in the river at those points. While state laws are also clear upon this point, the enforcement of them seems largely a matter of local sentiment.

The remnants of the clam beds at Alma, Fountain City, and Minneiska, appear to be the ones affected in this way. The appraisal work here was unusually difficult due to the fouling of the collecting apparatus on such obstructions as slag, old iron, etc., in the water. From the economic standpoint, the least which may be granted is that such rubbish has the effect of rendering the mussels but difficultly accessible to the fisherman, and he is inclined to let such beds alone. Such mussel resources are therefore not utilized. On the other hand, it is recognized that materials such as sand, coal, cinders, ashes, logs, decaying wood, bark, sawdust, as were often encountered, have a distinctly injurious effect upon fish when dumped into the water. This is important, when it be remembered that fish carry the larval young of the mussels about with them. Such a combination may account for the scarcity of young shells in the beds, or tend to render the environment a more difficult one to combat, whatever be the more direct reason.

As the situation is today, the sand bars created by the dams may, following certain conditions such as flood or drought, harbor mussels in sufficient abundance as to make their taking by hand fairly profitable. Characteristically abundant and commercial species found on such sand bars are the three-ridge and blue-point, (*Quadrula alicata* and *undulata*), pig-toe, (*Quadrula undata*), pocketbook, (*Lampsilis ventricosa*), with lesser quantities of the pimple back, (*Quadrula pustulosa*), hickory nut, (*Obovaria ellipsis*), and monkey face, (*Quadrula metanevra*). Most of these shells, especially the pocket books, were of an excellent quality for button making.

In many cases the mussels, especially the younger ones inhabiting the sand bars, were observed to be dying in large numbers as the result of their inability to move with the water as it fell from the flood stages. The utilization of the mussel resources below Lake Pepin therefore seems to demand that the mussels be taken from the sandbars by hand when desirable for commercial purposes, and that the stranded animals be given the conserving care such as fish receive in rescue work. By way of experiment, the party stocked two sections of an area in which mussels were nearly absent, but in which conditions seemed quite favorable, with younger shells of various species, collected from the sand bars, where, by the way, shells are more abundantly taken by hand than from the bottom by crowfoot bars.

While the sloughs are dammed off from the river for the ultimate purpose of draining them, they are as rich, if not richer in mussels than the main river. Excellent examples of sloughs with a richer fauna are the Belvedere and Straight Sloughs, and the West Newton Chute. In all these, shells were collected by hand or by crowfoot bars. Work

with the latter in deeper portions of Straight Slough and West Newton Chute in their lower stretches, revealed the fact that young beds of shells of commercial quality were flourishing under conditions which might be favorable for restocking, despite the ultimately desired effect of the dams, as the sloughs are to some extent fed with local drainage. Piles of shells at these points indicated the extent of former clamming operations. Certain species, such as the bull head, (*Pleurobema aesopsus*), as we collected it, apparently find their most congenial environment here. Shells collected from the sloughs appear to have brighter colors and a finer grain than those secured from the river proper.

When the preceding data on general conditions in the areas and the status of the mussel fisheries are considered in entirety, it becomes evident that before the mussel resources of these areas can be improved, some practicable basis must be determined, from which measures looking forward to the protection and the improvement of the mussel resources can be inaugurated. This is all the more important when it is remembered that the states of Wisconsin and Minnesota are pioners in the legislation for the protection of mussel resources, it is quite likely that other states will enact similar measures. The reason for this study and appraisal of mussel resources in certain areas of Wisconsin and Minnesota thus becomes clear.

IV. METHODS.

(a.) Description of outfit for collection of shells.

The work was approached from the standpoint of the mussel fisherman, a bar and crowfoot outfit being used to collect the shells. The outfit was towed from place to place by a Government Launch. In the areas above Lake Pepin, (I-VI. inc.,) 100 hooks were attached to each of the 16-ft. bars. Below Lake Pepin, starting at Read's Landing, (areas VII.-X. inclus.), the river bottom is heavily infested with snags, so the bars were shortened to 10 ft., with a consequent reduction in the number of hooks on each to 75. In the first named areas, the data presented represents the results of three trials of the same length of drag with the bars, (300 ft.) at each of the localities, (those to be checked five years hence), indicated. In the remaining areas, the number of drags was increased from 3 to 4, to compensate for the reduction in the number of hooks, but otherwise the procedure was the same.

Additionally, the john-boat had at its bow, a hand windlass bearing 300 ft. of stout, (⅝ in.) line, to the free end of which an anchor was attached. In proceeding from locality to locality, the windlass was locked, and the boat towed by a separate piece of line. Two separate dredgings were also made of the bottom of the river in each locality, proceeding from the same initial point. The dredge used consisted of a heavy rectangular frame work of iron about 18 in. in length, 6 in. in breadth, at the mouth, and 6 in. in height. To it was fastened a large and very closely woven net with the capacity of about a bushel, and with meshes varying from 1-16 to ⅛ in. The net was protected by a canvas cover attached at one end to the iron framework, and open at the other. Ropes, ½ in. were attached to iron rings on the shorter side of the frame work, and these lead forward to a single rope 50 ft. in length, secured in the stern of the john-boat. The longer and outer edges of the iron framework were provided with coarse, triangularly shaped teeth, 4 in. in length, while the mouth was guarded by 4-5 stout iron wires, running vertically to the longer axis of the iron framework and spaced about 3 in. apart. The teeth provided for the dislodgement of shells and other materials from the bottom of the river, while the guards around the mouth prevented the ingress of very large gravel or other objects. Additionally, the length of rope with which it was attached, provided for reaching the greatest depth of bottom, while after the dredge was lifted, and the attached rope drawn in about 4-5 of its length, the launch could speed up, and thus most of the mud and sand obscuring the contents of the dredge washed away. By means of the dredge, a fair idea of conditions on the bottom of the particular locality could be determined. Such data would later be useful in connection with propagation experiments.

(b). Collecting Mussels for study and appraisal.

When it was determined to appraise a particular locality, a starting point was determined by methods shortly to be described, the windlass and the tow-line were released, and

the launch going ahead unreeled the 300 ft. of line into the water until it was very nearly taut, when the operator of the launch dropped the anchor at the free end. For the purpose of temporarily anchoring the john-boat while the line was being payed out, one of the bars, usually that one to be placed to the rear, was at favorable opportunity, dropped into the water in such a way that it laid at right angles with the shore, and dragged parallel to it. When it had touched bottom, it was secured into position by means of props and by knotting its rope around one of the uprights. As shortly thereafter as the boat had swung into a favorable position as to render less liable the entangling of the hooks of the bars, the remaining bar was dropped and secured likewise.

After the anchor was dropped and the bars properly played, one of the two operators in the john-boat, windlassed the latter by slow and steady turns up to the point where the anchor had been dropped, observing from time to time the relative apparent motion of the shore line to make certain that snagging or fouling of the bars was not causing the john-boat to pull the anchor towards it in the meantime. When such was found to be the case, the bars were pulled up, the catch discarded, and a new trial made. When the john-boat had been properly windlassed up to the anchor, the latter and the bars were pulled up, the mussels taken off the hooks and thrown into a tub. The launch then towed the john-boat back to the original starting place, when this procedure was repeated twice again for each locality, the mussels obtained from the 3 trials being counted together. Dead shells obtained were not recorded.

The use of the dredge has already been indicated to some extent. Mature mussels caught in it were included among those obtained as previously described. The residue of the net was then examined. After the gravel and larger biological specimens which could be easily seen were removed by hand, the remainder was then screened in the water through sieves of varying fineness, until the juvenile mussels which were especially sought could be picked out by hand. Juveniles were also obtained from masses of water weed pulled up by the crowfoot bars and the dredge. The larger number of them

were obtained from the water weed, to which they were attached by their byssus thread. The dredge had the disadvantage of being apt to foul on some obstruction, and was besides very unwieldy, being apt to hinder the progress of the work. Juveniles taken were at once preserved in a mixture of 4 per cent formalin, 70 per cent alcohol and shell dust, the latter substance preventing erosion of the shell by the other chemicals. They were labelled, counted, and shipped to the Fairport Biological Station. The number obtained at each locality is expressed in parenthesis after the number of mature mussels obtained there; upon the sum of the two at any locality all calculations are made. Other biological specimens were at early opportunity shipped to the various specialists for identification, and the results of their work, which is hereby gratefully acknowledged, is comprised in the notes on the various areas.

(c). Determination of localities.

The course of the river was followed by means of a set of maps of the river published by the Mississippi River Commission, and by a copy of the current edition of the light list for the 13th Lighthouse District as in use by navigators on the river. The position of each locality surveyed is indicated on the maps used, which are now in possession of the U. S. Biological Station, Fairport, Iowa. On these maps, the localities are numbered according to area, and to the order in which they were examined. Thus 1-3 on the map indicates Area 1 and the third locality in it. Reference to the data to follow are to be similarly understood. As previously indicated, only the three best localities in each Area are reported upon.

It was not found practicable to draw into the maps these localities on an exact scale. The markings largely indicate the relative position of the locality with regard to the shore line at the time, the more absolute one being obtained by reference to the descriptive material given in connection with the markings on the maps. The more absolute data concerning the position of the locality was obtained by reference to some object or formation along the shore which seemed of a fairly permanent nature, such as the Government Lights or

Day Marks or other improvements along the river, ravines, elevation of adjacent hills, clumps of bushes, trestles, etc. The first 2 types of reference points were not used when anything better could be observed. The light list referred to gives the distances of these markers and lights from more accurately defined points such as bridges, etc. As data furnished by local clammers was sometimes found to be misleading, positions of productive shell beds were frequently determined by a trial drag with a single bar at varying distances from the shore, when, after encouraging results, the three consecutive drags with both bars were attempted. All beds of shells of fair extent which the party encountered are also indicated upon the maps mentioned.

Once the reference point was established, the distance across the water of the starting point of the drag from this was estimated independently by the three members of the party. The average taken of these distances is that one given in the descriptive material of the localities, and in case of great varieties in estimate, the more probable distance was verified by measurement of other points on the map within sight, and by the making of comparisons. A map case of the type used in the U. S. Army, provided with compass and transparent waterproof cover was found to be a convenient carrier for the maps in the field, where the localities could be promptly indicated. A leather-bound notebook of the type used by engineers was found to be serviceably adaptable for the recording of data. It should be borne in mind, however, that as the larger portion of the work was accomplished under conditions of high water, it was difficult to accurately estimate the position of the normal shore line, and the distances given are those of the position of the outfit from the nearest land above water at the time.

V. LIST OF SPECIES COLLECTED.

The following list embraces those species of mussels collected within the areas surveyed. Besides indicating the common name by which the mussels are known to clammers, the older scientific names of Simpson's Descriptive Catalogue of the Naiades are given, and their equivalent in the forthcoming Pilsbry-Ortman-Walker nomenclature, which follows more closely the rules of modern zoological nomenclature.

COMMON NAME	SCIENTIFIC NAME	
Commercial Species	After Simpson	After Ortmann
Niggerhead	Quadrula ebenus	Fusconaia ebena (Lea.)
Niggerhead	Quadrula solida	Pleurobema catillus (Con.)
Hickory Nut	Obovaria ellipsis	Obovaria olivaria (Raf.)
Pimple Back	Quadrula pustulosa	Quadrula pustulosa (Lea.)
Maple Leaf	Quadrula lachrymosa	Quadrula quadrula (Raf.)
Monkey Face	Quadrula metanevra	Quadrula metanevra (Raf.)
Purple Pimple Back	Quadrula tuberculata	Rotundaria granifera (Lea.)
Three Horn Warty Back	Obliquaria reflexa	Obliquaria reflexa (Raf.)
Pig Toe	Quadrula undata	Fusconaia undata (Barnes.)
Blue-Point	Quadrula plicata	Amblema peruviana (Lam.)
Three-Ridge	Quadrula undulata	Amblema costata (Raf.)
Wash Board	Quadrula heros	Megalonais heros (Say.)
Buck Horn	Tritogonia tuberculata	Quadrula verrucosa (Raf.)
Mucket	Lampsilis ligamentina	Actinonais carinata (Barnes.)
Higgin's Eye	Lampsilis higginsii	Lampsilis higginsii (Lea.)
Lake Pepin Mucket	Lampsilis luteola	Lampsilis siliquoidea (Barnes.)
Butterfly	Plagiola securis	Plagiola lineolata (Raf.)
Deer Toe	Plagiola elegans	Amygdalonais truncata (Raf.)
Pocket Book	Lampsilis ventricosa	Lampsilis ventricosa (Barnes.)
Yellow Sand Shell	Lampsilis anodontoides	Lampsilis anodontoides (Lea.)
Slough Sand Shell	Lampsilis fallaciosa	Lampsilis fallaciosa (Smith.)
Black Sand Shell	Lampsilis recta	Eurynia recta (Lam.)
Bull Head	Pleurobema acsopus	Plethobasus cyphyus (Raf.)
(No Common Name)	Lampsilis subrostrata	Eurynia subrostrata (Say.)
White Heil Splitter	Symphynota complanata	Lasmigona complanata (Barnes.)
Fluted Shell	Symphynota costata	Lasmigona costata (Raf.)
Pink Heel Splitter	Lamnsilis alata	Prostera alata (Say.)
Rack Pocket Book	Arcidens confragosus	Arcidens confragosus (Say.)
Elephant Ear	Unio crassidens	Elliptio niger (Raf.)
Spike	Unio gibbosus	Elliptio dilatatus (Raf.)
Ohio River Pig Toe (?)	Pleurobema pyramidatus	Pleurobema pyramidatum (Lam.)
Elk Toe	Alasmidonta marginata	Alasmidonta marginata (Say.)
Sugar Spoon	Plagiola donaciformis	Amygdalonaias donaciformis (Lea.)
NON-COMMERCIAL SPECIES *		
Slop Bucket	Anodonta grandis	Anodonta grandis (Say.)
Paper Shell	Anodonta corpulenta	Anodonta corpulenta (Cooper.)
Squaw Foot	Anodonta imbecillis	Anodonta imbecillis (Say.)
Paepr Shells	Strophitus edentulus	Strophitus edentulus (Say.)
	Lampsilis gracilis	Leptodea fragilis (Raf.)
	Lampsilis laevissima	Proptera laevissima (Lea.)
Snuff Box	Lampsilis parva	Carunculina parva (Barnes.)
Floater	Truncilla triquetra	Truncilla triquetra (Raf.)

VI. RESULTS.

These include data compiled upon the absolute and relative abundance of each species of mussel found in the areas appraised, together with such geographical or other information likely to be of use in expediting the rechecking of these results after a period of protection, or which might have a bearing upon propagation experiments. The number of shells of each species collected in each locality is given under the heading of the latter, and the percentage of this in the total catch in the locality is indicated. The average of the three percentages thus obtained for each species in each area is taken to

represent the relative abundance of that species in the area. An asterisk, (*), indicates that the species was found to be less than 1 per cent in the area and locality involved. A blank space opposite the name of a species indicates that living shells were not collected in either the area or the localities of it.

AREA I.

Boundaries; lower half of Diamond Island, Miss. R. to Red Wing, Minn., at High Bridge. Status, subject to fishery. Length in Linear Miles, 4.2. Physical Conditions, estimated 7-8 ft. high water. Current about 5 miles per hour. Bottom mostly gravel and sand. Middle sections of area infested with snags.

LOCALITIES REPORTED UPON. (ref. maps.)

I—1. Starting point of drags Govt. Day Mark 958-n near center of Diamond Island, 25 ft. from shore on Minnesota side of channel. July 7, 1920.

I—2. Starting point of drags Govt. Day Mark 958-k, (above island 23), Wisconsin side of channel, 30 ft. from shore, about ½ mile down stream from preceding locality.

I—6. Starting point of drags, 300 ft. upstream from Govt. Day Mark 958-g across the mouth of slough about 1 mile above Red Wing on Minnesota side, 50 ft. from mouth of slough. July 9, 1920.

NOTES ON AREA.

Certain species, as *E. dilatatus*, *B. granifera*, are at present

AREA I.

COMMERCIAL SPECIES *	Locality I-1	% Total Catch in Locality	Locality I-2	% Total Catch in Locality	Locality I-6	% Total Catch in Locality	Average % Catch in 3 Localities
Fusconaja ebena	7	1.5%	1	*			*
Fusconaja cuneolus	3	*	3	*	1	*	*
Obovaria olivaria	133	30%	141	34%	5	1.9%	21.8%
Quadrula postulosa	23	5%	7	*	1	*	2.5%
Quadrula quadrula			6	1.4%	1	*	*
Quadrula metanevra	7	1.5%	7	1.7%			1.66%
Rotundaria granifera							
Obliquaria reflexa	10	2.2%	4	*			1.5%
Fusconaja undata	7	1.5%	3	*	1	*	*
Amblema peruviana	11	2.4%	3	*			1%
Amblema costata			14	3.4%	4	1.5%	1.6%
Megalonais heros	10	2.2%					*
Quadrula verrucosa	9	2%	3	*			*
Actinonais carinata	26	5.9%	46	11.2%	12	4.7%	7.3%
Lampsilis higginsii			1	*			*
Lampsilis siliquoidea	18	4%	6	1.4%	32	12.5%	5.9%
Fleidola lineolata			1	*			*
Amygdalonais truncanta	17	3.8%	5	1.2%			1.6%
Lampsilis ventricosa	51	11.9%	44	10.9%	29	11.2%	11%
Lampsilis anodontoides					3	2.1%	*
Lampsilis fallaciosa	1	*			4	*	*
Eurynia recta	9	2%	16	3.9%			1.9%
Eurynia subrostrata							
Plethobasus cyphyus	1	*					*
Lasmigona complanata	18	4%	2	*	1	*	1.4%
Lasmigona costata							
Proptera alata	23	5.2%	14	3.4%			2.8%
Arcidens confragosus							
Elliptio niger	1	*	3	*			*
Elliptio dilatatus	7	1.5%	6	1.4%			1%
Pleurobema pyramidatum							
Alasmidonta marginata							
Amygdalonais donaciformis	3	*					*
TOTALS	395	8.66%	336	78.7%	94	33.9%	63%
NON-COMMERCIAL SPECIES *							
Anodonta grandis					48	19%	6.3%
Anodonta corpulenta	1	*	12	2.9%	69	29%	10.6%
Anodonta imbecillis	12	2.7%	35	8.5%	5	1.9%	4.3%
Strophitus edentulus	11	*			4	*	*
Leptodea fragilis	17	3.8%	15	3.6%	34	13.6%	7%
Proptera laevissima	17	4%					*
Carunculina parva							
Truncilla truncata							
TOTALS	47	10.5%	62	15.8%	161	65.4%	28.2%
TOTALS ALL SHELLS	442	97.1%	408	89.3%	255	89.3%	91.2%

clammed out of this area. Two large piles of these shells, said to have come from this region were observed in Lake Pepin. Indications are that this area constitutes a metropolis

for *O. olivaria*, although the largest shells of this species were obtained at Wabasha. *A. corpulenta* of the river at this point seems to be much thicker than the same species as obtained from the sloughs. Locality I-2 is known to old time clammers as the Trenton Bed. While still fairly productive, no clammers were observed working it at this time. Juveniles were comparatively rare in this area.

AREA II.

Boundaries, Red Wing, Minn., to Bay City, Wis. Status, closed to fishery. Length in Linear Miles, 5.8. Physical Conditions, 7 ft. high water; current about 3 miles per hour; bottom mostly sand and mud; snags most abundant toward the Wisconsin shore. Water weed in lower stretches.

LOCALITIES REPORTED UPON. (ref. maps.)

II—1. Starting point of drags 300 ft. upstream off Wisconsin shore from Govt. Day Mark 958-e, on edge of main channel about 40 ft. from shore. July 10, 1920.

II—2. Starting point of drags 35 ft. from shore, about ¼ mile downstream from Govt. Day Mark 958-d, opposite bathing houses and summer camp on Minn. shore. July 10, 1920.

II—4. Starting point of drags 100 ft. downstream from Govt. Day Mark 958-b, 45 ft. from Minnesota shore.

NOTES ON AREA.

Collecting in this area was best on the edge of the channel. It was extensively clammed some years ago. At present, there appear to be fewer shells of the Quadrula group than others. *Truncilla triquetra* was first recorded from the upper region of the river at this point. Juveniles, especially of *Anodonta* and *Lampsilis sp.* are more abundant here than in the preceding area.

AREA II.

COMMERCIAL SPECIES *	Locality II-1	% Total Catch in Locality	Locality II-2	% Total Catch in Locality	Locality II-4	% Total Catch in Locality	Average % Catch in 3 Localities
Fusconaja ebena	1	*	1	*	1	*	*
Pleurobema cordatum			2	1%	5	1.8%	1%
Obovaria olivaria			47	23.5%	32(4)	11.8%	12%
Quadrula postulosa			7	3.5%	8	2%	1.6%
Quadrula quadrula			3	1.5%	3	1%	1.5%
Quadrula metanevra					2	*	*
Boondaria granifera			8	4%			1.3%
Obliquaria reflexa			2	*	19	6.2%	2.6%
Fusconaja undata							
Amblema peruviana					27	8.9%	3.1%
Amblema costata	1	*					*
Megalonais heros					4	1.3%	*
Quadrula verrucosa			1	*	20	6.6%	2.8%
Actinonais carinata							
Lampsilis higginsii	18	6.6%	9	4.5%	13	4.2%	5.1%
Lampsilis siliquoidea					1	*	*
Plagiola lineolata			3	1.5%			*
Amygdalonais truncata	49(5)	19.9%	54	27%	6	1.9%	16%
Lampsilis ventricosa			2	1%			*
Lampsilis anodontoides							*
Lampsilis fallaciosa	1(1)	*	1	*	13	4.2%	1.7%
Eurynia recta							
Eurynia subrostrata							
Plethobasus cyphyus	1	*			4	1.3%	*
Lasmigona complanata							
Lasmigona costata	56(1)	21%	2	1%	24	7.8%	9.9%
Proptera alata					6	1.9%	*
Arcidens confragosus							
Elliptio niger					2	*	*
Elliptio dilatatus							
Pleurobema pyramidatum							
Alasmidonta marginata					1	*	*
Amygdalonais donaciformis							
TOTALS	134	47.5%	149	72%	195	60.8%	58.9%
NON-COMMERCIAL SPECIES *							
Anodonta grandis	20	11.9%	17	8.5%	15	5.1%	8.5%
Anodonta corpulenta	33(2)	12.4%	17	8.5%	16	5.1%	8.6%
Anodonta imbecillis					13	4.3%	1.4%
Strophitus edentulus					8	2%	*
Leptodea fragilis	25(1)	28%	14	7%	15	5%	13%
Proptera laevissima					36	11.9%	8.9%
Carunculina parva							*
Truncilla triquetra	2	*			1	*	*
TOTALS	133	52.3%	48	24%	104	33.4%	35.4%
TOTALS ALL SHELLS	267	99.9%	197	96%	299	94.2%	94.2%

AREA III.

Bounderies, Bay City, Wis. to Maiden Rock, Wis., and Frontenac, Minn. Status, subject to fishery. Length in Linear Miles, 5.7. Physical Conditions, 7 ft. high water; current about 2 miles: bottom, gravel, mud, and some sand. Comparatively free from snags. Water weeds fairly common in upper stretches of area.

LOCALITIES REPORTED UPON. (ref. maps.)

III—1. Lake Pepin, starting point of drags 1,500 ft. towards point with Light 957 from Wacouta Point, Minn., 100 ft. from shore, starting at a clump of low willows. July 14, 1920.

III—4. About 2 miles below Bay City on Wisconsin shore, starting at a clump of willows and poplars at lower end of promontory with an altitude of 680. Drags 75 ft. off shore July 15, 1920.

III—8. Drags from Point No-Point to Frontenac Point in a straight line between them, starting 300 ft. from shore of first, and finishing 75 ft. from shore of second. July 16, 1920.

NOTES ON AREA.

In this section of Lake Pepin there exist clam beds known from their adjacent regions as the Maiden Rock and Warrenton Beds. After poor success here, we learned from clammers, that while this was ordinarily a good locality, it was at this time covered with 6 in. of decaying vegetable matter brought in by the unusual rains of the summer, and this prevented the hooks from taking hold. Juveniles were somewhat less abundant than in the preceding area.

During the entire period of our collecting in Lake Pepin, and less noticeably so in the lower stretches of the river, there was observed on the surface of the lake, masses of algal plankton occurring in the form of dots, short rods and tendrils. Messrs. H. W. Clark and R. S. Corwin of the Fairport Biological Station state additionally concerning it, "the alga is practically all *Aphanizomenon flos-aquae*. It is predominant in the plankton algae of the Upper Mississippi. It is abundant in Lake Pokegama also. There were one or two colonies of *Anabaena spiroides* and one *Difflugia cratera* in the mass examined."

The abundance of such plant food in Lake Pokegama and Lake Pepin may account in some degree for the abundance and excellent quality of the fat muckets found in those Lakes. Fresh water sponge was abundant on the Minnesota side of the lake.

AREA III.

COMMERCIAL SPECIES *	Locality III-1	% Total Catch in Locality	Locality III-4	% Total Catch in Locality	Locality III-8	% Total Catch in Locality	Average % Catch in 3 Localities
Fusconaja ebena							
Fleurobema carillus							
Obovaria olivaria							3.8%
Quadrula postulosa	3	3.5%	5	6.5%			*
Quadrula quadrula			2 *	2.6%			
Quadrula metanevra							
Truncilla granifera							
Obliquaria reflexa	2	2.4%	1	1.3%	5	5.8%	3%
Fusconaja undata	5	5.8%	8	10.4%	14	14.9%	10.4%
Amblema peruviana			3(1)	5.2%	11	11.7%	5.9%
Amblema costata	8	9.5%	8(1)	11.7%	3	3.2%	8.1%
Megalonais heros			4	5.2%			1.7%
Quadrula verrucosa							*
Actinonais carinata			2	2.6%			*
Lampsilis higginsii			1	1.3%			
Lampsilis siliquoidea	32(1)	39.2%	5	6.5%	33(4)	39.5%	28.4%
Plagiola lineolata							
Amygdalonais truncata							
Lampsilis ventricosa	3	3.5%	4	5.2%	1	1%	3.2%
Lampsilis anodontoides							
Lampsilis fallaciosa							1%
Eurynia recta	1	1.2%	1	1.3%			
Eurynia subrostrata							
Plethobasus cyphyus			2	2.6%	1	1%	1.2%
Lasmigona complanata							*
Lasmigona costata	1	1.2%			10	10.7%	11.2%
Proptera alata	5	5.8%	13	16.9%			
Arcidens confragosus							*
Ellipsio niger			1	1.3%			
Ellipsio dilatatus	8	9.5%	5	6.5%	1	1%	7.3%
Fleurobema pyramidatum							
Alasmidonta marginata							
Amygdalonais donaciformis							
TOTALS	70	83	67	86.8%	83	83.3%	81.7%

NON-COMMERCIAL SPECIES *

Anodonta grandis	9	10.5%	2	2.6%			4.4%
Anodonta corpulenta	2	2.4%	6	7.8%	5	5.3%	5.2%
Anodonta imbecillis	2	2.4%			(1)	1%	1.2%
Strophitus edentulus							
Leptodea fragilis			2	2.6%	2	2.1%	1.6%
Proptera laevissima							
Carunculina parua							
Truncilla truncata	1	1.2%					
TOTALS	14	16.5%	10	13%	10	10.5%	13.5%
TOTALS ALL SHELLS	83	100%	77	100%	93	93.8%	95.2%

AREA IV.

Boundaries, Maiden Rock, Wis., and Frontenac, Minn. to Lake City, Minn. and Stockholm, Wis. Status, closed to fishery. Length in Linear Miles, 6.7. Physical Conditions, 5 ft. high water; bottom varying from pebbles, to sand and mud; current 1½ to 2 miles per hour. Patches of water weed abundant.

LOCALITIES REPORTED UPON. (ref. maps.)

IV—9. Opposite Mrs. Coles estate, starting at point between brown barn and white house at 700 ft. elevation, 65 ft. from shore, proceeding toward bend. July 19, 1920.

IV—11. Along Lake City Park front, starting at a poplar tree in front of fishermen's shanty, proceeding downstream toward bend in stone wall. 250 ft. off shore. July 20, 1920.

IV—12. At Lake City, between Lake City Point Light and breakwater, starting 40 ft. off shore, from center of space between small house and ice-house. July 20, 1920.

NOTES ON AREA.

Clammers believe this area to be pretty well clammed out, although it contained more juvenile shells than previously encountered in other areas. This fact seems reasonably due to the propagation experiments which the Bureau of Fisheries has been conducting in the region for several years. This area really produces the larger number of juveniles than any other considered, but as adult shells from these localities are in the great minority, the juveniles are not represented in the check localities given. All data submitted for juveniles is from the standpoint of their frequency in clam beds, whereas below Lake Pepin they were found to be most abundant on the sand bars. The juveniles were mostly *L. siliquoidea*. The water weeds encountered were *Vallisneria spiralis*, *Ceratophyllum demersum*, and various species of *Potamogeton*. The party gained the impression that the abundance of juveniles in an area was related to the abundance of the water weed. Species of fresh water snails, and a crayfish collected were determined by Dr. A. E. Ortmann to be *Campeloma subsolidum* (Anthony) species of *Goniobasis* and *Pleurocera*, while the crayfish was *Cambarus* (*Faxonus*) *virilis*, Hagen.

AREA IV.

COMMERCIAL SPECIES*	Locality IV-9	% Total Catch in Locality	Locality IV-11	% Total Catch in Locality	Locality IV-12	% Total Catch in Locality	Average % Catch in 3 Localities
Fusconaja ebena							
Lampsilis cafillus							
Obovaria olivaria							
Quadrula pustulosa	1	*	(1)	*	1	*	*
Quadrula quadrula			3	1.2%	3	1.9%	1%
Quadrula metanevra			1	*	1	*	*
Q. undaria granifera			1	*			*
Obliquaria reflexa							
Fusconaja undata	3	1.3%	2	*	1	*	*
Amblema peruviana	32	14.4%	37	24.5%	19	8%	15.6%
Amblema costata	36	16.2%	17	7.3%	27	11.6%	11.7%
M. calensis heros							
Quadrula verrucosa							
Actinonais carinata							
Lampsilis higginsii	1	*					*
Lampsilis siliquoidea	88(1)	40%	91	37%	102(5)	46.4%	41.1%
Plagiola lineolata							
Ampoldalonais truncata	3	1.3%	2	1%			*
Lampsilis ventricosa	5	2.2%	17	7.3%	19	8.1%	5.8%
Lampsilis anodontoides							
Lampsilis fallaciosa	2	*					*
Dysnia recta	4	1.8%	2	1%	4	1.7%	1.5%
Eurynia subrostrata							
Plethobasus cyphyus							
Lasmigona complanata	1	*	1	*	3	1.2%	1%
Lasmigona castata			(1)	*			*
Proptera alata	11	4.9%	12	5.1%	7	3%	4.3%
Arcidens confragosus							
Elliptio niger							
Elliptio dilatatus	3	1.3%	6	2.6%	16	6.9%	3.6%
Pleurobema pyramidatum							
Alasmidonta marginata							
Amycodonais donaciformis	1(3)	1.8%	2	*	3	1.2%	1%
TOTALS	195	85.2%	216	87%	211	90%	88.6%
NON-COMMERCIAL SPECIES*							
Anodonta grandis							
Anodonta corpulenta	8	3.6%	5	2.1%	9	3.8%	3.2%
Anodonta imbecillis	13	5.8%	(1)	*	(6)	2.6%	2.8%
Strophitus edentulus	4	1.8%	6	2.6%	8(1)	1.7%	2%
Leptodea fragilis			1	*			*
Proptera laevissima			2	1%			*
Carunculina parua	1	*	1	*	2	*	*
Truncilla triquetra			1	*	1	*	*
TOTALS	26	11.2%	17	5.6%	22	8%	8%
TOTALS ALL SHELLS	221	96.4%	233	92.7%	233	98%	94.6%

AREA V.

Boundaries. Lake City, Minn. and Stockholm, Wis. to Pepin, Wis. Status, subject to fishery. Length in Linear Mile, 5.3. Physical Conditions, 5 ft. high water during survey; current two miles per hour; bottom mud and sand with a few pebbles; occasional patches of water weed.

LOCALITIES REPORTED UPON. (ref. maps.)

V—5. Off Lake City shore near hospital, starting opposite first tree on bank north of hospital, 120 ft. from shore. July 23, 1920.

V—6. Below Camp Grounds, (southeast of Lake City), starting at point adjacent to 900 elevation, (Asplund's farm), at distance 15 ft. from shore. July 24, 1920. Minnesota shore.

V—10. About 1¼ miles from Deer Lake, (Wisconsin shore), and ¼ mile from pier at Pepin, starting point at nearest house on Wisconsin shore with 2 outbuildings in the rear. 600 ft. off shore.

NOTES ON AREA.

Compared with adults, juveniles were more abundant here than in any other area. This area was the one most worked in Lake Pepin during the summer of 1920, and some valuable pearls had their origin here. While fresh water sponges had been encountered from the beginning of the trip, such were more abundant in Lake Pepin than elsewhere. Specimens collected and forwarded to Professor Frank Smith, University of Illinois, were identified as *Spongilla fragilis*, Loidy.

AREA V.

COMMERCIAL SPECIES *	Locality V-5	% Total Catch in Locality	Locality V-6	% Total Catch in Locality	Locality V10	% Total Catch in Locality	Average % Catch in 3 Localities
Fusconaja ebena	.....	.....	.....	.....	6	2.4%	*
Pleurobema cutillus	.....	.....	15	3.7%	.....	.....	*
Obovaria olivaria	.....	.....	.....	.....	.....	.....	.....
Quadrula postulosa	1	*	.....	.....	2	*	*
Quadrula quadrula	.....	.....	3	*	1	*	*
Quadrula metanevra	.....	.....	1	*	1	*	*
Rotundaria granifera	.....	.....	.....	.....	.....	.....	.....
Obliquaria reflexa	4	1.4%	7	1.7%	1	*	1%
Fusconaja undata	40(0)	17%	73(2)	18.7%	55(3)	23.2%	19.6%
Amblema peruviana	30(4)	11.9%	24(4)	1.8%	21	8.4%	7.8%
Amblema costata	.....	.....	59	14.7%	.....	.....	4.9%
Megalonais heros	.....	.....	.....	.....	.....	.....	.....
Quadrula verrucosa	1	*	.....	.....	.....	.....	*
Actinonais carinata	.....	.....	.....	.....	.....	.....	.....
Lampsilis higginsii	.....	.....	.....	.....	.....	.....	.....
Lampsilis siliquoidea	104(20)	43.4%	108(13)	30.2%	69(4)	29%	34.2%
Plagiola lineolata	.....	.....	.....	.....	.....	.....	.....
Arcyodalonnis truncata	2	*	6	1.5%	2	*	1%
Lampsilis ventricosa	20(3)	8%	44(6)	10.7%	45(5)	18%	12.3%
Lampsilis anodontoides	.....	.....	.....	.....	1	*	*
Lampsilis fallaciosa	3	1%	.....	.....	1	*	*
Eurynia recta	1	*	8	2%	2	*	1.5%
Eurynia subrostrata	.....	.....	.....	.....	.....	.....	.....
Plethobasus cyphyus	.....	.....	1	*	.....	.....	*
Lasmigona complanata	5	1.7%	1	*	2	*	1%
Lasmigona costata	.....	.....	.....	.....	.....	.....	.....
Proptera alata	5	1.7	11	2.7%	10	4%	2.8%
Arcidens confragosus	.....	.....	.....	.....	.....	.....	.....
Elliptio niger	.....	.....	.....	.....	.....	.....	.....
Ellipsis dilatatus	18	6.3%	20	5%	10(1)	4.4%	5.2%
Pleurobema pyramidatum	.....	.....	.....	.....	.....	.....	.....
Ala-midonta marginata	.....	.....	.....	.....	.....	.....	*
Amygdalonais dongaiformis	3	1%	2	*	.....	.....	.....
TOTALS	272	93.4%	386	92.4%	241	89.4%	89.8%
NON-COMMERCIAL SPECIES *							
Anodonta grandis	.....	.....	.....	.....	2	*	1.2%
Anodonta corpulenta	5	1.7%	4	1%	(1)	*	*
Anodonta imbecillis	1	*	1	*	.....	.....	1%
Strophitus edentulus	4	1.4%	6	1.5%	.....	.....	.....
Leptodea fragilis	.....	.....	.....	.....	3	1.2%	.....
Proptera laevissima	.....	.....	.....	.....	.....	.....	.....
Carunculina parva	.....	.....	.....	.....	.....	.....	.....
Truncilla triquetra	.....	.....	.....	.....	.....	.....	.....
TOTALS	10	3.1%	11	2.5%	6	1.2%	2.2%
TOTALS ALL SHELLS	282	96.5%	397	94.9%	247	90.6%	92%

AREA VI.

Boundaries, Pepin and King's Coulee to Read's Landing, Minn. Status, closed to fisheries. Length in linear Miles, 4. Physical conditions, 4 ft. high water; current about 2 miles. Bottom, mud and sand, with a great deal of water weed on the Wisconsin side. Cobbles, gravel, and riff-raff on the Minnesota shore.

LOCALITIES REPORTED UPON. (ref. maps.)

VI –3. Starting point, 700 ft. north of point marked 682.99 and 673.42 on map, at foot of Lake Pepin, 500 ft. off shore. July 27, 1920.

VI –5. Starting point 1,000 ft. southwest C. M. & St. P. R. R. trestle at culvert opposite Knud Johnston's Coulee, (1760 elevation), 150 ft. from shore. July 28, 1920.

VI –6. One mile upstream from bridge at Read's Landing, 300 ft. s. w. of C. M. & St. P. R. R. at base of stone quarry, 700 ft. from Minnesota shore. July 28, 1920.

NOTES ON AREA.

Next to Area V, the juveniles found were most abundant here. Locality 6 in this area represents a re-juvenating bed at the base of Lake Pepin, clammed out years ago, and at that time producing many niggerheads. The only living specimen of *R. granifera* taken in the lake was secured at this place, although previously large numbers of dead shells were seen. At this point there was collected for the first time, *Pleurobema Pyramidatum*. Both localities 5 and 6 had comparatively few old shells in them. Locality 3 is shunned by clammers on account of the rocky bottom at this place, yet certain clammers who know the region are able to make good hauls here. Juveniles were fairly abundant. Specimens of *Plagiola lineolata* were particularly large. Fresh water sponges, and Bryozoa of species to be later given were also obtained here.

AREA VI.

COMMERCIAL SPECIES *	Locality VI-3	% Total Catch in Locality	Locality VI-5	% Total Catch in Locality	Locality VI-6	% Total Catch in Locality	Average % Catch in 3 Localities
Amygdala ebena					16	3.6%	1.2%
Amblema catillus					7(1)	1.8%	*
Quadrula olivaria					13	2.9%	1%
Quadrula postulosa			2	*	5	1.1%	*
Quadrula quadrula	3	2%	3	*			*
Quadrula metanevra	1	*	1	*	23	5.2%	2%
Quadrula granifera					1	*	*
Obliquaria reflexa			2	*	8	1.8%	1%
Plagiola undata	6(1)	4%	138	28.9%	22	5%	12.5%
Amblema peruviana	5(2)	4.8%	51(1)	10.9%	66	15%	10.3%
Amblema costata							
Meleagrinalis heros							
Quadrula verrucosa							
Arcidens carinata							
Lampsilis higginsii							
Lampsilis siliquoidea	33(4)	25.5%	92(9)	21.2%	53(3)	12.8%	19.8%
Lampsilis			3	*	9	2%	1%
Plagiola lineolata			5(3)	1.6%	16(3)	4.3%	1.3%
Amygdalonais truncata	53(5)	40%	26(5)	6.5%	31(6)	8.5%	18.3%
Lampsilis ventricosa							
Lampsilis anodontoides					2	*	*
Lampsilis fallaciosa					2	*	*
Proptera recta	8	5.5%	9	1.8%			3.2%
Proptera subrostrata							
Dysnomia cyphyus							
Lasmigona complanata	4	2.9%	4	*	4	*	1.4%
Lasmigona costata							
Proptera alata	4	2.7%	21	4.4%	21	4.8%	3.9%
Arcidens confragosus					1	*	*
Obliquaria niger							
Dilatata dilatatus	5	3.4%	74	15.5%	75	17.2%	12%
Pleurobema pyramidatum	2	*					*
Micromidonta marginata							
Amygdalonais donaciformis					3	*	
TOTALS	132	90.6%	449	90.8%	391	86%	85.6%

NON-COMMERCIAL SPECIES *

Anodonta grandis					7	5.6%	3.2%
Anodonta corpulenta	6	4.1%					1%
Anodonta imbecillis	(1)	*	10	2.1%			*
Strophitus edentulus	1	*			5	1.1%	
Leptodea fragilis	1(1)	1.3%	5(2)	1.4%	21(1)	5%	2.6%
Proptera laevissima							
Carunculina parva							
Truncilla triquetra							
TOTALS	10	5.4%	17	3.5%	34	11.7%	6.7%
TOTALS ALL SHELLS	142	96%	466	94.3%	425	97.7%	85.3%

AREA VII.

Boundaries, Read's Landing, Minn., to Minneiska, Minn. Status, open to fishery. Length in Linear Miles, 20.9. Physical conditions, 5 ft. high water; current 4-6 miles per hour. Bottom, sandy, with many imbedded snags, especially in upper portion.

LOCALITIES REPORTED UPON. (ref. maps.)

VII—4. 320 ft. upstream from Government Light 946, along water front at Wabasha, 49 ft. from shore. July 31, 1920.

VII—6. Teepeeota Point, 350 ft. west of willows at the point, 150 ft. from shore line. July 31, 1920.

VII—14. Off Alma, Wis., starting 50 ft. north of R. E. Jones' Mill, 40 ft. from shore. August 3, 1920.

NOTES ON AREA.

Few juveniles were to be seen in this area. On the site of an old shipyard at Wabasha, remnants of a clam bed with some young shells were found. The bed is hindered in regeneration by the amount of rubbish, iron wire, etc., dumped in the locality. The same conditions hold for locality VII-4. Further down at Teepeeota point was a remnant, composed of gigantic shells of an old clam bed, in which juveniles were totally absent. The bottom in this locality seemed well suited to mussel growth, there being no rubbish, few if any snags. The current has probably carried away the juveniles. Much effort was expended in this and other areas to locate clam beds by the method already described, but most of the productive ones have been covered up. There are few if any water weeds in this area except in the sloughs.

In the vicinity of Alma, (Govt. Light 926 and the R. E. Jones Mill), other remnants of beds exist, composed of giant "niggerheads" and "warty backs." Only a slight idea could be gained of these latter, as the bottom was so snaggy that it was unprofitable to attempt work with the crowfoot bars. Formerly this bed was worked with a pitch fork. At the lower limits of this area shells were more abundant, and were more easily secured from sand bars than any place else. The upper portion of West Newton Chute was very prolific in this respect. Species of snails and crayfish as recorded previously were common here.

AREA VII.

COMMERCIAL SPECIES *	Locality VII-4	% Total Catch In Locality.	Locality VII-6	% Total Catch In Locality.	Locality VII-14	% Total Catch In Locality.	Average % Catch in 3 Localities
Fusconaja ebena	......	......	......	......	2	7%	2.3%
Pleurobema catillus	10	6.3%	3	2.1%	1	3.8%	4.3%
Obovaria olivaria	......	......	8	5.6%	4	15.4%	7%
Quadrula postulosa	7	4.4%	7	4.9%	5	19.8%	9.7%
Quadrula quadrula	1	*	1	*	......	......	*
Quadrula metanevra	20	12.6%	......	......	7	26.9%	13.2%
Quadrula granifera	......	......	......	......	......	......	......
Obliquaria reflexa	......	......	3	2%	1	3.8%	1.9%
Fusconaja undata	11	6.9%	7	4.9%	1	3.8%	5.2%
Amblema peruviana	......	......	15	10.6%	1	3.8%	4.8%
Amblema costata	17	10.7%	3	2%	......	......	4.2%
Megalonais heros	......	......	......	......	......	......	......
Quadrula verrucosa	5	3.1%	6	4.2%	1	3.8%	3.7%
Actinonais carinata	33	20%	......	......	......	......	6.6%
Lampsilis higginsii	......	......	......	......	......	......	......
Lampsilis siliquoidea	......	......	3	2.1%	......	......	*
Plagiola lineolata	2	1.2%	1	*	......	......	*
Amygdalonais truncata	......	......	1	*	......	......	*
Lampsilis ventricosa	14	8.8%	46	32.6%	1	3.8%	15.1%
Lampsilis anodontoides	1	*	1	*	......	......	*
Lampsilis fallaciosa	......	......	......	......	......	......	......
Eurynia recta	20	12.6%	8	5.6%	......	......	3.3%
Eurynia subrostrata	......	......	......	......	......	......	......
Plethobasus cyphyus	......	......	......	......	2	7.7%	2.5%
Lasmigona complanata	......	......	4	2.8%	......	......	*
Lasmigona costata	......	......	......	......	......	......	......
Proptera alata	2	1.2%	9	6.3%	......	......	3.3%
Arcidens confragosus	......	......	......	......	......	......	......
Elliptio niger	......	......	......	......	......	......	......
Elliptio dilatatus	8	5%	7	4.9%	......	......	4.4%
Pleurobema pyramidatum	......	......	......	......	......	......	......
Alasmidonta marginata	2	1.2%	......	......	......	......	*
Amygdalonais donaciformis	......	......	......	......	......	......	......
TOTALS	153	94%	133	90.6%	26	99.2%	96.5%

NON-COMMERCIAL SPECIES *

Anodonta grandis	......	......	......	......	......	......	......
Anodonta corpulenta	......	......	......	......	......	......	......
Anodonta imbecillis	......	......	......	......	......	......	......
Strophitus edentulus	2	1.2%	1	*	......	......	1%
Leptodea fragilis	1	*	3	2.1%	......	......	1%
Proptera laevissima	2	1.2%	4	2.8%	......	......	1.3%
Carunculina parua	......	......	......	......	......	......	......
Truncilla triquetra	......	......	......	......	......	......	......
TOTALS	5	2.4%	8	4.9%	......	......	3.3%
TOTALS ALL SHELLS	158	96.4%	141	95.5%	26	99.2%	99.8%

AREA VIII.

Boundaries, Minneiska, Minn. to Fountain City, Wis. Status, closed to fishery. Length in Linear Miles, 10.8. Physical Conditions, 2 ft. high water: current about 2 miles per hour. Bottom, sand, mud, cobbles, mud, riff-raff, and infested with snags.

LOCALITIES REPORTED UPON. (ref. maps.)

VIII—1. Starting at Govt. Light 902.35 ft. off shore, south of island 4. August 11, 1920.

VIII—10. One-half mile around the bend from Govt. Light 896.35 ft. off shore, starting point adjacent to coulee south of Chimney Rock. August 11, 1920.

VIII—19. Straight Slough, 100 ft. south of the north of the first large slough leading from it, (at upper end) to the C. M. & St. P. R. R. tracks from 655 elevation; on opposite shore at distance 20 ft. from banks. August 16, 1920.

NOTES ON AREA.

This area stands third in the abundance of juveniles found. Remnants of a bed were found along the water front at Minneiska. This is given in locality VIII-1. Locality VIII-10 represents the old Chimney Rock Bed. Juveniles secured in this and succeeding areas were obtained from sand bars principally by hand.

In this area, there were frequently collected upon the sand bars crayfish which Dr. A. E. Ortmann of the Carnegie Museum, Pittsburgh, Pa., pronounced to be *Cambarus (Eaxohus) virilis* Hagen, (males of the second form,) and *Cambarus blandingii acutus* Gerard, (males of the second forms).

As early as the latter part of July there was noticed a brilliant bluish-green scum upon the shore of the sloughs and sand bars. Some of the material was sent to Dr. G. T. Moore, director of the Missouri Botanical Garden for identification. Dr. Moore stated it "was a mixture of 3 blue-green algae, the major portion being *Clathrocystis serrigensa*, with occasional colonies of *Coelosphaerium kuetzingianum*, as well as occasional colonies of *Anabaena flos-aquae*. This mixture is a very common one and has been associated for a number of years with the phenomenon known abroad as the "breaking of the meres." In this country it is generally referred to as the "flowering of the waters."

Dr. C. B. Davenport, of the Carnegie Station for Experimental Evolution, Cold Spring Harbor, N. Y., identified specimens of Bryozoa forwarded him as *Pectinatella magnifica*. These were collected from Fountain City Bay, Fountain City, Wis. He indicates that the following additional species may be expected to occur in the Mississippi also, viz. *Urnatella gracilis, Paludicella ehrenbergii, Fredericella sultana, Cristatella mucedo* and various species of *Plumatella*. Some of these species are known from the Illinois River, and on account of the resistance which the statoblasts have to the digestive fluids of birds, have become widely distributed over the whole country east of the Rocky Mountains.

AREA VIII.

COMMERCIAL SPECIES *	Locality VIII-1	% Total Catch In Locality.	Locality VIII-10	% Total Catch In Locality.	Locality VIII-19	% Total Catch In Locality.	Average % Catch in 3 Localities
Fusconaja ebena	3	21.4%					7.1%
Pleurobema catillus	2	14.3%					4.7%
Obovaria olivaria					3(1)	4.2%	1.4%
Quadrula postulosa			1	8.3%	1	1%	2.8%
Quadrula quadrula							
Quadrula metanevra	1	7.1%					2.3%
Rotundaria granifera							
Obliquaria reflexa			1	8.3%			2.8%
Fusconaja undata			6	50%	12	12.6%	21%
Amblema peruviana	2	14.2%	1	8.3%	10	10.5%	11%
Amblema costata	2	14.2%					4.7%
Megalonais heros							
Quadrula verrucosa							
Actinais carinata	1	7.1%					2.3%
Lampsilis higginsii							
Lampsilis siliquoidea					1(10)	11.5%	3.8%
Plagiola lineolata							
Amygdalonais truncata							
Lampsilis ventricosa			1	8.3%	30(15)	4.7%	18.4%
Lampsilis anodontoides							
Lampsilis fallaciosa							
Eurynia recta	1	7.1%	1	8.3%			5.1%
Eurynia subrostrata					1	1%	*
Plethobasus cyphyus							
Lasmigona complanata			1	8.3%			2.7%
Lasmigona costata							
Proptera alata							
Arcidens confragosus							
Elliptio niger							
Elliptio dilatatus							
Pleurobema pyramidatum							
Alasmidonta marginata							
Amygdalonais donaciformis							
TOTALS	12	85.4%	12	100%	84	87.8%	90.1%

NON-COMMERCIAL SPECIES *

Anodonta grandis							
Anodonta corpulenta	2	14.2%			1	1%	5%
Anodonta imbecillis							
Symphynota complanata					1	1%	*
Leptodea fragilis					5(3)	8.4%	3%
Tetragonia tuberculata					1	1%	*
Proptera laevissima							
Carunculina parva							
TOTALS	2	14.2%	12	100%	11	11.4%	8%
TOTALS ALL SHELLS	14	99.6%	12	100%	95	99.2%	98.1%

AREA IX.

Boundaries, Fountain City, Wis. to Winona, Minn. (High Bridge). Status, open to fishery. Length Linear Miles, 8.6. Physical Conditions, 2 ft. high water; current 4 miles. Bottom, gravel and mud, with less amount of riff-raff than in preceding areas.

LOCALITIES REPORTED UPON. (ref. maps.)

IX—2. South end of Island 62, across the mouth of a slough, starting 20 ft. from nearest shore. Aug. 18, 1920.

IX—22. Straight Slough, about 3 miles from mouth, across the mouth of the first slough above island with 655 elevation. 25 ft. from north shore. Aug. 21, 1920.

IX—31. 800 ft. northwest of the N. W. R. R. bridge at Winona, 35 ft. from sheer boom. Aug. 23, 1920.

NOTES ON AREA.

An old bed of "niggerheads" existing at Wild's Landing was found to be absolutely covered with sand deflected by the dams. No trace of a bed said to exist in the vicinity of Island 55 was found. The best collecting in this area was from the sandbars, and in the lower portion of the area we frequently encountered very large specimen of *Anodonta grandis*. Many stranded pocketbooks, (*Lampsilis ventricosa*) were found cut open for pearls, presumably by the foreign element of the population of Winona.

Locality IX-22 is in the upper portion of Straight Slough near Winona. At the present time it is a flourishing bed, indicating that conditions are favorable here for mussel growth. Fresh water snails, (*Pleurocera acuta, Raf.*) and a form of *Sphaerium stamineum* Conrad, as determined by Dr. Bryant Walker, were abundant here.

AREA IX.

COMMERCIAL SPECIES *	Locality IX-2	% Total Catch In Locality.	Locality IX-22	% Total Catch In Locality.	Locality IX-31	% Total Catch In Locality.	Average % Catch in 3 Localities
Fusconaja ebena			15	28.5%	[illegible]	3.4%	13%
Plethobema catillus					[illegible]	1%	*
Obovaria olivaria	1	3.5%	2	3.8%	13	6.3%	4.5%
Quadrula postulosa			1	1.9%	8	3.9%	1.9%
Quadrula quadrula			7	13.3%	49	23.8%	12.5%
Quadrula metanevra							*
Strophitus undata granifera					1	*	*
Obovaria reflexa	1	3.5%	6	11.4%	26	12.7%	9.2%
Fusconaja undata			2	3.8%	3	1.4%	1.4%
Amblema peruviana							
Amblema costata							*
Megalonais heros					4	1.9%	*
Quadrula verrucosa					7	3.4%	1%
Actinonais carinata							
Lampsilis higginsii	3	10.7%					3.5%
Lampsilis siliquoidea					4	2%	1%
Plagiola lineolata			3	5.7%	3	1.4%	2%
Amygdalonais truncata	3(5)	28%	4	7.6%	18	8%	14.6%
Lampsilis ventricosa							8%
Lampsilis anodontoides	7	24.5%			14	6.8%	4.2%
Lampsilis fallaciosa			3	5.7%			
Eurynia recta							
Eurynia subrostrata			2	5.8%	8	3.9%	3.1%
Plethobasus cyphyus							1%
Lasmigona complanata	1	3.5%					
Lasmigona costata					1	*	*
Proptera alata							
Arcidens confragosus							
Elliptio niger			1	1.9%	7	3.4%	1.8%
Elliptio dilatatus							*
Plethobema pyramidatum					3	1.4%	*
Alasmidonta marginata					3	1.4%	1.2%
Amygdalonais donaciformis	1	3.5%					
TOTALS	22	77.2%	46	87.4%	180	86.1%	81.5%

NON-COMMERCIAL SPECIES *

Anodonta grandis	1	3.5%			1		1.5%
Anodonta corpulenta	1	3.5%					1%
Anodonta imbecillis	1	3.5%	2	3.8%	15	7.4%	5%
Strophitus edentulus	3	10.7%	3	5.7%	8	3.9%	6.7%
Leptodea fragilis							
Proptera laevissima							
Carunculina parva							
Truncilla triquetra							
TOTALS	6	21.2%	5	9.5%	24	11.3%	13.7%
TOTALS ALL SHELLS	28	98.4%	51	96.9%	204	97.4%	95.2%

AREA X.

Boundaries, Winona, Minn. (high bridge) to La Moille, Minn. Status, closed to fishery. Length in Linear Miles, 7.2. Physical Conditions, 2 ft. high water; current 4 miles per hour; bottom, sand and gravel; many snags.

LOCALITIES REPORTED UPON. (ref. maps.)

X—4. Sheer boom, 450 ft. north of Burlington bridge at Winona; drags 15-25 ft. from edge off Minnesota shore. August 24, 1920.

X—6. Above Homer, starting opposite 700 ft. elevation and dragging down to point with 655 elevation; 25 ft. off Minnesota shore. August 25, 1920.

X—9. Starting at point adjacent to Homer at 680 elevation, 25 ft. from shore. August 25, 1920.

NOTES ON AREA.

Locality X-4 represents what appears to be a thriving and previously unworked bed of shells, extending beneath the Burlington bridge at Winona. While shells are fairly common at Homer Station, riff-raff on the bottom made their collection somewhat difficult. In the vicinity of Govt. Day Mark 851-a (840-86 elevation) the party planted 150 pigtoes, (*F. undata*), and 100 three ridges, (*A. peruviana*) in hopes of ultimately starting a bed there. Fresh water sponges and crayfishes of the identification already given were also collected at Homer.

AREA X.

COMMERCIAL SPECIES *	Locality X-4	% Total Catch In Locality.	Locality X-6	% Total Catch In Locality.	Locality X-9	% Total Catch In Locality.	Average % Catch in 3 Localities
Fusconaja ebena	7	7.9%	7	4.9%	7	5.4%	6.1%
Pleurobema catillus	.....	.....	2	1.4%	2	1.5%	1%
Obovaria olivaria	25	28.2%	9	6.3%	41	31%	21.8%
Quadrula postulosa	8	9%	3	2%	7	5%	5.3%
Quadrula quadrula	.....	.....	.....	.....	.....	.....	.....
Quadrula metanevra	4	4.5%	25	17.5%	15(2)	13.2%	12%
Rotundaria granifera	.....	.....	.....	.....	.....	.....	.....
Obliquaria reflexa	2	2.2%	4	2.8%	6(1)	5.4%	3.6%
Fusconaja undata	12	13.5%	9(1)	7.4%	6	4.6%	8.5%
Amblema peruviana	3	3.4%	4(1)	3.7%	1	*	2.8%
Amblema costata	.....	.....	2	1.4%	.....	.....	*
Megalonais heros	.....	.....	.....	.....	.....	.....	.....
Quadrula verrucosa	2	2.2%	8	5.9%	2	1.5%	3.2%
Actinonais carinata	4	4.5%	3	2.2%	1	3.9%	3%
Lampsilis higginsii	.....	.....	3	2.2%	.....	.....	*
Lampsilis siliquoidea	.....	.....	.....	.....	2	1.5%	*
Plagiola lineolata	1	1.1%	1	*	1	*	1%
Amygdalonais truncata	.....	.....	6(2)	5.9%	.....	.....	1.9%
Lampsilis ventricosa	.....	.....	15(1)	11.8%	16	12.4%	7%
Lampsilis anodontoides	.....	.....	1	*	.....	.....	*
Lampsilis fallaciosa	.....	.....	.....	.....	.....	.....	.....
Eurynia recta	.....	.....	5(1)	4.4%	5	3.9%	2.7%
Eurynia subrostrata	.....	.....	3	2.1%	1	*	*
Plethobasus cyphyus	.....	.....	.....	.....	.....	.....	.....
Lasmigona complanata	5	5.6%	1	*	.....	.....	1.9%
Lasmigona costata	.....	.....	.....	.....	.....	.....	.....
Proptera alata	.....	.....	.....	.....	.....	.....	.....
Arcidens confragosus	.....	.....	.....	.....	.....	.....	.....
Elliptio niger	5	4%	5	4%	.....	.....	2.6%
Elliptio dilatatus	1	1.1%	4	2.8%	1	1.1%	1.8%
Pleurobema pyramidatum	.....	.....	.....	.....	.....	.....	.....
Alasmidonta marginata	.....	.....	.....	.....	2	*	*
Amygdalonais dopaciformis	.....	.....	1(1)	1.4%	2	1.5%	1%
TOTALS	79	87.2%	128	90%	121	91.8%	88.3%
NON-COMMERCIAL SPECIES *							
Anodonta grandis	.....	.....	2	1.4%	1	*	1.2%
Anodonta corpulenta	.....	.....	.....	.....	.....	.....	.....
Anodonta imbecillis	.....	.....	.....	.....	.....	.....	.....
Strophitus edentulus	.....	.....	6	4.2%	2	*	1.7%
Lasmigona fragilis	9	10.1%	4	2.8%	2	1.5%	4.6%
Proptera laevissima	.....	.....	(1)	*	.....	.....	*
Carunculina parva	.....	.....	.....	.....	.....	.....	.....
Truncilla triquetra	.....	.....	(1)	*	.....	.....	.....
TOTALS	9	10%	14	8.4%	5	1.5%	7.5%
TOTALS ALL SHELLS	88	97.2%	142	98.4%	126	93.3%	95.8%

From the data presented under the title of each area, the following tabulation is made, dealing with the absolute abundance of shells in the areas appraised:

Area and Status as to Fishery	No. Shells Commercial Species per Linear Mile	No. Shells Non-Commercial Species per Linear Mile	Average All Shells per Linear Mile
I. Open	197.1	66	263.1
II. Closed	84.1	47.9	131.5
III. Open	39	5.61	44.61
IV. Closed	92	10.3	102.3
V. Open	166.8	7	173.8
VI. Closed	243.25	15.5	258.75
VII. Open	14.5 (16.13)	1 (6.55)	15.5 (22.68)
VIII. Closed	10. (43)	1.2 (2.8)	11.2 (45.8)
IX. Open	28.24 (54)	4.76 (7.6)	33. (61.6)
X. Closed	45.3 (62.91)	4 (8.3)	49.3 (71.24)

In the preliminary report of this survey, (p. 2) the data given on the absolute abundance of shells in Areas VII-X inclusive, was based in large part on collections of shells by hand from sand bars, as the latter embraced the larger number of best localities in the areas indicated. As it would be difficult to use such data in the future as a basis of comparison and rechecking, there has been substituted in this final report data obtained from other localities in these areas by the use of the bar and crowfoot outfit. Since it is felt that, due to the conditions described, that the latter represents the true absolute abundance of shells in the areas, there are added in parentheses to the above the results obtained from collecting by hand on the 3 best sandbars of these areas. For each of the 3 localities taken in account for each area, the data thus presented embodies the efforts of 3 men collecting by hand 30 minutes, a total consumption of 90 minutes time, and about that required to make 3 drags with the bars in any given locality. The results from the sandbars may be interpreted to represent the maximum of shells in the particular area.

VII. REMARKS AND RECOMMENDATIONS.

The tables given indicate that commercial species of mussels in the areas appraised are most abundant in the vicinity of Red Wing, Minn., and in Lake Pepin. There is a decline in the number of the mussels in succeeding stretches of the river until the lower half of Lake Pepin is reached. Upon leaving the lake, a most marked diminution in their numbers occurs but on the other hand the absolute number of shells increases going down stream, showing that the necessary conditions for mussel life are present, and, on the whole, steadily improving. When it appears practicable to attempt the rehabilitation of the mussel beds below Lake Pepin, the following recommendations based upon the preceding information may receive consideration, viz:

1. Restoring old, but favorably situated beds in closed areas with advanced juveniles of commercial species. Such beds are those existing at the foot of Lake Pepin, Wabasha, Teepeeota Point, and those at Winona and Homer, Minn. If judged by the abundance of juveniles collected, the areas to be stocked in order are VI, VIII, IV.

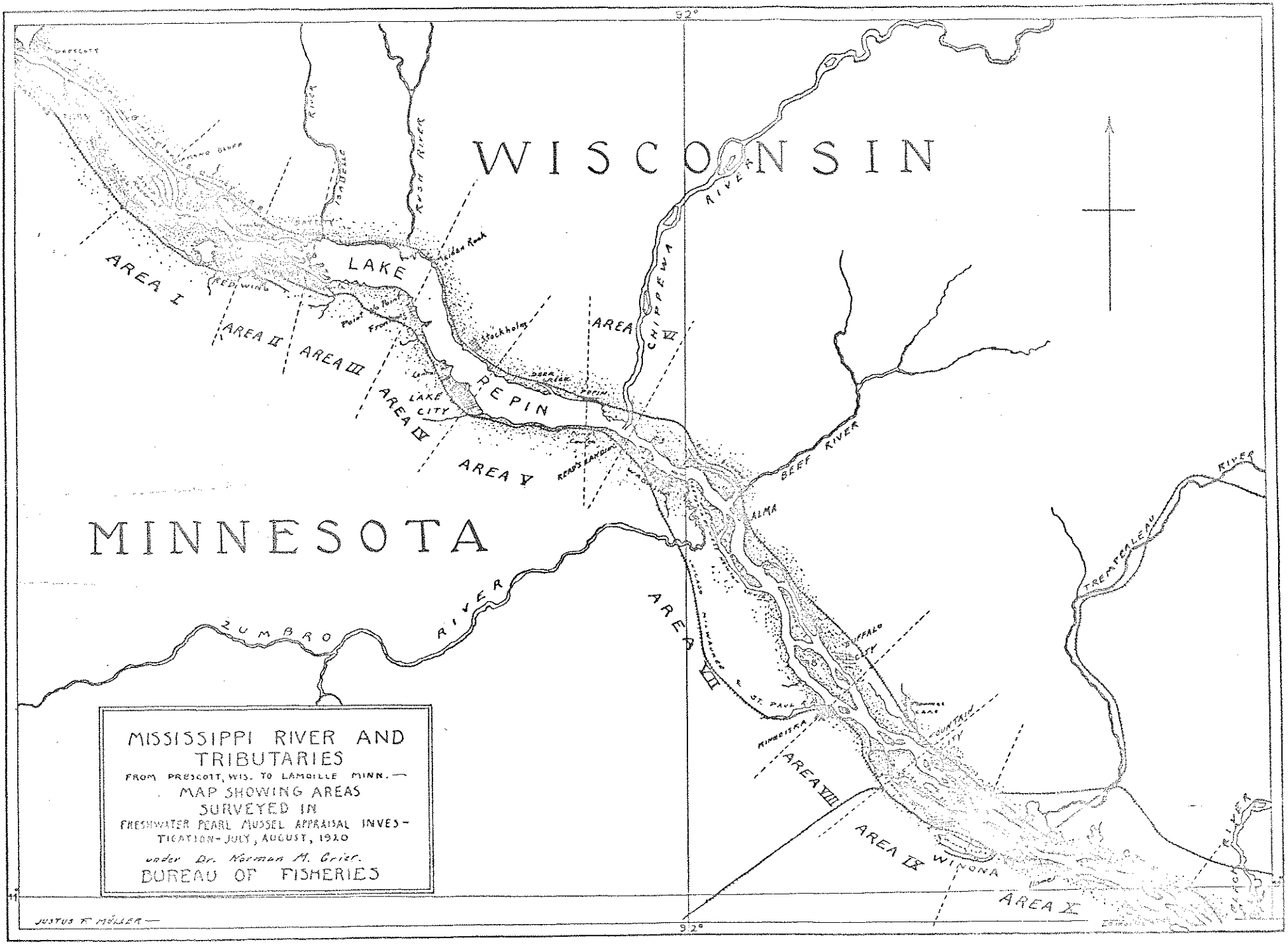
2. Restocking and propagation of desirable species in certain sloughs, both in open and closed areas, as the young shells in the former case would be protected by the prevailing sentiment among mussel fishermen toward them. Sloughs offering some promise in this respect are the Belvedere below Minneiska, West Newton Chute near Alma, and the Straight Slough near Winona.

Corrections in Botanical Nomenclature.

OLIVER ATKINS FARWELL.

Dilepyrum erectum (Schreb.) N. comb. *Muhlenbergia erecta* Schreb., Besch. Gras. II 139. pl. 50 (1772-9). *Dilepyrum cristosum* Mx., Fl. Bor. Amer. 1:40 (1803).

Mr. A. S. Hitchcock, in The Genera of Grasses of the United States, (U. S. Dept. Agriculture Bulletin No. 772) p. 145, (1920) places the genus *Dilepyrum* Mx. as a synonym of *Muhlenbergia* Schreb. and remarks that either of Michaux's species are equally eligible as the type and that the second


WISCONSIN
MINNESOTA
LAKE PEPIN
AREA I
AREA II
AREA III
AREA IV
AREA V
AREA VI
AREA VII
AREA VIII
AREA IX
AREA X
RED WING
LAKE CITY
ALMA
WINONA
BUFFALO CITY
FOUNTAIN CITY
CHIPPEWA RIVER
BEEF RIVER
TREMPEALEAU RIVER
ZUMBRO RIVER
MISSISSIPPI RIVER AND TRIBUTARIES
FROM PRESCOTT, WIS. TO LAMOILLE MINN.—
MAP SHOWING AREAS SURVEYED IN FRESHWATER PEARL MUSSEL APPRAISAL INVESTIGATION—JULY, AUGUST, 1920
under Dr. Norman M. Grier.
BUREAU OF FISHERIES
JUSTUS F. MÜLLER—