SOME FACTORS AFFECTING THE HATCHING OF NORTHERN PIKE EGGS UNDER HATCHERY CONDITIONS

by

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INTRODUCTION

A research project to determine some of the factors affecting the hatching of northern pike eggs under hatchery conditions, and the extent which they might influence such operations was undertaken at Lisbon, North Dakota, during the spring of 1954. The hatchery facilities used were located at the North Dakota State Game and Fish Department hatchery at Lisbon. The research project was conducted from April 12, 1954 to May 10, 1954.

Through reviewing the literature and inquiring of other organizations that work with northern pike, it is evident that very little has been published on the artificial propagation of this fish. Northern pike have been hatched in this manner for a good many years, but few research findings, if any such research has been carried on, have been put into print. Several states, among them North Dakota, Ohio, and Michigan, are carrying on research projects on this subject at the present time.

Since there is so little available information written concerning the propagation of the pike, it was decided that research along this line could be carried on in conjunction with the usual spawn taking and egg hatching at the North Dakota stations.

The northern pike, Esox lucius Linnaeus, is looked upon as an important game fish throughout most of its range due to the fact that it is not particular as to what it eats, thus it can be caught by nearly

all angling methods. Its being widely distributed, fairly easily caught, growing to large sizes, and providing excellent eating all tend to make this fish one of the most sought after of our fresh water game fishes.

To fishery management technicians in several of the northern and central states the pike is an important game species for several reasons. First would be the fact that it is so much sought-after and, therefore, is a popular game fish. A second reason is that the pike is a "good management tool" when stocked in proper places. In cases of over-populations of game or rough species where other control methods are not feasible, the introduction of northern pike has become a useful means in some areas, of slowly controling the undesirable fish and at the same time providing another game species in those waters. A third reason that the pike is so important to management agents is that a quick return is received. These fish not only help to cut down the populations of the other fish present, but also grow rapidly, reaching legal or catchable length in one year on occasions, and certainly within two years. These fish are considerably easier to introduce into northern waters containing a fish population of the same or other species and obtain success in the establishment than are many other species in North Dakota. The last and a very important reason for the artificial propagation of the northern pike is that this fish, like salmon and trout, can be captured on spawning runs, their eggs taken and hatched in hatcheries.

Another fact to be considered is that by hatching pike eggs in hatcheries an improvement upon natural spawning success can be obtained even though hatchery success may be very low. Three separate experiments in Michigan in 1939, 1940, and 1942 indicated that in natural

spawning of pike the mortality was over 99½ percent, and in an experiment there in 1937, the natural mortality was greater than 99 3/4 percent (3, p. 135). Experiments in Ohio in 1954 showed a natural mortality of over 99 3/4 percent too (5, p. 7). Thus, a greater percent of success can be obtained in artificial propagation, even though a larger total number of fish will not be hatched in hatcheries than in the wild.

LIFE HISTORY

Among the most widely used common names of the pike are the following: northern pike, common pike, great northern pike, jack fish, snake, pickerel, jack pike, and pike. The name most accepted and seemingly the best fitted to this fish is northern pike.

The northern pike is naturally found over most of northern North America, extending from Alaska eastward and southward throughout most of Canada, east of the Rocky Mountains. In the United States, this fish was found in the northern states from North Dakota to Ohio and New York. Pike are also native to northern Europe and Asia. This fish has been successfully introduced elsewhere, thus extending its range slightly to the west and south from eastern Montana to Kansas and hence eastward to the Atlantic States.

It has a long head, prominent eyes, and a large mouth and teeth. The mouth terminates in a horny beak-like structure. The entire fish is usually covered with a heavy coating of mucous, much more so than other fresh-water fishes. It has light spots or bars on a dark background, which serves to distinguish it from the muskellunge. (The

muskellunge has dark markings on a lighter background just the opposite from the pike.) The dorsal fin is located far back on the body, just above the anal fin, and contains 14 to 19 rays. There are 14 to 16 branchiostegal rays, and 5 or fewer mandibular pores on the under side of each half of the lower jaw. There are approximately 125 scales in the lateral line. The front and the top of the head are without scales, the cheeks are fully scaled, and the lower half of the opercle is scaleless. The pike grows rapidly and to large size, reaching 50 pounds and 3 to 4 feet in length.

The growth rate of this fish depends upon the productivity of the body of water in which it is found and in the length of the growing season. Throughout its range the average length at the end of the first year would be about 8 inches, and around 14 to 17 inches at the end of two years. In some shallow lakes in southwestern North Dakota pike reached a length of 16 to 18 inches in one year, and were 20 inches long by the end of their second summer. Under normal growing conditions, the northern pike grows considerably in length but little in weight until it reaches 18 to 20 inches. At that length the fish begins to put on more weight and girth in proportion to its length. Pike ordinarily reach sexual maturity in the third year, at an average size of 17 to 23 inches (8, p. 53). Those growing faster may become spawners at two years of age, and yearling fish of 13 to 15 inches have been captured on spawning runs (15, p. 528).

Eggs will range in size from one-twelfth of an inch to about one-third inch, smaller fish and first spawners having the smaller ones, usually. Observations of workers at egg-taking stations in North Dakota

seem to indicate that in certain lakes, eggs appear to run in uniform sizes regardless of the size of the fish. Eggs are measured by volume, and average about 50 to 60 thousand per liquid quart. The total number of eggs per female pike will depend upon the size of the fish (3, p. 133). Small fish, 13 to 15 inches, will have an average of 7,500 eggs (8, p. 53); medium sized fish, 25 to 28 inches, will lay around 50 to 60 thousand; and large pike, 20 to 30 pound fish, will lay between 150 and 200 thousand eggs per individual. Some authors have estimated that these large fish will produce upwards of one-fourth to one-half million eggs (8, p. 53). However, it appears that more recent investigations indicate that 250 thousand would be about a maximum number for most of the huge pike.

The eggs are very adhesive and sink in the water, sticking to vegetation, brush, and other obstacles that they may come into contact with. In contrast, muskellunge eggs are semi-bouyant and non-adhesive. Under natural conditions, eggs normally hatch in 12 to 15 days, depending upon the water temperatures. Northern pike spawn early in the spring, sometimes moving into the spawning areas before the ice breaks up. They begin their spawning activities as soon as the ice goes out, ascending small streams, or using shallows of lakes and even flooded grassy or weedy areas around lakes as long as vegetation is present in the water. The eggs are spawned at random by the females, being fertilized immediately by the males. Eggs attach to the vegetation, where they hatch unattended. Those eggs that do not come into contact with vegetation or other obstacles settle to the bottom and are possibly smothered in

silt or clay, unless the bottom is composed of firm material and wave action can keep them aerated. The young fish ordinarily remain in these areas for the first year, or until the water level forces them out into deeper depths or back into the lake.

The first food of the young pike is made up of small crustaceans, aquatic insects and their larvae, and other small organisms. However, in a few weeks these fish begin to feed on other fish, which make up the greatest part of their food from that time on. Pike do not adhere strictly to other fish, but will eat any animal matter that they can swallow, including turtles, frogs, muskrats, young ducks, mice, and such. They are voracious feeders, requiring enormous supplies of food, and will remain actively feeding all year long.

The northern pike is found in a wide variety of habitats, from extremely large, cold, and deep lakes and streams with a fair current to sluggish streams and shallow, warm ponds. Since the latter are frequently very fertile and contain an abundant supply of food organisms, these fish are best suited to the shallower bodies of water. In them the pike thrives and grows rapidly.

RESULTS OF VARIOUS ORGANIZATIONS

The following results and statements were obtained from the North Dakota Game and Fish Department concerning its methods of pike hatching operations (9, p. 1):

"It has been a common practice during the spawn taking of northern pike to trap the fish during the first part of their spawning run, and if the fish are not in condition for spawning, to hold them in large

cribs constructed of netting material until the water temperatures have gotten to a stage where the fish are ready to spawn. Hatching success from fish that have been held in such a manner as compared to fish taken from the traps and immediately spawned has definitely indicated that the proper way to handle the fish, at least under conditions in North Dakota, would be to take the fish from the traps, take the ripe fish and immediately spawn them when they are removed from the traps, and turn loose the fish that are not ready for spawning at that particular time, rather than to hold them in cribs.

"Experiments carried out with the hatch from eggs taken from one individual indicate that the eggs that come out during the first part of the spawn taking are the eggs from which the better success is gained at the hatchery."

In this respect, it was also suggested that the spawn taker should take only from 30 to 60% of the eggs that come out first, to insure that only ripe eggs were obtained. North Dakota further indicated that efforts should be taken to keep egg-taking operations as clean as possible and not to allow mucous from the fish to drip or mix with the eggs. They stated that the dry method of egg-taking is probably the best.

Finally they stated, "In fish of the size from four to eight pounds at least one male should be used with each female, and it would probably be better if two males were used if they were available at the time. The eggs should not be stirred with the finger. Rather they can be stirred well enough by swirling the eggs in the spawn taking pan; mixing the milt very thoroughly. Experiments carried out with various harmless dyes have proven that the sperm will permeate completely

throughout the mass of eggs by swirling the pans and not using any type of mechanical agitation."

Recent tests in North Dakota indicate that the eggs should be hardened at the egg-taking station for three or four hours before being transported to the hatchery. They may be held in screen trays at the hatchery from 12 to 24 hours with no apparent harm (9, p. 3).

The following results were obtained at the Federal Fish Cultural Station located at Valley City, North Dakota. Batches of eggs from Lake Darling that were hatched at this station had no success. Most of the eggs were moved to the new hatchery at Bald Hill Dam and run in water from the reservoir. The highest percent of hatch received on the eggs from Buffalo Lodge Lake was about one-half of a percent. Eggs taken from Bald Hill Reservoir were hatched at the Valley City hatchery, and success was about 36% on the combined groups. The hatching success ranged both higher and lower on individual groups. These eggs were taken in a similar manner to those hatched experimentally at the Lisbon hatchery. Another group of eggs taken from the Sheyenne River within two miles of the hatchery were hatched at the Federal hatchery. A success of 51% was obtained on this group. This latter group was handled in a similar manner to those from Bald Hill Reservoir (6, p. 1).

Workers at the United States Fish and Wildlife Service Hatchery at Guttenberg, Iowa, experimented with the use of cheesecloth bags as containers for the eggs during the hardening stage. They had considerable success with this method. Other Federal stations have been using wire baskets to hold the eggs during the hardening period with successful results (11, p. 2).

The United States Fish and Wildlife Service Hatchery at Valley City, North Dakota, used well water during most of its hatching operations and had little trouble with the eggs sticking in the jars. However, when they switched to the use of river water, from the Sheyenne River, the eggs began to stick and required much more attention from the workers (6, p. 1).

George Butler, of the Manitoba Department of Mines and Natural Resources, has found that apparently any delays between taking the eggs and placing them in the hatcheries and also exposure to direct sunlight will result in considerable mortality to the eggs (2, p. 2).

Leslie Bennett, of the New London, Minnesota, Federal Hatchery states that in his 15 years of hatchery work, the best percent of hatch that he has obtained on northern pike was 68%, and that that wasn't on the entire hatch (1, p. 1).

The State of Wisconsin has obtained hatching success of 85 to 90% by using the following methods (12, p. 1).

1. Check females in nets to determine if they are ripe so that eggs flow easily.
2. Take the eggs and fertilize a pan of them as quickly as possible, within 3 to 4 minutes after spawn taker begins to strip eggs.
3. Wash sperm from eggs with lake water and transfer eggs to submerged carrying screens as quickly as possible, within 6 minutes. Let them water harden at least 15 minutes.
4. Transport eggs on screens bundled together in an angle iron case submerged in water to the hatchery.

Time - 20 minutes to 6 hours later.

5. Eggs are put up directly in hatching jars. Eggs will stick together but the lumps are just put in the jars.

6. After several days the egg lumps are feathered apart. The eggs then roll very nicely and no longer stick together.

7. A siphon is used to remove any injured or dead eggs.

The following is a report of an experiment carried on by the Michigan Department of Conservation in the spring of 1954 (16, p. 1):

"This spring we collected eight quarts of pike eggs from Lac Vieux Desert, Gogebic County. The fish were taken in fyke nets in shallow, mucky bays at the mouths of inlets on April 27 and 28. The eggs were taken by the dry method, i.e., a moistened pan was used. Since the females ran small in size, eggs from several females were taken in the same enameled pan with milt being added from the males after each female was stripped. No more than one-half quart of eggs was taken per pan. As soon as the eggs had been fertilized they were stirred with the fingers and just enough water added to cover the eggs. They were then set aside from five to fifteen minutes and were then washed and rolled repeatedly until they had hardened. Hardening took place usually from one-half hour to an hour. Pike eggs are notorious for sticking to the pan and each other and these were no exception. Eggs taken April 27 stuck much more than those taken April 28, apparently because of the colder water April 27. The water temperature was 38 on April 27 and 43 on April 28. Eggs were broken up and loosened from the pan by pouring water over them down the side of the pan. Repeated pourings of water usually loosens most of the eggs. Those which continued

to stick to the pan were discarded. As soon as the eggs had become fully rolled or hardened and completely separated from each other they were added to a common collection in an enameled pail.

"The eggs were kept for one week in floating screened trays in a small inlet to the lake. The water temperatures varied between 32½ to 46 degrees. The eggs were carried to this stream in the pails without any jars. After the first week the eggs were carried by truck 600 miles to our Drayton Plains State Fish Hatchery in the southern part of the State. Again the eggs were prevented from jarring by being carried in pails (two quarts per pail) suspended by rubber straps in small boxes. The eggs hatched about ten days later but I am unable to give you the temperature range of the hatchery's water. The hatch was approximately 60% and the fry were strong and healthy. Apparently it did not harm these eggs to be subjected to two periods of colder water temperature. The first period occured in the stream when the temperature dropped to 32 and ice formed on the screen trays. The second cold period occured during transport when the water temperature fell to 34. I believe that pike eggs are not susceptible to extreme cold temperatures but that muskellunge eggs may be since muskellunge eggs handled in the same way were a total loss. I think the pike eggs are acclimated to cold temperatures since the water temperature in pike spawning marshes usually ranges from near freezing to 60 or 70. Muskellunge eggs, however, being laid in deeper waters and in the lake are probably not subjected to any colder temperatures than 39."

A standard procedure for the taking and hatching of the eggs as given by H. S. Davis in his book, Culture and Diseases of Game Fishes

is as follows (7, p. 102):

Take care not to get slime on the eggs.

Strip eggs into a pan and fertilize immediately.

Use fingers to mix thoroughly together.

Allow to stand 2 to 3 minutes, then add fresh water.

Add mucky water and mix thoroughly with the eggs to keep them separate.

In one to 2 minutes wash thoroughly, swirling the pans several times.

Set aside to harden, then place in battery jars.

If eggs stick in the jars, use a feather on them to loosen them up and keep them rolling.

Workers at the Federal Hatchery at New London, Minnesota, found that when malachite green was used on the eggs as a fungus control, the eggs so treated did not stick in the jars, but that the control (untreated) eggs did. The treated eggs also had a hatching success of 20%, whereas those in the control group had a success of but 10%. However, a similar experiment at the Federal Hatchery at Guttenburg, Iowa revealed no difference in the hatching success of the two similarly treated groups (14, p. 30).

Leslie Bennett of Minnesota suggested that yellow clay should be used as a muck for the eggs before they are brought to the hatchery, to insure that the eggs will not stick together. He also said that the eggs should be washed thoroughly out in the field, and that the eggs should be washed several times or placed in moving water to insure this. He advocated stirring the eggs by hand while in the hardening stage

(1, p. 1).

The following substances were suggested to be used on the eggs to keep them from sticking together by various organizations: Clay, cornstarch, and powdered calcium carbonate. Wisconsin intimates that nothing should be used, that the eggs will separate in due time (12, p. 1). Malachite green was suggested to be used as a fungicide, and "Phygon-XL" was suggested for the water supply, to combat unicellular algae (11, p. 1).

Experiments conducted in Ohio in 1954 utilized the following methods of handling the eggs and sperm during fertilization of the eggs:

1. Eggs stripped into moist pan and milt into the eggs.

2. Eggs stripped into a moist pan, milt into water and poured over the eggs.

3. Eggs stripped into $\frac{1}{4}$ inch of water and milt into eggs and stirred.

4. Eggs stripped into $\frac{1}{4}$ inch of water and milt into eggs, not stirred.

5. Eggs stripped into moist pan, milt picked up with a burette containing water and distributed over the eggs.

The hatching success for the five methods was as follows: 1 - 50 percent, 2 - 28.7 percent, 3 - 20 percent, 4 - 46 percent, and 5 - 22 percent. This would indicate that method number 1 was the most successful, closely followed by method number 4 (5, p.5).

KNOWN FACTS ABOUT PIKE HATCHING

From past experience in North Dakota, correspondence with other organizations, and from the little that has been published, the following facts are known about the artificial propagation of northern pike eggs:

The eggs can be stripped from the adult fish, as can the milt or sperm from the male, and can be fertilized on the site. The eggs should be hardened before being placed in battery jars for best success. Usually the eggs stick in the jars during hatching, unless treated with some substance or thoroughly hard. The eggs can be hatched in battery jars. Success of hatching varies greatly but is usually much lower than for other fish that are artificially propagated. Water temperatures apparently affect the eggs to some degree. Water temperatures can be controlled, thus the length of time the eggs take to hatch can be governed. The length of time that the eggs take to hatch is controlled by the water temperatures. Pike embryos sometimes hatch dead and pike fry are as delicate to handle as are the eggs. Fungus attacks the eggs at times, but can be controlled, and usually doesn't attack healthy eggs.

PROCEDURES

REASON FOR AND LOCATION OF THIS RESEARCH PROJECT

Due to the lack of information on the subject of artificial propagation of northern pike, the study was undertaken to experiment with various methods of handling and transporting northern pike eggs. This was attempted in order to discover any weak links that might shed some

light on why the normal hatching success is so low. One of the problems in artificial hatching of these eggs is having an available brood supply near the hatcheries.

Three egg-taking stations were established, two at great distances from the hatchery and one within about 50 miles. Individual stripping crews were placed on duty at each station, using similar methods but changing or varying these methods from time to time. The egg-taking stations were situated at Lake Darling, west of Minot and about 260 air-miles from the hatchery; at Buffalo Lodge Lake, east of Minot about 200 air-miles from the hatchery; and at Bald Hill Reservoir (Lake Ashtabula), about 50 miles from the hatchery. The hatchery used was the state owned hatchery at Lisbon, North Dakota.

EQUIPMENT USED

The following is a list of all equipment used during the spawn-taking, transportation of eggs, and hatching operations of this research project:

Rubber intake hose and screen.

Electric pump.

Gasoline emergency pump.

Lead pipe -- to conduct water.

Metal storage tank.

Gas-burning boiler -- to heat hatchery water.

Fine screen -- at water inlet to troughs.

Battery -- constructed of wood, having a supply trough located above hatching jars and a trough to convey water away below that.

Wooden faucets -- driven into holes in supply trough, which were to furnish water to jars.

Rubber tubing -- about 1½ feet long or less, which were attached to the faucets and led the water into the jars.

Metal cylinders -- into which the rubber tubes were inserted and which rested on the bottoms of the jars by means of small legs, which left space between the cylinder and the bottom of the jar for the water to circulate through. These could be moved somewhat in order to control the angle at which the water came into the jars.

Hatchery or battery jars -- round jars about 2 to 2½ feet tall, with spouts at the top, in which the eggs were hatched. Some were new and made of plastic, the older ones being made of glass. The glass ones had spouts formed at their tops. The plastic ones were made of clear material and had black plastic spouts that screwed into the tops of the jars. The plastic jars were much lighter in weight than were glass jars of the same size.

Large wooden tanks -- placed on the floor of the room about 3 feet high, by 3 feet wide, by 20 feet long. These tanks were used to temper the containers of eggs, to hold the trays and such that the eggs were hardened in, and to dispose of the water once it had gone through the battery.

Hardening trays -- made with wooden sides, 15 inches square by 3 inches high, and having window screen bottoms.

Feathers -- wing feathers of turkeys attached to the ends of small-diameter sticks, about 15 inches long. Used to stir the eggs with while they were in the hatchery jars.

Wire spoon -- made of window screen and attached to the end of a small stick, about 15 inches long. Used to remove foreign matter from the hatchery jars.

Siphon -- made of ½ inch rubber tubing attached to a one-foot piece of copper tubing, and about 6 feet long. Used to siphon dead eggs and foreign material from the jars.

Metal pails -- used to muck and wash eggs in, and to siphon eggs into.

Hoop or fyke nets -- used to capture brood stock.

Holding cribs -- made of netting material.

Metal boats -- used to transport fish from traps to cribs and also used by personnel.

Enamelware pans -- into which the eggs and milt were stripped and mixed.

Gallon jars -- to transport eggs.

Cardboard cartons -- to carry jars.

Airplane -- Piper "Supercub", to transport eggs.

Pickup truck -- to haul eggs.

Automobile -- to haul eggs.

Thermometers -- to check water and air temperatures.

Microscopes -- to check the water supply and the egg development.

Oxygen testing equipment.

Jackson turbidimeter -- to check hatchery water supply.

METHOD OF CAPTURING BROOD STOCK

Hoop nets constructed of treated cotton material and equipped with

long leads or wings of the same substance were set in the shallow areas of the lakes, where the adult northern pike were known to congregate during their spawning runs. The fish were captured in these nets and then transferred to holding cribs that were constructed of similar but heavier netting. These cribs were located near the spawn-taking camp or headquarters, which were but temporary scenes of operation. The fish were removed from the live-traps each morning, placed in boats filled with water, and transported to the cribs to be held until they were ready to spawn.

HANDLING EGGS AND BROOD STOCK

As the fish became "ripe" and ready to spawn, they were removed from the holding crib by one worker and handed to the spawn taker. The following method was used at Lake Darling, by the crew there:

The adult pike were held in the cribs until ripe, or until time permitted for stripping. Eggs and sperm were stripped into shallow, moist, enamelware pans. First one male was stripped into the pan, then one female, then another male. All eggs were taken from each female, regardless as to whether or not all eggs were ready to come at the same time. The spawn-taker handled each fish firmly. The sperm and eggs were mixed immediately by pouring the contents of one pan gently into another pan and back again. Fingers were not used to mix them.

The fertilized eggs were then poured into gallon jars, which had been previously filled about one-fourth full of water. Several pans of fertilized eggs, with surplus sperm still mixed amongst them, were

poured into the jars until each jar was one-fourth to one-half full of eggs. This procedure took from 15 to 30 minutes. The jars of eggs were then shaken violently to swirl the eggs and sperm around. The jars were also turned end for end several times in order to thoroughly mix the eggs and sperm and to wash the eggs. Surplus water was then poured off, new water added, the jars shaken again, and the water was once more poured out. The jars of eggs were filled with water, and placed under the surface of the lake and sealed. They were then set aside for about an hour.

At the end of an hour's time, as time permitted, the eggs were washed in the jars by changing the water and rinsing about five times. These jars of fertilized eggs were held at the spawn-taking station until enough jars accumulated to make up one airplane load. This amount was usually two day's spawn take. Thus, about one-half of the load was held about 24 hours before being flown to the hatchery. The jars of eggs and water were then shipped to the hatchery in cardboard cartons. Most of them were sent by airplane, but some were transported by private car.

The methods of handling the eggs and the brood stock at Buffalo Lodge Lake was quite similar, except that the eggs were not handled so violently during the washing process. The eggs taken at Bald Hill Reservoir were stripped from the females more gently, only the ripe ones being taken. They were washed from 5 to 8 times immediately upon being fertilized. The eggs were also washed gently by changing the water in the pans and pouring it out again.

Shipments of eggs from Lake Darling station and from Buffalo Lodge Lake station were transported to the hatchery by both automobile and by

airplane or by combinations of the two methods. All shipments of eggs from Bald Hill Reservoir were taken to the hatchery by pick-up truck. Most of the eggs from all egg-taking stations were shipped in gallon jars of water, which were placed in cardboard cartons. However, some groups from Bald Hill Reservoir were sent in open containers of water, i. e. enamelware and metal pails.

HATCHERY PROCEDURE

The shipments of eggs were taken from the airport to the hatchery by truck. As soon as the cases of eggs or containers of eggs arrived at the hatchery, the temperature of the water in the containers was taken. If it was different from that of the hatchery water, the containers were placed under water in a large tank of hatchery water and allowed to temper until the water temperatures were equalized, or until time permitted to further care for the eggs.

After tempering, the eggs were usually washed several times by changing the water in the containers and rinsing. The eggs were then allowed to harden by various methods. Some were placed in cheese-cloth bags and suspended in the slowly moving water of the big tank, some were left in the original jars, after being washed, with the lids removed and placed under water, and the majority of the groups were poured into wire trays which floated in the water. Having hardened for various periods of time, the eggs were ready to be placed in the battery jars.

Some groups were mucked with a clay solution before being placed in the jars, then rinsed several times and placed on the battery. About two quarts of eggs were first placed in each battery jar. As the eggs

quit sticking together or if they did not stick, they were doubled up so that about three quarts of them were in each battery jar. If the eggs stuck, as most of the un-mucked ones did, they were stirred or worked loose with feathers tied to the ends of small wooden handles. The early groups of eggs were stirred quite regularly, whereas the later groups were touched only if they began to rise to the top of the jars, due to the water pressure below the clumps of sticking eggs.

The eggs were checked regularly every few minutes until they began to roll properly. Then they were checked every hour, when the water temperatures, air temperatures, and such were checked. Periodically, as time permitted, the dead eggs were siphoned off the tops of the hatching jars. The dead eggs were lighter in weight than the live ones and eventually kept working to the top as the eggs continued to roll in the jars. These dead eggs were then disposed of so as not to have them around the hatchery to serve as suitable medium for fungus. The eggs that remained in the battery jars were kept there until they hatched.

HATCHERY WATER SUPPLY

During the first part of the hatching period, all of the hatchery water was obtained from the Sheyenne River. The upstairs battery was supplied by a pump, which pumped the water out of the river and into a storage tank in the attic of the hatchery building. The water ran from there, by gravity, down into the boiler, through it, and into the supply trough. The regular pump was an electric one. However, a gasoline operated pump was used in the event of electrical failure. The battery in the basement was fed by the water from the one upstairs, after it had

been used there, or by direct gravity flow from the river. The basement battery was below the level of the water above the dam in the river, thus one battery could be run at all times in case neither of the pumps worked.

Shortly after hatchery operations began, a well was dug outside the hatchery and the upper battery was run on well water from that point on. The electric pump was moved from the river pump house and placed by the well. The well water was pumped up into the upper battery directly, bypassing both the storage tank and the boiler. After this water was used, it was returned to the well, as the well did not produce enough water to continually supply the battery. Periodically used water was drained out of the hatchery so that a complete change of water in the well could be obtained every day or so.

Water straining devices were placed over the ends of the hoses, which carried the water from the river and from the well. However, small obstacles still entered the hatchery water supply. These foreign obstacles consisted of debris, insects and larvae, algae, silt, etc. A wire screen, constructed of fine window screening, was placed at the point where the water entered the battery trough. This screen caught most of the material; only the very minute substances going through.

Any such items as were not caught, or that passed through when the screens were removed for cleaning, were siphoned off or removed from the battery jars by a small spoon, which was also made of fine window screening. Thus, the eggs were kept as clean as possible at all times.

The water course through the hatchery was as follows:

The water was pumped from the river or from the well and, after entering the trough in the battery, was conducted to the battery jars through wooden faucets, rubber tubes, metal cylinders, and entered the jars at the bottom. The water then circulated up through the eggs in the jars, keeping them rolling, and left the jars by way of spouts at the top. From the jars the water went into a lower trough and then was carried away by way of a pipe, on the lower battery, or a small trough, on the upper battery. It then went into a large wooden tank, which was located on the floor of the hatching room. From the tank in the upper battery the water could either be circulated down through the lower battery or shunted out into the river. Once the water was circulated through the lower battery and tank, it was funneled out into the river by way of a sewer.

HATCHERY CONDITIONS DURING HATCHING PERIOD

Many of the early groups of eggs turned very dark in color within a day or two after being placed on the battery. These groups were being run in river water. Even the later groups sometimes turned dark right away, when placed in river water in the basement. During the first eleven days of the hatching operations there was a heavy growth of free floating algae in the river water. Thus the water had a trace of greenish white color. This was not measureable with turbidity instruments, but was recorded as a trace of turbidity. Under the microscope eggs that were on the battery showed a heavy coating of this algae. This coating collected other foreign particles which stuck to the outside of the eggs. It is believed that this coating of algae and particles

was causing the death of many of the eggs on the battery. In the battery jars, this algae coating was also causing the eggs to stick together. Then too, the algae on the eggs produced gas-bubbles which, in turn, carried or floated the eggs up to the tops of the jars and out into the troughs. Thus a continual watch had to be maintained and the feathers used to release the bubbles of gas from the eggs and from the sides of the jars.

Nearly all of the eggs that were placed on the battery without being mucked in clay solution would begin to stick after a few days, or hours. In order to keep them from rising to the top and floating out of the jars, when water pressure became too great under the mass of eggs, they were stirred from time to time with the feathers. Some of the groups received much more stirring than did others. Some of the first groups were stirred almost continually, whereas some of the later groups were not touched unless water pressure forced them to the top. Then a hole was started along the side of the jar to relieve the pressure and to allow the eggs to settle back to the bottom, and the eggs were allowed to stick until they began to work loose by themselves. All of the first groups were finally mucked with clay in order to make them roll freely. None of the last groups were mucked. They were allowed to stick and to work free in a few days. One group, that was brought from Bald Hill Reservoir immediately after being taken from the fish, was placed on the battery without being mucked and did not stick at any time.

After eleven days of operation at the hatchery, the river water cleared up so that it was classed as clear. However, eggs put on river

water in the battery jars, continued to turn dark in a few days. The upper battery was run on the river water for the first nine days of the hatching period. Then a well was dug outside the hatchery building, near the river, and plumbing was completed in a few days. The upper battery was then cleaned out, scrubbed, and drained. Well water was run into the battery and it was operated on this water for the rest of the hatching period. This well water was of nearly the same temperature as was the river water, and continued to be so throughout the operating of the hatchery. During the first two days that the well water was running through the battery, it was very turbid. The turbidity recordings ranged from 100 to 400 p.p.m. Then on the third day it cleared and became turbid only when the level in the well was drawn down quite a ways. That day the readings ranged from 0 to 125 p.p.m. From the fourth day on the water was absolutely clear. Then on the 17th day, there was a trace of turbidity, not measureable.

After about two weeks of running the upper battery on well water, this water began to become slimey and took on a rather offensive odor. Whereas fungus showed up on the dead eggs in the river water in about four days, no fungus appeared on the eggs run on well water. No algae was present in the well water, either. The oxygen content of both the river and well water was sufficient at all times. Dead eggs in the well water did not turn dark in color, but retained their golden-orange hue at all times. They also did not become soft and light and work to the top, as did those in the river water. The eggs in the well water remained hard, though dead, and did not separate from the good eggs until they had been on the battery nearly two weeks. Then they began

to separate rapidly.

The upper battery was started on heated river water and run on such for the first two days of hatching. The heated water was kept just slightly above 50 degrees F. The boiler was then turned off for four days. The temperature of the river water had risen to nearly equal that of the heated water within about two days after the hatching began. After having been off for four days, the boiler was turned on rather high, since the eggs were being lost anyway. This time the water was heated for about three days and kept in the high 50's. The well water and the unheated river water remained in the high 40's and near 50°F., for the first fifteen days of the hatching. On the 16th day the water in both the river and the well increased rapidly in temperature, making a three to five degree climb in one day. After two days of such temperatures, the water became normal again for two days. Then a cold spell occured and the water temperatures in both river and well lowered rapidly, remaining in the low and mid forties for slightly over a week.

During the first part of the hatchery operations, the air temperatures kept warming slightly, then a "cold snap" occured during the last two days of April and the first week in May, with snow flurries, wind, and much cloudy weather. Air temperatures dropped down to freezing and below nearly every night for more than a week. Thus, the air temperature lines followed the same trend as those of the water.

The following groups of eggs were run in river water entirely throughout the hatching period.

Buffalo Lodge Lake Groups I, II, III, IV, and V.

Lake Darling Groups I, II, III, VI, VII, VIII, and IX.

Bald Hill Reservoir Group III.

The following groups were started on well water, then switched to river water:

Lake Darling Groups V and X.

The following groups were run entirely on well water throughout the hatching period:

Buffalo Lodge Group X.

Bald Hill Reservoir Groups I and II.

HATCHING EXPERIMENTS

The pike eggs used for experimental purposes in this research project were separated into three general categories, determined by where they were taken. These three general classifications were divided into individual groups, dependent upon the time that they were taken. These groups were further broken down into batches of eggs, when parts of groups were treated differently at the hatchery. If groups were not broken down into batches, the entire group was handled as a unit.

BUFFALO LODGE LAKE

The following experimental groups of eggs were taken from pike captured at Buffalo Lodge Lake:

GROUP I.

Eggs taken: 2:00 p.m., 4-12-54.
Temperatures when taken: Water 62°F., Air 65°F.
Number of eggs: 321,640. Number of eggs per linear inch: 10.5.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 6:30 p.m., 4-13-54.

Temperature of water in shipped containers: 64°F.

Hatchery conditions upon arrival: Water 50°F., Air 72°F., Turbidity, trace.

Time tempered: 1½ hours. From 6:30 p.m. until 8:00 p.m.

Time and method hardened: Not hardened, placed immediately on the battery.

Placed on battery: 8:00 p.m., 4-13-54.

Conditions on battery: Water 50°F., Air 63°F., Turbidity, trace.

Eggs eyed: 12:00 a.m., 4-21-54.

Conditions: Water 55½°F., Air 46°F., Turbidity, trace.

Eggs hatched: 12:00 p.m., 4-21-54.

Conditions: Water 55°F., Air 42°F., Turbidity, trace.

Final disposition: Embryos taken from hatchery and stocked in the Sheyenne River, 4-24-54.

Remarks: Twenty-eight and one-half hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. The jars of eggs were placed in the big tanks to temper immediately. They were tempered for 1½ hours, removed and placed immediately on the battery, without being placed in hardening trays and without being mucked. The eggs were started in two jars, then spread out into four jars 14 hours later. Three jars of eggs were mucked with corn starch 23 hours after being placed on the battery. One jar (jar-A) was left

untreated, as a control.

The first three jars were mucked with a clay solution 5 hours after being mucked with the corn starch, 28 hours after being placed on the battery. Again, jar-A was left untreated. The mucked eggs were doubled up into two jars 44 hours after being started. Fungus began to appear on dead eggs 4 days after they were placed on the battery. The mucked eggs were again doubled up into one jar, as dead eggs continued to be removed. Finally, the mucked eggs and control jar-A were mixed together and placed in one jar about 5½ days after being placed on the battery.

The eggs began to eye-out in a little more than 7 days after being started on the battery. They began to hatch in a little less than 8 days. Most of the eggs seemed to be hatching out dead. Those hatching dead had deflated yolk-sacs and the eye-spot appeared not to have been properly developed. The remaining embryos (about 30,000) that were in healthy condition were liberated in the Sheyenne River 10 days after being placed on the battery.

GROUP II, NO. I

Eggs taken: 3:00 p.m., 4-13-54.

Temperatures when taken: Water 56°F., Air 58°F.

Number of eggs: 321,640. Number of eggs per linear inch: 10.5.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 6:30 a.m., 4-13-54.

Temperature of water in shipped containers: 64°F.

Hatchery conditions upon arrival: Water 50°F., Air 72°F., Turbidity, trace.

Time tempered: 2 hours. From 6:30 p.m. until 8:30 p.m.

Time and method hardened: 12½ hours, in gauze bags.

Placed on battery: 9:00 a.m., 4-14-54.

Conditions on battery: Water 51°F., Air 60°F., Turbidity, trace.

Final disposition: No hatch, all eggs thrown out.

Remarks: Three and one-half hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. The jars of eggs were placed in the big tank to temper immediately. They were tempered for two hours, removed and placed in gauze bags to harden. They were then removed from the gauze bags, after hardening for 12½ hours, and placed on the battery, without being mucked. The eggs were started in three jars, then changed into four jars 1 hour later. All jars were mucked with corn starch 11 hours after being placed on the battery. Then all jars were mucked with a clay solution and spread out into five jars 14 hours after being started.

The boiler was turned off 22½ hours after the eggs were placed on the battery, as the river water temperature had risen. The eggs were doubled up into three jars 48 hours after being started on the battery. Fungus began to appear 3½ days after starting. Dead eggs were continually removed as they worked to the tops of the jars. Two quarts of dead eggs were removed on the fourth day. The remaining eggs were doubled up into one jar after 5 days. The remaining eggs were finally thrown out after about 11 days.

The eggs began sticking together and to the sides of the battery jars a few hours after being placed on the battery. They were worked over with a feather to keep them from floating out of the jars and in order to try and get them to rolling. They still stuck, therefore, they were mucked with the corn starch, and later with the clay solution to get them rolling. After being mucked they rolled very well.

GROUP II, NO. 2.

Eggs taken: 3:00 p.m., 4-13-54.

Temperatures when taken: Water 56°F., Air 58°F.

Number of eggs: 540,940. Number of eggs per linear inch: 10.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 6:30 p.m., 4-13-54.

Temperature of water in shipped containers: 64°F.

Hatchery conditions upon arrival: Water 50°F., Air 72°F., Turbidity, trace.

Time tempered: 16 hours. From 6:30 p.m., 4-13-54 until 10:30 a.m., 4-14-54.

Time and method hardened: Left in original jars over night.

Placed on battery: 10:30 a.m., 4-14-54.

Conditions on battery: Water 52°F., Air 69°F., Turbidity, trace.

Final disposition: No hatch, all eggs thrown out.

Remarks: Three and one-half hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery.

The jars of eggs were placed in the big tank to temper immediately. They were tempered for 16 hours, or rather were allowed to harden in the jars overnight. They were then removed, washed, and placed on the battery, without being mucked. They were started in five jars. One jar (jar-A) was mucked with a clay solution 3½ hours after being placed on the battery. The eggs had begun to stick within 3 hours after starting.

In hopes that fewer eggs per jar would allow them to roll properly, the eggs were spread out into six jars 7½ hours after being placed on the battery. Another jar (jar-B) was mucked with corn starch after 9 hours. The unmucked eggs were doubled up so that the group was back to five jars again, 10 hours after being put on. All jars, except jar-A were mucked with a clay solution after 14 hours. Jar-A had been treated with a clay solution 10½ hours earlier, and had been rolling very well since that time. Meanwhile, the eggs in the other jars had been sticking all that time.

The boiler was turned off 21 hours after the eggs were put on the battery because the river water temperature had come up to near that of the heated water. The jars were again doubled up as dead eggs were continually removed, and as the eggs were rolling very easily. They were put into four jars after 29½ hours. Fungus began to appear on the dead eggs 3½ days after starting them. Several pints of bad eggs were removed and placed in a separate jar on the fifth day in order to keep them under observation. This jar of bad eggs was thrown out and the remaining eggs were concentrated into three jars 2 hours later. The remaining eggs were finally thrown out after about 11 days.

GROUP III, NO. I

Eggs taken: 4-14-54

Temperatures when taken: Water a.m. 50°F., p.m. 55°F., Air 52°F.

Number of eggs: 818,720. Number of eggs per linear inch: 11.5.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 11:55 a.m., 4-15-54.

Temperature of water in shipped containers: 40°F.

Hatchery conditions upon arrival: Water 50°F., Air 48°F., Turbidity, trace.

Time tempered: 3 3/4 hours. From 1:15 p.m. until 5:00 p.m.

Time and method hardened: Hardened in original jars.

Placed on battery: Batch A at 6:00 p.m., 4-15-54. Batch B at 9:00 p.m., 4-15-54.

Conditions on battery: Batch A; Water 50°F., Air 45°F., Turbidity, trace. Batch B; Water 49°F., Air 36°F., Turbidity, trace.

Final disposition: No hatch, eggs thrown out.

Remarks: Nearly 24 hours elapsed between the time that the eggs were taken and the time that they reached the hatchery. The jars of eggs were left out of water for one hour and 20 minutes after they arrived, then placed in the big tank to temper. One group (batch A) was tempered for 3 hours and 45 minutes, then removed. The eggs were poured from the original jars into metal cans to be mucked. A clay solution was then added into the cans of eggs and the eggs mucked for 20 minutes. The eggs were then washed, in 50 degree river water, and

placed on the battery.

The second group (batch B) was tempered, or allowed to harden in the original jars, for 7¼ hours, then mucked, washed, and placed on the battery. The two batches were mixed together and doubled up into five jars 12 to 15 hours later. Since these eggs were mucked before being placed on the battery, they did not stick at any time. Fungus began to appear on the dead eggs on the third day, and were continually removed from time to time. The remaining eggs were finally thrown out after about 11 days.

GROUP III, NO. 2.

Eggs taken: 4-14-54.

Temperatures when taken: Water a.m. 50°F., p.m. 55°F., Air 52°F.

Number of eggs: 842,960. Number of eggs per linear inch: 11.5.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 11:55 a.m., 4-15-54.

Temperature of water in shipped containers: 40°F.

Hatchery conditions upon arrival: Water 50°F., Air 48°F., Turbidity, trace.

Time tempered: 2 3/4 hours. From 1:15 p.m. until 4:00 p.m.

Time and method hardened: Hardened in trays, 22½ hours.

Placed on battery: 2:30 p.m., 4-16-54.

Conditions on battery: Water 49°F., Air 54°F., Turbidity, trace.

Final disposition: No hatch, eggs thrown out.

Remarks: Nearly 24 hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. The jars of eggs were left out of the water for one hour and 20 minutes after they arrived, then placed in the big tank to temper. The eggs were tempered for 2 hours and 45 minutes, then removed from the jars and placed in trays to harden. They were hardened in the trays for 22½ hours, then removed and washed in 49 degree river water, and placed on the battery.

The eggs began sticking 1 hour and 45 minutes after being placed on the battery. The water was ½ degree warmer than when the eggs were started. All of the eggs were mucked with a clay solution after 3 hours on the battery. Thereafter, the eggs rolled nicely. Dead eggs were removed from time to time. Finally the remaining eggs were thrown out about 12 days after being started.

GROUP IV.

Eggs taken: p.m., 4-16-54.

Temperatures when taken: Water 43°F., Air 60°F.

Number of eggs: 842,960. Number of eggs per linear inch: 10.4.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrival at hatchery: 5:30 p.m., 4-16-54.

Temperature of water in shipped containers: 51°F.

Hatchery conditions upon arrival: Water 50°F., Air 58°F., Turbidity, trace.

Time tempered: Not tempered, placed immediately in trays.

Time and method hardened: Hardened in trays, in river water in the lower battery. Batch A, 23½ hours. Batch B, 41 hours.

Placed on battery: Batch A, 5:00 p.m., 4-17-54. Batch B, 10:30 a.m., 4-18-54.

Conditions on battery: Batch A; Water 49½°F., Air 56°F. Batch B; Water 47½°F., Air 50°F., Turbidity, trace.

Final disposition: No hatch, eggs thrown out.

Remarks: About 3 hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. The jars of eggs were not tempered, but were placed immediately in trays in trays in the basement, to harden. Batch A was removed from the trays after hardening for 23½ hours. They were mucked with a clay solution, washed, and placed on the battery. Since all of the eggs still felt very soft, the remaining eggs (batch B) were left to harden a bit longer.

Batch B was removed from the trays after hardening for 41 hours. They were mucked with a clay solution, washed, and placed on the battery. None of the eggs stuck after being mucked and started. However, this entire group did not harden properly, even though plenty of time was allowed for this. Dead eggs were removed periodically. Finally, the remaining ones were discarded, too.

GROUP V.

Eggs taken: p.m., 4-16-54.

Temperatures when taken: Water 43°F., Air 55°F.

Number of eggs: 877,200.

Method of transporting: By airplane. Eggs shipped in sealed

gallon jars of water.

Arrived at hatchery: 11:30 a.m., 4-18-54.

Temperature of water in shipped containers: 42°F.

Hatchery conditions upon arrival: Water 47½°F., Air 50°F., Turbidity, trace.

Time tempered: 23 hours. From 11:30 a.m., 4-18-54 until 10:30 a.m., 4-19-54.

Time and method hardened: In trays for 24½ hours.

Placed on battery: 11:00 a.m., 4-20-54.

Conditions on battery: Water 56°F., Air 57°F., Turbidity, trace.

Final disposition: No hatch, eggs thrown out.

Remarks: At least 40 hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. The jars of eggs were immediately placed in the big tank to temper. They were left in the jars to temper for 23 hours. All told, the eggs were in the jars about 63 hours before being removed and placed in trays to harden. After hardening for another 24½ hours, they were removed from the trays, mucked with a clay solution, washed, and placed on the battery. Thus, about 87½ hours elapsed between the time that the eggs were taken and the time that they were placed on the battery.

The boiler was turned off when the eggs were brought into the hatchery, but had been turned on by the time that they were placed on the battery. It was turned off again after the eggs had been on the battery for about two days. The trace of turbidity had disappeared from the river water before the eggs were removed from the battery. Finally, all of the eggs were thrown out, as they were not hatching.

GROUP X.

Eggs taken: 4-22-54.

Temperatures when taken: Water a.m. 40°F., p.m. 43°F.; Air a.m. 38, p.m. 40.

Number of eggs: 423,980.

Method of transporting: By automobile to Lake Darling, then by airplane to the hatchery. In sealed jars of water.

Arrived at hatchery: 5:00 p.m., 4-23-54.

Temperature of water in shipped containers: 56°F.

Hatchery conditions upon arrival: Water 48°F., Air 68°F., Turbidity, trace.

Time tempered: 1½ hours.

Time and method hardened: In trays for 40½ hours.

Placed on battery: 11:00 a.m., 4-25-54.

Conditions on battery: Water 49°F., Air 55°F., Turbidity, none.

Eggs eyed: 9:00 a.m., 5-6-54.

Conditions: Water 46½°F., Air 45°F., Turbidity, none.

Final disposition: Eyed eggs stocked in the Sheyenne River, 5-8-54.

Remarks: A little more than 24 hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. The jars of eggs were placed in the big tank to temper immediately. After tempering for 1½ hours, the eggs were removed from the jars and placed in trays to harden. They hardened for 40½ hours, then were removed from the trays and placed on the upstairs battery, on well water,

without being mucked. Nineteen hours after being put on the battery, the eggs began to stick. The water temperature had dropped two degrees in that time. The eggs were not worked over, except to keep them from floating out of the jars. They stuck for 24 hours, then began to roll freely again.

The eggs began to "eye-out" about 11 days after being put on the battery. The water temperature was 2½ degrees lower than when the eggs were started on the battery. All of the eggs were moved to the basement battery and put on river water 12 days after being started on the upstairs battery. The eyed-eggs were stocked in the Sheyenne River 13 days after starting.

LAKE DARLING

The following experimental groups of eggs were taken from pike captured at Lake Darling:

GROUP I AND II.

Eggs taken: A.M., 4-15-54 and 4-16-54.

Temperatures when taken: Group I; Water 35°F., Air 35°F. Group II; Water 36°F., Air 35°F.

Number of eggs: 1,315,800. Number of eggs per linear inch: 10.4.

Method of transporting: By airplane: Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 5:30 p.m., 4-16-54.

Temperature of water in shipped containers: 51°F.

Hatchery conditions upon arrival: Water 50°F., Air 58°F., Turbidity, trace.

Time tempered: Not tempered.

Time and method hardened: In trays for 17½ hours.

Placed on battery: 11:00 a.m., 4-17-54.

Conditions on battery: Water 49°F., Air 52°F., Turbidity, trace.

Eggs eyed: 4:00 p.m., 4-23-54.

Conditions: Water 49°F., Air 67°F., Turbidity, trace.

Eggs hatched: 8:00 a.m., 4-25-54.

Conditions: Water 50°F., Air 48°F., Turbidity, none.

Final disposition: 250,000 embryos were stocked in Lake Tewaukon, 4-25-54.

Remarks: Groups I and II were mixed together during shipment to the hatchery, thus were treated as one group from that time on. At least a day and a half elapsed between the time that the eggs in Group I were taken and the time that they arrived at the hatchery. Just a few hours elapsed from the time that the eggs in group II were taken until they reached the hatchery. The eggs were not tempered, but were placed immediately in trays to harden. After hardening for 17½ hours, they were removed from the trays, mucked with a clay solution, washed, and placed on the battery.

Since the eggs were mucked at the start, they did not stick at any time. Dead eggs were continually removed throughout the hatching period. The eggs began to eye-out 6 days after being placed on the battery. About 8 days after being started, they began to hatch. Two hundred and fifty thousand embryos were stocked that night, in Lake Tewaukon. A 19% hatch was obtained.

GROUP III.

Number of eggs: 928,000.

Method of transporting: By automobile. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 2:00 p.m., 4-19-54.

Temperature of water in shipped containers: 39½°F.

Hatchery conditions upon arrival: Water 47½°F., Air 54°F., Turbidity, trace.

Time tempered: 24 hours.

Time and method hardened: In jars for 22 hours.

Placed on battery: 12:00 p.m., 4-21-54.

Conditions on battery: Water 48°F., Air 42°F., Turbidity, trace.

Final disposition: No hatch, eggs thrown out.

Remarks: The original "shipping ticket" that should have arrived with the group was missing. Therefore, the time and date of egg-taking and the conditions at the egg-taking station were not known. This group was transported by automobile, instead of by airplane. The jars of eggs were immediately placed in the big tank to temper. After tempering for 24 hours, the eggs were washed in their original containers, then left in them to harden. After hardening in the jars for another 22 hours, the eggs were removed and placed on the battery in the basement, on river water. One jar of eggs was decomposing and was thrown out at that time.

The eggs were kept under observation for a few days, then the entire group was thrown out.

GROUP V.

Eggs taken: 1:00 to 3:30 p.m., 4-21-54.

Temperatures when taken: Water 42°F., Air 45°F.

Number of eggs: 2,561,824.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 1:00 p.m., 4-22-54.

Hatchery conditions upon arrival: Water 46°F., Air 50°F., Turbidity, river, trace; well, 110 p.p.m.

Time tempered: 1 hour.

Time and method hardened: In trays for 8 hours.

Placed on battery: 10:00 p.m., 4-22-54.

Conditions on battery: Water 47°F., Air 46°F., Turbidity, 375 p.p.m.

Changed to river water: 5:00 p.m., 4-24-54.

Conditions: Water 49°F., Air 57°F., Turbidity, trace.

Final disposition: No hatch, eggs thrown out.

Remarks: At the egg-taking station, the fish were cribbed for 24 hours and/or less before the eggs were taken. The eggs were then kept in jars for 24 hours before being transported to the hatchery. Upon arrival at the hatchery, the jars of eggs were placed immediately in the big tank to temper. After tempering for one hour, the eggs were removed from the jars and placed in trays to harden. The eggs hardened for 8 hours, then were removed, mucked with a clay solution, washed, and placed on the upstairs battery, on well water. They did not stick, since

they had been mucked before being started.

The eggs were kept on the well water for 43 hours. When first put on, the water was very turbid (375 p.p.m.), but cleared up considerably before the eggs were moved to the basement. At the time the eggs were transferred to the basement battery, the turbidity of the well water had increased from a trace to 50 p.p.m. again. The eggs were then put on river water, which had a trace of turbidity and had one degree higher in temperature. Dead eggs were removed periodically, then the entire group was discarded after 11 days.

GROUP VI.

Eggs taken: 10:30 a.m. to 12:00 p.m., 4-23-54.

Temperatures when taken: Water 42°F., Air 48°F.

Number of eggs: 2,105,280.

Method of transporting: By airplane. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 5:00 p.m., 4-23-54.

Temperature of water in shipped container: 57°F.

Hatchery conditions upon arrival: Water 48°F., Air 68°F., Turbidity, river, trace; well, 170 p.p.m.

Time tempered: 20 hours.

Time and method hardened: In trays for 49 hours.

Placed on battery: 2:00 p.m., 4-26-54.

Conditions on battery: Water 49½°F., Air 48°F., Turbidity, none.

Final disposition: No hatch, eggs thrown out.

Remarks: From 5 to 6½ hours elapsed from the time that the eggs

were taken until they arrived at the hatchery. Upon arrival at the hatchery, the jars of eggs were placed immediately in the big tank to temper. After tempering for 16 hours, 8 of the original 12 jars were sent to the hatchery at Valley City. The remaining 614,040 eggs were allowed to harden in trays for 49 hours, after having tempered for a total of 20 hours. They were tempered and hardened in well water. When removed from the tempering jars, the eggs were washed, then placed in the trays to harden. After hardening, the eggs were removed, washed again, and placed on the battery in the basement in river water.

The eggs began sticking 16 hours after being placed on the battery. During the second day on the battery the eggs turned very dark in color. They were not worked over while they were sticking, a feather being used but once in a while to keep them from floating out of the jars. Finally the eggs worked loose and began to roll again in about 36 hours. Dead eggs were removed periodically, and the entire group was thrown out by the 7th day.

A total time of 74 hours elapsed between the time that the eggs were taken and the time that they were placed on the battery. Twenty-five hours passed before they were removed from the original jars.

GROUP VII.

Eggs taken: 11:00 a.m. to 12:30 p.m., 4-24-54.

Temperatures when taken: Water 45°F., Air 48°F.

Number of eggs: 1,574,960.

Method of transporting: By automobile. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 6:00 p.m., 4-25-54.

Hatchery conditions upon arrival: Water 50°F., Air 56°F., Turbidity, none.

Time tempered: 1 hour.

Time and method hardened: In trays for 39½ hours.

Placed on battery: 10:30 a.m., 4-27-54.

Conditions on battery: Water 49°F., Air 49°F., Turbidity, none.

Eggs eyed: 8:00 a.m., 5-4-54.

Conditions: Water 41½°F., Air 34°F., Turbidity, none.

Final disposition: About 10,000 eyed eggs stocked in Sheyenne River, 5:30 p.m., 5-6-54.

Remarks: The fish were cribbed for 24 hours and/or less before eggs were taken. The eggs were then transported to the hatchery by automobile. About 30 hours elapsed between the time that the eggs were taken and the time that they reached the hatchery. Upon arriving at the hatchery, they were placed immediately in the big tank to temper. The jars of eggs tempered for one hour. They were then removed from the jars and placed in trays to harden. After hardening for 39½ hours, the eggs were removed from the trays, washed, and placed on the battery in the basement, on river water. The eggs had been tempered and hardened in well water.

The eggs began sticking 7½ hours after being placed on the battery. They were not worked over while sticking, but were feathered only often enough to keep them from floating out of the jars. The eggs began to roll freely again about 36 hours later. A large number of dead eggs was thrown out 6 days after being placed on the battery. The remaining

eggs began to eye-out in about 7 days. These eyed eggs, about 10,000, were stocked in the Sheyenne River 9 days after starting on the battery, and 12 days after being taken from the fish.

The eggs were kept in the original jars for about 31 hours before being put in the hardening trays. Seventy and one-half hours elapsed between the time that the eggs were taken and the time that they were placed on the battery.

GROUP VIII.

Eggs taken: 9:00 to 10:45 a.m., 4-25-54.

Temperatures when taken: Water 44°F., Air 42°F.

Eggs, number: 1,399,520.

Method of transporting: By automobile. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 6:00 p.m., 4-25-54.

Hatchery conditions upon arrival: Water 50°F., Air 56°F., Turbidity, none.

Time tempered: 26½ and 40½ hours.

Time and method hardened: In trays for 1 week.

Placed on battery: 2:00 p.m., 5-3-54.

Conditions on battery: Water 42°F., Air 38°F., Turbidity, none.

Final disposition: No hatch, all eggs thrown out.

Remarks: At least 7 hours elapsed between the time the eggs were taken and the time that they arrived at the hatchery. The jars of eggs were put immediately in the big tank to temper in well water. The jar lids were removed after 3½ hours and the jars were left under the water.

Eggs from half of the jars were placed in trays to harden after tempering for 26½ hours. The remaining eggs were placed in trays after 40½ hours. The eggs were allowed to harden in the trays, then were left there to hatch. All of the battery jars were full at the time. Therefore, the eggs in the trays were turned every hour or so.

The eggs were removed from the trays, dead eggs removed, and placed on the battery in the basement, on river water, after having been in the trays for about one week. After being on the battery for another week, all of the eggs were thrown out.

GROUPS IX AND X.

Eggs taken: Group IX; 12:30 to 1:30 p.m., 4-26-54. Group X; 9:00 to 10:00 a.m., 4-27-54.

Temperatures when taken: Group IX; Water 44°F., Air 45°F. Group X; Water 44°F., Air 42°F.

Number of eggs: Group IX; 1,052,640. Group X; 877,200.

Method of transporting: By automobile to Bismarck, then by airplane to the hatchery. In gallon jars of water.

Arrived at hatchery: 5:30 p.m., 4-27-54.

Hatchery conditions upon arrival: Water 48°F., Air 58°F., Turbidity, none.

Time tempered: 16 hours.

Time and method hardened: In trays for 2 to 5 days.

Placed on battery: 4-30-54 and 2:00 p.m., 5-3-54.

Conditions on battery: Well; Water 46°F., Air 35°F., Turbidity, none. River; Water 42°F., Air 38°F., Turbidity, none.

Final disposition: No hatch, eggs thrown out.

Remarks: In group IX, about 28 hours elapsed from the time that the eggs were taken until they arrived at the hatchery. In group X, about 8 hours passed. The two groups were mixed together upon arriving at the hatchery. The jars of eggs were placed immediately in the big tanks to temper. After tempering for 16 hours, four of the original eleven jars were sent to the Valley City hatchery, and the rest were placed in trays to harden.

After hardening, the eggs were left in the trays to hatch. They were turned once every hour or so. At that time, all of the battery jars were full. After two days, two trays of eggs were placed on the battery upstairs, on well water. The remaining eggs were left in the trays for about 5 days, then were placed on the battery in the basement, on river water. The first jars were moved to the basement battery after having been on well water for one week. About two days later the entire groups were thrown out.

BALD HILL RESERVOIR

The following experimental groups of eggs were taken from pike captured at Bald Hill Reservoir:

GROUP I.

Eggs taken: 12:00 p.m., 4-17-54.

Temperatures when taken: Water?, Air 65°F.

Number of eggs: 877,200.

Method of transporting: By truck. Some eggs were shipped in open pails and some in sealed gallon jars of water.

Arrived at hatchery: 2:00 p.m., 4-18-54.

Temperature of water in shipped containers: Jars, 46°F., Open pail, 49°F.

Hatchery conditions upon arrival: Water 48°F., Air 55°F., Turbidity, trace.

Time tempered: Jars, 7 hours. Pail, not tempered.

Time and method hardened: Jars, not hardened. Pail, in trays for 49 hours.

Placed on battery: Jars; 9:00 p.m., 4-18-54. Pail; 3:00 p.m., 4-20-54.

Conditions on battery: Jars: Water 47½°F., Air 42°F.; Turbidity, trace. Pail: Water 56°F., Air 49°F.; Turbidity, trace.

Final disposition: No hatch, eggs thrown out.

Remarks: The eggs in the jars were held in the back of a pick-up truck overnight, before being transported to the hatchery. Twenty-six hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. They were shipped in both sealed jars and in an open pail. The eggs in the jars were termed batch-A, and those in the open pail were batch-B.

Batch-A: As soon as the eggs arrived at the hatchery, the jars were placed in the big tank to temper. After tempering for 7 hours, the eggs were removed from the jars, mucked in a clay solution, washed, and placed on the battery. They were not allowed to harden, other than when they were tempering.

Batch-B: Immediately upon arriving at the hatchery the eggs in the open pail were removed and placed in trays to harden. They were not

tempered. After hardening for 49 hours, the eggs were removed from the trays, mucked in a clay solution, washed, and placed on the battery.

The eggs from both batches were kept under observation for several days, then the entire group was discarded.

GROUP II.

Eggs taken: 2:30 p.m., 4-23-54.

Temperatures when taken: Water 42°F., Air 59°F.

Number of eggs: 1,608,200.

Method of transporting: By truck. Eggs shipped in open containers of water.

Arrived at hatchery: 6:00 p.m., 4-23-54.

Hatchery conditions upon arrival: Water 48°F., Air 66°F., Turbidity, trace.

Time tempered: Batch-A; in trays for 20 hours. Batch-B; in trays, but time not known.

Placed on battery: 2:00 p.m., 4-24-54.

Conditions on battery: Water 48°F., Air 57°F., Turbidity, 0 to 125 p.p.m.

Eggs eyed: 8:20 a.m., 5-4-54.

Conditions: Water 43°F., Air 34°F., Turbidity, none.

Eggs hatched: 9:00 a.m., 5-9-54.

Final disposition: 34% patch, fry moved to rearing ponds.

Remarks: Three and one-half hours elapsed between the time that the eggs were taken and the time that they arrived at the hatchery. They were transported to the hatchery in open containers of water, and

hauled by pick-up truck. The eggs in the enamel-ware container (Batch-A) were not tempered, but were put immediately in trays to harden. Those in the metal bucket (Batch-B) were tempered in the tank for a while, then placed in trays. After hardening for about 20 hours, the eggs were removed from the trays, washed, and put on the battery upstairs, on well water.

The eggs stuck in the jars for a short time, then worked free by themselves. The dead eggs remained firm and orange for several days, and did not separate from the good ones. After about 12 days on the battery, they began to separate and work to the top. As they did so, they were removed and placed on separate jars instead of being thrown away. For the next three days the dead eggs were removed about twice a day, and placed on separate jars. All jars of bad eggs were put on river water in the basement. The remaining good eggs began to eye-out 10 days after being put on the battery. They began to hatch 15 days after starting. During the last week on the battery, the water temperatures dropped about 8 degrees, then slowly began to rise again. A 34% hatch was obtained.

GROUP III

Eggs taken: 11:00 a.m., 4-25-54.

Number of eggs: 321,640.

Method of transporting: By truck. Eggs shipped in sealed gallon jars of water.

Arrived at hatchery: 2:30 p.m., 4-25-54.

Hatchery conditions upon arrival: Water 49°F., Air 61°F.

Turbidity, none.

Time tempered: 3 hours.

Time and method hardened: In trays for 40½ hours.

Placed on battery: 10:00 a.m., 4-27-54.

Conditions on battery: Water 49°F., Air 48°F., Turbidity, none.

Eggs eyed: 12:00 a.m., 5-7-54.

Conditions: Water 47½°F., Air 34°F., Turbidity, none.

Eggs hatched: 9:00 a.m., 5-9-54.

Final disposition: 35% patch, fry moved to rearing ponds.

Remarks: Three and one-half hours elapsed between the time that the eggs were taken and the time that they reached the hatchery. The eggs were thoroughly washed immediately after having been taken from the females and fertilized with sperm. They were then placed in gallon jars of water and sealed under water. The jars of eggs were then put in a truck and taken immediately to the hatchery. Upon arriving at the hatchery, the jars were placed in the big tank to temper. After tempering for 3 hours, the eggs were removed from the jars, washed, and placed in trays to harden. They were left in the hardening trays for 40½ hours, then removed, washed again, and put on the battery upstairs.

The eggs did not stick at any time, but rolled freely throughout the hatching period. Dead eggs remained firm and orange for several days, and did not separate from the good ones for about a week. When they finally began to separate and work to the tops of the battery jars, they were removed and placed in separate jars in the basement. Ten days after being put on the battery, the eggs began to eye-out. Twelve days after starting, they began to hatch. During the last week of hatching,

the water temperatures dropped about 8 degrees, then began to slowly rise again. A 35% hatch was obtained.

ANALYSIS OF PROJECT RESULTS

The percent of hatch of each individual group of eggs ranged from 0 to 35 percent. The Buffalo Lodge Lake groups ranged from 0 to 9 percent, the Lake Darling groups ranged from 0 to 19 percent, and those in the Bald Hill Reservoir groups ranged from 0 to 35 percent. The average hatching percent for the groups from the various egg-taking stations was as follows: Buffalo Lodge Lake .8, Lake Darling 2.5, and Bald Hill Reservoir 23.5. The total average hatching percentage for all groups combined was 5.2.

The percent of egg hatch in groups from these stations that were handled at the Federal Hatchery in Valley City were as follows: Buffalo Lodge Lake groups .5; Lake Darling groups 0; and Bald Hill Reservoir groups 36. In addition, eggs taken from the Sheyenne River and within a mile of the hatchery had a success of 51%.

The eggs were touched very little, if at all, with the hands during the spawn-taking or hatching. In the group hatching those eggs that were handled very gently at the taking station, such as those from Bald Hill Reservoir, resulted in a better hatching percentage than those handled more roughly, such as those from Lake Darling.

The type of container that the eggs were transported in seemed to have no affect on the hatching results. However, it is believed that placing fewer eggs in each container would have insured better water circulation throughout the jar and would have also lessened the danger of

injury to the eggs through crushing, smothering, or bumping against each other.

No correlation could be determined between the hatching success and the method of transportation, except that those eggs transported by truck from a shorter distance had a much better over-all percent of hatch. It is, therefore, believed that the method of transportation did not affect the eventual hatching success.

It appeared that a large percentage of the eggs were dead upon arrival at the hatchery. This could have been due to several factors:

Too many eggs were taken from each fish, resulting in many unripe and injured eggs, as well as unfertilized ones.

Eggs were not washed thoroughly enough or soon enough, resulting in foreign matter, blood, etc. being shipped with eggs, and in eggs sticking together.

Eggs were handled too roughly during washing and placing in containers, thereby crushing and injuring some.

Too many eggs were placed in each container, thus, many were crushed.

Containers of eggs were held at the egg-taking station too long before being transported to the hatchery, resulting in many eggs beginning to decompose by the time they reached the hatchery.

Eggs were transported too far, resulting in long delays and in much handling.

Water temperatures at the taking stations and at the hatchery seemed to have no influence on the resulting hatch success. However, the

warmer temperatures maintained in the hatchery for a short time increased the development and thus shortened the hatching time of the eggs.

The size of the eggs arriving at the hatchery was nearly the same for all groups but two. All of the groups of eggs that had any hatching success were of the larger sizes.

Provided that the eggs were in good shape when they arrived at the hatchery, the condition of the water in the hatchery appeared to have the greatest influence as to how the groups would turn out. Water that was supplied from the river contained algae, silt, and other particles that coated the eggs and appeared to smother or otherwise affect them. Gas produced by the algae formed bubbles on the eggs and at times floated many of them out of the hatching jars. Insects in the river water, particularly water boatman, attached themselves to the eggs and thus floated to the top with the eggs, resulting in the loss of these eggs. Dead organic matter in the river water provided a suitable environment for fungus to get a start. The river water contained a fairly heavy growth of this fungus. This fungus growth attacked the dead eggs, but was not as harmful as the algae and the silt. Mineral content remained constant, and oxygen content remained adequate throughout the hatching period, and appeared to have no influence on the results.

The well water contained no algae or foreign matter. None of the groups of eggs that were switched from well water to river water or in the reverse manner had any hatch. Those groups run entirely on river water had hatching success ranging from 0 to 19%. The groups run entirely on well water had a 2 to 35% of hatch. However, this may

have been due to the fact that the latter groups were considered to be better than the others and were left on well water all of the time.

All of the groups with successful hatches were hardened in trays or were hardened before being shipped to the hatchery. Those hardened by other methods such as those in bags, in jars, etc., did not have any success. All of the groups with successful hatches were tempered not more than three hours. None of the batches tempering for longer periods hatched out.

The eggs in all of the groups with hatching success were not held in the original shipping containers longer than 31 hours.

Those eggs that were worked over with feathers fared no better than those not touched. The eggs mucked with the clay or corn starch solutions had no advantage over the untreated ones in bringing about a higher percent of hatch. Whether the eggs stuck in the jars or not had no correlation with the hatching success.

The use of plastic and glass battery jars resulted in no particular difference in hatching percentage. The plastic jars were much lighter in weight than were the glass ones and they were not as fragile as those of glass. Hence, the plastic jars were much easier to work with.

Hatchery conditions were too crowded with eggs to properly care for them all in such a way as to obtain a good percentage of hatch.

The time elapse from the taking of the eggs until they arrived at the hatcheries correlated with the hatching success somewhat. The groups with the best percentage of hatch arrived within 3½ hours, whereas those being held for longer periods at the taking stations had varying results. Following is the correlation of hatching success at

the Lisbon and Valley City hatcheries with the average time elapse from the time the eggs were taken until they reached the hatchery (see plate 1):

Lisbon - The average time elapse that is the highest has the lowest hatching success and so on in inverse ratio. There is a direct correlation in each group.

Valley City - All percents directly correlate in an inverse ratio, except the groups from the Buffalo Lodge Lake Station. However, the time elapse was the highest and the hatching success was still extremely low.

The shipments of eggs were made from a minimum distance of about 50 miles and a maximum of about 260 air-miles. The percent of hatch of all the eggs from the shorter distance was much better than that for the groups from farther away. In fact, the hatching success at both the Lisbon and Valley City hatcheries was best for those groups from the shortest distance away. Following is the correlation of distance each egg-taking station is from the hatcheries and the hatching success of groups from those stations (see plate 2):

Lisbon - There is a direct correlation in an inverse ratio, except for the Buffalo Lodge Lake groups. However, the distance is great and the resulting hatch was very poor.

Valley City - There is a direct correlation in an inverse ratio in all groups. The farther the eggs were transported, the poorer the percent of hatch. Those from a much closer station had a much higher success.

CONCLUSIONS

A better success will be obtained by taking ripe fish and spawning them immediately, rather than holding them in cribs to ripen first. Spawn taking operations should be conducted in as clear water as possible so as to keep the eggs from becoming contaminated with foreign substances. Use at least one male per female in fertilizing the eggs in order to obtain adequate fertilization (9, p. 2). Though the results do not seem to reveal that fingers should not be used in mixing the eggs, the swirling method is as good a method of mixing and may be preferred since it will lessen the chance of contaminating or crushing the eggs (5, p. 5). Care should be taken not to get mucous on the eggs during the stripping procedure.

Transporting the eggs long distances and long delays before they reach the hatching stations result in a very low hatching success. However, careful handling of the eggs, taking only larger and mature eggs, taking only those that are ripe and flow easily, washing the excess milt from them and rinsing the eggs several times immediately, gentle mixing of sperm and eggs and gentle handling, and proper hardening of the fertilized eggs at the egg-taking stations before transporting to the hatcheries will insure a better percentage of hatch.

The method of transportation, whether by airplane, automobile, or truck, seemed not to affect the eggs as much as the care of transporting them and care taken not to jar or crush them. If jars are to be used, not more than one-fourth to one-half of the jar should be filled with eggs.

From the results of these experiments and those of other organizations, it appears that the factors influencing the resulting hatches most are those that occur before the eggs are transported to the hatcheries. However, it is concluded that egg-taking stations should be located as near to the hatcheries as possible, even though more fish may be caught easier elsewhere. By taking fewer eggs and handling them in the manner mentioned above, it is believed that a much higher percent of hatch can be obtained. This higher percent of hatch should then result in producing as many fry and in a more efficient and economical manner, as was done with larger numbers of eggs handled by methods presently being used.

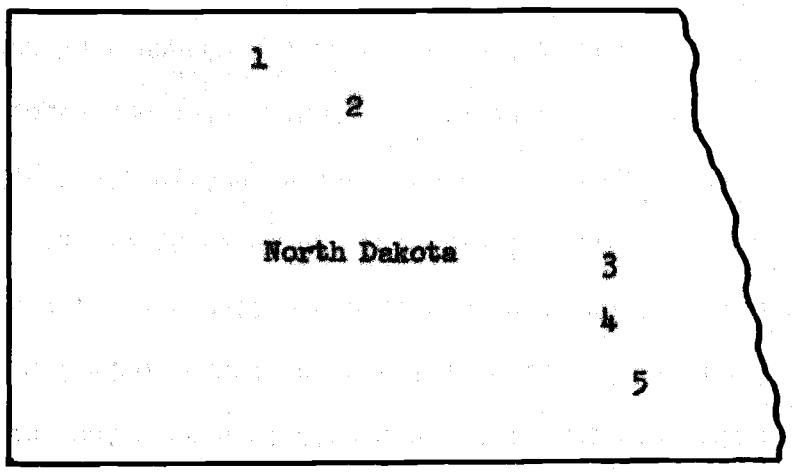
The eggs should be tempered upon arrival at the hatchery, if the temperatures in the shipped containers differ from that of the hatchery. The time tempered need not be for more than one-half hour. In fact, the eggs should be removed from the shipping containers as soon as possible and placed either in trays or more preferably in the hatching jars. Providing that the eggs are in good shape when they arrive at the hatchery, they may be held in trays for as long as 24 hours with no apparent harm. This practice should be carried on only if there are no battery jars available at the time.

The hatchery water supply should be as free of foreign matter, such as debris, insects, silt, algae, and fungus, as possible. All of these factors affect the hatching eggs somewhat and should be eliminated. If oxygen content and chemical composition of well or spring water is such that it may be used for hatchery purposes, it would be more desirable than most river water because it is naturally

free from most of the foreign materials mentioned above. Well or spring water has a more consistent temperature, which is also more to be desired, unless the water temperatures are to be controlled at the hatchery.

Varying or changing water temperatures seem to have no affect on the resulting hatch of the eggs, but do govern the length of time that it takes for the eggs to hatch and apparently affects the adhesiveness of the eggs. If the eggs do stick in the battery jars, it is not recommended that they be mucked or feathered more than is necessary to keep them in the jars.

Figure 1. Locations of Hatcheries and Egg Taking Stations involved in the report.



1. Lake Darling.
2. Buffalo Lodge Lake.
3. Bald Hill Reservoir.
4. Valley City Federal Fish Hatchery
5. Lisbon State Fish Hatchery

CAPTIONS FOR GRAPHS

Plate 1. Relationship of hatching success at both the Lisbon and Valley City hatcheries to the number of hours of time elapsed between the time that the eggs were taken and the time that they arrived at the hatcheries. As in all of the following graphs, initials used stand for the place that the eggs were taken at. BL - Buffalo Lodge Lake, LD - Lake Darling, BH - Bald Hill Reservoir, and SR - Sheyenne River.

Plate 2. Relationship of hatching success at both the Lisbon and Valley City hatcheries to the distance in miles that the eggs were transported from egg-taking station to hatchery.

Plate 3. Average daily water temperatures at the Lisbon Hatchery during the hatchery operations. The solid line represents the average daily temperatures and the dots indicate the daily maximum and minimum temperatures. The upper graph shows the river water temperatures. The center graph shows the temperatures of the upstairs battery. Until April 22, the battery was run on river water that could be controlled. From that date on, it was run on unheated well-water. The lower graph indicates the temperatures of the basement battery. Until April 22, it was run on water from the upper battery. From that date on, it was run by gravity feed directly from the river.

Plate 4. Outside air temperatures throughout the hatchery operations.

Plate 5. Egg hatching success of groups run on the various types of water.

Plate 6. Turbidity of the river and well water throughout the hatchery operations.

Plate 7. A - Hatching success for groups from the various egg-taking stations at the Lisbon Hatchery. B - Average time the eggs from the various stations were tempered upon arrival at the hatchery. C - Average time the eggs from the various stations were hardened at the hatchery. D - Hours of time elapse between the time that the eggs were taken and the time that they were placed on the battery.

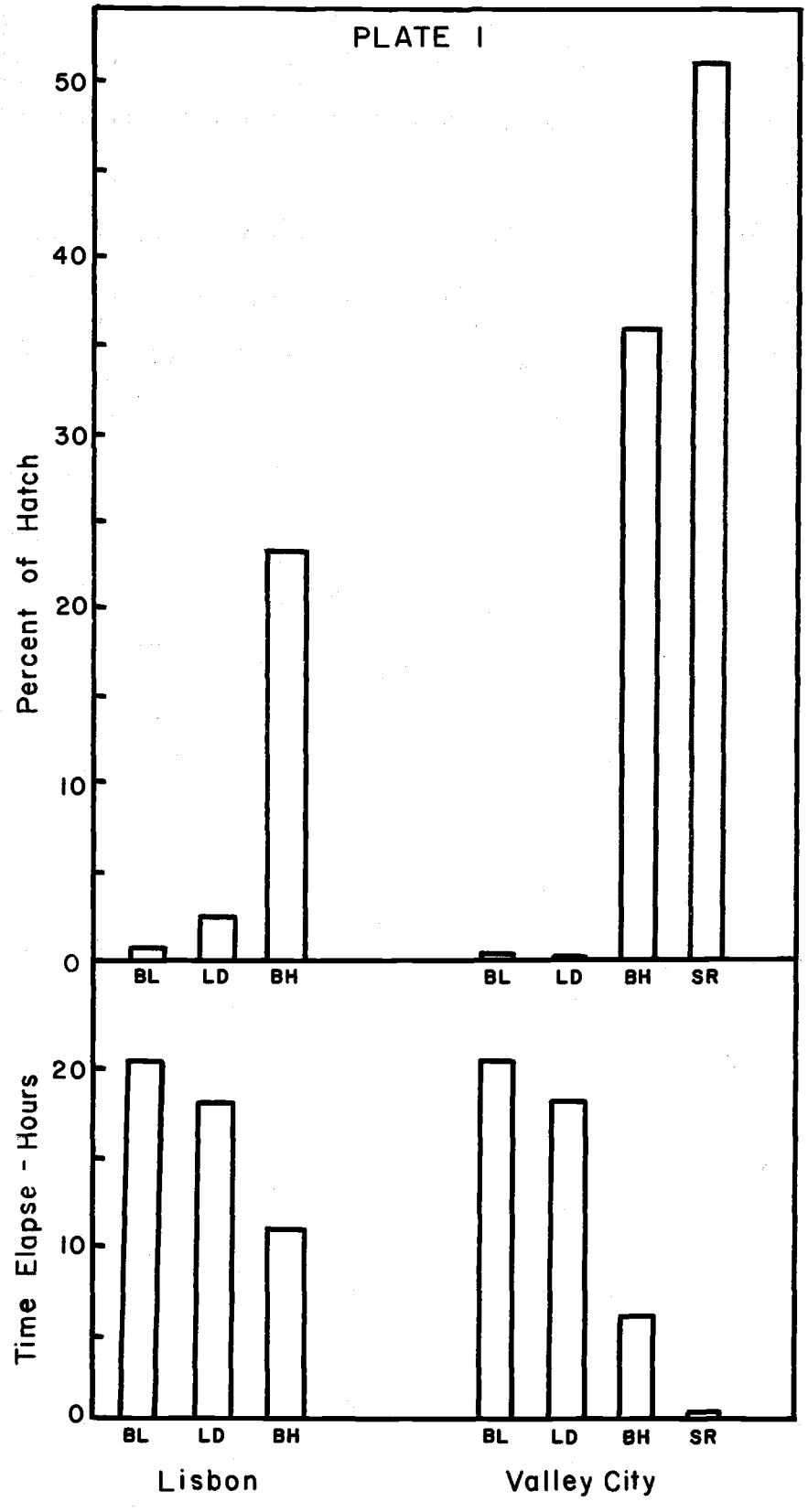


PLATE I
Percent of Hatch
50
40
30
20
10
0
BL
LD
BH
BL
LD
BH
SR
Time Elapse - Hours
20
10
0
BL
LD
BH
BL
LD
BH
SR
Lisbon
Valley City

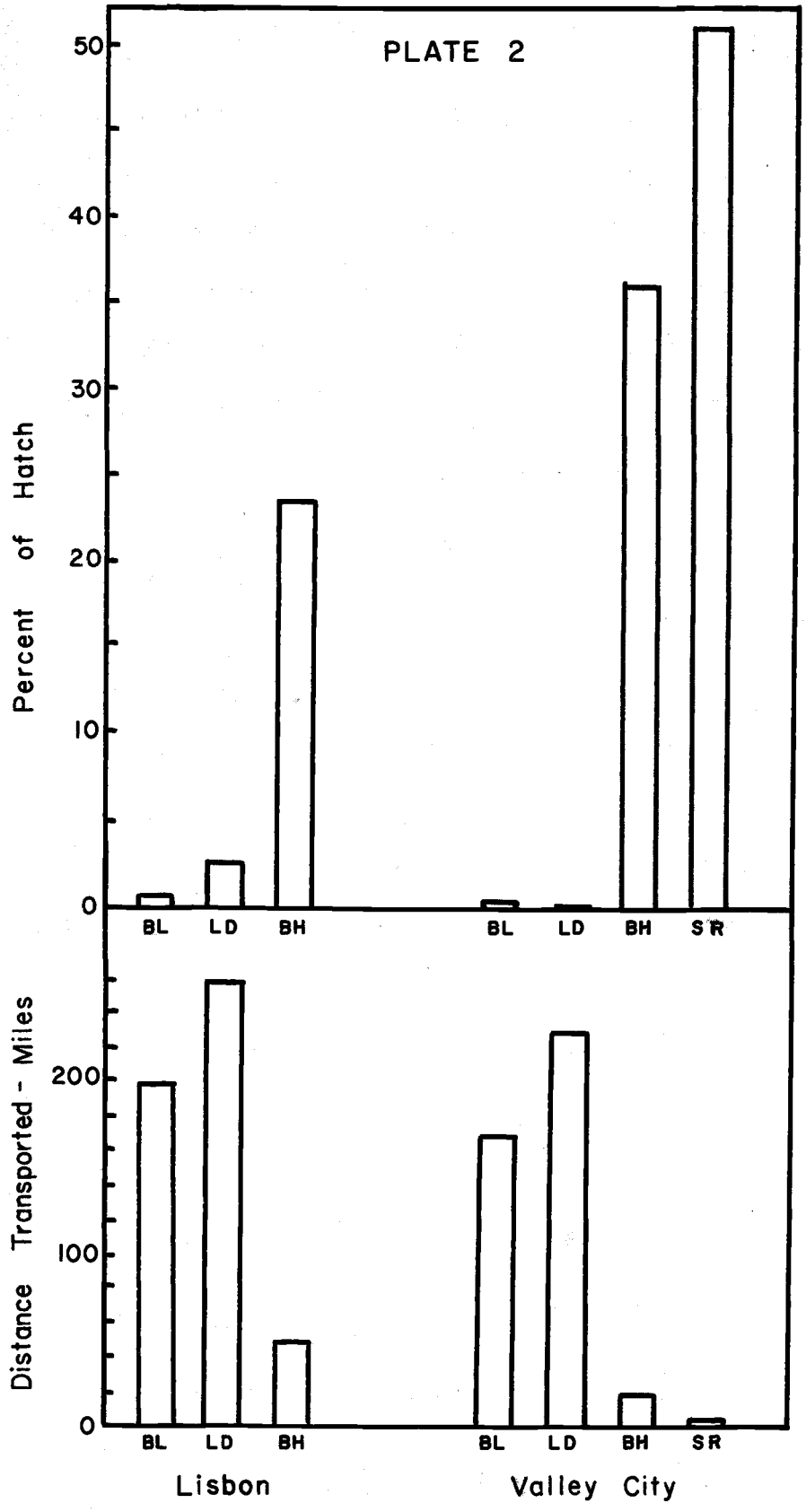
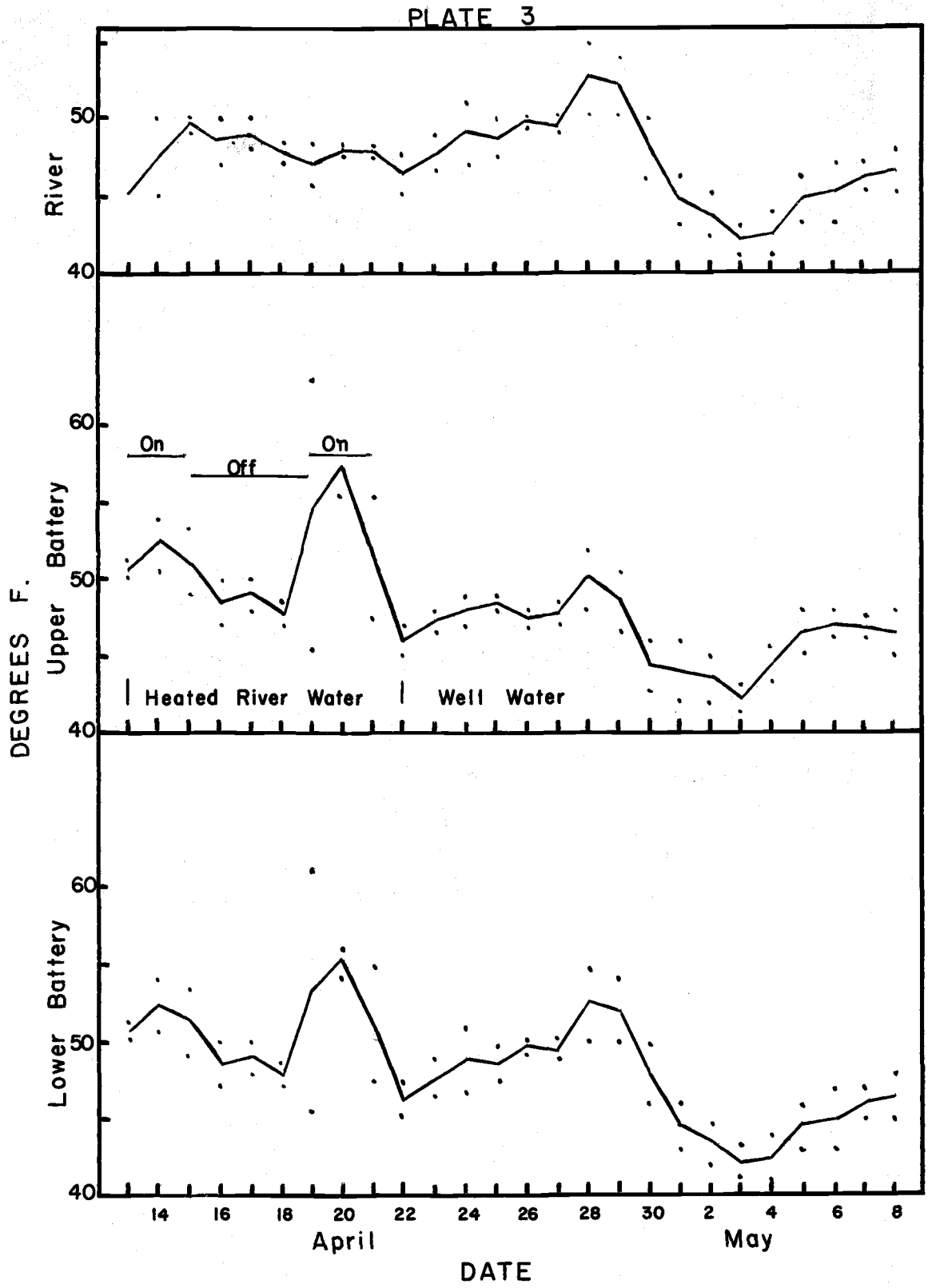


PLATE 2
Percent of Hatch
50
40
30
20
10
0
BL
LD
BH
BL
LD
BH
SR
Distance Transported - Miles
200
100
0
BL
LD
BH
BL
LD
BH
SR
Lisbon
Valley City

PLATE 3



AVERAGE DAILY WATER TEMPERATURES

PLATE 4

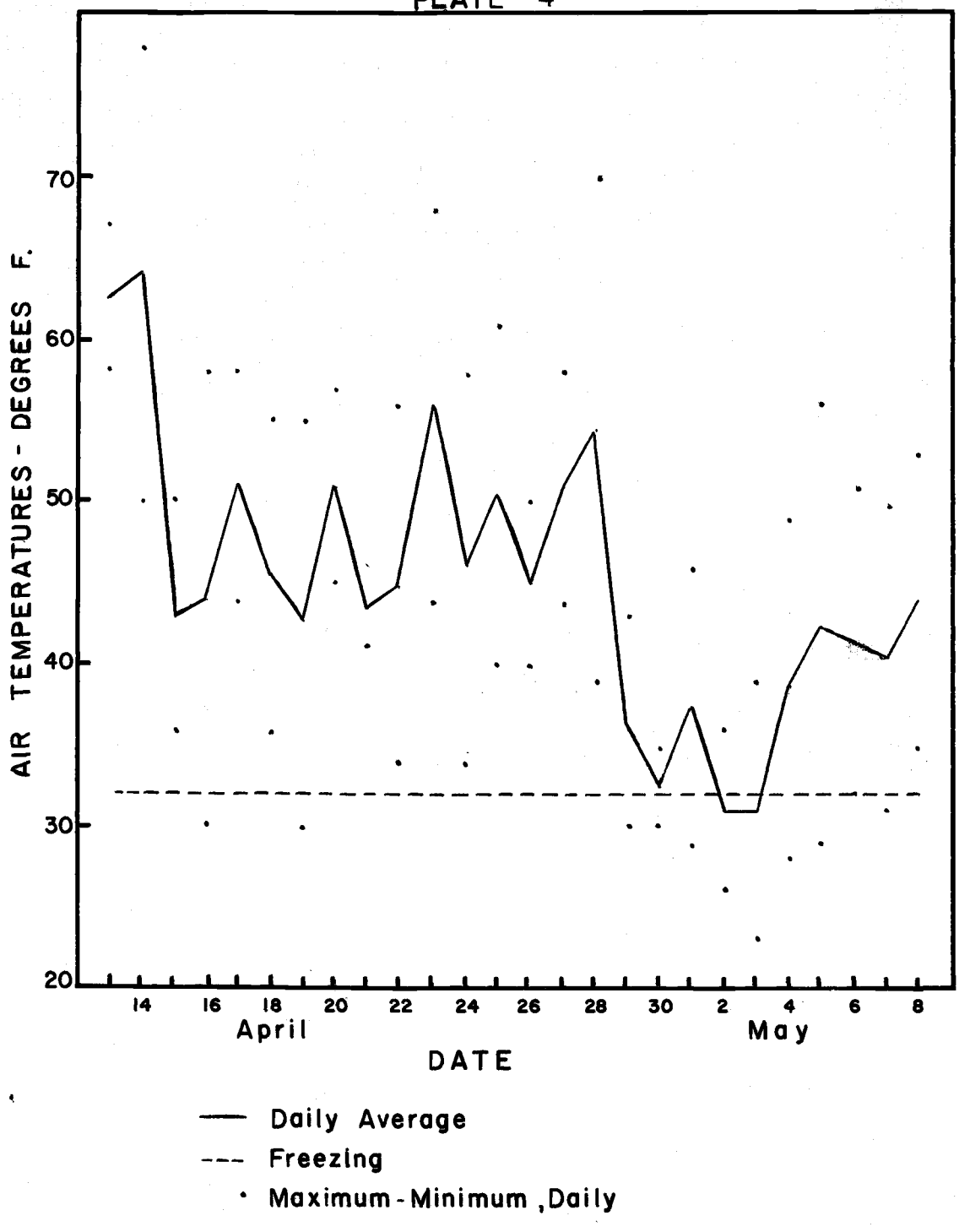

AIR TEMPERATURES - DEGREES F.
70
60
50
40
30
20
14
16
18
20
22
24
26
28
30
2
4
6
8
April
May
DATE
Daily Average
Freezing
Maximum - Minimum, Daily

PLATE 5

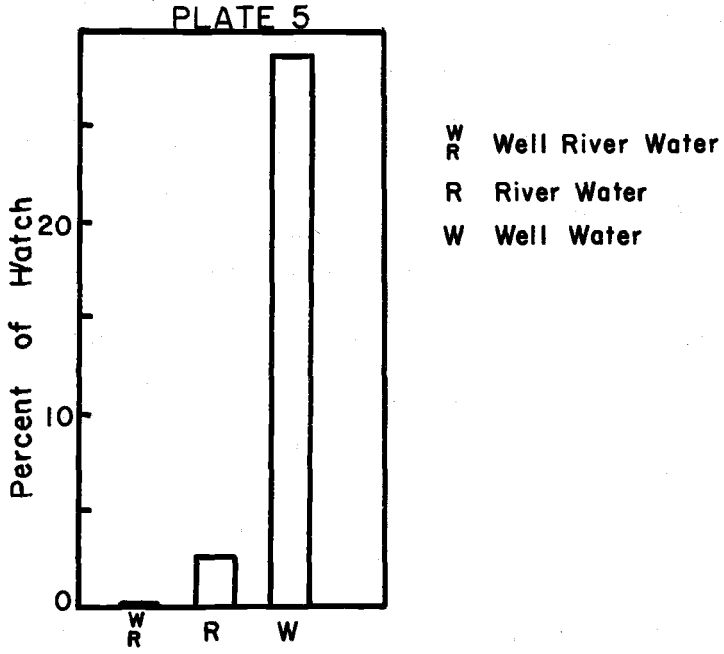


PLATE 6

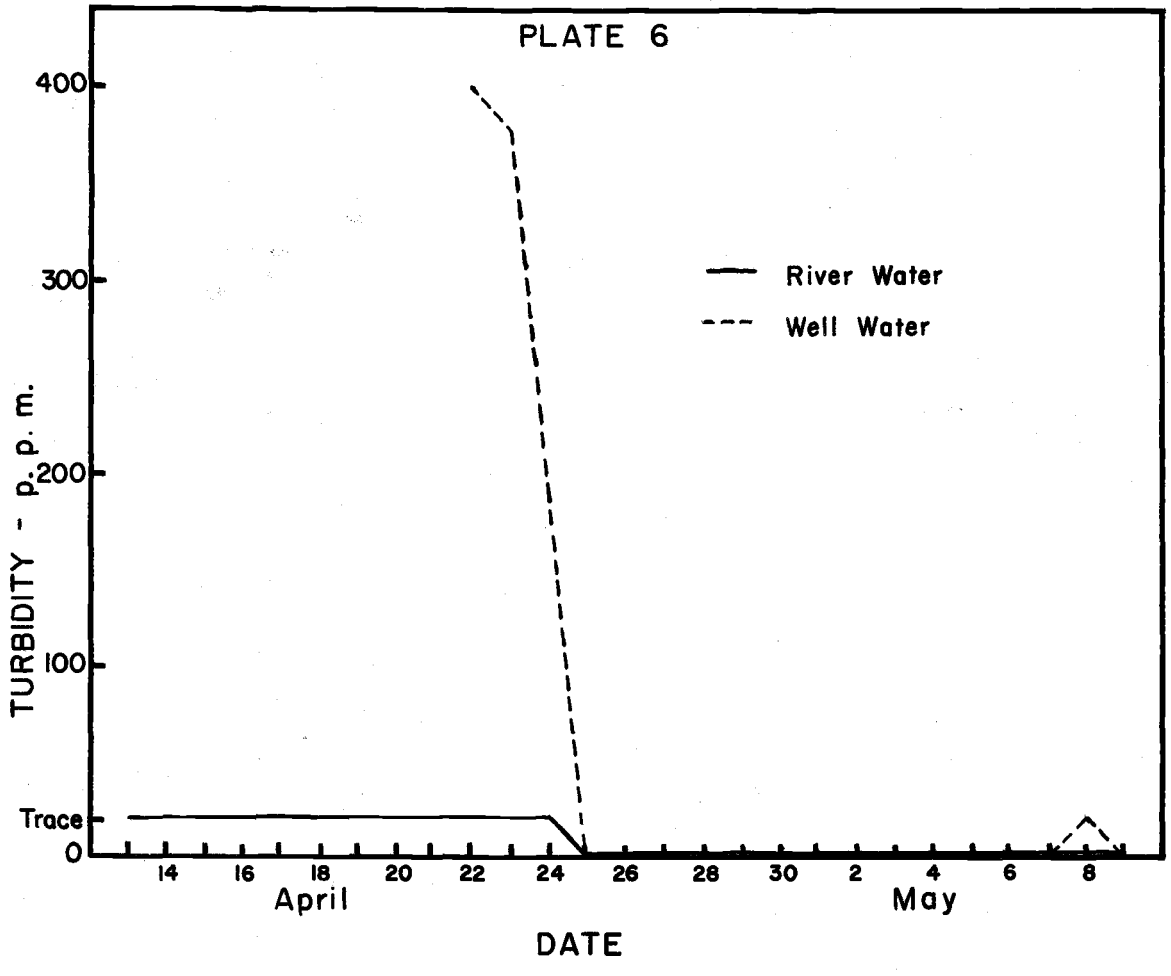
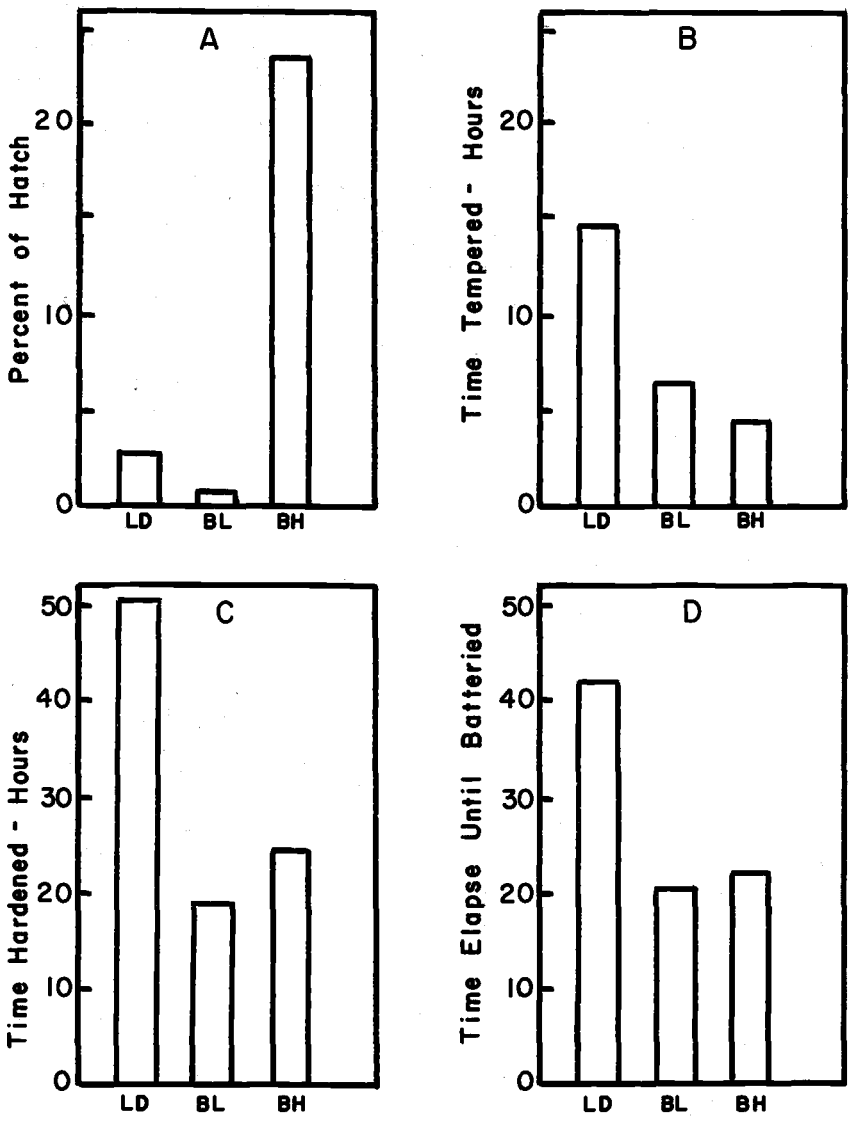
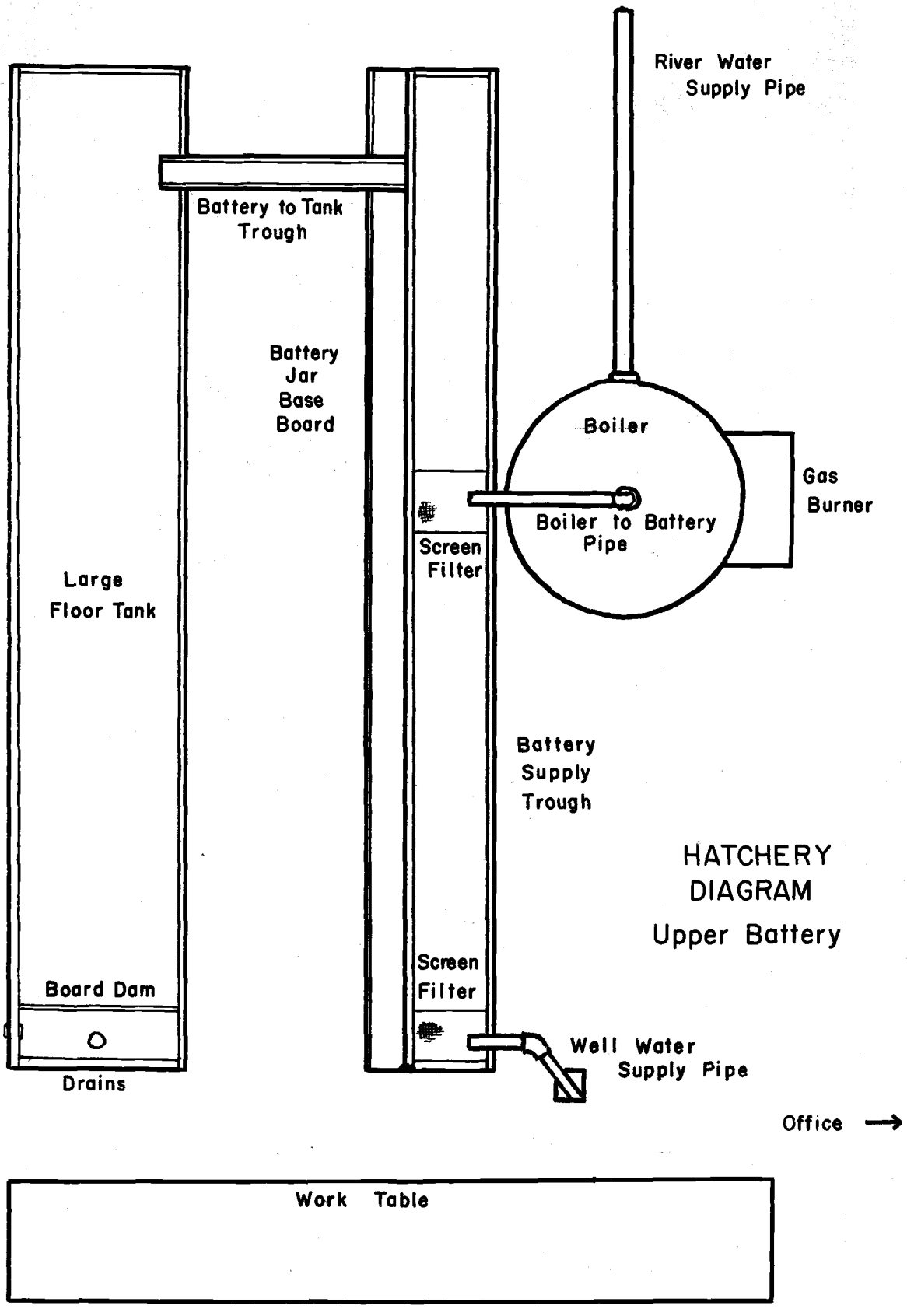
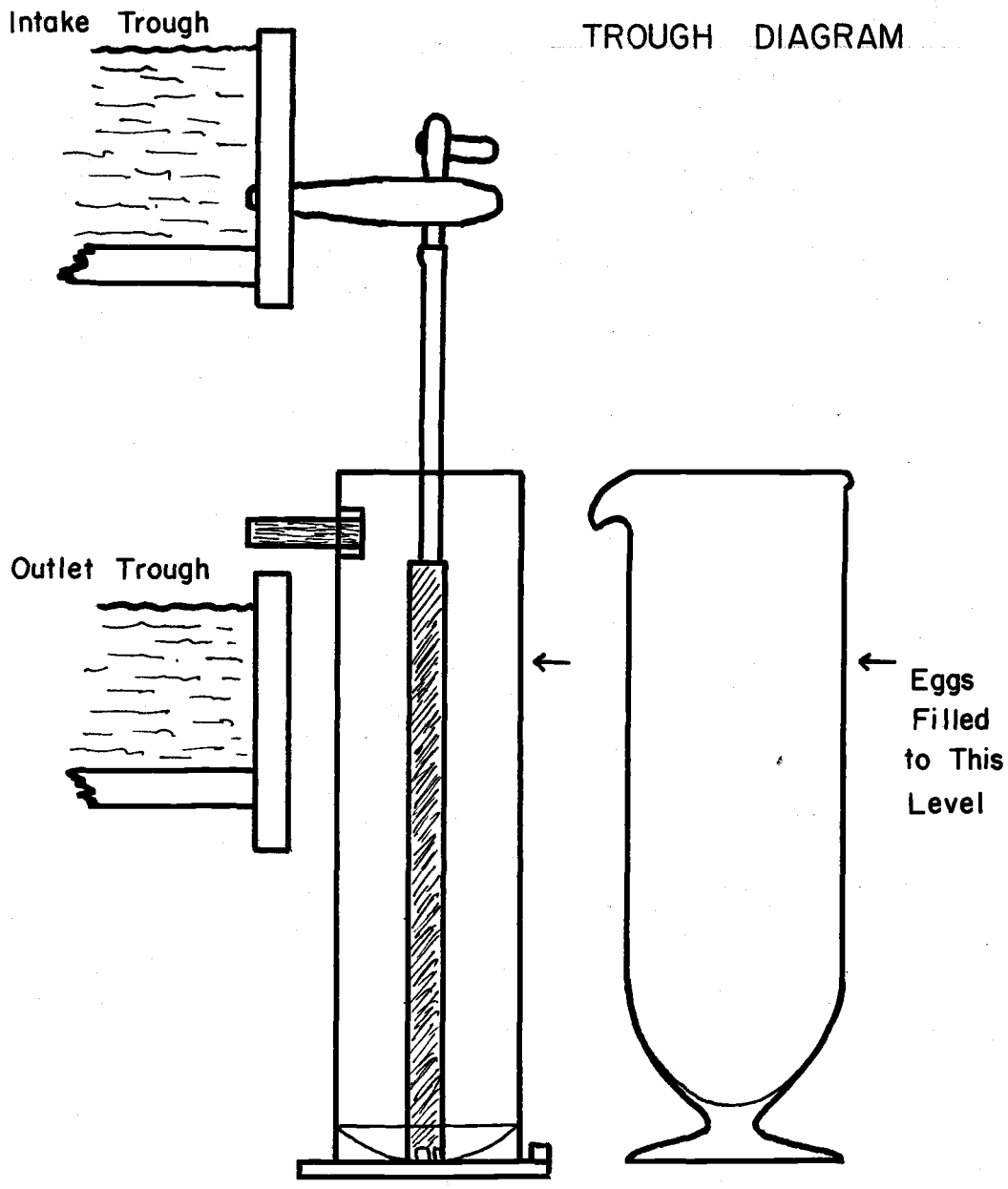


PLATE 7


A
Percent of Hatch
0
10
20
LD
BL
BH
B
Time Tempered - Hours
0
10
20
LD
BL
BH
C
Time Hardened - Hours
0
10
20
30
40
50
LD
BL
BH
D
Time Elapse Until Batteried
0
10
20
30
40
50
LD
BL
BH


River Water
Supply Pipe
Battery to Tank
Trough
Battery
Jar
Base
Board
Boiler
Gas
Burner
Boiler to Battery
Pipe
Screen
Filter
Large
Floor Tank
Battery
Supply
Trough
HATCHERY
DIAGRAM
Upper Battery
Screen
Filter
Board Dam
Well Water
Supply Pipe
Drains
Office →
Work Table

BATTERY JAR AND TROUGH DIAGRAM



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