THE FAIRPORT FISHERIES BIOLOGICAL STATION: ITS EQUIPMENT, ORGANIZATION, AND FUNCTIONS

By Robert E. Coker, Ph. D.

Assistant in Charge of Scientific Inquiry, Bureau of Fisheries

(Formerly Director of the Station)

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CONTENTS.

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FUNCTIONS OF THE STATION.

By means of the Fairport fisheries biological station, with personnel of investigators and fish culturists, equipment of laboratories and ponds, and apparatus for scientific and practical work, the Bureau is enabled to inaugurate a more positive effort for the promotion of all fishery interests of the Mississippi Basin. This institution is located upon the Mississippi River, approximately midway between St. Paul and the mouth of the Ohio, 8 miles above Muscatine, Iowa, and 20 miles below Davenport, Iowa, and Rock Island, Ill.

The station, with permanent and temporary employees and associates, engages in the propagation of the pearly mussels; in the cultivation of fishes with experimental and practical ends; in the investigation of problems relating to mussels, to fishes and to fishery conditions; and in biological research. With such scope, this biological station affords a nucleus for many phases of the Bureau's activities for the promotion of fishery interests in interior waters. Its operations are not restricted to the station or to its vicinity, but extend into the distant parts of the basin, as evidenced by the propagation of mussels in Minnesota, Wisconsin, Indiana, and Arkansas, and by the investigation of fishery resources and biological conditions in South Dakota and Tennessee, in Minnesota and Louisiana, and elsewhere.

In brief, the institution is a "fish-cultural experiment station," as well as a center for mussel propagation and for investigations in laboratory and field. The broad field and the varied responsibility do indeed require care against the dissipation of energies, but all activities so far have been coordinated in such a way as to make them mutually helpful and contributory to a common end. It is the function of the station in the first years to lay a secure foundation upon which, as means and agents become available, the service may be continually extended.

ESTABLISHMENT OF THE STATION.

The station was established by act of Congress in 1908; the construction was begun in the late fall of 1909; with temporary equipment, the station began operations in the investigation of mussel problems in June, 1910; the propagation of mussels on a practical scale was entered upon in 1912; the main laboratory building was constructed in 1912

and 1913, and opened for general investigations June 15, 1914. In response to the urgent request of local organizations, there was held on August 4, 1914, a formal celebration of the opening of the laboratory, with exercises of dedication. The attendance of some 5,000 persons, the sympathetic addresses by men of prominence in public life and by scientific men of established repute, and the presentation of a memorial tablet,[a] were regarded as manifestations of an unusual public interest and a gratifying indorsement of the purposes of the Bureau as expressed by this new endeavor.

The equipment and the several phases of activity of the station are briefly described under several heads, but it is not found practical to separate in description the practical and the experimental aspects either of the propagation of mussels or of the fish-cultural operations.

EQUIPMENT OF THE STATION.

BUILDINGS AND PONDS.

The main laboratory building is about 100 by 50 feet, with two complete stories, besides a finished half story and a basement (pl. LXXV). The building includes offices for administration, six laboratory rooms, a museum, a preparation room, a photographic room, a library, storerooms, packing room, eleven dormitory rooms, dining room, kitchen, and bathrooms. The laboratory is provided with steam heat, with filtered water service throughout, and with running river water in the basement. A fume chamber with proper vent is built in the chemical laboratory and there are many sinks, tanks, and aquaria where required. The several floor plans are shown in text figures 1 to 4.

There is also a tank house which is a one-story building, 25 by 50 feet, located near the laboratory (pl. LXXVI). Nearly all of the tanks in the laboratory and tank house are of concrete of light but substantial construction, and painted concrete floors generally are found where water is used.

An important building is the boiler and pump house on the river bank about 700 feet from the laboratory. Other necessary buildings are the boat and net house, the temporary laboratory, the storehouse and carpenter shop, the shell-testing plant, the barn, and five cottages affording living quarters for members of the regular staff (pl. LXXVII, fig. 3 and 5).[b]

Up to the present time there have been constructed 17 earth ponds, the largest of which is a little over an acre in extent. They are intended primarily for rearing fish which constitute a reserve stock for use in mussel propagation and for experiments in the propagation of fish and mussels. The larger units generally have a depth of 6 feet in deepest portion. The total acreage of earth ponds is about 7 acres. There are also 14 small concrete-lined ponds with a combined area of about 4,800 square feet. The concrete-lined ponds are designed for retaining fish or for experimental work relating to the growth of mussels or to other problems as they may arise. (See map following p. 405.)

THE WATER SYSTEMS.

Two systems of water are used. The crude river water of the Mississippi at this place contains the necessary elements for the life of fish and mussels, and after standing in the earth ponds, under the active influence of sunlight and vegetation, it develops a

[a] In memory of J. F. Boepple, founder of the fresh-water pearl button industry and late shell expert of this station, presented by those who have built an important industry upon the foundation so well laid by Mr. Boepple.

[b] Other ponds are in construction (May, 1916.)

FIG. 2.—Fisheries Biological Station. Southwest portion of grounds, with principal buildings. Mississippi River in background. From left to right, temporary laboratory, boat-house, concrete ponds of series C, storage reservoir in foreground, tank house, and main laboratory.

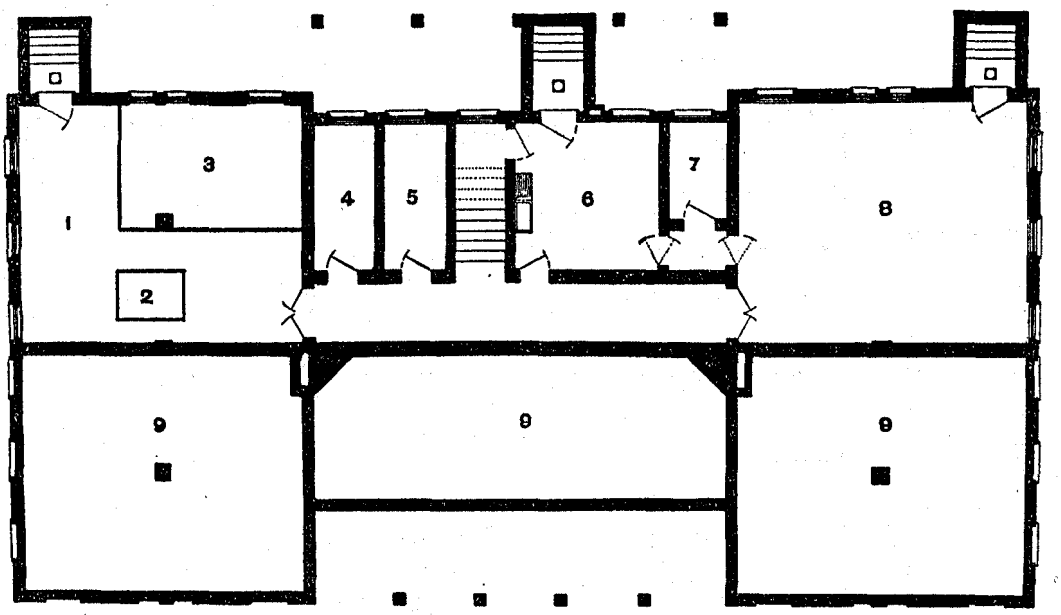


FIG. 1.—Plan of basement of laboratory. 1, Furnace room; 2, steam boiler; 3, coal bin; 4, store room; 5, toilet; 6, kitchen; 7, pantry; 8, dining room; 9, not excavated.

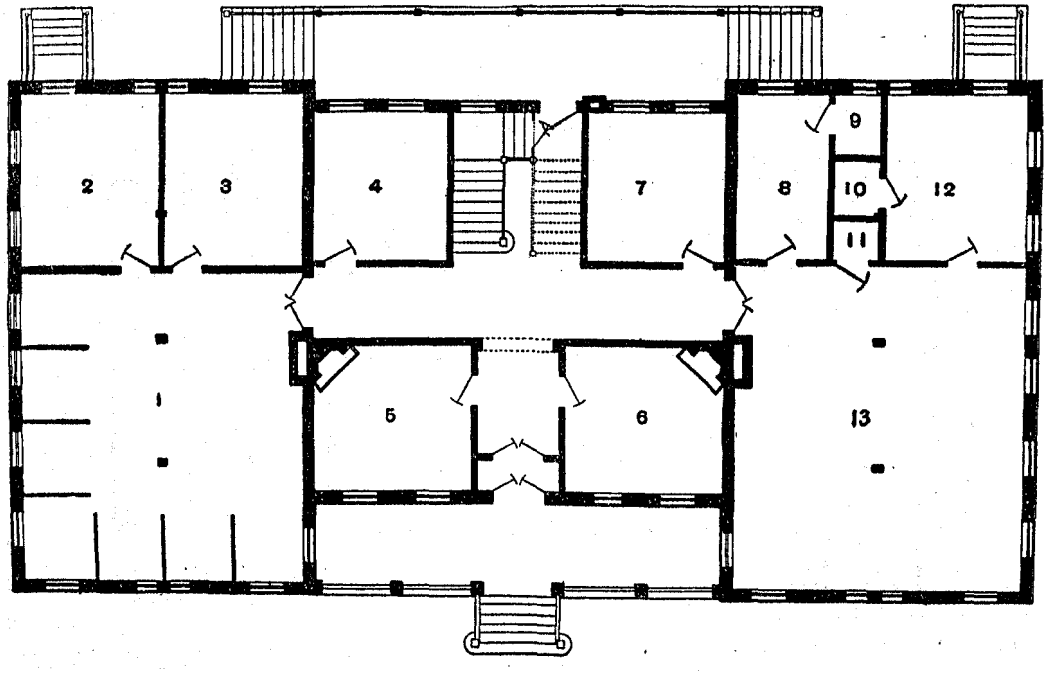


FIG. 2—Plan of main floor of laboratory building. 1, General laboratory; 2, library; 3, chemical laboratory; 4, sterilizing and embedding room; 5, general office; 6, director's office; 7, stock room; 8, packing room; 9, closet for office storage; 10, alcohol closet; 11, janitor's closet; 12, preparation room; 13, museum.

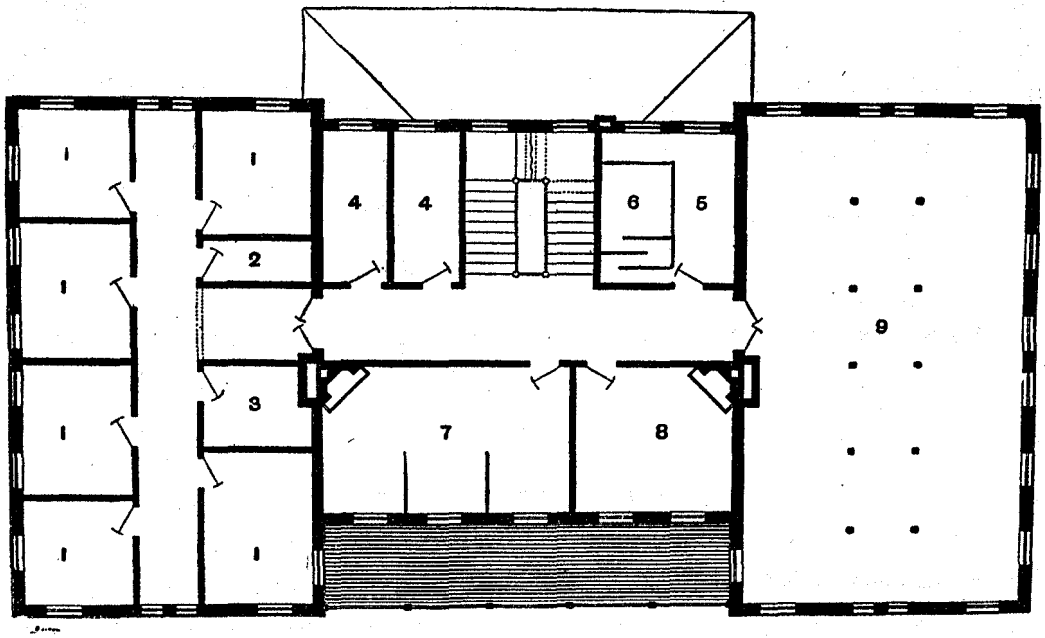


FIG. 3.—Plan of second floor of laboratory building. 1, Six bed chambers; 2, linen closet; 3, janitor's closet; 4, two bathrooms; 5, photographic room; 6, dark room; 7, north laboratory; 8, director's laboratory; 9, west wing.

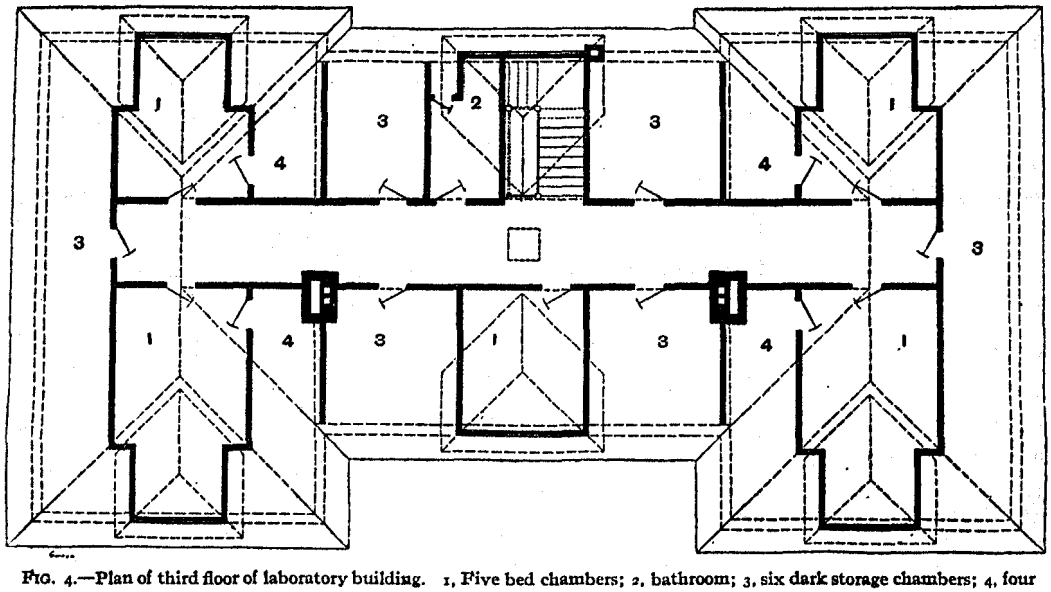


FIG. 4.—Plan of third floor of laboratory building. 1, Five bed chambers; 2, bathroom; 3, six dark storage chambers; 4, four large closets.

rich stock of food to form a peculiarly favorable condition for fish life. For domestic and scientific purposes it is also necessary to have a small supply of clear water, which is obtained by passing river water, after preliminary sedimentation, through a covered gravity sand filter.

The pumping equipment consists of two 60-horsepower return tubular boilers and three steam turbine-driven centrifugal pumps. The two larger pumping units are of 40 and 20 horsepower and have capacities of 1,400 and 800 gallons per minute, respectively; the crude river water is delivered through a main of 14 and 10 inch pipe to the storage reservoir, from which there is a gravity flow to the ponds, to the tank house, to the basement of the laboratory, and to the temporary laboratory, which has been converted into a hatchery (text fig. 5, p. 393).

The storage reservoir for river water has, in approximate terms, an area of nine-tenths of an acre, a depth of 14½ feet at the outlet, and a capacity of 2,000,000 gallons. The reservoir allows opportunity for sedimentation of the coarser particles in the river water and for the development of the elements of fish food. While pumping operations are usually carried on for five to eight hours each week day, the capacity of the reservoir makes it possible to discontinue operations in case of emergency for two or three days.

The smallest pumping unit is a 15-horsepower steam turbine-driven centrifugal pump which delivers filtered water to low and high pressure cisterns, respectively, which are constructed of concrete in the ground and covered (text fig. 6). The low-pressure cistern is of 60,000 gallons capacity and at sufficient elevation to supply all floors of the laboratory building; it is connected also to the tank house and the barn. The high-pressure cistern is of about 4,000 gallons capacity and located about 75 feet higher, so as to supply the cottages and hydrants upon the hillside (text fig. 7). The use of the two cisterns permits substantial economy in pumping operations, since it is not necessary to lift any considerable amount of water higher than is requisite for the intended service. The clear water is obtained by passing a small portion of the water from the storage reservoir through a gravity sand filter of about 20,000 gallons maximum daily capacity, located near the boiler house. The filtered water is not absolutely pure, but has been used with satisfaction.

There must, of course, be complete systems of pipe lines for water, sewers, and drains, and these comprise in all about 3 miles of underground piping (text fig. 4, 5, 6 and 7). The water-pipe lines are principally of cast-iron, well asphalted within and without, with bevel joints and the sections drawn together by bolts. Some threaded pipe is used, but the asphalted cast-iron has been most satisfactory. To prevent freezing, the water lines are laid with a minimum of 4 or 5 feet of cover, according to location. The size of water pipes varies from 2 to 14 inches; that of sewers and drains from 4 to 15 inches. A feature of the pipe lines is the provision of emergency connections. It is possible to cut out the reservoir and to pump directly into all units ordinarily supplied from the reservoir (text fig. 5). Similarly, it is possible to pump directly into all buildings and hydrants supplied from the clear-water cisterns (text fig. 6). The former connection is accomplished by the insertion of proper valves at a junction point just south of the railway, and the latter by a short emergency line on the hillside. An explanation of the emergency connection on the reservoir line will be of interest.

It will be noted from the plan of the river water system, as shown in text figure 5, that the 10-inch "reservoir supply line" (through which water passes from the pumps to

the reservoir) and the 8-inch "pond supply" (through which water returns from the reservoir to the ponds below the railroad) pass through the same culvert beneath the railway tracks, and are therefore parallel and closely approximated for a short distance. A little south of the railroad, a crossover connects the two lines, as may be seen in the foreground of figure 7, plate LXXVIII. There is a valve in the crossover which is ordinarily closed, so that the two lines function quite distinctly. It is possible, however, to open this valve and at the same time to close a valve in the reservoir supply line just above the crossover. If the pumps are then set in operation, the water passes through the 14-inch portion of the reservoir line as far as the crossover, where it turns into the pond supply and its various branches, and will even flow into the lower end of the reservoir unless the valve controlling the normal outlet from the reservoir be closed. Again, if for any reason it becomes necessary to operate both pumps at the same time and thus to force an unusually large volume of water through the reservoir supply line, the friction head may be substantially lowered, by leaving open all valves in connection with the crossover. The discharge through the 14-inch pipe then divides into several streams, passing through (*a*) the 10-inch continuation of the reservoir line, (*b*) the 8-inch pond supply, and (*c*) the 4-inch "A-B branch." In this case the water may be permitted to enter the reservoir at both ends, that is, through the normal outlet as well as through the inlet.

The plans of drains and sewers are shown in text figures 7 and 8. All sewers from buildings north of the railroad and the drains from the reservoirs, cisterns, and upper tiers of ponds, converge into a main 12-inch line, which discharges into a storm channel in the eastern part of the grounds. Through this storm channel the waste water passes into the river some distance below the intake for the pumps.

OTHER EQUIPMENT.

At the present time the station owns two launches, one of which is kept on Lake Pepin, Minn., at a considerable distance from the station (pl. LXXIX, fig. 11), the other being regularly used at Fairport. There are also three small power flatboats employed in investigations and in fishing operations and a number of small rowboats both at the station and in the field.

The original temporary laboratory has been equipped with a battery of hatching jars which may be used for experimental purposes or for practical hatching operations, as opportunities and necessities arise.

It is unnecessary in this place to mention in detail the scientific apparatus such as is ordinarily found in a biological laboratory, or to refer to the various field and mechanical tools that are necessary for the maintenance of an institution of this size located at a distance from an important town.

Mention should be made, however, of the fact that the station has a complete outfit of simple button-making machinery of the old type, by means of which commercial tests of shells can be made by cutting and finishing buttons or novelties. The machinery is that which was formerly used by the late J. F. Boepple, who founded the freshwater pearl button industry. The shell-testing shop is the small building seen at the extreme left of figure 3 (pl. LXXVII), being designated on the map as the temporary pump house.

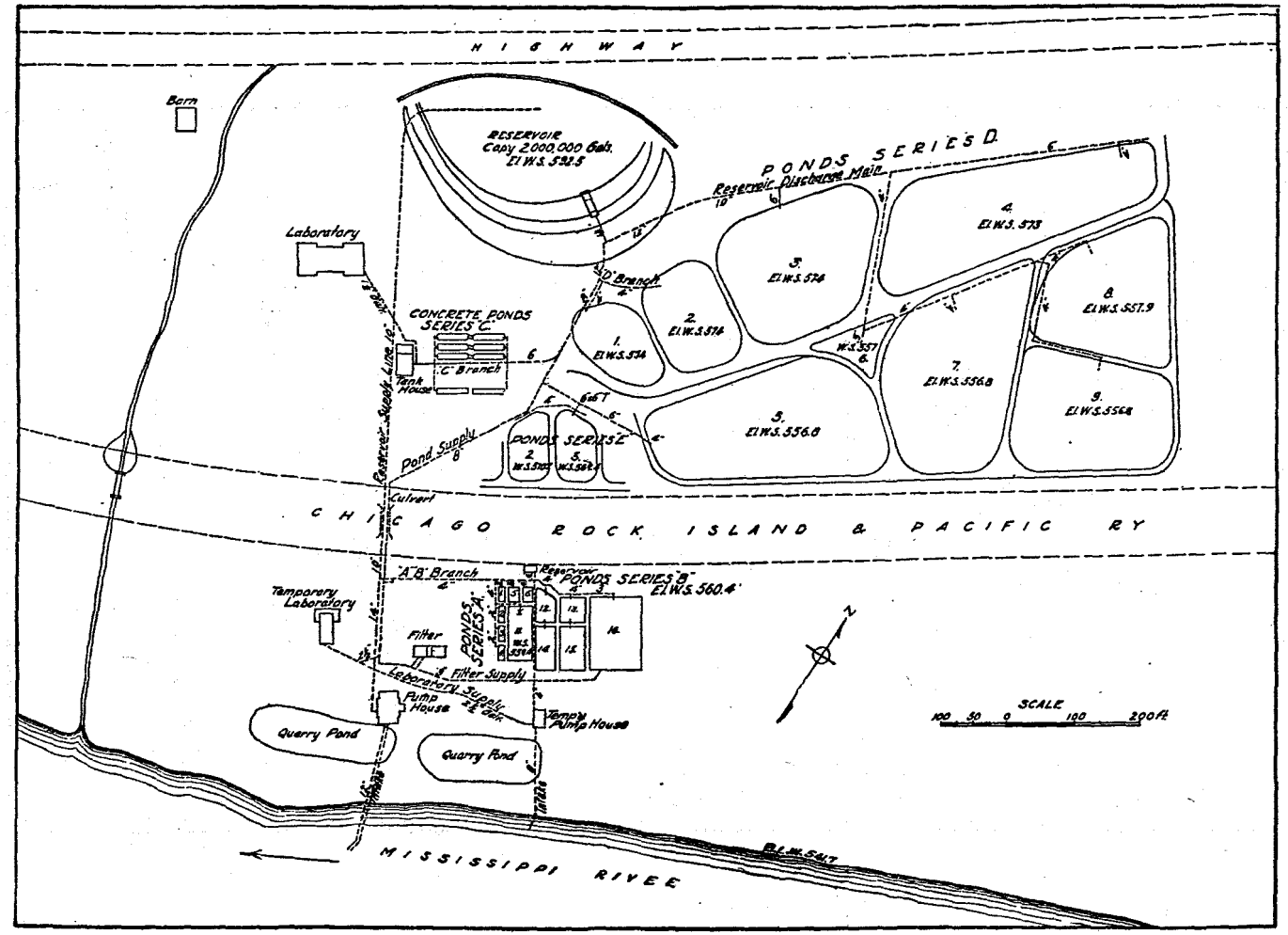


FIG. 5.—Plan of river water system, Fairport station.

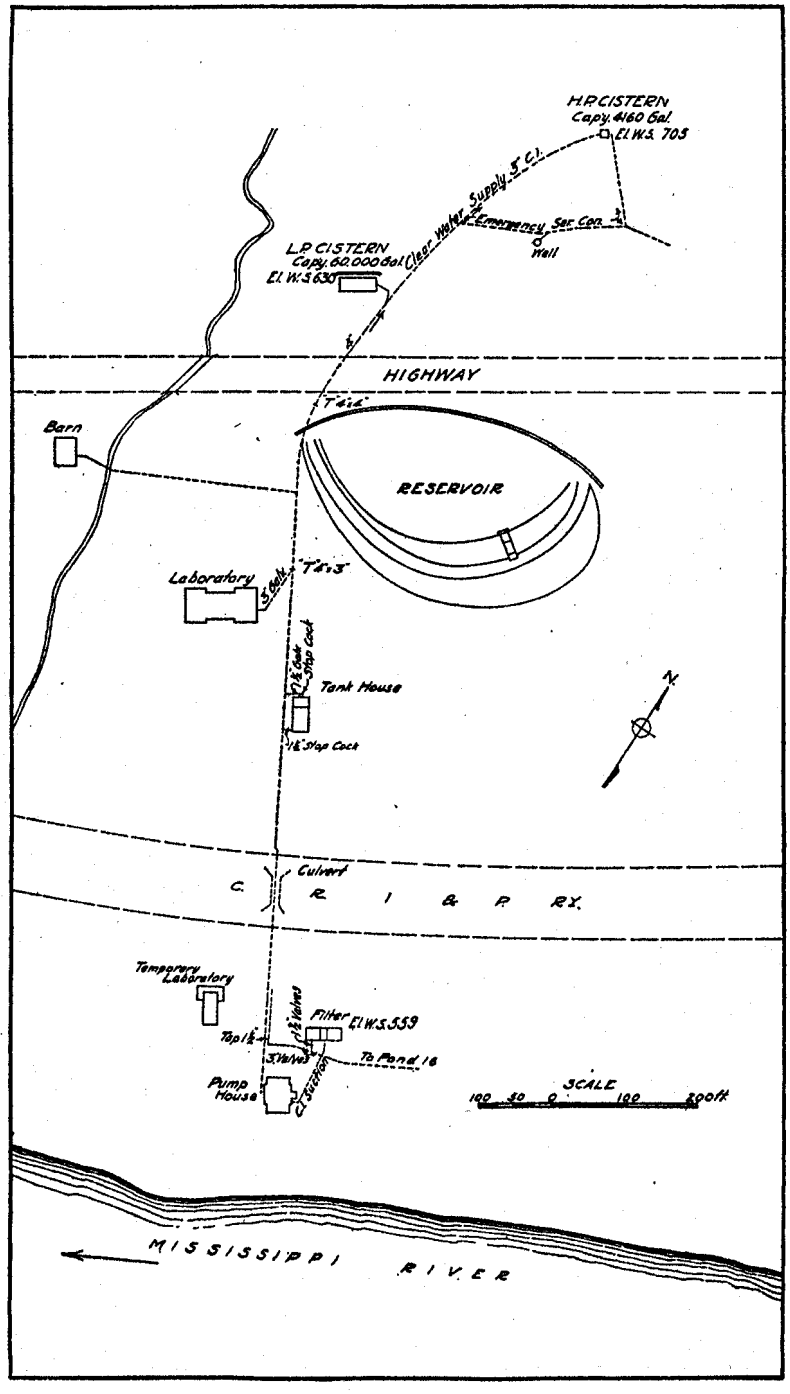


FIG. 6.—Plan of clear-water supply, Fairport station. (See also fig. 7.)

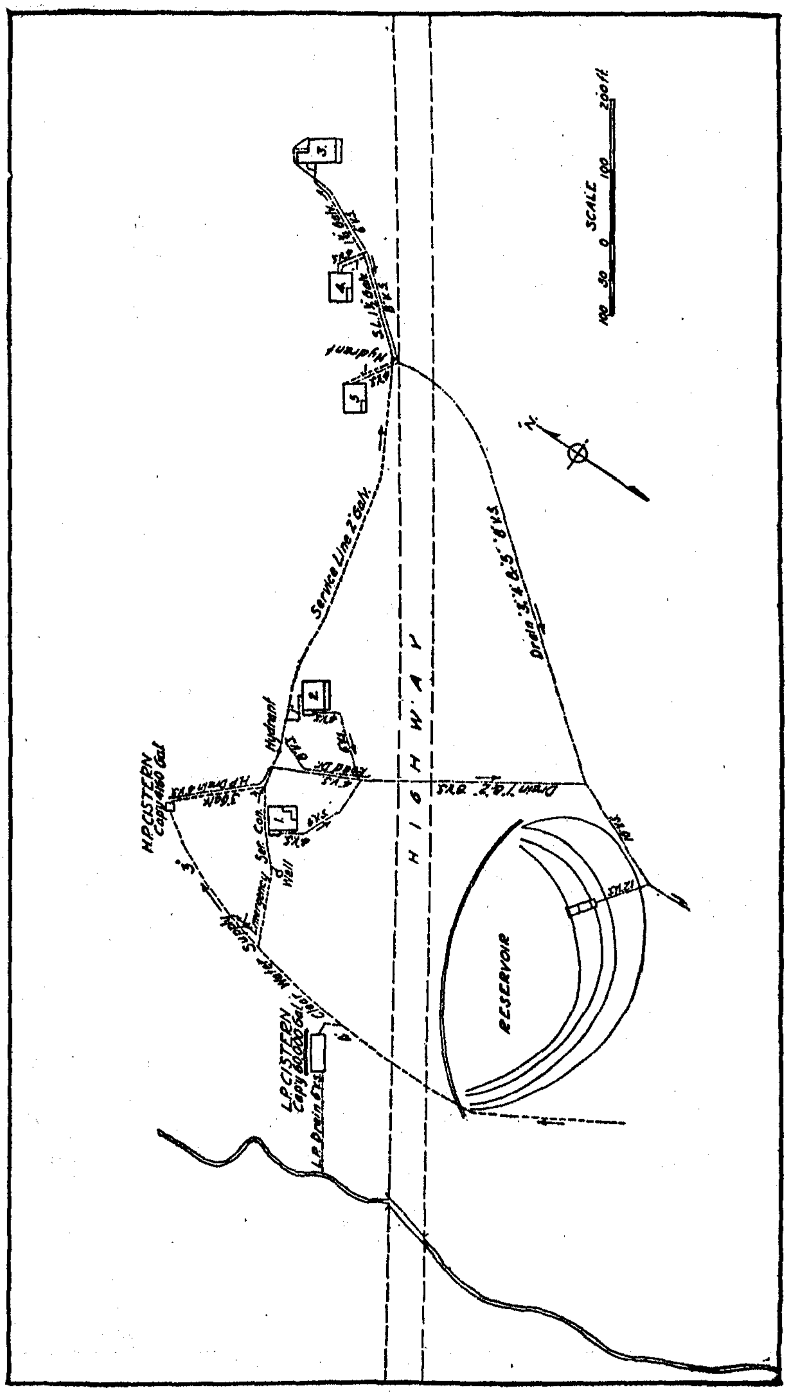


FIG. 7.—Plan of clear-water service and upper portion of sewage system, Fairport station. (See also fig. 6 and 8.)

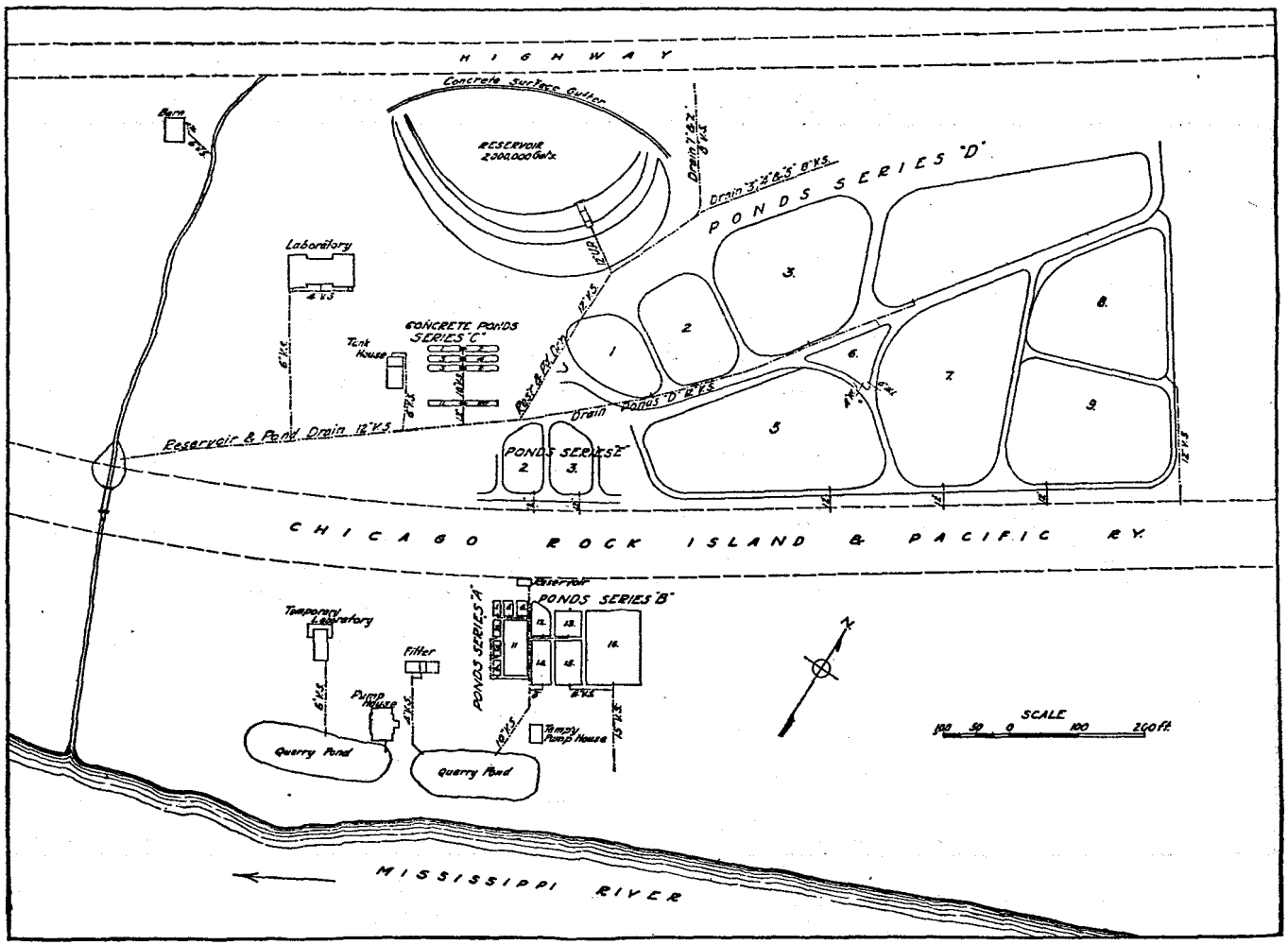


FIG. 8.—Plan of drains and sewers, Fairport station. Practically all sewage is conducted into the river below the intake of the pumps. (See also fig. 7.)

PERSONNEL.

The personnel consists of the director, superintendent of fish culture, four scientific assistants, including two associated with the Homer station, a shell expert, a foreman, two laborers, an engineer, and two firemen. The work of the station is not carried out by these men alone; in the propagation of mussels, which is distributed over a wide territory, it is necessary to engage temporary foremen who, as the heads of local parties, assume no light measure of responsibility. In a later place reference is more appropriately made to the associated investigators who must contribute so largely to the ultimate usefulness of the institution.

GROUNDS OF THE STATION.

The grounds of the station comprise 60 acres and will afford opportunity for subsequent expansion with the construction of additional ponds. Being intersected by the Rock Island double-track railway, and by the county highway, the grounds are divided into three portions which happen to be somewhat distinct in character. (See map following p. 405.)

The lower or southern grounds between the railway and the river afford convenient locations for pumping station, boathouse, shops, and ponds, series A (concrete) and B (earth). (Pl. LXXVII, fig. 3.) The lowest parts of the lower grounds are only slightly flooded by the highest stages of the river, but the pond embankments and the floors of all buildings are above the highest recorded flood stage—that of 1892. Technically, this level is 560 feet, referred to the Memphis datum, while "low" water is 541.689 feet. The highest stage attained since the establishment of the station is 555.4, in 1912, the lowest being about 1½ feet below "low."

The main grounds north of the railway and south of the highway comprise over 30 acres of original meadow and bottoms, mostly suited for ponds. There is a generally moderate slope rising more abruptly to the highway. This region affords excellent sites for the chief buildings, laboratory and tank house, for the storage reservoir (water surface 592.5 feet), and the principal ponds (pl. LXXVI, fig. 2; pl. LXXVII, fig. 4). A small portion, known as the western grounds, is cut off by a natural drain channel, or storm gulley, and is occupied by the barn lot and a field that is not at present utilized, except as pasturage for the station horses.

Above the highway is a beautiful hillside, somewhat terraced naturally and covered by an original grove of walnut and oak (pl. LXXVII, fig. 5). While the cottages are conveniently and attractively located upon the principal terraces, yet practically nothing has been done to mar the naturally beautiful features of the grove. Since the hill ascends rather quickly to an elevation nearly 200 feet above the river, it has been easy to find favorable spots where the high and low pressure cisterns could be constructed at a moderate cost and under ground, while still at sufficient heights to give the desired pressures. The water surface elevations of these cisterns are 630 and 705 feet, respectively, or at heights of 69.5 and 144.5 feet above the floor of the pumping station.

It will be manifest that the grounds as a whole possess most favorable features in the way of natural drainage, ample space for the construction of ponds, and natural and easy grades for the construction of reservoirs, cisterns, and pipe lines for gravity flow

to the buildings and fish-cultural ponds. It has previously been shown how, in the location of reservoir and low and high pressure cisterns, advantage has been taken of the grades to obviate the pumping of any water higher than is necessary for the desired head and thus to provide for minimizing the perpetual cost of operation.

A word should be said as to the unusual natural beauty of the location. The particularly graceful outline of the hillside gives an effective background for the main building as viewed from the river or the railway, while its heights offer vantage points for the survey of the entire station. In the architectural and engineering features of the station proper, consideration has been given to simplification and to harmonizing of design with reference to the natural endowment. Much of the attractiveness of the station and much of the congeniality of the laboratory for persevering and enthusiastic labors is fairly attributed to the inspiriting influence of the appropriate natural surroundings.

BIOLOGICAL ENVIRONMENT.

In fisheries or in biology, studies in a laboratory can only be supplemental to those based upon outdoor nature. A true biological station must be larger out of doors than indoors. While, therefore, a full report could properly be written upon the subject of the environment, it is beside our intention in this place to offer more than the mention of some general features of the surroundings which will suggest the nature of the habitats available for study.

It is manifest that the assembly of fish-cultural ponds, supplied originally with water from the Mississippi but permitted to develop essentially pond conditions, stocked with abundant aquatic vegetation and rich in entomostraca, insect adults and larvæ, together with the customary variety of smaller animal forms that thrive on the bottom, amidst the vegetation or in free-swimming condition, offer favorable opportunities for biological and physical studies bearing upon problems of fish food, as well as for investigations of more particular scientific interest.

The river with its willow-lined shores, its variety of sandy bars, gravel and mud bottoms, deeper channels, and quiet eddies below the wing dams, presents many favorable conditions for investigations where collecting may be done by hand, by dredge, by nets, or by seines. Fishes of many species, turtles, mussels, *Necturus*, etc., are not only near at hand, but are taken daily in course of the routine collecting of the station.

Just across the river are the islands and lowlands of Illinois, where distinctive conditions are found amid the intricate slues and in the ordinarily isolated overflow ponds that form the favored breeding grounds of some species of important fishes.

Botanists find a rare interest in certain striking habitats within a couple of miles of the laboratory, such as Wyoming Hill, Wild Cats' Den, and, on the Illinois side, "Turtle Slide" and "The Grottoes." Especially The Grottoes and Wild Cats' Den are of a character unique for the geographic region, displaying striking plant associations and presenting opportunities for examination of trees and plants of great rarity for the territory, some of which are growing in luxuriant natural abundance.

At some distance from the station, and yet reached by a day's journey by steamboat, by launch, or by rail, is the newly formed Lake Cooper above the dam at Keokuk and Hamilton. Here, as pointed out in a previous report,[a] are unexampled opportunities

[a] Coker, Robert E.; Water-power development in relation to fish and mussels of the Mississippi. U. S. Bureau of Fisheries, document 805. 1913.

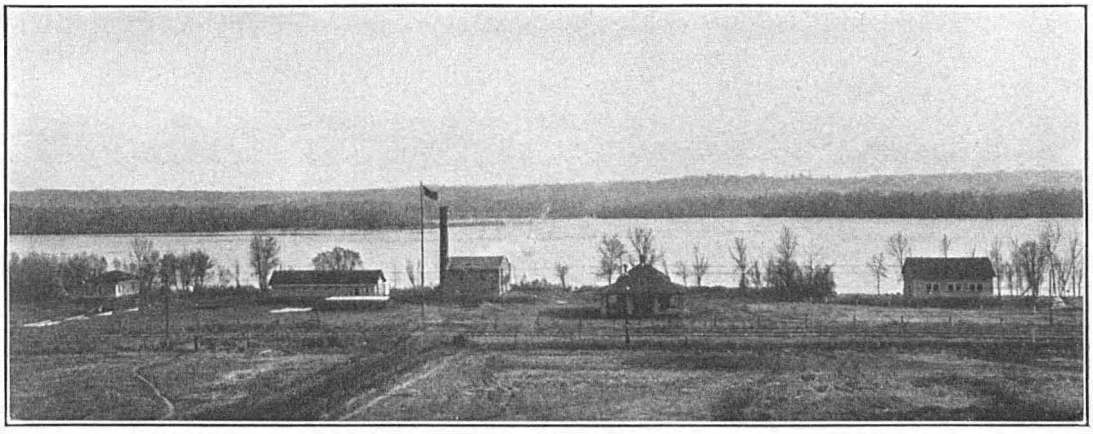


FIG. 3.—From left to right, concrete ponds of series A, shell-testing shop, storehouse and carpenter shop, concrete filter bed, flagstaff (old position), boiler house, temporary laboratory, boathouse.

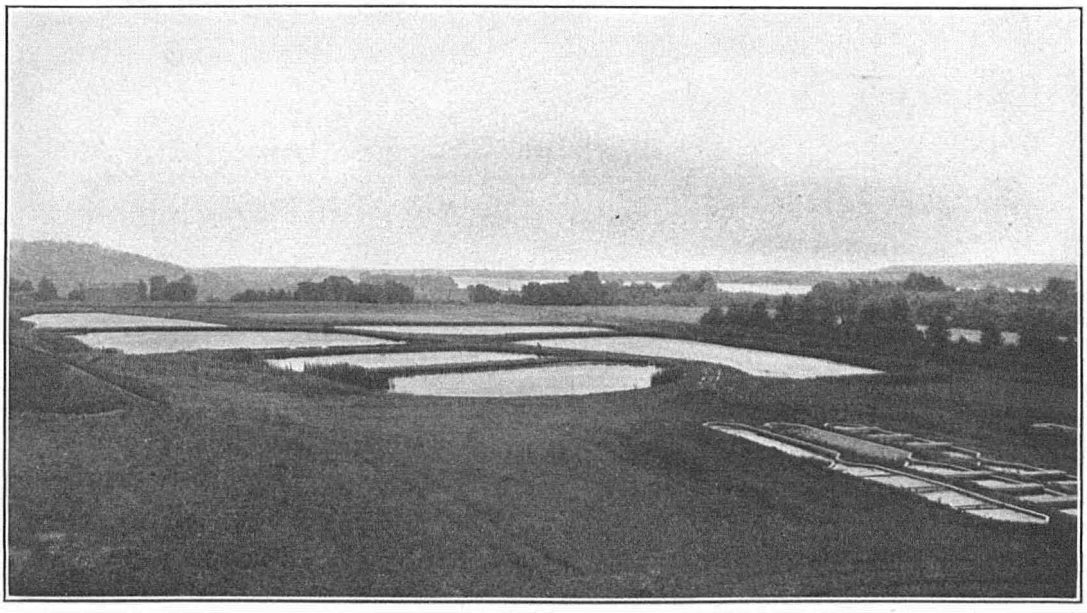


FIG. 4.—Ponds, series D, concrete ponds, series C, and southeast portion of grounds. The largest pond is a little more than an acre in extent. (See also fig. 13.)

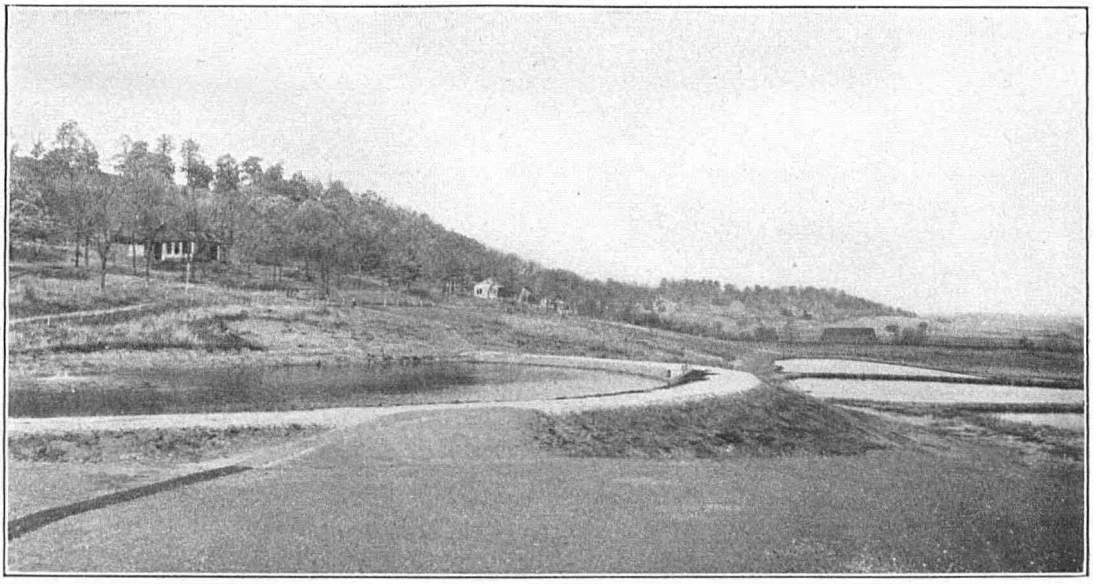


FIG. 5.—On hillside, director's cottage, and in the distance cottage of foreman, scientific assistant, and superintendent. In foreground, reservoir and ponds, series D.

for the study of the development of lake conditions and of the effect of such conditions upon the abundance of commercial fishes. As far as its means permit, the Bureau has already availed itself of these advantages for studies of the movement of fishes and of the effect of the new conditions upon the supply of fish food and the development of fishery resources. A good deal of valuable data has already been secured.

The favorable features of location and environment which have been described under the heads of "Grounds" and "Biological environment" are some of those which dictated the establishment of the station at Fairport.

MUSSEL PROPAGATION, BY EXPERIMENT AND PRACTICE.

ORGANIZATION AND GENERAL PLAN.

In the practical propagation of mussels the Fairport station serves as headquarters for field operations conducted throughout the Mississippi Basin, including the Mississippi River and its various tributaries. There may be in the field at one time from two to six field parties operating near the station or at distances of several hundred miles, and all parties are organized under the superintendent of fish culture.

While the available personnel and means do not permit of covering the extensive field, the present endeavor is to restrict the operations to certain localities favorable for the work and needing of replenishment, and to distribute these localities as widely as practicable through the territory. Hence operations are now conducted in Lake Pepin of Minnesota and Wisconsin, on the Mississippi at Fairport, Iowa, on the Wabash in Indiana, and on the White and Black Rivers of Arkansas.

Each field party is under the direction of a competent head, who may be a permanent or temporary employee, sent out from the Fairport station or from the central office in Washington to work under the direction of the Fairport station. The crews employed in the seining of fishes, inoculating them with glochidia, and liberating them again in the river are made up of local laborers or fishermen temporarily employed.

There is no definite outlay of apparatus required. The chief of the party is provided with a compound microscope or a dissecting microscope, an ordinary Coddington magnifier, the usual dissecting instruments, and a field equipment which may consist of seines, fyke nets, tubs, tanks, buckets, etc. A Government-owned launch and rowboats may be used or launch and rowboats may be employed in the region where the operations are conducted. It is generally convenient to use flat-bottom rowboats of small size, 16 to 24 feet in length, but a launch is also practically necessary in order that more rapid movements can be made from place to place, thus extending the sphere of operations possible for a day's work. In some cases the field parties can find accommodation in towns conveniently situated, but in other cases a house-boat must be rented in order that the fishing party may have a place in which to sleep and board.

The methods of propagation are based upon a peculiar feature of the normal course of development of fresh-water mussels. The very young fresh-water mussels, with rare exception, when first liberated from the incubation pouches of the parent, must become parasitic upon fish in order to pass through the next stage of their existence. To this end, if the chance offers after liberation, the young mussels, or glochidia, as they are called in this stage, attach themselves to the gills, fins, or scales of a fish. The mussels of economic importance attach themselves almost exclusively to the gills. In attaching or biting on the fish a very slight wound seems to be caused, which begins at once to

heal over; but in the process of mending the glochidium is overgrown and thus inclosed within the tissues of the fish. The mussel is now actually an internal parasite, in which condition it remains for a period of two weeks, more or less. It is thus conveyed wherever the fish goes, until, when the proper stage of development is reached, it frees itself from the host and falls to the bottom; if through favorable fortune it finds suitable lodgment, it continues its growth to form an adult mussel.[a]

The glochidia are so small that the infection, if not excessive, has no apparent injurious effect upon the fish that serves as host. Investigations by the station have shown that mussels do not attach to fish indiscriminately, but that for each species of mussel there is a limited number of species of fish which may serve as host. Particular instances are mentioned on a later page.

The task of propagation is to bring together suitable fish and the glochidia of mussels. Careful studies of natural and artificial infections show that a moderate sized fish may successfully carry in parasitism from 1,000 to 2,000 of the microscopic glochidia, but that under the chance operation of nature few of the glochidia find a lodgment upon the proper fish or upon any fish.

During the last fiscal year, in round numbers, 344,000,000 glochidia were liberated in parasitic condition, 208,000 fish being employed in the operations. A considerable proportion of these glochidia undoubtedly fall upon unfavorable ground or from other causes fail of reaching maturity. However, it is the large number which can be infected and liberated at small expense that justifies a confidence in the accomplishment of commensurate benefits. The average cost per 1,000 glochidia artificially infected in the fiscal year 1915 was 2.7 cents, inclusive of overhead expenses.

METHODS OF PROPAGATION.

The operation of infecting the fish with glochidia is a very simple one, though the methods may vary considerably with each party. Essentially the method is as follows:

(1) The first step is to secure a number of gravid mussels in order to obtain a supply of glochidia. Generally this can be accomplished by visiting the beds where mussel fishermen are engaged in work, looking over the catch, and picking out the desired number of gravid females, for which a small sum may be paid.

(2) These mussels are then opened, the marsupial passages are cut out, placed in a pan of water, where they may be opened with scissors or scalpel and the glochidia squeezed out into the water. The glochidia are taken up with a suitable pipette and placed in a small container, such as a glass or can. Usually this operation is delayed until the fish have been obtained.

(3) It is now necessary to secure as many fish as possible by means of seine or nets, and the species of fish must be appropriate for the species of mussel to be propagated. (See pl. LXXIX fig. 8–10.) After the fish are transferred from the seine to tubs or tanks, and when a suitable number of fish are in the tanks, overcrowding being avoided, a lot of glochidia are thrown into the water. (See pl. LXXIX, fig. 11.) There is no definite rule as to the number of glochidia to be used with any number of fish, but the person in charge is guided by his experience with due regard to the temper-

[a] There are one or two species of mussels which need not attach to fish, but these are of no commercial value. There are a few species which during the period of parasitism increase in size manifold, being true parasites; but the greater number of species are between these two extremes, using the fish for conveyance and protection, but certainly deriving no considerable amount of nourishment.

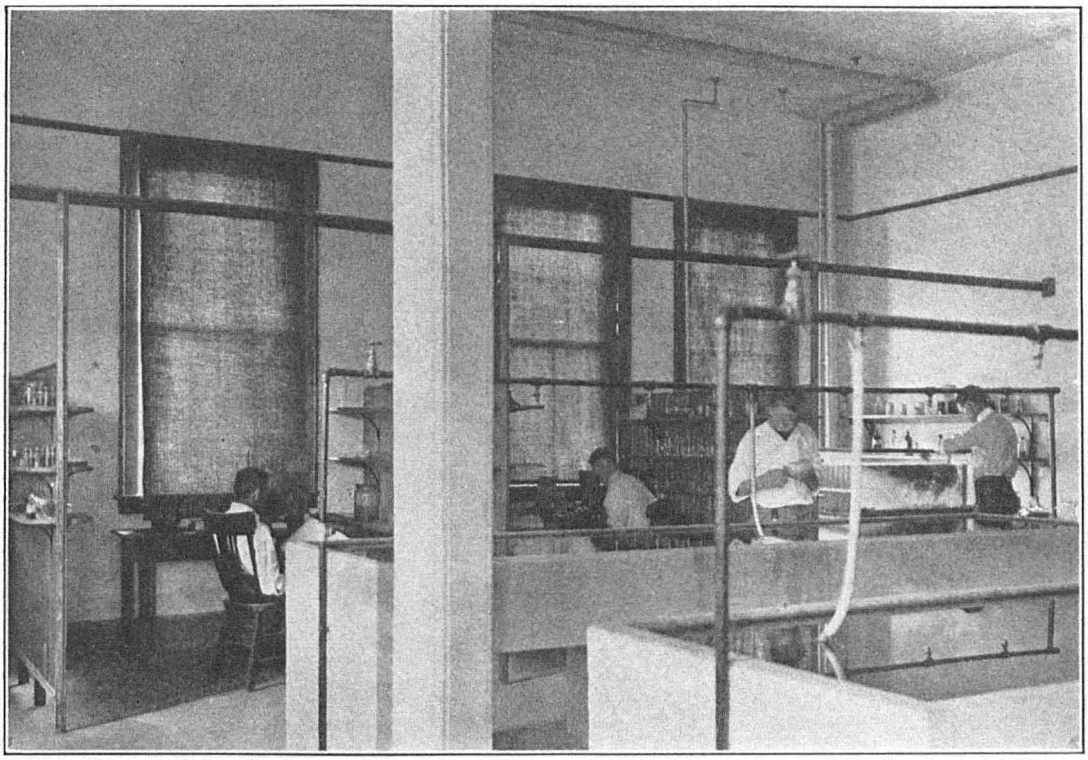


FIG. 6.—Interior of general laboratory, showing alcove arrangement and concrete tank tables.

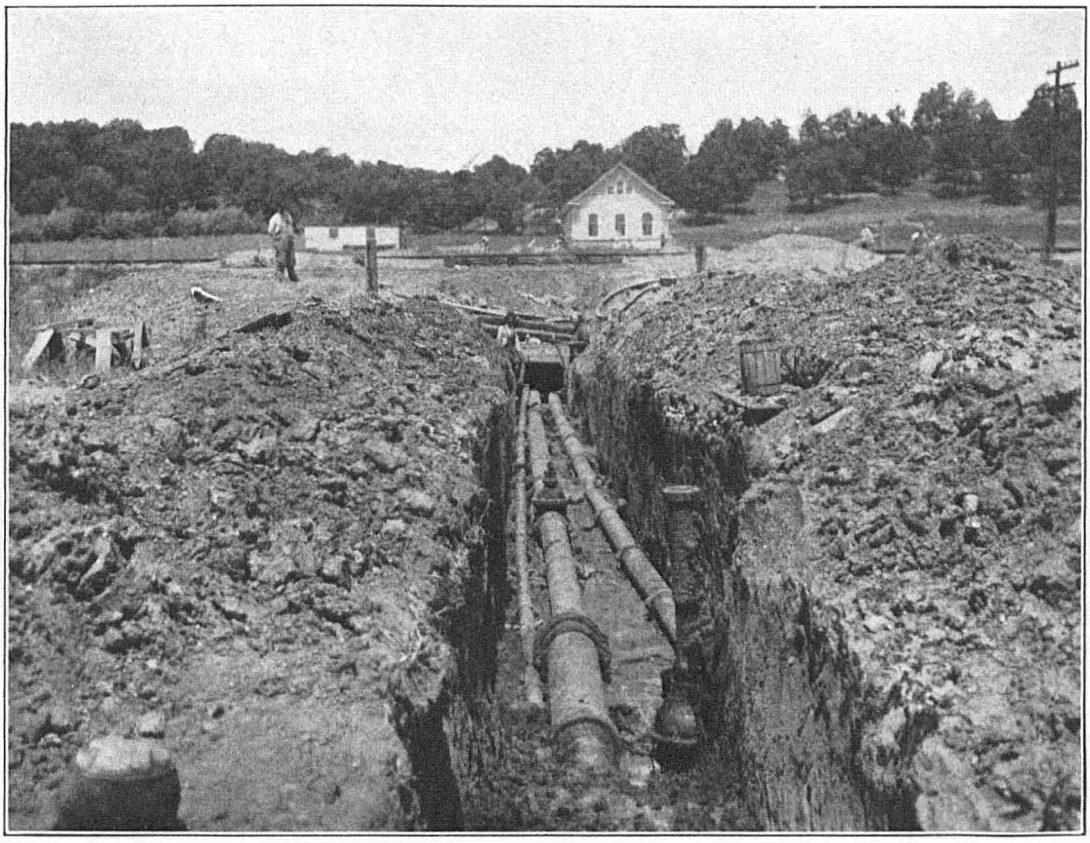


FIG. 7.—Three principal cast-iron pipe lines entering culvert beneath railway tracks. From left to right, the 4-inch clear-water supply, the 14-inch (reducing to 10-inch) reservoir supply, and the return 8-inch pond supply. In the foreground a valve box is seen; the valve controls an emergency "crossover" connection between reservoir supply and pond supply. (See text, p. 392.)

ature of water, the number and size of fish, and the activity of the glochidia. The fish may remain exposed to the glochidia for a period of 5 to 20 minutes. From time to time a specimen of fish is taken by hand, or with a small hand net, and the gills examined to ascertain if a sufficient degree of infection has obtained. When, in the judgment of the operator, the fish show the optimum degree of infection they are ready for liberation.

(4) Using buckets or small nets, the fish are transferred from the tank back into the river or the entire tub may be turned over into the river. This concludes the operation of infection as ordinarily carried on in a practical way.

INVESTIGATIONS RELATING TO PROPAGATION.

A good deal of experimental work is being carried on at the station to determine what species of fish are best suited for certain species of mussels, to ascertain the period of parasitism and the life history of the young mussels after parasitism, and to lead to such improvement of methods as will make the work most productive of practical results.

In addition to the study of special problems of importance, three general lines of investigation have been carried on practically continuously. These are (1) the daily collection of fish from the river for study of the condition of natural infection, (2) experiments in artificial propagation, employing various species of mussels and fish and keeping careful observation of the methods and results, and (3) the study of the habits and distribution of juvenile mussels. The results have been so favorable as to justify the continuance of these studies for a considerable time.

The fishes of the sunfish family, game fishes, such as the bass, crappie, sunfish, etc., are usually used for the mucket (*Lampsilis ligamentina*) and the fat mucket (*Lampsilis luteola*). For a very important mussel, the pimple-back (*Quadrula pustulosa*), the Siluridæ, or catfishes, are found to be best suited. One of the best species of mussel, the "niggerhead" (*Quadrula ebenus*), is known to become parasitic only upon one species of fish, the river herring, *Pomolobus chrysochloris*. This fish is so delicate that it has been impossible to handle it in a practical way, and, therefore, no operations in the propagation of this mussel are yet pursued. Some experiments have been conducted which are promising of success. Examples of the herring found during the breeding season of the "niggerhead" are usually so heavily infected that it may not be necessary to use artificial methods with this mussel, although the abundance of the fish should be promoted. The matter is now under investigation. A very valuable species of mussel, the yellow sand-shell (*Lampsilis anodontoides*), is parasitic upon the several species of gar.

Other investigations are now being conducted with reference to the possibility of rearing young mussels after parasitism in ponds or in floating crates, and the preliminary results are as encouraging as could be expected. It is interesting to note that from glochidia of commercial species of mussels artificially infected upon fish at this station, young mussels have been reared within a period of two years to such a size that it was possible to cut and finish buttons from the shells (pl. LXXX). Some of these were reared in floating crates and some in one of the larger earth ponds. They are not only the first mussels to be reared to such a size from artificial infection, but they are the first commercial forms known to have grown in ponds. The experiments have not yet

advanced to a stage where any definite statements can be made as to the practicability of rearing fresh-water mussels in waters other than the natural mussel streams.

Two years ago an interesting discovery was reported by Lefevre and Curtis, when it was found that some glochidia of the squaw-foot mussel (*Strophitus edentulus*) developed into young mussels without becoming parasitic. Howard, in our laboratory, has since extended these observations by showing that the glochidia of that species will also develop by the customary mode of parasitism and by the discovery that another species, a small "floater" (*Anodonta imbecillis*), will develop without parasitism. Neither of these species, the only ones that have ever been made to develop without the use of a fish as host, is of any commercial importance, but it suggests itself as an important investigation that methods should be sought for causing other and useful species to develop without the fish. Whether the problem should prove simple or difficult, it is worthy of the endeavor.

The interesting and very practical discoveries which have been made, as a result of the close association of practical and investigational work, and the direct bearing of the information gained upon the promotion of the natural resources are held to demonstrate the essential wisdom of Congress in providing at the beginning that the propagation of mussels and the investigation of mussels should go "hand in hand."

The most clearly outstanding feature of our work is the absolute dependence of mussel conservation upon fish conservation in the broadest sense. There can not be abundant mussels if there are not abundant fishes. There can not be varied mussel resources if there are not varied resources in fin fishes. Probably no step for the promotion of the mussel fishery would yield greater benefits to that fishery than effective efforts for the conservation of fin fishes.

The interlocking interests of shell fishers and fin fishers is properly a matter of particular interest and worthy of emphasis, although, of course, the conservation of fishes rests upon a far broader basis than any consideration of value derived from the dependence of shell fisheries.

PROPAGATION AND RECLAMATION OF FISH WITH EXPERIMENTAL AND PRACTICAL ENDS.

The pond-cultural operations are planned to be carried out with particular experimental objects. It is hoped by careful observational and experimental methods to contribute to the improvement of methods of cultivation of pond fishes, especially as relates to the rearing of fish to a size suitable for the table. It is held as a most important responsibility of the station to stimulate and to guide the development of fish farming as a more widespread industry. This function as a fish-cultural experiment station should rightly be regarded as second to none, but its full accomplishment will depend upon the future provision of means proportionate to the labors involved and the far-reaching benefits to be gained.

Meantime the propagation of mussels and of fishes is well carried on hand in hand. While it is not feasible now to rear the quantity of fish requisite for the propagation of mussels, it is attempted by means of the experimental operations of pond culture at the station to obtain a reserve stock of young fish of several species which in the fall are infected with mussels and liberated in the river. A threefold purpose is served in the increase both of the fish and of the mussels in the public waters and in the acquisition of experimental data.

FIG. 8.—Seining fish from overflow water for infection with glochidia of mussels. (See text, p. 403.)

FIG. 10.—Seining fish in Lake Pepin for mussel propagation.

FIG. 11.—Transferring the fish to the infection tank. The foreman standing in the boat is pouring the glochidia from a can into the tank. (See text, p. 400.)

FIG. 9.—Sorting the fish for infection with glochidia.

From the account of the operations of mussel propagation it is seen that the supply of fish for use in mussel propagation is obtained chiefly by seining in the public waters. In the spring after the heavy floods there are many overflow ponds near the course of the rivers which are filled with water and fish during the flood and which are left isolated as the water recedes. Under natural conditions these ponds will dry up and the fish will die. In connection with the work of mussel propagation some of the overflow ponds are seined out and such fish as are suitable for infection with mussels are used in that work. These and other fish that are taken are then liberated in the main course of the river; thus a double object is accomplished in the reclamation of fish, which would otherwise be lost, and in the infection with glochidia of mussels. During the past fiscal year 66,645 adult fish were reclaimed in this way. While this reclamation work, as carried on at the Fairport station, is incidental to propagation work, the benefits are of great importance and would in large part justify the entire expense of the field work in propagation. The Bureau also carries on an extensive work in the reclamation of fish which is not connected with this station.

INVESTIGATIONS.[a]

STUDIES OF MUSSELS.

The investigations relating to the natural and artificial propagation of mussels have already been referred to in connection with the work of propagation. Such experiments and observations are those which have received the principal attention of the permanent staff continuously and which have been most productive of results. The systematic study of conditions of natural infection, the careful experimental observation of artificial infections of mussels on various species of fish, the systematic study of glochidia, the investigation of the early or juvenile life history and distribution of juveniles, the rate of growth of mussels, the structure of shell and conditions affecting its abnormalities, the formation of pearls, the chemical and physical properties of mussel shell, the utilization of mussel meats—these are some of the problems which have been engaged upon, and several of which have been reported by the different investigators. As illustrations of the nature of results gained, there may be mentioned the accumulation of observations making easier the identification of mussels in the glochidium stage, the discovery of the particular relations existing between mussels and fishes, there being a restricted group of hosts for each species of mussel, the discovery of an additional case of development without parasitism, the discovery of important enemies of the juvenile mussels, the observation that rate of growth in some important species is more rapid than had ever been supposed, the observation that interruptions of the growth of mussels may cause effective flaws or faults in the structure of the shell, and the demonstration that mussels may directly absorb nutritive substances from solution in the water.

Mention must be made of the investigation of streams and lakes productive of mussels. In some cases the studies have been in the nature primarily of economic reconnoissances, in others more particular attention has been given to the facts and problems of distribution and ecological relations. The Kankakee, the Maumee, the

[a] In so brief a summary of the investigation it will not be necessary or practicable to associate each topic with the name of an investigator. It is, however, desired to mention the names of those whose studies have contributed to the success of the station. Profs. George Lefevre, W. C. Curtis, and Charles B. Wilson, H. Walton Clark, Dr. A. D. Howard, Thaddeus Surber, A. F. Shira, Prof. F. D. Barker, J. F. Boepple, J. B. Southall, Ernest Danglade, E. P. Churchill, F. B. Isely, W. I. Utterback, and the present writer have appeared as authors of published reports emanating from this laboratory. Among others who are now conducting experiments and investigations are Emerson Stringham, H. L. Canfield, Dr. A. S. Pearse, R. H. Linkins (with Prof. H. B. Ward), and Miss Susanne Parsons (with Prof. F. D. Barker).

Cumberland, the Illinois, and the Fox Rivers have been reported upon as well as various streams in Oklahoma, Missouri, Minnesota, and South Dakota, and Caddo Lake in Texas.

Yet other studies have related to the methods and condition of the mussel fishery, and the essential measures of protection and conservation of the resources both in mussels and in fish.

INVESTIGATION OF FISHES, WITH REFERENCE TO HABITS, PROPAGATION, AND ENVIRONMENTAL CONDITIONS.

The operations of fish propagation with experimental ends in view has been alluded to on a previous page. Two fundamental objects are the encouragement of fish farming and the laying of a surer foundation for the intelligent conservation of the public fish resources. Problems which are now receiving especial attention are: The possibilities of promoting the abundance of fish food in artificial ponds; the proper association of species of fish for best results in pond culture; the study of the migrations, habits, and food of fresh-water fishes; the effect of artificial improvements or developments in the course of streams upon the abundance or distribution of fishes; and the propagation and rearing of buffalofish, an important commercial fish that is diminishing in abundance. It is thought that the station is now in a position to direct some effective attention to these significant problems, although its activities under present conditions can not be nearly so broad as the importance and the complexity of the problems would justify.

During the past year buffalofish, from eggs artificially fertilized and hatched in the laboratory, were reared in the ponds of the station under varying conditions. The results at the close of the season were most encouraging as regards the percentage of survival under the least favorable conditions of food supply and crowding and the rate of growth under better conditions. From 180,000 fry planted first in a small new pond and subsequently removed to a new pond of 1 acre extent, barren of vegetation and with only the scant natural food supply in a pond of this kind, about 50,000 fingerling buffalofish were obtained in the fall, having a length from 1 to 6½ inches. Where a small number were placed in a small pond with good growth of vegetation, an average length of more than 6 inches resulted. About 19,000 of the buffalofish were retained for further growth under experimental conditions.

Other experiments are being conducted with such food fishes as the bass, bream, crappie, and catfish. While the progress of these investigations is satisfactory, it is yet too early to announce definite results.

ASSOCIATE OR TEMPORARY INVESTIGATIONS.

From the description of the equipment of the station, it is manifest that the laboratory and the ponds, as well as the natural environment, afford unusual facilities for the investigation of problems of biology. It is the policy of the Bureau to encourage the use of its facilities by competent investigators for the promotion of biological studies. Every step of the endeavors of the Bureau for the promotion of fishery interests shows the essential need of more knowledge than is now possessed. We do not know enough either of the habits and development of economic forms or of the

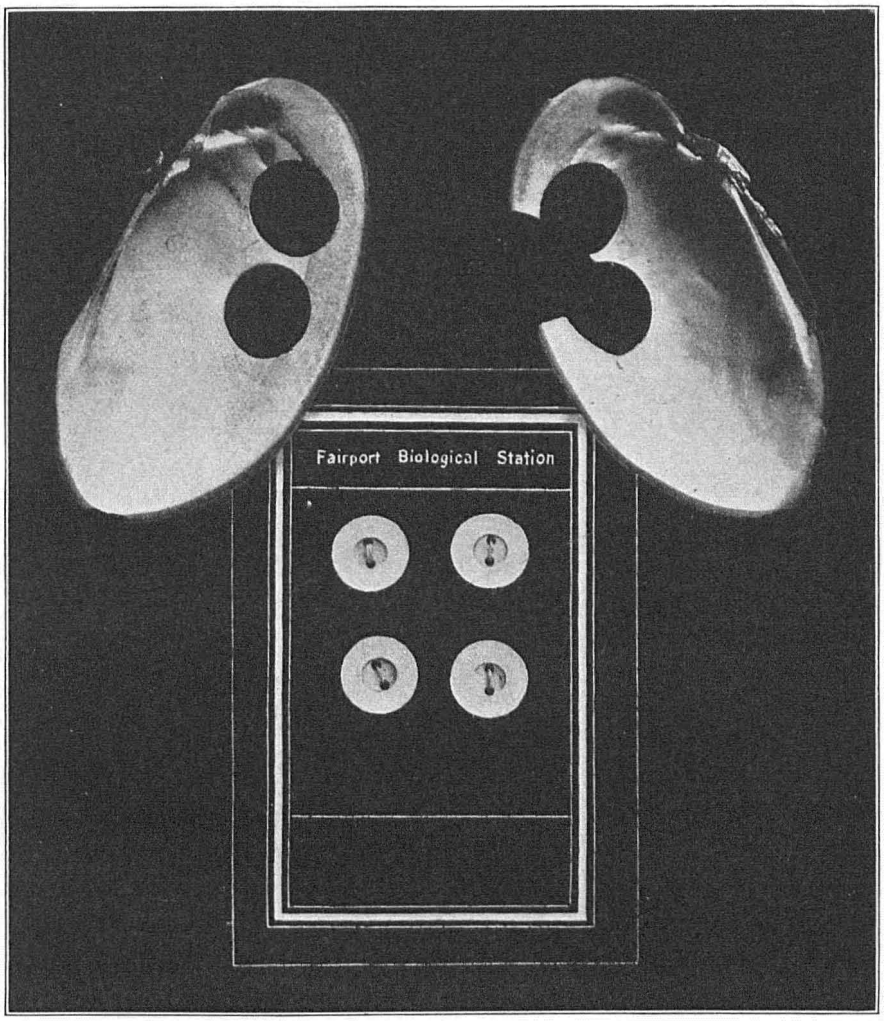


FIG. 12.—Shells of mussels reared in a pond from glochidia artificially infected upon fish. The buttons were cut from the shells within two years from the date of infection. The quality is good, but the shells are yet too thin for commercial uses. (See text, p. 401.)

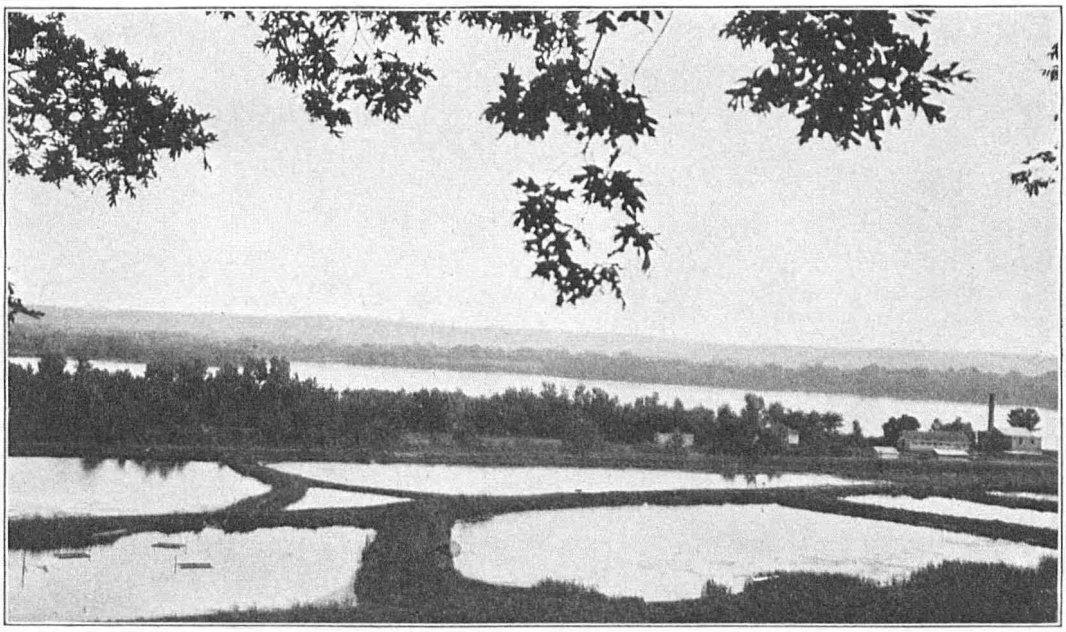
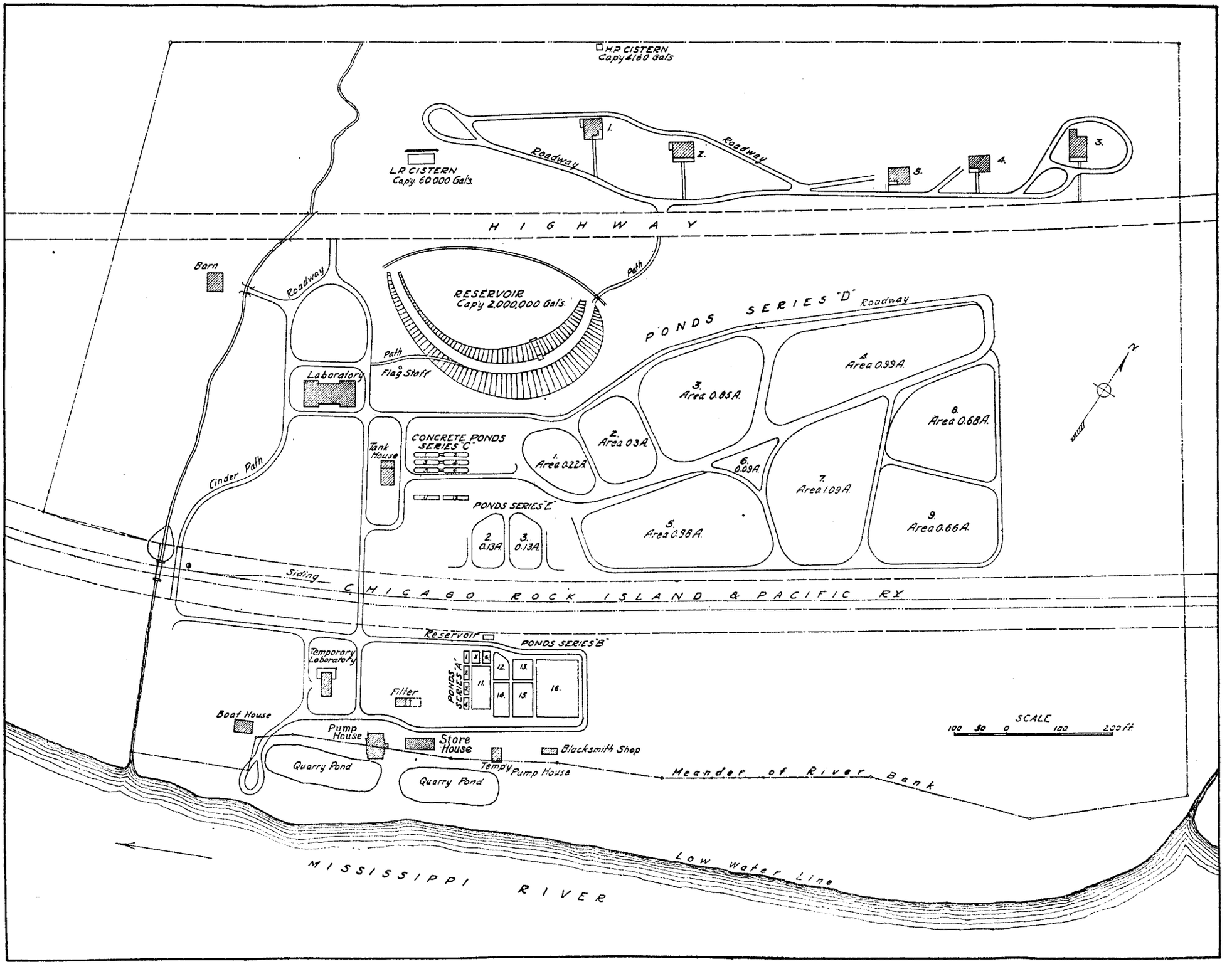


FIG. 13.—Ponds used for experiments in cultivation of fish and mussels. The mussels of figure 12 were reared in the pond in right foreground. Buffalofish are being reared in pond in left background.



Map showing general plan of Fisheries Biological Station, Fairport, Iowa, 1916. The grounds comprise 60 acres, rising from the bank of the river at low water to an elevation of about 170 feet near the high-pressure cistern.

conditions of their existence; and such conditions involve an unlimited variety of elements. Before we can form a proper judgment of the possibilities of fishery development or take any intelligent step for increasing the abundance of fish life we have to know something of the favorable and the unfavorable features of the environment of the fish, something of the enemies, the parasites, the competitors, the food elements, and the minute forms upon which the prey of fish subsist; finally, we are compelled to study the chemical and the physical conditions of the streams or lakes or ponds. It is a fair statement that the possibilities of effective service for the promotion of fisheries are directly proportionate to the growth of knowledge of fresh-water biology, including the environmental conditions.

It is impossible for the Bureau alone to cope with a task thus outlined. Therefore, in pursuance of the custom established since the beginning of the Fish Commission, the Bureau not only manifests its sympathy with the excellent investigations pursued by other institutions but invites to its laboratories for temporary periods the men of technical skill and ability whose services it is not always practicable to employ. Particularly during the summer season, therefore, there are found in the laboratory a number of temporary investigators, whose relation to the Bureau is upon one or another basis. Appointments with stated compensation can be extended to a limited number of skilled scientists who will engage upon problems selected or approved by the Bureau as of immediate importance. The Bureau may direct the course of these studies and the time and manner of reporting. There are other investigators who find in the laboratory the facilities necessary for the prosecution of their studies and who make application for the occupancy of tables. To these, upon the approval of the application, the Bureau is glad to extend its facilities freely, and the applicant enters upon his studies without compensation or reimbursement of expenses, other than the free use of the ordinary facilities. It is perhaps unnecessary to state that the Bureau gives due consideration both to the equipment of the applicant and to the proposed subject of investigation. The relation in such cases is one of mutual benefit; the table occupant receives privileges for which a substantial compensation might be necessary in some institutions, and the Bureau finds its future practical efforts facilitated by the increase of knowledge resulting from studies regarding the local forms or local conditions. The advantages of association and coordination in scientific work are too well known to require emphasis.

Some important phases of the work of the Bureau, including the operations of mussel propagation, owe their origin to studies which were pursued primarily for scientific ends but which were given practical effect through the volunteer or temporary association of university men with the Bureau, involving relatively small demands upon the appropriated funds. The general policy of offering judicious encouragement to biological research was at the beginning the expression of a well-founded faith; at the present time it is based upon the sure demonstration of experience.