

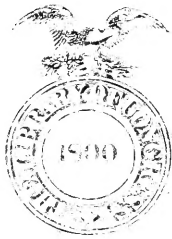
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The protection of freshwater  
mussels

1914



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DEPARTMENT OF COMMERCE

BUREAU OF FISHERIES

HUGH M. SMITH, Commissioner

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# THE PROTECTION OF FRESH-WATER MUSSELS

By R. E. COKER, Ph. D.

*Director U. S. Biological Station  
Fairport, Iowa*

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Bureau of Fisheries Document No. 793



WASHINGTON  
GOVERNMENT PRINTING OFFICE

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# THE PROTECTION OF FRESH-WATER MUSSELS.

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By R. E. COKER, Ph. D.,

*Director United States Biological Station, Fairport, Iowa.*

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## PRESENT CONDITIONS.

### THE MUSSEL INDUSTRY.

The history of the fresh-water mussel industry gives illustration of the promptness with which an American industry may be developed once the pathway is found. Undertaken in a small way scarcely more than a score of years ago, the manufacture of pearl buttons began almost immediately to assume the proportions of an important national industry. As early as 1898, when the enterprise was only 6 years old, there were about 50 factories in more than a dozen towns along the Mississippi. With improved machinery and methods further expansion occurred, until within a few years the output approximated 30 million gross of buttons, with a value of many millions of dollars. The growth of the industry has continued to the present time, but exact figures will not be available until the Bureau has completed a statistical survey now in progress.

Not less important has been a resultant economic change, or modification of custom, that has affected practically every person in the country. Where marine pearl was in rare use, fresh-water pearl, with its quality and price, came to fill a universal requirement. In one decade pearl buttons were high in price, used only upon the better clothing, and commonly saved when clothing was discarded, while in the most general use were buttons of metal or agate or wood, which rusted or broke or warped. In the next decade good pearl buttons, neat and durable, were available to everybody and used upon the widest variety of clothing. A former luxury had become a common necessity.

Coincident with the rise of the manufacturing industry, there developed an important and widespread fishery, directly employing thousands of persons and indirectly affecting persons and communities of varied occupation. Commencing on the Mississippi

River, the fishery gradually spread from stream to stream, passing from depleted territory to new and rich fields, until it embraced practically the entire Mississippi Basin and a portion of the Great Lakes drainage, from Minnesota to Louisiana, north and south, and from Ohio, West Virginia, and Tennessee on the east to Arkansas, Kansas, and South Dakota on the west.

#### DEPLETION OF THE RESOURCES.

Extension of territory could not be continued indefinitely. While up to the present time the industry has not failed to obtain shells in quantity sufficient for the market demands, it has become perfectly clear that the perpetuation of the industry as one producing a staple product that is both good and within reach of all people depends upon successful propagation and effective protection. The supply is now maintained by regularly invading new territory (and it is scarcely possible to go farther in this direction), by seeking out the smaller tributaries of the mussel streams, which could not formerly have been worked with profit, and in some measure by the devising of methods that are more effective in capture of mussels. Notwithstanding these developments, all of which indeed conduce to more exhaustive fishery, an increasing proportion of very small shells is being taken, the bottoms are being more thoroughly cleaned, and the price of shell has advanced to a relatively high figure.

A high price for shell has, of course, its advantages. It is good for the fishermen, provided they can find the shells, and it stimulates the manufacturers to eliminate waste and to use the most economical methods. On the other hand, if unbalanced by protective restrictions, a continued rise in price is of disastrous consequence. It impoverishes the beds by driving the fishermen to the most exhaustive manner of fishing; even the very smallest shells that can be captured, which should never be removed from the beds, are taken and marketed, and this, unfortunately, is the actual case at the present time. (See pl. 1.) Ultimately the higher price of shell becomes an element in the price of the finished product and is paid by the public at large without corresponding advantage to a single person connected with the industry.

Let it be repeated that a high price to the fishermen is desirable, but in the present condition they reap no benefit. A higher price for a disproportionately smaller product brings no added profit. None are so directly interested in the conservation of mussels as the fishermen themselves.

Of what advantage is it to the fishermen of the Wabash River, or to the State of Indiana, that shells are now more valuable, when a river that once supported a really important shelling industry is

now practically depleted? Wherein is the benefit to Illinois, when only one fisherman can engage in shelling to-day where six worked with profit five years ago? What profit will Arkansas find, when its rivers are now the scene of the most exhaustive mussel fishery ever known and the future is being robbed by the removal of infant shells that are shipped to the markets to be subsequently thrown into the discard by the manufacturers as too small for any useful purpose?

#### THE INTERESTS OF THE COMMUNITY.

An earlier general interest in the subject would have been awakened had there been a better knowledge of the importance of shelling industries to the communities at large. As an illustration, the case of Madison, Ark., may be mentioned. The town itself has a population of about 300 and is supported by lumbering, farming, and fishing industries. During each of the past two years shells and pearls have been marketed at this place to the value of about \$20,000. This was a crop that could be counted upon regardless of weather conditions during the season, and it constituted a substantial element in the income of the community at large. Can this income be counted upon in the future? A dozen years ago fishermen made their wages when shells brought \$4 per ton, and they can do no better at this time, when they receive \$23 per ton. In 1913 they took 200 to 300 pounds per day, where originally they made daily hauls of 1,000 to 1,800 pounds. The shells are now, it appears, about one-sixth as abundant as they were a dozen years ago. This is a rapid rate of depletion, and it is evident that the future can have little to offer unless something is done to insure the self-perpetuation of the mussel beds.

The town of Black Rock, Ark., which has a population of about 1,000, offers an illustration where both fishing and manufacture are involved. It is estimated that approximately \$50,000 is brought into the town and the territory about it each year, of which by far the greater amount is paid out in the town of Black Rock itself. What does the future hold for this place? Reliable information shows that while a few years ago a sheller could take 1,200 pounds or more per day from the Black River at Black Rock, the daily catches now run from 100 to 200 pounds. Although shells are bringing about \$20 per ton, there is scarcely a daily wage to be made, and as a consequence the shell fishery immediately about Black Rock is almost negligible. The shelling is now prosecuted principally above Black Rock, in the upper waters and tributaries of the Black River, as about Pocahontas and elsewhere. The process of depletion is unchecked and the condition is clearly such as to awaken the enlightened sentiment of the community and the State at large

to support measures that will insure permanent life and prosperity to the industry. Here is a business that yields a relatively fixed return in comparison with agricultural industries, which are so generally affected, favorably or unfavorably, by the vicissitudes of weather conditions.

It is of much more immediate concern to the community at large than it is to the purchasers of shells or to the shellers themselves that the resources of a particular region should be conserved. It is a comparatively simple matter for the manufacturer to strip his plant and to remove his machinery to another locality with undepleted resources; it is an easy thing for the sheller, with his scant equipment in a house boat, to float down the river, looking to find another temporary home where his labors may be more profitable. It is the interest of the community that is threatened. The loss of a substantial industry affects the profits and the welfare of innumerable persons who may have known little of their indirect interest in a business in which they did not immediately participate. The communities most immediately affected are those of the river towns which, as a general rule, are too limited in their sources of fixed income.

From the standpoint of community economy, an unfortunate feature of the mussel-fishery, as it has been pursued up to this time, has been its nomadic character. The policy everywhere has been to clean up the beds of a locality, or of a stream as a whole, and then to move to new regions. Temporary cutting plants, or "factories," have frequently been established in the vicinity of active shelling, to move subsequently as the local fishery passed away. Only the larger and more firmly established branch plants of the principal factories have maintained a fixed location.

It will be brought out later in this report that it does not appear possible to insure the best condition of the mussel beds, except by some plan of rotation; but it would be desirable and favorable to the interest of all for the mussel fishery to be a permanent and dependable feature of the industrial life of the broader communities, if not of particular restricted localities.

The perpetuation of the mussel resources may well receive the best consideration of every State concerned and of the National Government as well. It affects the welfare of thousands of shellers, of hundreds of river towns over the broad Mississippi-Missouri Basin, of manufacturers and laborers, east and west, and, it might be said, of every user of pearl buttons, which comprises practically the entire population of the country.

The Government and the States can accomplish the desired object by two principal means—artificial propagation and legislative protection. It is the province of the present paper to deal primarily

with the subject of protective measures, but it will be advisable to give first an abbreviated account of the conditions and possibilities of artificial propagation, especially as the results of propagation will be greater or less according to the degree of protection extended to the young mussels.

#### ARTIFICIAL PROPAGATION OF MUSSELS BY THE GOVERNMENT.

##### ESTABLISHMENT OF PROPAGATION.

The Bureau of Fisheries has always maintained an active interest in the development of the fresh-water mussel fishery of America, which, in its importance and breadth of territory, is entirely unique in the world. As early as 1897 and 1898, the shell fishery being then only 4 or 5 years old, the Fish Commission undertook investigations relating to the various phases of the industry, and several reports were published dealing with the natural history of mussels, the shell and pearl fisheries, and the button industry. In a general report on the subject Dr. Hugh M. Smith then recommended measures for the protection of mussels. No action followed, and in consequence the scene of the most important fisheries has greatly shifted since that time.

Some years later there began a special investigation of the reproduction of mussels, which resulted in the methods of artificial propagation as developed by Prof. Lefevre and Prof. Curtis, of the University of Missouri, in association with the Bureau. The Government then established the Fairport Biological Station to engage in the propagation of mussels and the studies of mussel problems, besides exercising wider activities in fishery investigations. For a number of years field investigations relating to the distribution, habits, and conditions of life of the mussels have been prosecuted by the staff and associates of the Bureau throughout the Mississippi Basin.

For the first two years at the Fairport station mussel propagation was carried on in an experimental way, but beginning with 1912 the practical operations have been conducted upon as large a scale and over as wide a territory as the available resources permitted. During the past two years mussels have been propagated chiefly in the Mississippi River from Lake Pepin, in Minnesota, to New Boston, Ill.; in the Wabash River in Indiana, and in the White and Black Rivers of Arkansas. During the year ended June 30, 1913, about 150,000,000 glochidia, or young mussels, were put out, and in the first half of the present fiscal year that number is fully equaled. Such figures appear large. It is not difficult by the methods of propagation to handle considerable numbers of glochidia; indeed, it is necessary to work on an ample scale, for in mussel propagation, as in most forms of fish culture, what we can now do is to aid the young over the most

critical period in their life history, after which they must be left to continue the struggle for existence by their own efforts.

We therefore plan to work in such a way that, even with the liberal discount that nature will surely apply to our returns, there may be left a real measure of benefit gained without undue cost. Many of the young will be lost from falling upon unsuitable bottoms and from many other unfavorable conditions, such as confront every young mussel in nature with more or less frequency. We would like to remove all of the unfortunate conditions productive of loss, both to the mussels that we put out and to those that are propagated entirely by natural means; but this, of course, is not possible. There are, however, artificial conditions which do injury to the younger mussels, and it is both desirable and practicable to prevent such damage as far as can be done reasonably.

#### RESULTS DEPENDENT UPON PROTECTION.

In the regular fishery for mussels the beds are continually dragged over with rakes, tongs, crowfoot hooks, or dredges. It is inevitable that the young mussels will suffer to some extent from this process. It is quite unnecessary, however, for the "infant" mussels, many of them too small for any use at all and many more too small for any economical or proper use in manufacture, to be entirely removed from the beds. Mussels are thus uselessly destroyed that might be left to grow to a size at which they would be both commercially valuable and properly usable; meantime, too, they might take their natural part in the reproduction of the species.

Furthermore, it would be desirable to leave portions of the rivers entirely undisturbed by the operations of shelling during periods of some years. This would accomplish a double object—it would leave the best conditions for the natural reproduction of the remnant of the old stock and for the growth of the young mussels and at the same time it would create a series of reserves in which artificial propagation could be carried on with the best conditions for maximum results. In such closed regions the young mussels would have to contend against only the normal unfavorable conditions which all mussels have ever had to withstand, without an added toll of destruction being taken by the direct and indirect effect of the operations of men.

The simple "closing" of a depleted region, if the exhaustion has not proceeded too far, may be expected to lead to sure betterment, and even in time, if the closure were for a very long period, to a restoration of the former condition when mussels were so richly abundant. It will be advisable, however, to supplement natural processes by the methods of artificial propagation in order that the

replenishment may be hastened and a greater result gained in a shorter time. We have to contemplate that the beds that may be closed will have to be reopened after a definite period, for the fishermen can not afford to work indefinitely on restricted and depleted areas, and the supply of available shells must be maintained. A proper solution as fair as possible to all will be found in a plan of rotation which will give rest periods to the different portions of a river in succession. Let this measure be supplemented as far as may be by Government or State propagation of mussels in the resting regions.

It is apparent that artificial propagation and protection are intimately related. Restrictive measures alone will yield benefits, but these will be greater if the protection is followed up by well-directed propagation. Artificial propagation pursued independently may be expected to bring results, but the advantages will be considerably diminished if no steps are taken to lessen the unnecessary destruction of the young mussels thus given a start upon life.

#### PROTECTION.

##### ESSENTIAL CONSIDERATIONS FOR EFFECTIVE LEGISLATION.

Although at least 20 States participate directly in the mussel fishery for the shell trade, only 2 or 3 of these have taken any action of any kind for the protection of the resources. In some others measures have been proposed at various times, but without receiving favorable consideration by the legislative bodies. Indeed, it is probably well that this is the case, in view of the fact that there has been no general presentation of the case from all sides to aid in a just consideration of the matter. The Bureau is prompted to make this report in the hope that suggestions based upon a long-continued investigation of the shelling industry in all its phases may be of material aid to the responsible bodies concerned in the determination of how best to perpetuate the mussel resources, giving due regard to the local conditions involved.

Any legislation to be most effective must fulfill certain general conditions. It must be based upon just consideration of the welfare of all classes legitimately interested in the business, including shellers, buyers, manufacturers, and the public generally. This is important not only because fairness demands it but because it is manifestly impracticable to enforce a law which is framed in disregard of economic requirements. A law that makes possible the creation of a monopoly, or one that drives the buyers and manufacturers from the territory, or that sacrifices the good of the industry to revenue production to the State, would be so manifestly unsound that further comment seems unnecessary.

Nevertheless, the element of sacrifice can not be entirely eliminated. In this case, as in others, ultimate benefits can scarcely be obtained without some temporary sacrifice, although it should be aimed to make the immediate loss felt as little as possible. It is the unwillingness of individuals to make voluntary sacrifices, independently, for the good of the mussel beds that makes legislation of any kind necessary. There is a demand for legislative action only because, in the end, the welfare of all parties concerned is dependent upon the promotion of abundant growth of mussels.

Finally an eminently desirable feature of any legislation is that it shall be so simple, plain, and undebatable as to minimize the difficulty of enforcement. Coupled with this there must be not only an effective penalty but machinery of enforcement that will work simply and certainly.

The measures to be proposed will be considered in the light of these requirements, together with the basic conditions offered by the natural history and the conditions of life and reproduction of the mussels.

#### EXAMINATION OF PROTECTIVE MEASURES.

##### TWO MEASURES FOR IMMEDIATE APPLICATION.

As appears from the remarks hitherto made, the restrictions which are immediately required for the preservation of the shell resources are—

(1) The imposition of size limits for the protection of young mussels.

(2) The adoption of a plan of rotation of closed regions, whereby the mussel beds may be given the best opportunity for propagation and growth.

We do not at this time advocate any other limitations, and it will be attempted to show that these are so simple to apply and so promising of effectual conservation that it is strongly advisable not to complicate the situation by a needless multiplicity of restrictions. These two measures will be fully discussed in subsequent sections of the paper.

##### MEASURES NOT SUITED TO EXISTING CONDITIONS.

Two other measures that have been more or less frequently proposed are the provision of a closed season during certain months and the restriction of the methods of taking mussels. While it is the purpose of the present paper to discuss more especially the positive suggestions that are offered, it is not out of place to give briefly some of the reasons for exclusion of measures which may have been suggested by friends of the industry with sincerity of purpose and which are not upon their face devoid of merit. Always let it have the first place in our minds that the one object in view is not to hamper but to develop the mussel fishery.



*Closed season of months.*—The aim in establishing a closed season for the mussel fishery during a portion of the year is either to protect the mussels from disturbance during a breeding season or else to diminish the extent of the fishery by limiting its duration.

It might be very proper to protect the mussels during the active breeding season, if such a season could be defined; but, as a matter of fact, the various species of mussels in any particular stream have different seasons of breeding. The mussel industry is based upon a considerable number of species of economic mussels. There is a group which has a short breeding term during the summer months. Such are the species known commercially as “niggerhead,” “pimple-back,” “monkey-face,” “maple-leaf,” “blue-point,” “three-ridge,” etc. The “washboard” seems to have an intermediate breeding term during the early fall, though it may be that in some cases it carries its spawn into the winter. Many of the more important species of mussels have a long term of breeding; in the latter part of the summer and in the early fall the eggs are deposited into brood pouches within the shell of the female, and there, after they hatch and develop, they are carried over the winter, to be liberated in the spring and early summer.<sup>a</sup> Of this kind are the “mucket,” “sand-shell,” “pocketbook,” “butterfly,” and others.

In view of the variety of commercial mussel species and the diversity of breeding seasons, it does not appear practicable to determine upon a closed season that will accomplish its particular purpose. The Illinois law prohibits the taking of mussels in any navigable water in that State between the 1st day of October and the 1st day of April; but, as illustrating how such a measure may apply in a particular case, practically all of the mussels in the principal river of that State—the Illinois River—are short term or summer breeders, spawning some in June, July, and August, others in October and about that time. Only a few carry the spawn, after its development, through the winter.

The principal objection to an enforced interruption of the fishery during a period of months is that it deprives the mussel fishermen of the right to earn a living by their profession during a portion of each year. This objection has real weight, and should be overborne only by decided advantages to be gained from a closed season.

*Restricting the methods of fishery.*—The principal implements for taking mussels are the crowfoot bar, the rake, the fork, the tongs or scissors fork, the dip net, and the dredge. These several pieces of apparatus are variously adapted to conditions of depth, rate of current, and character of bottom, as well as to the aptitudes and customs of the fishermen. Before a method should be prohibited it should be

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<sup>a</sup> Possibly these mussels liberate glochidia to a limited extent during the fall and winter; but the general statement is well founded.

known that it can be replaced by one of the more suitable methods, or else that it is so positively injurious as to require its elimination. The only implement of capture against which complaints are generally made is the crowfoot hook, but this is the only method in general use which is adapted for taking mussels in the deeper water, and it is probably in more common use than any other method. Perhaps in time improvements upon this hook will be adopted to lessen its injuriousness, or other methods capable of replacing it will be better known. In the light of present conditions it would work an unnecessary hardship upon a very large number of fishermen to prevent its use, especially when it appears that the protection of the mussels can be accomplished by methods more equitable to all concerned.

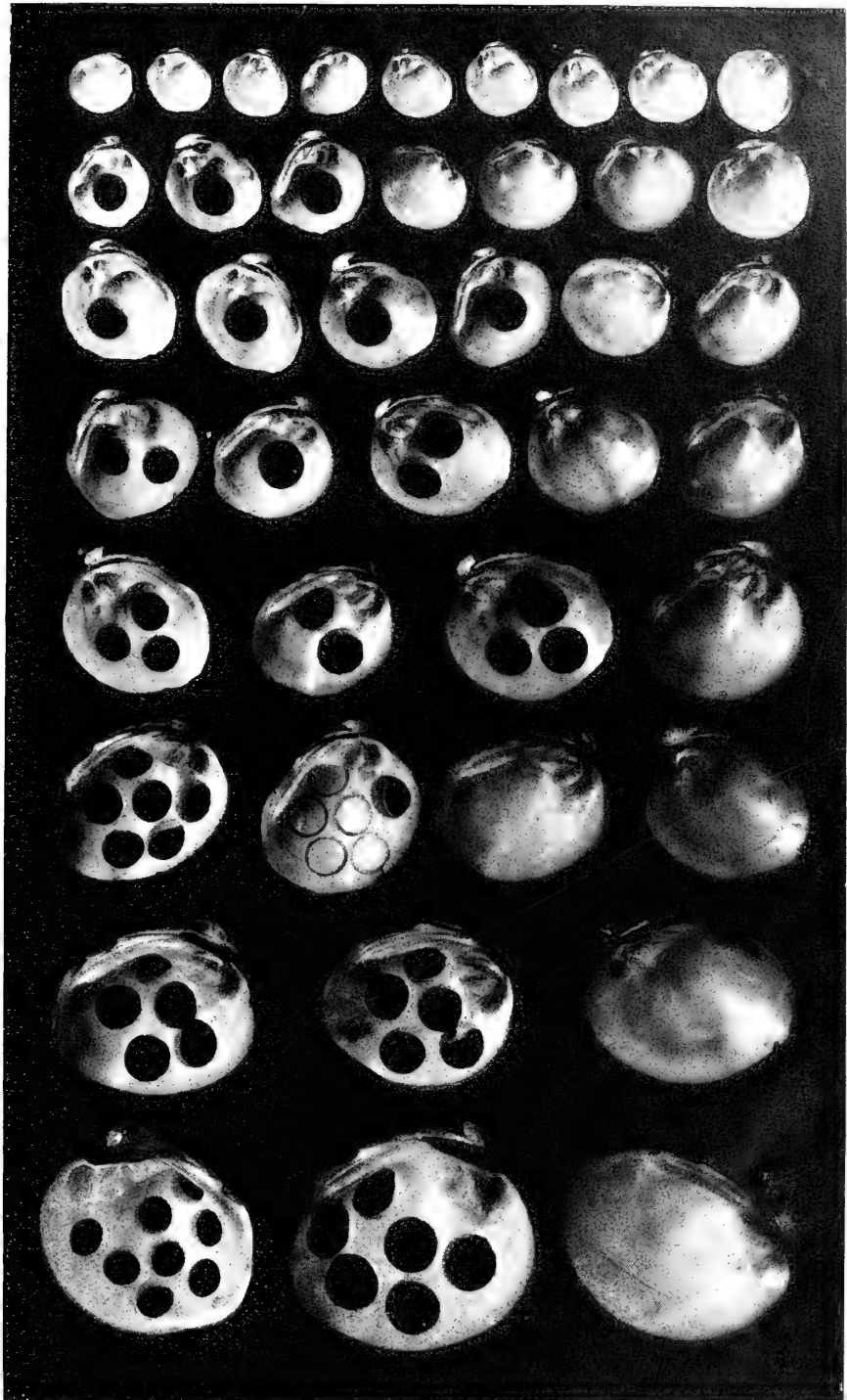
Still other measures have sometimes been advanced looking to the limitation of the number of shellers to be permitted to work within a given territory or to the leasing of shelling rights. Since such proposals have not yet been offered in connection with any properly worked-out plan by which serious injustice would be avoided and the interest of the public safeguarded they may be dismissed with the remark that it is not simply the protection of mussels that is desired but the protection of the mussels for human use without interference with common human rights. The absence of inherent wrong in an idea does not commend it if it carries within itself the seeds of its own defeat by a method of application, or a want of method, that allows opportunity for manifestly unjust and intolerable conditions to arise.

There remains to deal with the necessity for the two measures that are advocated and to discuss the methods of application. This can be more adequately done in distinct sections.

#### SIZE LIMIT—NECESSITY AND APPLICATION.

##### EXHAUSTIVE NATURE OF THE FISHERY.

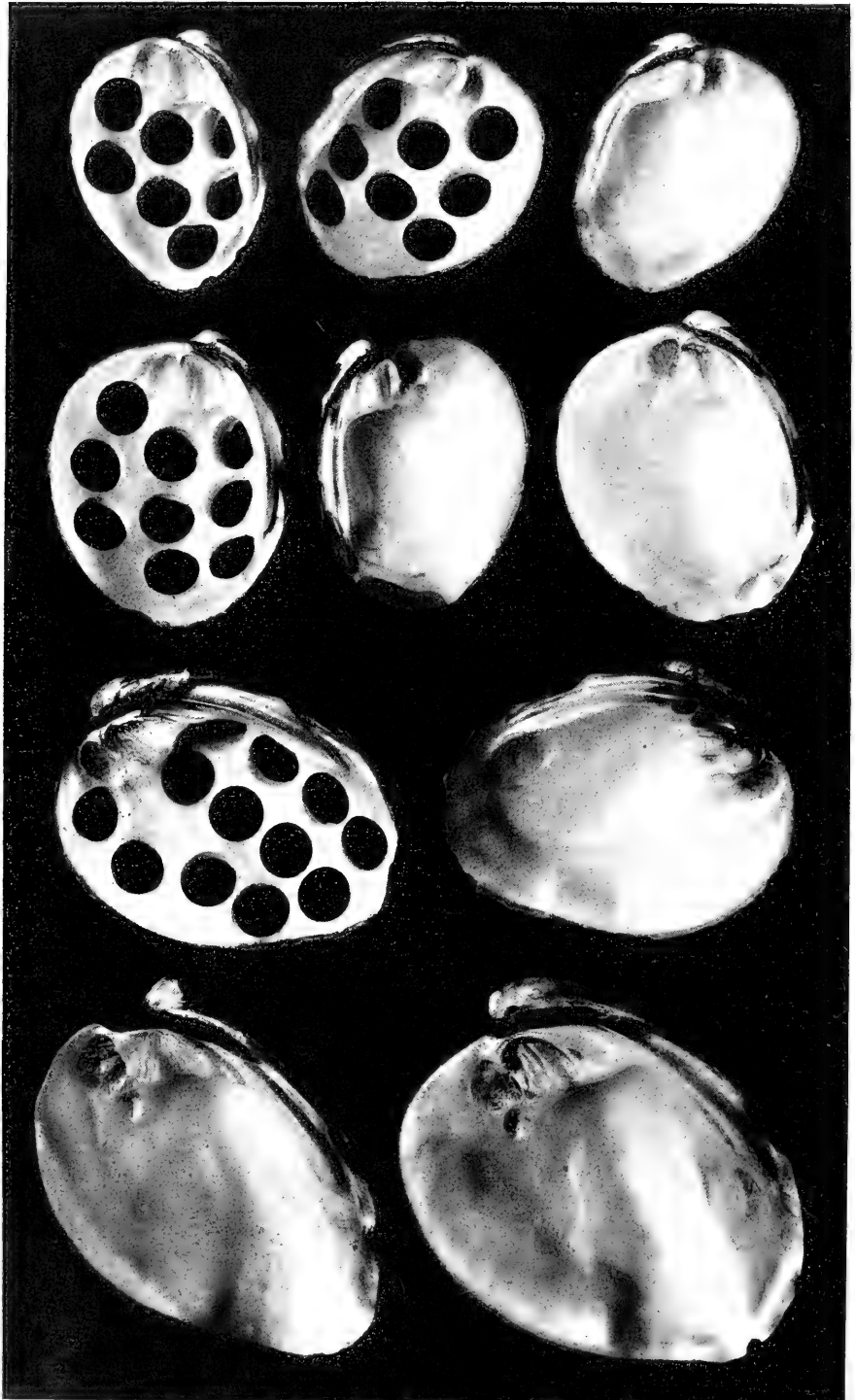
The necessity for imposing restrictions upon the size of mussels to be removed from the beds is brought out more clearly by the photographs than could be done by any lengthy discussion. All of the shells shown in plates I and II were actually taken for market, sold, and shipped to the factory. The smallest ones (in the three upper rows on plate I) were not wanted at any factory; they were bought only because the fishermen had thrown them into the piles along with the larger shells, "to add weight." Most of the very smallest shells, those under 1 inch in length, are subsequently lost in handling, by falling through the forks or otherwise wasting as they are thrown into the car or from the car to the bin. None of the shells in the three upper rows of plate I would ordinarily be used by any manufacturer. It is true that some of the shells shown



SMALL SHELLS ACTUALLY MARKETED. ALL EXCEPT THOSE OF THE THREE LOWER ROWS SHOULD BE LEFT IN THE RIVERS.

[About one-half actual size, which is shown in inches at right of plate.]

In.



LARGER SHELLS MARKETED AND ADVANTAGEOUSLY USED.

[About one-na f actual size, which is shown in inches at left of plate.]

have had one blank cut out, and these were actually cut at a commercial plant, but the instance was a very rare one and was certainly unprofitable. Even if the manufacturer desired it, the cutters will not handle shells from which only one blank can be cut, since the waste of time outweighs the saving of material.

Consequently all shells less than about  $1\frac{1}{2}$  inches in length, no matter what the quality, are thrown into the discard. *There can be no difference of opinion as to the pure wastefulness of taking shells of this size.*

The shells shown in the illustration are not the smallest that could be found. Some shells observed in the fishermen's boats were only one-half inch in the greatest diameter. Out of the water these are entirely without use. The fisherman who saves them, thinking that they add weight to his heap, would doubtless be surprised to learn that he would have to handle several times and clean 200 of such shells to add 1 cent to his earnings, for it would take nearly half a million of them to make 1<sup>c</sup> ton.

The shells in the fourth and fifth rows, counting from the top in plate II, are used at the factories when received, and are sometimes particularly favored where the quality is as good as in those from many Arkansas rivers, and the shells will yield two or three blanks of 16 to 20 lines. Such blanks are of a suitable thickness and work up economically besides having a good quality. Some of the shells in these two rows show how blanks of 18, 16, and 14 lines are worked out, a "line" in button measure representing the fortieth part of an inch.

The use of shells taken between  $1\frac{1}{2}$  and 2 inches in greatest diameter does not, therefore, like the marketing of those under  $1\frac{1}{2}$  inches, represent absolute waste, but it does denote relative waste or real short-sightedness from the economic point of view. Shells of this size will average about 30,000 pairs to the ton, while mussels of such a practical size as  $2\frac{1}{2}$  inches will average only 15,000. The number of blanks obtained from a ton of shells of the latter size would be just the same as from a ton of the smaller shells, notwithstanding that only half as many shells are handled. *We are thus, when using the smaller shells, depleting the mussel beds at twice the necessary rate without any corresponding advantage.*

#### WASTE ILLUSTRATED.

There is given below a table that will repay careful examination as illustrating the wastefulness of using the small shells. While the figures must be understood to be only approximate, they are based upon careful weights and counts of a number of shells from several localities. The shells were all "niggerheads" and were all obtained after shipment to factories.

The first two columns show the limits of size for each lot used, the greatest diameter being the basis of measurement.

The third column shows the approximate number of pairs of shells composing a ton, the unit of purchase; multiplying this number by 2 would give the number of single shells per ton.

In the fourth column there is given, in the case of the critical sizes, the number of 18-line blanks readily taken from a single shell (which is one-half the number yielded by a pair of shells, or an individual mussel).

The fifth column indicates the number of gross of blanks, by computation, yielded by a ton of shells. This computation is based upon the cutting of 18-line blanks (not the larger 20-line blanks that have been taken from some of the larger shells in the illustration). Some of these shells are cut excessively close to the tips, on account of taking too many larger line blanks. It must be understood that different sized shells are adapted for different lines of buttons. The data herein is for comparative purposes only.

TABLE OF SIZES, WEIGHTS, AND BUTTON PRODUCTION FOR NIGGERHEAD SHELLS (APPROXIMATE FIGURES).

Longest dimension.		Number of mussels per ton.	18-line blanks per single shell.	Quantity of blanks per ton.	Refer to illustration.
Greater than—	Less than—				
<i>Inches.</i>	<i>Inches.</i>			<i>Gross.</i>	
$\frac{3}{2}$	1	174,000	-----		Plate I—
1	$1\frac{1}{2}$	110,000	-----		1st row.
$1\frac{1}{4}$	$1\frac{1}{2}$	55,000	-----		2nd row.
$1\frac{1}{2}$	$1\frac{3}{4}$	33,000	2	917	3rd row.
$1\frac{3}{4}$	2	26,000	3	1,008	4th row.
2	$2\frac{1}{4}$	20,000	4	1,111	5th row.
$2\frac{1}{4}$	$2\frac{1}{2}$	15,000	5	1,042	6th row.
$2\frac{1}{2}$	$2\frac{3}{4}$	10,500	6	875	7th row.
					8th row.
				} Grad- ually dimin- ishing to less than 650 per ton.	
$2\frac{3}{4}$	3	8,500	a 7-8		Plate II—
3	$3\frac{1}{2}$	6,200	a 10		1st row.
$3\frac{1}{2}$	4	4,000	a 12		2nd row.
4	-----	3,200	a 14		3rd row.
					4th row.

<sup>a</sup> At the time of making this table only a few of the larger-sized shells were available, so the estimates of blanks are less accurate.

It may be seen from the table that a marketable ton of niggerheads could be composed of the shells of 3,200 or of 33,000 mussels, according as the shells were 4 inches in length or only  $1\frac{1}{2}$  inches. As a matter of fact, no marketed ton is ever composed of mussels of an exactly uniform size; furthermore, the extremely large niggerhead shells are very rare and generally not very desirable on account of inferior quality and disproportionate waste. A ton of shells from a region of depletion will also include a number of the smallest and not strictly marketable shells.

Now, let us take a concrete illustration: Several counts of mussels gathered by shellers in the White River near Clarendon, Ark., were made in October, 1913; from these an average was taken that fairly represents the catches being made at that time in that region. It was found that 60 per cent by number of the shells taken were of a size less than 2 inches in greatest dimension; also that a ton of shells comprised 20,500 pairs, of which 12,300 were less than 2 inches. Now, it is evident that if these smaller shells were returned to the bed we would be depleting the bed less than one-half as fast as at present. This would be the substantial advantage that such a size limit would have to the mussel beds; and any advantage to the mussel beds is an ultimate advantage to the fishermen, manufacturers, and all others in any way dependent upon the perpetuation of the mussels. Under the working of a 2-inch size limit, 60 shells out of every 100 then being taken on the niggerhead beds of that vicinity would have been thrown back. This seems to be asking a good deal, but not so much as at first appears, for the undersized shells constitute only 38 per cent of the weight or selling value of the shells taken.

On the other hand, both sheller and manufacturer would be saved the trouble of handling over and over again an unnecessarily large number of shells. A ton of shells (from the same locality) comprising only those above 2 inches in greatest dimension would contain about 13,000 pairs, or 37 per cent less than the number now found in a ton (20,500), while these shells, the smallest ones being eliminated, would produce at least 10 per cent more buttons of corresponding sizes.

#### SIZE LIMIT IN RELATION TO ECONOMY.

The figures given above are, of course, based upon counts and computations of shells from a particular locality and must not be assumed to have any general application, but the facts and principles derived do have a universal bearing. If such a size limit as 2 inches is adopted, the saving to the mussel beds and to the future of all interested parties is out of all proportion to the immediate loss to any party; and even the immediate loss is to some extent compensated by the saving resulting from having to do with a lesser number of shells that yield a greater number of buttons per ton.

Undeniably some temporary sacrifice is entailed, but unless it be admitted that temporary sacrifice will be accepted, it is useless to consider any manner of restriction for ultimate benefit.

There is one point that is brought out in the table on page 14 that merits attention from the broad standpoint of economy. In all shells there is a proportion of unavoidable waste, since the entire weight of the shell can not be transformed into buttons. In very small shells we may expect an undue waste, on account of the fact that

only one or two blanks can be cut out, leaving a larger bulk of shell in proportion to the number of blanks gained. On the other hand, in very large shells a high degree of waste is involved because of excessive thickness, which must be ground from the blanks, and because of the extra weight of the discarded portion. Somewhere between these extremes is the size of shell that yields the largest number of blanks as compared with the waste or the weight of shell that does not go into buttons. As shown by the data in the fifth column of the table, the shells a little above 2 inches in size are those (for this species) that make the best yield per ton for the small lines for which there is the greatest general demand.

#### REASONS FOR THE PROPOSED 2-INCH LIMIT.

Argument might be made in favor of a higher size limit as being still more favorable to the preservation of the mussels, but it is sufficient to say that the economic conditions would not justify a higher limit. At 2 inches a sufficiently severe restriction is placed upon the fishery, and to go further would be practically to prohibit the pursuit of shelling in so many localities that excessive hardship would be caused.

As consideration thus far has been given almost exclusively to the niggerhead shell, the question may well be raised, Will the same limit apply to other species of shells? The minimum size of 2 inches suggested can be taken as an absolute minimum, since there is no species of any importance for which it would be too high. This minimum would not, however, give the same degree of protection to the larger forms, such as the washboard, the bluepoint, and the mucket. Should a minimum size be fixed with particular reference to any one of these varieties, it would necessarily be a good deal higher.

In the present paper recommendation is made for this one-size limit alone, for the following reasons:

1. All conditions considered, it is the most appropriate limit that could be designated for the niggerhead mussel, which is at present the most important species of wide distribution, and which is, furthermore, the species most liable to rapid extermination. This and species closely like it, as the pigtoe, the pimple-back, and the maple-leaf, are chiefly those that are now being taken in the very small sizes.

2. The same size applies equally well to the related species just mentioned, as well as to the "hickory-nut," or "Missouri niggerhead," and the "butterfly."

3. The larger species, as the "washboard," "bluepoint," and "mucket," are generally so evidently valueless in the small sizes that shellers do not take them. At least it is not yet of observation that particular injury is being done to these species in this way.



4. To insure the least trouble of enforcement of the law, it is necessary that a minimum size be set, below which no shells of any species may be retained. There are many different species of commercial mussels, and some of them so intergrade as to make exact determination a nice matter in some cases. Distinct size limits for the different species would introduce peculiar difficulties into the practical workings of enforcement; it would be more troublesome to the sheller to observe the law voluntarily, and loopholes for evasion would more easily be found by the offender of wrong intent.

Should conditions in certain States or streams subsequently require a higher limit for particular kinds of shells, a supplemental limit may be fixed for designated species; but this could be done without affecting the application of a 2-inch limit as an absolute or universal limit below which no shells of any species could be lawfully taken. It is desirable that few different limits should ever be used, and it seems expedient to have but one size limit until the first legislation shall have been tried out.

#### DETAILS ESSENTIAL TO EFFECTIVE LEGISLATION.

In concluding this section emphasis may be laid on the value of certain details of legislation.

*Allowable margin of undersized shells.*—While it may seem desirable that no undersized shell at any time should be taken away, nevertheless it is necessary to make allowance for a margin of unintentional error. Only if the shellers and buyers were to apply an instrument of measure to each individual shell would all possibility of error be eliminated. The sheller will naturally, after a few measurements, come to judge by the eye, and it is desirable that the law should be somewhat liberal, rather than too stringent in the allowance for mistakes. There should, accordingly, be a supplemental provision that if not more than 5 per cent of the shells by number (not by weight) of any bushel are found to be below the size limit, the law shall not be presumed to be violated.

*Illegal possession.*—To be practicable of enforcement, the law should be so worded as to make it illegal not only to bring ashore or to offer for sale, but also to have in possession, fresh-water mussels or clams of a size less than 2 inches in greatest dimension. This one provision will obviate much unnecessary expense, as well as undesirable complications in the detection of violations and the prosecution of offenders. Furthermore, since buyers of the shells would be equally liable to prosecution, the effect would be to destroy the market for undersized shells, and thus in the most effective way to restrain the shellers from taking them.

*Method of measuring mussels.*—It will be noted that the method of measure is stated as "in greatest dimension," with a view to elimi-

nating every possibility of uncertainty or difference of opinion. Mussels are sometimes measured in length or width or height, but on account of the irregular form of mussel shells these dimensions are not always interpreted in the same way. In testing the blank-making capacity of a shell, commercial men sometimes measure the "width on the face"; that is, between the lateral hinge tooth and the lower margin of the shell. This measure can of course only be taken from an open shell, and therefore could not serve for our purpose. It is worth while to call attention to the fact that a 2-inch shell as measured in greatest dimension would be a good deal smaller than a 2-inch shell in commercial measurement.

An inspector would need to be equipped with an ordinary rectangular caliper. If a shell should be found to measure more than 2 inches in any linear direction it would be considered as above the size limit.

#### CLOSED REGIONS—NECESSITY AND APPLICATION.

In addition to the provision of size limits it is strongly recommended that certain portions of the rivers be closed for rest periods covering several years. It might be thought that in regions of extreme depletion the operation of a size limit would, by making the fishery less profitable, have the effect of causing a practical rest period, but this can not be expected, for, stimulated by the high price of shells and the ever-present hope of making a pearl find, the local shellers will hardly ever desist entirely from the fishery.

No better way of giving protection to mussels can be found than that of entirely stopping the shelling upon a series of beds, although the plan must be applied in such a way as not to reduce the supply of mussels unduly and suddenly and with as careful regard as possible to the established interest of communities.

#### INJURY TO SPAWNING MUSSELS AND TO YOUNG.

Some of the conditions that make a system of closed regions particularly advisable for the conservation of fresh-water mussels may be briefly mentioned:

1. It has been previously stated that some of the mussels are spawning, or with spawn, during any period of the year. Many of the most important species are spawning during the late spring, early and mid summer; other equally important species form their eggs in the late summer, when they become fertilized and develop into the glochidium stage, but the mother clam retains them in marsupial pouches within her shell during the entire winter and even into the summer. All species of mussels carry the eggs in the marsupial pouches during the process of development to the glochidium stage

or longer, whether the period be for a few weeks or for a few months. In this condition the mussels are said to be gravid. It is readily observed that when gravid mussels are disturbed they frequently discharge the young, regardless of whether these are mature enough to be liberated from the parent or not; certain species, such as the niggerhead, are particularly likely to do this.

In the commercial fishery, therefore, not only is much spawn destroyed when large gravid mussels are captured, but it is quite probable that other mussels, disturbed on the bottom, though not captured, are caused to abort the young in an immature stage when they are entirely unable to complete the development without the parent.

2. In the stage of existence immediately after liberation from the parent, the young mussels are parasitic upon fish. We are not here concerned with them during this period of the life history. When they are dropped from the fish many of the young mussels do not at once take up life in the sand or mud of the bottom, but we find them forming delicate threads by which they hang from plants or sticks or stones or from clam shells, and thus are kept from being washed away or smothered in the mud of the bottom. We may imagine the harm to these little mussels that is unavoidably wrought when the beds are continually dragged over. In like manner, the little shells that are just beginning to take hold in the bottom may be torn out by the rake or hooks, to be smothered or washed away to less favorable bottoms. It will be remembered that when mussels first begin life in the thread stage or in the bottom if the thread stage is omitted, they are too small to be found without a microscope.

3. One of the principal methods of capturing mussels is with the bar and hooks dragged over a large area of mussel bed in taking a relatively small number of shells. There is chance for these hooks to injure many little shells when each drag, requiring a period of only a few minutes, covers a space of bottom 16 feet wide and several hundred feet long. Nevertheless, it is not certain that there is any method to take its place, and any implement used will accomplish some injury to the very youngest mussels.

#### CONSIDERATIONS DETERMINING SIZE OF CLOSED REGIONS.

In planning for the closing of portions of rivers for periods of years consideration should be given to community needs as well as to general economic and biological conditions. On the one hand, the closure will be more effective in result, as well as easier of enforcement, if the regions of closure are made very large; while, on the other hand, making the closed regions smaller might cause less economic inconvenience. If, for example, the entire Illinois River should be closed to mussel fishery for a period of several years, there

might be a substantial uncompensated loss to some communities, where there are factories employing labor to cut shells derived from that river. On the other hand, should we divide the river up into small sections of 2 or 3 miles in extent, some of which would be open while others would be closed under the law, it is apparent that such a plan would be almost impossible of enforcement. To prevent shelling from being carried on in all these little closed areas would require a force of wardens and an expense entirely incommensurate with the object to be gained.

It is held advisable to divide a river within a single State into some four or six sections for the purpose of establishing closed regions. One-half—that is, two or three—of these sections, taken in alternation, could be ordered closed for a period of five years, during which no mussel fishing at all should be allowed in the closed sections, although it would be regularly prosecuted in the alternate portions of the stream. It would be convenient to break a river at points where there was a substantial community interest in the shelling.

#### PRACTICABLE DIVISION OF RIVER SYSTEMS ILLUSTRATED.

For example, let us apply this method of dividing a stream to the White and Black Rivers in Arkansas. Starting from the headwaters of the Black River, we find the first center of economic interest at Black Rock, another on the White River at Newport, and a third at Clarendon. Now, the river might properly be broken at these points, forming four main sections. The fishery might then be entirely prohibited for several years from the mouth of the river to Clarendon, while permitted from Clarendon to Newport, and again prohibited from Newport northward to Black Rock on the Black River, and to Batesville or other suitable point on the upper White, while permitted from Black Rock and Batesville northward on all the tributaries. We would have the river system divided into four sections, which would be probably as nearly equivalent as could be expected. Furthermore, none of the three towns mentioned would be cut off from the local supply of shells, except in one direction.

The shellers, generally speaking, would be little affected, since, with their house boats, they could move from one portion of the river to another. Those shellers who do not use house boats, but are local residents and go out only by day from their homes, would be most affected, and it is these generally who are most in favor of closing portions of a river. They recall how much more easily shells were taken in past times when the shells were abundant, and they would be willing to do something else meantime in order that the beds may be given a rest and the shells again become numerous. Shelling has no attraction over any other form of crude labor when the shells are so scarce that a wage can scarcely be made.

Taking the St. Francis River in Arkansas as another illustration, the river might be broken at Madison, Parkin, and Marked Tree. It is true that there are not many mussels, according to report, above Marked Tree, but the region between Madison and Parkin has beds which may well balance the remainder of the river.

The Wabash River, Ind., is one in which the need for protection is most evident; and this stream could be divided at Vincennes and two other points selected with reference to their economic interest in shell-ing and with regard to an equitable division of the river system.

It might seem that an ideal method of rotation would be based upon the division of a system into six portions, only one of which should be worked in any one year; a new portion would be opened each year, while each territory would enjoy a rest period of five years between successive "open" years for that particular territory. It will be evident that such a scheme, however correct in theory, would be entirely impracticable. The plan of keeping certain regions closed for periods of years while other regions are worked continuously during a corresponding period of years may have some imperfections, but it is probably the best that can be worked out without practically suspending the industry. Undoubtedly the plan will work most efficiently if a proper discretion is used in its application.

#### PROCEDURE FOR ESTABLISHING CLOSED REGIONS.

The law should plainly stipulate and establish the principle of the closure of the rivers by regions or sections, but the determination of which specific sections are to be closed should be left for determination after investigation by properly qualified authorities.

A comparatively simple plan may be suggested under which the most careful consideration could be given to the local conditions involved as well as to the rights of the State as a whole. The legislature could authorize and instruct the proper State authorities, as the State fish commission, to give due consideration and study to the needs of the mussel industry and determine what portions of the streams of the State should be closed to the mussel fishery for a period of years. It could be further provided that, after the preliminary determination of plans for closure, due advertisement should be made in all regions affected and opportunity given for public hearings in such regions, after which the commission should submit its final recommendations to the governor of the State, who should then issue a proclamation ordering the entire interruption of a mussel fishery in the regions selected for closure. The original legislative act should provide that the proclamation so made should have the full effect of law, and should specify the penalties that

would be incurred by violations. It is desirable also that the governor, upon recommendation of the commission, should have power to reopen the closed regions when such action was judged necessary.

#### ENFORCEMENT OF THE LAW.

*Powers of officers.*—It is necessary not only that the duty of enforcement of the law be assigned to specified State officers, but also that they be expressly given the right to inspect and examine mussels or shells in the boats or on land and be empowered to seize mussels or shells held in violation of the law. It is practically impossible to bring about convictions when the opportunity is allowed for destruction of the evidence between the time of detection and the date of trial.

*Permits for special cases.*—In cases where for the purposes of investigations it may be necessary to take small mussels, the State officers charged with the enforcement of the law should have by law the right to issue special permits for the taking of undersized mussels for scientific uses and not for sale.

*Expenses of mussel protection.*—The plans which have been advanced in this report can be carried out with a minimum of expense. The simplicity of the measures would reduce the trouble and cost of inspection to the smallest practicable figure. The assignment of the duties of enforcement to existing State commissions or boards which already have field deputies or wardens obviates the creation of any special offices for execution of the mussel laws.

The question of whether steps should be taken to raise special funds on account of the additional burdens that would be placed upon the present boards is one that would be determined by each State in the light of its own conditions and established customs. It would be very undesirable to create a burdensome tax; to do so would only react against the State, and in the end the tax would be paid by the shellers, who are now making only a meager living, for the local shellers would have to sell in competition with the shellers from States where more liberal conditions prevail.

It is another matter, however, to require a nominal license fee for the privilege of working upon the public mussel beds. Such a fee need not be greater than \$1 or \$2 per season, an amount which could be paid by anyone who wished to shell seriously. Perhaps the idea of a fee of any kind would arouse some antagonism among a certain class of shellers who would enjoy the public stores without return of any kind. Some shellers favor such a license system, and the writer believes that they must all eventually come to see that it works to their own particular advantage in many ways. It tends to create a class of professional shellers, besides providing the necessary means for promoting the abundance of shells.

**SUMMARY OF RECOMMENDED LEGISLATION.**

The legislation recommended for protection of mussel beds, based upon the considerations discussed in the preceding pages, may be summarized as follows:

- I. (a) A single size limit should be fixed as applicable to all shells taken. The minimum size here proposed is 2 inches.
  - (b) The method of measuring the shell should be defined as "in greatest dimension."
  - (c) Possession of undersized shells, whether or not sold or offered for sale, should be illegal.
  - (d) There should be an allowable margin of undersized shells for unintentional violation.
- II. (a) Alternate portions of rivers or river systems should be closed for a period of years, to permit recuperation of mussel beds.
  - (b) The units of division of a river system should be large enough to make enforcement practicable with least expense.
  - (c) The river would conveniently be broken at the few points where there is most community interest involved in the shelling.
  - (d) Approximately five-year periods of closure are recommended, with some discretion allowed to executive officers as to duration of period.
  - (e) Closed regions should be established by proclamation of the governor of the State, after expert examination of the mussel beds and after public hearings on the subject in the communities affected.
- III. (a) Officers charged with enforcement of the law should be empowered to examine mussels or shells in boats or on land and to seize the catch in case of violation, as well as to arrest or cause arrests to be made.
  - (b) Provision should be made for the issue of permits for the taking of mussels of any size or in any region for scientific uses and not for sale.















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