Original: Fish Division
cc: Education-Game
Institute for Fisheries Research
R. S. Marks
J. A. Scully
C. T. Yoder
Drayton Plains Hatchery
J. E. Williams

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

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Report No. 1365

THE TECHNIQUES OF REARING FINGERLING WALLEYE AND MUSKELLUNGE AS PRACTICED BY WISCONSIN AND MINNESOTA, AND THE STATUS OF THIS PROGRAM AS A MANAGEMENT TOOL

By

John E. Williams

Abstract

The Michigan Fish Division has for several years been interested in raising predatory game fishes (walleye, pike and muskellunge) to fingerling size, on a limited scale, in order to experimentally stock them for maintenance, for control of pan fish populations, and to have on hand stock for introduction into new waters or for reintroduction where mortalities such as winterkill have occurred. Since Michigan's production of these predator fingerlings has not been consistently successful, the author visited the Wisconsin Fish Management Division to observe the techniques being used by them in raising muskellunge and walleye fingerlings. These techniques are discussed, and the methods used in Minnesota for rearing walleyes, as given in published literature and the Tri-State Fisheries Conference minutes, are outlined for comparative purposes.

Wisconsin muskellunge fingerling rearing is conducted at the Woodruff and Spooner hatcheries. Muskie spawners are trapped in natural lake bays, the fertilized eggs are hatched at the hatcheries, and the fingerlings are reared in hatchery ponds to a length of 4 to 8 inches.

Important considerations involved are: holding muskie fry until the yolk-sac has been absorbed before planting in ponds; control of insect, fish and amphibian predators in the ponds by rotenone poisoning and by surface application of fuel oil; furnishing the muskies with sufficient amounts of food, consisting of "water fleas" for the first week, sucker fry for the next few weeks, and minnows for the remainder of the season; cropping throughout the summer; and constant surveillance of the ponds for indications of developing hazards. Muskie fingerlings are produced in numbers approximating one half million yearly at a cost of about $0.10 each. A few yearlings have been raised experimentally but have cost over $1.50 each.

Wisconsin raises muskellunge principally for maintenance stocking in lakes in which the natural population has been (or is thought to be in danger of being) depleted either by heavy fishing pressure, predation by pike, or by winterkill; they are also occasionally stocked where predation is needed to correct an overabundance of stunted pan fish. In none of this stocking (except possibly for reintroduction after winterkill) has adequate research shown that this stocking has been beneficial.

Walleye fingerlings are raised in Wisconsin both in natural potholes, which are managed cooperatively with sportsmen, and in large, state-owned, drainable ponds. Both in natural and state-owned ponds fertilizer is added to promote growth of animal plankton, which serves as the walleyes' food, since forage fish are not added. The ponds are also cropped periodically during the season to give greater yield, and the total production normally is over a million fingerlings yearly.

Walleyes are raised in Wisconsin for much the same reasons as are muskellunge; again adequate research has not proved that raising walleyes to the fingerling stage before planting is significantly beneficial for maintenance or for the control of pan fish.

Minnesota's walleye rearing techniques are reviewed and are similar to Wisconsin's. Total production reaches over 5 million fingerlings annually. Although Minnesota was one of the first to prove that fry-planting of walleyes for maintenance was worthless, they have not adequately tested the effectiveness of their fingerling planting program.

Recommendation is made that Michigan continue and enlarge the experimental rearing of fingerling walleyes, pike and muskellunge for the purposes outlined above, using the ponds available at present and the more successful techniques discussed in the report. It is further recommended that fish reared during this program be used to adequately test the results of both stocking for maintenance and for pan fish control. If these stocking procedures are conclusively found to be valuable management tools, the program should be enlarged and research initiated to determine the rate of stocking and the lakes which need stocking.

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By

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The Michigan Fish Division has been interested for some time in the raising of predatory game fish, such as walleye, muskellunge and pike, to fingerling size. Certain other northern states, especially Wisconsin and Minnesota, have supported such a program for several years and previous to this (with Michigan) had been raising and stocking many millions of predator fry each year. The purposes of these plantings are said to have been fourfold; (1) to maintain the numbers of predatory game fish in lakes with heavy angler pressure, (2) to bolster predator populations in lakes where pan fish were overly numerous and consequently stunted, (3) introductive stocking where biological examination has indicated that one of these species is lacking but should do well, and (4) reintroductive stocking where mortality, such as winterkill, has depleted the population. So far neither Wisconsin nor Minnesota has presented evidence that purposes 1 and 2 have been accomplished by such plantings.

For several years Michigan has been raising walleye and pike fingerlings, and more recently has attempted to raise muskellunge fingerlings, on a limited experimental basis in order to have available supplies of these fish for possible control of pan fish populations, introductive stocking or reintroduction. However, Michigan's experimental program has not progressed too well, in that fingerlings have not been produced consistently in sufficient numbers.

Ponds used for fingerling walleyes at Drayton Plains Hatchery range from 3.7 to 7.8 acres in size. Complete failures resulted in 1951 in a 4.2-acre pond and in 1952 in a 3.7-acre pond. Ponds are usually stocked with fry (hatched from eggs secured at the Newaygo transfer) about May 1, and drained and harvested during the middle of July. Survival to the fingerling stage here in 1951 was 10% (21,500 fingerlings) and in 1952 was 1% (9,400 fingerlings). Production has varied from an average of 500 fingerlings per acre in 1952 to 1,130 per acre in 1951.

Walleye ponds at Wolf Lake Hatchery range from 3/4 acre to 4 acres in size. A failure resulted in a one-acre pond in 1952; however, it was suspected that this pond lost its fish to the next pond below, as the latter, stocked with only 12,000 fry, produced 10,000 fingerlings. Ponds at Wolf Lake were stocked about the same time as those at Drayton Plains and were drained at the end of June in 1952, producing 2-inch fingerlings. Survival of walleyes at Wolf Lake has varied from 1.3% (5,318 fingerlings from 400,000 fry) in 1951 to 17 1/2% (20,000 fingerlings from 114,000 fry) in 1952. Production in 1951 averaged 1,063 fingerlings per acre and in 1952 averaged 3,480 fingerlings per acre.

Pike fry were stocked at Drayton Plains Hatchery in 1950 and 1952 at rates ranging from 2,800 to 12,500 per acre in ponds ranging from 4 to 8 acres in size. The fry were stocked about the first of May, and the ponds were drained in July of 1950 and September of 1952, producing fingerlings from 6 to 12 inches in length. The survival of these fry to fingerlings was about 0.15 to 0.20% or 56 to 75 fingerlings from 30,000 to 50,000 fry. Production ranged from 4 per acre in 1951 to 17 per acre in 1952.

Experimentation with the propagation of muskellunge at Drayton Plains hatchery in 1951 resulted in the collection of 10,000 eggs; none of these hatched, due probably to infertility of the milt. In 1952, 15,000 eggs were secured of which about 6,000 hatched. These fry were placed in a small experimental pond, but probably due to a combination of warm water, predaceous insects and soft bottom, no fingerlings were produced.

Because of Michigan's inconsistent results in raising these predator fish to fingerling size, it was suggested during the summer of 1952 that the writer visit Wisconsin (at their kind invitation) and examine their methods of raising walleye and muskellunge fingerlings, and then report on the procedures being used there. Accordingly, in August, 1952, ten days were spent in northern Wisconsin visiting the Woodruff and Spooner hatcheries and discussing methods with Mr. Arthur Oehmcke (Area II Coordinator) and Mr. Clarence Wistrom (Area I Coordinator). At the same time information was gathered relative to muskellunge habits and habitat, in order to determine what type of water muskellunge do best in. This information may be used in selecting lakes to be stocked with muskellunge in Michigan, and will be presented in a later report. The wholehearted cooperation of Mr. Wistrom and the staff of both hatcheries and headquarters, and especially the considerable time and assistance given by Mr. Oehmcke, were greatly appreciated and should be reciprocated if the opportunity arises.

WISCONSIN MUSKELLUNGE PROPAGATION

Wisconsin's entire muskellunge fingerling production is carried out at two hatcheries--Woodruff (Area II Headquarters) and Spooner (Area I Headquarters); the two stations are located in the northeastern and northwestern parts of the state, respectively. Muskie spawn-taking started in the 1890's and fry-raising was continued until 1930 when a muskellunge fingerling rearing program was begun at Woodruff. In 1938 a rearing station was begun at Spooner, and ponds were placed in operation in 1939, numbering 20 by 1940. Not until 1941 was research initiated for the production of large numbers of fingerlings annually.

About twenty lakes in the Northeast Area and two in the Northwest Area have been netted in the spring for spawners. Muskies spawn either in shallow, weedy lake bays or in the muck-bottomed, snag-filled backwaters of inlet and outlet streams. Netting is confined to lake bays because these areas are usually more accessible and easier to net. As soon as the ice goes out in the spring (usually during the last half of April), frame hoop (fyke) nets are put in. A 50-foot lead is anchored to shore, and the net is set perpendicular to shore in 2 to 5 feet of water. Wings are generally not used. The nets are checked only in the morning, for muskies usually do not enter during the day. If predominantly one sex is taken by the net, the excess is released. Some fish are occasionally left in the net as decoys. Usually at the beginning of the season most fish will be green, and these are all released near the net. A large, wide-beam, flat-bottomed boat with square bow and stern is used to lift nets. As the muskies are dipped out of the net they are placed in a small (200-gallon) stock tank in the boat. As many as 46 muskies have been taken in one lift. In Area II in 1952, a total of 7 nets fished in 3 lakes for 13 days, capturing 288 muskies of which 197 were males. Area I nets caught 389 fish of which 52 were ripe females. The spawning season usually lasts from one to two weeks and runs from about the last week in April to the first week or two in May, or whenever the water temperature of the bays reaches 50° to 55° F.

The method of stripping and fertilizing muskellunge eggs is similar to that used for trout or pike. A ratio of 3 to 4 males to one female is preferred as the males usually emit very little milt. Five or six small dishpans, 10 inches in diameter and 3 1/2 inches deep, are used to collect small amounts of eggs. About 8 or 10 ounces of eggs are introduced into the moistened (with olive oil, etc.) pan by applying pressure to the belly of the female. Two men are needed to strip the fish, one man holding the head of the fish toward him by grasping a pectoral fin in each gloved hand. The second man holds the tail of the fish with his left hand and strips the eggs with his right. After the eggs are secured in the pan, the female is returned to the tank and a male is handled in the same manner. If 2 to 4 cc. of milt are not forthcoming from the male, enough males to give this amount are stripped. Fifteen to twenty ounces of fresh lake water are then added to the pan in order to activate the sperm for proper fertilization. (Only enough water to cover the eggs should be used, in order to keep dilution of the sperm to a minimum). The pan is set aside for 5 to 10 minutes while other pans are filled. After all 6 pans have been filled and as the eggs begin to mat or jell, the milt is washed off and fresh water is added. After the eggs have been thoroughly cleansed by 4 or 5 washings in the small pan, they are added to a 15-quart pail containing fresh water. The eggs are deposited in the container by floating from top to bottom. They rest in this pail for 1 to 2 hours, with several washings during this period, before being transported to the hatchery. Mr. Oehmcke feels that, while the eggs are always sensitive to jarring, they are extremely so during the first few hours and should be handled carefully during this time. It is also believed that the milt should be put on the eggs as soon as possible, but if the eggs were kept dry there would probably be little harm in a delay of 5 minutes or so. No materials such as chalk or clay are added to prevent sticking, for if the above method is followed, the eggs will separate after 30 to 40 minutes. It is important when stripping the fish into the pan, that no mucous be introduced as it will clog the micropyle of the egg and prevent entrance of the sperm.

Method of Hatching

At the hatchery the quantity of eggs is measured by a 32-ounce graduate and the eggs are then introduced into 4-quart hatching jars. The water-hardened eggs number about 45,000 to 50,000 per fluid quart. The eggs are incubated in these standard hatching jars for a period ranging from 8 to 20 days, depending upon the water temperature, which at Woodruff Hatchery is usually around 67° at this time. Success in hatching has varied from 50 to 90%, with an average of around 75%.

Description of Ponds

Woodruff Hatchery is supplied by gravity from a natural lake and has a total of 14 ponds, of which 4 are experimental and .07 acre in size. The remaining 10 production ponds vary from .08 acre to 3.5 acres. However, the 3.5-acre pond (Fig. 1) is much larger than the rest; the remaining nine ponds, which produce the bulk of the fingerlings, average .27 acre. The 3.5-acre pond has been dropped from production of fingerlings because of continual poor production. It is felt that small ponds are much more successful, and the acreage under production at Woodruff since 1943 has averaged about 2 acres per year. Both the inlets and outlets of all ponds are screened to prevent the loss of muskies and the introduction of other fish. However, no filtering system is used; such a system is regarded as unnecessary because fry that enter before stocking are killed by rotenone and those that enter afterward grow slower than the muskies and thus serve as food. The ponds slope gradually from a depth of 2 feet at the intakes to 5 1/2 feet at the outlets. All ponds have hard gravel bottoms and the sides of some are rip-rapped. Although the hard bottom is maintained, aquatic plants (mostly waterweed or elodea (Anacharis canadensis), coontail (Ceratophyllum demersum) and some pondweeds (Potamogeton sp.)) are present but kept down so that they do not form dense beds.

The Spooner Hatchery has a total of 16 ponds, twelve of which, with a combined area of 20 acres, are used for muskellunge fingerlings. These ponds are supplied by two intakes from the Yellow River Flowage and the water passes down a concrete flume to the inlet bulkhead of each pond. These inlets, as well as the outlets, are supplied with fish screens, but in addition both intakes have been rebuilt to allow flow through filter chambers. These underground chambers, oval in shape (about 15 feet x 10 feet x 5 feet deep), contain a filter running the length of the chamber. The filter resembles a wall or dyke, the sides of which are reinforced heavy screen while the center is a 2-foot layer of crushed rock. The filters have not been impervious to fish, however, for perch fry found their way into the ponds last spring. These ponds, as those at Woodruff, are hard-bottomed with rip-rapped sides and contain scattered vegetation (Fig. 2).

Pond Preparation and Control of Aquatic Predators

All ponds which are not being used for yearling production are drained at the end of the fingerling harvesting (August or September) and are left empty until the following spring. They are cleaned of muck and weeds after draining. Keeping ponds empty has the advantage of controlling muskrat populations. However, many of the ponds can not be drained thoroughly, and these small pockets of water are capable of harboring minnows and insect larvae for long periods. Before any means of controlling predators were tried on these ponds, production was nearly always distressingly small, averaging 4.6% of the fry stocked. Final harvesting and draining of these poor-producing ponds usually showed large numbers of insect larvae, sticklebacks, tiger salamanders or mud puppies. Most common among the insects were the predaceous diving beetles (Dytiscidae), whose larvae are called "water-tigers." There are many species, ranging in size up to 1 1/2 inches in length in the adults, and both adults and larvae are very predaceous on young fish. Other aquatic insects present which were predaceous on fish included the larvae of the whirligig beetles (Gyrinidae), the larvae and adults of the water-scavenger beetles (Hydrophilidae), the adults of aquatic bugs such as the electric light bug (Belostomatidae), water-scorpions (Nepidae), back-swimmers (Notonectidae), and water-boatmen (Corixidae) and the nymphs of the dragon- and damsel-flies (Odonata). Advanced dytiscid larvae have been noticed killing 4- to 5-inch muskie fingerlings, and experiments at Spooner have shown them capable of catching and killing 4 muskie fry/hour throughout a 24-hour day. Similarly, sticklebacks make serious inroads on fry, but after the fingerlings have reached 2-3 inches they begin to feed on the sticklebacks.

Wisconsin is convinced that its increased production of fingerlings in recent years is the result of the almost complete control of these predators. In fact, predator control is rated second only to food supply as a necessity for large-scale survival of fry to fingerlings. Predators not only kill the muskies themselves but can seriously reduce the numbers of forage fish introduced for the muskellunge. Since predator control was adopted, the number of forage fish needed to produce each muskie fingerling has been reduced 75 to 85%.

The best method of controlling sticklebacks and other fish which may winter-over in the ponds is by poisoning with rotenone. Accordingly, applications of rotenone are made to all pockets and wet areas before the pond is filled in the spring. Although no figures are available on the concentration of rotenone used, about 15 pounds of 5% rotenone were used in 1952 to spray the regions of the drained ponds which still contained water. Of the total 3 acres of pond, probably less than 1 acre needed poisoning. Needless to say, the rotenone is applied at a rate which is considered more than adequate to kill even the most resistant fish. Larval tiger salamanders (which hatch about the end of April), both immature and mature mud puppies, dragonfly nymphs and whirligig beetle larvae are all killed by rotenone since they are gill breathers. A large number of dragonfly nymphs in a pond has been known to cut the production of fingerlings (smallmouth bass) by 50% (Kingsbury, 1937). After poisoning, the ponds are flushed out and filled with water. The ponds are then treated with commercial fuel oil to kill the larvae and adults of insects which must come to the surface to breathe. The oil forms a heavy film on the surface and kills the insects either by direct contact or by preventing their breaking the surface film. Chief among those killed in this manner are the larvae and adults of the diving beetles, and the nymphs and adults of the bugs such as back-swimmers, water-boatmen, etc. Ponds in Wisconsin are treated with fuel oil either by pouring it on the windward side or by spraying from the bank on small ponds. Meehean (1937) recommended pouring the material on the windward side; when the oil was sprayed on the results was a film too thin to control anything but the smaller insects. Kerosene and a mixture of one part cod-liver oil to three parts gasoline has also been used for this purpose. Fish oil alone will not kill by contact and often the smell is objectionable. Fuel oil has the disadvantage that it will kill some daphnia, but if it is applied before the daphnia are introduced, this undesirable effect should be overcome. In 1952, Woodruff Hatchery used 34 gallons of fuel oil for 2 1/2 acres of pond, or about 14 gallons/acre. If the fuel oil is sprayed on the ponds it should be done on calm days. Fuel oil can be applied to the ponds as soon as they are refilled after poisoning. After a few days, the water can be run through the ponds for some time and the inlets then closed so that the pond may "work" before the addition of fry. The fuel oil will not harm fish when applied in this manner, therefore if concentrations of insects are noted at a later date a second application can be made.

Ponds which have been completely drained and dried are no protection against many of the insects, as eggs and pupae can resist considerable periods of drought. For this reason, dragonfly nymphs may appear again, after poisoning of the ponds with rotenone, and it may be necessary to treat the ponds with rotenone in the fall (after the fish have been removed, and before final draining) to keep their numbers down the next year.

Constant checking of the ponds is necessary to observe increases in predaceous insects, as a sudden "hatch" of eggs or transformation of pupae may increase the population tremendously from one day to the next; if the fish are in a susceptible stage (particularly fry) their numbers can be reduced rapidly. Any fish found dead in the pond should be examined carefully for evidence of insect attack, as many insects do not consume the entire fish. Back-swimmers and other aquatic bugs only suck out the juices, and no visible sign may be in evidence as to the cause of death. Diving beetles, however, which also only suck out juices, will usually leave small mandible marks on the ventral side near the head. Fish killed by dragonfly nymphs are usually distinguishable, as this nymph only eats the soft stomach tissue. If evidence is found of heavy dragonfly nymph predation, after the fingerlings have reached several inches in size, it may be quite worthwhile to remove and plant the fingerlings immediately. Since the nymphs of dragonflies and the larvae of diving-beetles usually attack fish from perches in vegetation, the absence of vegetation in the ponds should help to prevent loss.

Sweeping through vegetation or along the bottom with a fine-mesh scap net will reveal the larvae and nymphs of insects if they are present in any numbers, and adult beetles and bugs can be seen under close observation. Wisconsin makes it a practice to check each pond daily for evidence of mortality (as well as other conditions), and somewhat less often for insect predators. Probably semi-weekly checks on insect numbers would be none too often.

Of course, if very few surface breathing insects are present in the pond at the start of the season, it may not be necessary to apply the fuel oil. Woodruff Hatchery found that after application to all ponds in 1946, only 2 ponds warranted this treatment in 1947. However, insect populations may increase greatly by the time the crustacea and muskie fry are added and, if this is the case, it is recommended that a kerosene emulsion (1 part kerosene to 3 parts fish oil) be applied to avoid killing the crustacea.

Fertilization

The two Wisconsin hatcheries are not in accord as to the value of fertilization of muskie ponds, and this difference in opinion is traceable to different techniques. The Spooner ponds are assumed to maintain a stock of daphnia from year to year, and none are introduced during the muskellunge fry stage; instead, the ponds are fertilized in order to bring about a "pulse". Currently at Spooner, commercial fertilizer of a 6-12-8, 6-12-12 or similar ratio is applied at the rate of 100 pounds/acre as soon as the ponds are filled in the spring. They admit however, that often no "bug" life is apparent in the ponds when the fry are in the crustacea-feeding stage. Also, algae troubles are frequently encountered later in the season, as a result of fertilization. The green alga, Hydrodictyon reticulatum, is the most destructive to fish, sometimes forming such heavy mats that thousands of fingerlings become enmeshed. Algae in their ponds have been controlled by serial treatment with $CuSO_4$, in which 0.33 ppm. of $CuSO_4$ is added to the water supply each day for 5 days. This has resulted in the killing of the algae completely but slowly enough so that its decomposition does not affect the oxygen supply. Fish are not harmed by this small amount of $CuSO_4$, but would be if the dosage were much higher. This is a dangerous procedure, for the chemistry of the water determines the amount of $CuSO_4$ to be used, and an amount which is not lethal in one situation may have this effect in another. (O'Donnell, 1943).

The only need for fertilization is for the production of crustacea; the suckers or other forage fish added to the ponds ordinarily don't last more than a few days before being eaten by the muskellunge. Thus no concern is necessary for providing these fish with food.

Woodruff does not fertilize its muskellunge ponds and does not depend on the inherent fertility of the ponds to produce crustacea. Instead, when muskie fry are ready to be planted in the ponds, large quantities of crustacea are introduced at the same time and for 10 days thereafter. (see forage page 19). Mr. Oehmcke feels that too often natural "pulses" in the ponds are either past or (usually) not yet at their peak at the time the fry depend on them. He is considering dividing off small corners of the pond and covering with glass in order to force cultures along more rapidly. Another possibility being considered is to operate two ponds as a unit, one strictly for the culture and the other for muskies. In this way it is thought one pond could be shallower and fertilized for crustacea, and then the culture could be transferred to the muskie pond when needed.

Perhaps it might be more economical of pond space to combine the two projects in one pond, blocking off part of it for daphnia and perhaps protecting it in some way from cold nights.

Fertilization has been tried at Woodruff, with soybean and cottonseed meal in 1942 and combinations of superphosphate and sheep manure in 1943, but the fertilization always worked too slowly at the low water temperatures during the early part of the rearing season. Thus no increase was noted in the crustaceans until after plankton-feeding by the fry was completed.

Care of Fry from Hatching until Planting in Pond

At Spooner, muskie fry are held in the hatching jars until the yolk-sac disappears and they swim up in the jars. (Muskie fry are unable to swim up after hatching until they have absorbed their yolk-sac. Placing them in a pond immediately after hatching might result in smothering on soft bottom). However, this method is a ticklish procedure, for if too much water is run through the jar, the first fry to swim up will likely be lost; if too little water is circulated, the fry are liable to smother. Consequently, what usually happens is that as soon as some of the fry are swimming up (temporarily) they are all added to the pond. The result is that many are not apt to resist predation or smothering. At Woodruff, considerable experimentation has been done concerning the best method of holding fry until the correct time to plant them in the ponds. Until recent years the method used consisted of putting the hatching jars, still connected to the water supply, in small aquaria as soon as the fry hatched (Oehmcke, 1949). Thus, as each fry lost its yolk-sac and was able to swim up the jar and over the lip it was confined in the aquarium. Before the eggs hatched, when the embryo was well formed and the shell still firm, they were measured and the allotment for each pond placed in a separate jar. Swimming fry usually did not appear in the aquaria until 11 to 15 days after transferal. After they had been swimming up for at least 2 days in the pond aquaria, they were placed in the ponds. However, the aquaria had a distinct disadvantage in that fry would often, with a burst of energy, clear the lip of the jar, get into the aquarium and settle to the bottom. Large numbers of the fry doing this before they had actually become free-swimming resulted in piles of them accumulating in corners and suffocating. Any silt in the water supply also settled to the bottom of the aquaria and increased the possibility of suffocation. Using this method of Wisconsin's at Drayton Plains Hatchery during 1952 resulted in the loss of 50% of our muskellunge fry for these same reasons.

Woodruff has now remedied this situation with a method very similar to New York's technique of placing the fry on hatching trays. The method involves placing the pond jars (hatching jars with each pond's allotment) in a screened box, instead of an aquarium, with the box resting on legs in a concrete tank. The jar and box are arranged in the tank so that the water level is about three quarters of the way up the jar and box. The jar rests on narrow boards so that the bottom of the jar is off the bottom of the box. The screened box is about 30 inches high, 24 inches wide and 42 inches long, but specifications were arranged so that several boxes would fit each concrete tank. The lip of the hatching jar is fitted to a rubber tube by a tin sleeve, to allow fry and water to enter the box near the bottom with a minimum of disturbance. The box is screened on all four sides and the bottom with 30-mesh bronze or copper screening. Thus adequate circulation of water is available, no silt collects in the bottom and smothering is avoided.

Every day fry which are swimming strongly are collected and placed in the respective ponds. The fry are carried in a large tub and are dipped from this into the pond, using a small boat to reach all parts of the pond. Before stocking ponds several fry are placed in each, in a screen box, for a day to be sure that the ponds are no longer toxic after poisoning.

Although fry are not placed in the ponds until 1 to 2 weeks after hatching, they are in no danger of starvation as long as some of the yolk-sac can be seen. In fact, their jaws do not completely form until the yolk-sac is about gone. However, once the yolk-sac is used up, they must have adequate food immediately, or they will starve in a few hours.

Fry-Stocking Rate in Ponds

At the present time Woodruff Hatchery is stocking ponds at the rate of 150,000 muskie fry per acre and Spooner at 100,000 per acre. Spooner, having more pond acreage, can use a smaller rate and increase the space factor somewhat. At Woodruff various rates of stocking, ranging from 14,000 to 750,000 fry/acre, have been tried experimentally. Results indicated that good survival was obtained throughout this range. However, some ponds planted at 130,000 to 160,000 fry/acre produced large numbers of good size fingerlings, and these ponds were much easier to manage and keep supplied with forage fish than were those stocked at a higher rate. The rate is, therefore, determined somewhat by the amount of forage available for the season, as well as the number of muskellunge fry available. Surplus fry are usually on hand, however, and these are stocked where it is considered more fry can be accommodated.

Forage

As soon as the muskellunge fry has absorbed its yolk-sac, it begins to feed on zooplankton, especially Cladocera or "water fleas". Since the small fry are not very mobile, it can be realized that for the first few days at least the fry are not able to search far for food.

Food must be available nearby and in sufficient amounts.

The most common "water flea" in muskie waters near Woodruff is a Polyphemous spp., and it has been found that the muskellunge definitely prefers this form over Daphnia spp., which make up the usual hatchery live-culture of "water fleas". Daphnia are definitely harder shelled than Polyphemous, which may be the reason for the preference. Elson (1941) found that in Ontario Polyphemous pediculis was the most common food in the stomachs of naturally produced muskellunge under 1 inch in length. Another common crustacean in natural waters which might be thought to be muskie fry food is the shell-less Copepod Cyclops. However, Wisconsin has found that muskie fry will not touch this Copepod.

Just preceding the pond stocking of fry, and for 10 days thereafter, Woodruff Hatchery keeps a tank truck busy hauling Polyphemous from nearby ponds and flowages where it is common. Shallow, warm, protected bays with no current and a mucky bottom are the best habitat of the "fleas". Other locations not mentioned by Wisconsin, but often teeming with crustaceans, are shallow, temporary woodland pools. Only a little leg work would be necessary to locate enough places so that the animals could usually be found when needed. However, waters can be "alive" with the organisms one day, and a week later few may be found. Therefore, there is a possibility that a hatchery culture that could be controlled, so as to bring on abundance at the proper time, would be an additional and/or more reliable supply. The Polyphemous are collected with silk bolting cloth seines, and 3 or 4 tank loads are added to each pond. (How much is a tank load of this material is a moot question!) Of course, the ponds have been shut off since poisoning, and the water is kept off until the muskellunge and forage are past the fry stage.

Muskellunge fry, if they have plenty of "water fleas", will grow rapidly, and in 7 to 10 days after beginning to feed they will have grown enough to prey upon small fish fry. From this point on, they will refuse to feed on the crustacea. Cannibalism will begin, to a large extent, soon after they reach 1 inch in length, unless an abundant supply of other species of fry are present. Thus, fry of the forage species should be planted in the pond about one week after the muskie fry are put in.

Wisconsin raises suckers and redhorse to the fry stage for feeding muskellunge. These are usually hatched at other hatcheries and trucked into Woodruff and Spooner when needed. The ideal procedure for accumulating sucker fry as forage is to gather eggs on staggered dates. If this can be accomplished, there is then no peak of the hatch coming off at any one station, and sucker fry plants can be staggered to coincide with the various hatches of muskie fry.

The initial plant of 2 to 3-day-old sucker fry is placed in the pond slightly before the muskie fry are ready to feed on them. If they are placed in the ponds immediately after hatching, there may be a high mortality of suckers. The first plant of forage fry is at the rate of 500,000/acre, when muskie fry are stocked at 150,000/acre. A few days later, or as they hatch, follow-up sucker fry are stocked at the rate of 10,000,000/acre.

As soon as hot weather begins, the pond inlet is opened, and 30-35 gallons of water per minute is allowed to flow through the pond to keep it from getting too warm.

After the muskellunge reach a length of 2 inches, shiners, fathead minnows or redbelly dace are introduced to the rearing ponds to supplement the food supply. To reach a length of 6 inches, one muskie fingerling is estimated to consume 300-500 forage fish in 60 days; therefore, in ponds producing large numbers of fingerlings it is necessary to add from 10,000-20,000 shiners, or other minnows, per acre at 3 to 4 day intervals (Oehmcke, op. cit.). In 1952, at Woodruff, 154 tank loads, estimated as containing 3,000,000 shiners and other forage fish, were added to about 2 1/2 acres of fingerling ponds. This introduction was, of course, supplemented by many of the suckers planted as fry, which had evaded capture and grown to larger size.

Although the eggs are often difficult to obtain in numbers, redhorse and cisco eggs have also been hatched in time to serve as fry-forage for the muskies. In general, sucker eggs taken in the north hatch at about the correct time for muskie fry feeding, but those taken in the south are usually farther advanced and are kept in ponds to be fed to the larger muskie fingerlings. It requires 7,000-8,000 quarts of sucker eggs to satisfy the muskellunge program, and suckers in enough numbers to supply this many eggs are gotten mostly from fish taken during the spawning season by rough fish removal crews.

In general it is considered best to stock sucker fry on the basis of "muskie fry stocked" rather than on a "per acre" basis. The rate of 100 sucker fry per muskie fry generally gives the best results. Since the number of larger forage fish required is dependent on several factors, such as number of muskies, length of rearing season, size of forage fish and size of pond, no rate of application is considered. The ponds are simply watched carefully throughout the season, and forage fish are stocked whenever the appearance or action of the fingerlings indicates the need.

An idea being considered at Wisconsin is that of dividing a pond, or connecting two ponds, by a screen. Muskies would be kept in one and suckers in the other. The size of the screen would be changed, as the muskies grew larger, to allow suckers of the best size to pass through as food. This would allow fertilization of the sucker pond (possibly connected with raising crustacea) to produce growth, and their numbers could be easily estimated. There is a possible disadvantage in this plan, however, since the muskies might congregate at the screen and, if suckers were slow in coming through, cannibalism might result. Another possibility being considered is to stock perch eggs, as collected from lakes, in the muskie ponds so that the perch, after hatching, would serve as food. However, muskie fingerlings much prefer suckers and shiners to perch and possibly would prefer each other over perch.

Spooner Hatchery's methods differ from Woodruff's in that "water fleas" are not added each year to the pond; instead a pond is fertilized to produce large numbers of *Daphnia magna* which winterover in the pond (see Fertilization, page 11). In 1952, a total of 200,000,000 suckers were stocked in Spooner's 20 acres of ponds, in which 2,225,000 muskie fry had been stocked (close to Woodruff's ratio of 100 suckers/muskie fry).

Caution should be exercised in the handling of suckers and shiners, as those which are bruised in seining, or handling, are likely to become badly fungused in the ponds. It is believed in Wisconsin that certain heavy mortalities of muskie fingerlings, after introduction of forage fish, were traceable to the eating of fungused fish (Oehmcke, *op. cit.*).

The proper food, in large enough quantities, at the correct time, is probably the most important factor in successful muskellunge fingerling rearing, and it can not be too greatly emphasized that a constant and continual check on the condition and amount of food present is absolutely necessary. Failure to notice decreased food supply in a pond can reduce fry or fingerling numbers by about 50% in 48 hours, through starvation or cannibalism. Complete failures of ponds are considered to be most often due to a poor supply of "water fleas," so that the fry starved before getting large enough to feed on sucker fry. A very good study of the problems of raising daphnia in ponds has been presented by Embody and Sadler (1934).

Cropping Methods and Growth Rate

Through experimentation in Wisconsin, it has been discovered that considerably better production is secured if the ponds are periodically cropped throughout the season. Starting about 3 weeks after stocking, the ponds are cropped daily until the end of the rearing period. Starting about 3 weeks after stocking, the ponds are cropped daily until the end of the rearing period. The pond is not disturbed by cropping at Woodruff, for a seine is not used. Instead, a wire box trap with lead is used to remove the 2" to 6" fingerlings. The traps are rectangular, measuring about 4 feet x 2 feet and are 3 feet in depth, with a cone funnel attached, and are covered with 8-mesh hardware cloth. A 16-mesh window screen lead is attached to the trap funnel and staked to the pond bank. Every day the traps are emptied and sorted with the smaller fingerlings being returned to the pond. At the beginning of the cropping season in June, the fingerlings removed average 2 inches in length and are removed at the rate of above 12,000 to 14,000 per day. At the end of the cropping in August, about 1,000 to 2,000 daily are removed. Each day's catch is stocked in an area lake or lakes.

Spooner Hatchery does not use traps, but seines the ponds daily to get the required number of fingerlings for each planting. This method, however, does roil the pond considerably and the excess handling probably does the fish no good. Seining is made easier by spreading tar paper over the pond bottom, near the outlet, early in the season so that vegetation will not interfere with the seine. The ponds are drawn down for seining only at the end of the season, and then some of them can be drained into seining basins.

Generally the muskellunge grow slowly for the first 25 days after hatching, as their fish-feeding habits are not well developed at this age. After 4 or 5 days of feeding on sucker fry, however, the growth rate takes a phenomenal ascent. Another sharp upward trend in growth is made after the muskellunge begin feeding on larger minnows, and rapid growth continues until the end of the rearing season. The majority of the fingerlings are removed by the end of 2 months, by which time they have reached 6 inches in length. Muskellunge reared at Woodruff in 1947 averaged as below during the growing season (Oehmcke, op. cit).

Rearing days (after planting)	Length (in mm.)
0	13.0
5	13.4
10	16.9
	Begin feeding on sucker fry
15	24.3
20	45.1
25	46.4
30	60.0
35	76.8
40	96.7
45	115.1
50	127.6
55	141.3
60	165.5
65	169.2
70	173.2
75	178.8
80	204.5

The range in size was not given for the above averages, but the following ranges in size have been gleaned from Oehmcke (1951).

Pond	Date	Range (inches)	Average
1	July 15, 1947	3.9-8.0	4.7
2	July 20, 1948	5.1-7.3	5.5
4	August 13, 1948	5.5-7.2	6.5

Production Rates and Cost

Typical of fingerling production at Woodruff Hatchery, before the more recent improvements were adopted, is that of 1942 given below (Oehmcke, 1949):

Pond	Acreage	Fry Stocked	Fingerlings Produced	% Survival
1	.24	56,000	468	0.8
2	.08	19,000	1,324	6.9
3	.12	56,000	983	1.8
4	.40	112,000	9,684	8.7
5	.25	168,000	5,177	3.1
6	.33	86,000	1,349	1.6
7	.34	112,000	504	0.5
8	.29	80,000	1,509	1.9
9	.38	44,000	11,836	26.9
Total or Average	2.43	733,000	32,834	4.5

Since advancements in rearing technique have been made, the survival rate has been increased to 11% in 1945, 30% in 1946 and 1947, 43% in 1948 and 27% in 1952. Production in 1948 amounted to a total of 457,141 fingerlings, of which 168,713 were produced at Woodruff and 288,428 at Spooner. Production in 1952 of 266,000 fingerlings included 199,341 raised at Woodruff.

While the cost of producing fry has been very low, the cost of rearing fingerlings has been fairly high. In 1947 fry cost $1.59/1,000 at Woodruff while in 1948 they cost $1.38/1,000. Raising these same fish to fingerling size in 1947 cost $0.12/fingerling and in 1948 $0.10/fingerling. In the cost of $0.10/fingerling raised in 1948 is included $0.0033 for cost of fry, $0.032 for cost of raising suckers and transporting to the hatchery for food, and $0.069 for rearing pond operation (including transferal of forage minnows).

In 1949, according to Wisconsin Activities Progress Report Number 35, 8.45% of the Wisconsin fish operations propagation dollar was spent on seasonal spawning of walleye, muskellunge, northern pike and suckers. Of this spawning expense, 49% was spent on walleyes, 26% on suckers, 15% on pike and 10% on muskellunge. Of the propagation dollar, 14.86% was spent on rearing pond operations of which walleye claimed 30%, muskie 22% and pike 46%. Trout operations were not included in the propagation dollar.

Selection of Lakes to be Stocked

Muskellunge fingerlings are now being used in Wisconsin for several different reasons. Many of the northern Wisconsin lakes and lake-chains which were once dominated by the muskellunge have become infested with pike, through introduction in the past both by unauthorized individuals and the careless supplying of fry to private persons. Since the muskie and the pike often spawn in the same general area, the young pike are several inches long by the time the muskellunge hatch, and thus prey upon these muskie fry. This has resulted (in both natural areas and hatchery experiments) in pike becoming dominant and the muskellunge getting increasingly scarce (Threinen and Oehmcke, 1950). Since the muskellunge is preferred over the pike as a game fish, every effort is being used by the Wisconsin Fish Management Section to bolster the muskie population and reduce the pike in these areas. Many of these lake-chains have had closed seasons and size limits removed on pike and the bag limit increased to 25. To supplement this program, traps are operated for pike during spawning runs, and the pike are removed and placed elsewhere where they are desired. In addition, heavy planting of muskie fingerlings and some yearlings are added each year. Thus, stocking will, it is hoped, help the muskie make a comeback in these waters.

Stocking of muskellunge fingerlings and yearlings is also being used in Wisconsin in lakes where pan fish populations are stunted and where biological examination indicates that stunting is occurring because of too large a population of pan fish, and too few predatory fish.

Another use of stocking in Wisconsin is to reintroduce or build up muskie populations which have been depleted by winterkill or other mortalities (such as the pike mentioned above) or by heavy angler pressure. Many of the better muskie lakes, which are subject to terrific angling pressure, are periodically stocked in an endeavor to maintain fishing of adequate quality.

In general, muskies are not often stocked in lakes in which they were not formerly present, and Wisconsin is attempting to keep the distribution of the muskellunge localized to the highlands of northern Wisconsin. However, within these areas muskellunge are sometimes introduced to lakes in which it appears that they would flourish, particularly if the lake has a pan fish problem. As a public relations gesture, lakes from which eggs are taken are usually stocked with fry or fingerlings that year (often with the surplus fry); thus the public does not feel its lake has been stripped of spawn that year.

Stocking Rate

Wisconsin recommends (Churchill, 1950) that in stocking predator fish to control stunted pan fish, they should be stocked at the rate of at least two effective fish per acre, and preferably 4 or 5. By "effective" is meant able to handle small pan fish efficiently and would probably be at least 20 inches for pike or muskellunge. In some of the Wisconsin lakes, in experiments of this kind, pike have been stocked at rates of from 4 to 14 adults per acre. Fingerlings, yearlings and adult hybrids (muskellunge x pike) have been stocked in the following combinations: 2 adults and 0.13 yearling/acre, 10 fingerlings and 0.25 yearling/acre, and 52 fingerlings and 2 yearlings/acre.

Mr. Oehmcke has recommended in the past that for lakes in which they are being planted for maintenance, muskies be introduced every three years at three times the rate for annual planting. This, he felt, would give a dominant year class which would simplify correlation of increased fishing success with that year class. He is now of the opinion that lakes be stocked every 10 years and heavily loaded when it is done. This planting would be done when the natural reproduction in the lake had been poor for several years and when few sublegal muskies were being taken.

For maintenance and introductive stocking, muskies are now being stocked at rates ranging from 3 to 20 fingerlings per acre. Little information is available as to the best rate of stocking, for it is not known what percentage of the fingerlings survive to become adults.

Results of Stocking

Wisconsin has little evidence concerning the effectiveness of its muskellunge fingerling planting program, although it is known that muskies have been successfully introduced into lakes where they were not previously present. Public relations have been so favorable (as with most instances of planting) that little incentive has been raised to determine the value of planting. The mere fact that Wisconsin stocked millions of muskie fry in the past, and is now stocking hundreds of thousands of fingerlings, has been sufficient to attract thousands of tourists for the muskie fishing. In most waters (except where pike have been introduced) the muskellunge fishing has held up well under this heavy pressure; whether or not this is due to Wisconsin's planting program is absolutely unknown. No pressure has been brought to bear on the Department to justify the expense of the program (probably under $50,000 each year, exclusive of salaries and hatchery maintenance), since all concerned apparently are happy over its supposed effect. In fact, even if research should show, as with many other types of propagation, that the planting was only a "drop-in-the-bucket" compared with natural production and that there was no correlation between planting of muskies and numbers of legal fish or fishing success, Wisconsin would find it difficult to convince resorters and tourists that abandoning maintenance stocking of muskellunge would not cause fishing to deteriorate.

In 1951 a small experiment was started in one lake to determine what percentage of the legal catch was made up of planted fish. Another similar experiment was begun in 1952. In both cases yearling muskies were tagged with ventral insert tags of red plastic, about 1 inch in length and with rounded corners. This was believed to be the only type tag which would remain with the fish until it reached the legal length of 30 inches (3-5 years). However, it would necessitate a close check on fish caught to detect these tags, and it is doubtful whether significant results will be forthcoming, since Wisconsin plans no publicity of the experiment on the two lakes and will rely on voluntary angler returns. It is personally thought that on fish of this size, and after this period, the tag will not readily be found by anglers. The internal anchor type tagwould possibly have been a better choice. Holding of experimental yearlings for 3 months following tagging resulted in no mortality due to tagging and the tags remained intact.

A recent compilation of Wisconsin Northeast Area experiments (Churchill, op. cit) on the experimental stocking of predators for population control indicated very inconclusive results. Of 5 lakes stocked with various numbers of adult pike and fingerling, yearling and adult hybrids, one had heavy removal by fishermen, and a second had been under study for too short a period. Of the remaining three lakes, one showed definite improvement of bass growth rate, one was inconclusive, and the last, (the most critical one) showed no improvement in pan fish growth rate. The lake which showed improvement (Punch Lake, Vilas County) has an area of 22 acres and originally contained only stunted largemouth bass. The addition of 36 yearling hybrids resulted in a definite increase in the size of all bass age-groups for three succeeding years. The lake which did not show improvement (Little Gypsy Lake, Oneida County) is a 20-acre lake which in 1946 had a large population of stunted bluegills and sunfish. Stocking adult male pike in 1946 and 1947 at the total rate of 14/acre had no recognizable effect on the bluegill or sunfish growth rates by 1949. However, the conclusion was set forth by Churchill that since one experiment was favorable, further experimentation was justified. It seems clear that this is an unproved technique which should be used only under careful control and where the results can be critically evaluated. Recommendations for this type of experiment, as outlined by Churchill, are:

(1). The determination of the presence of a stunted population, and the growth rate of important species, before stocking,

(2) It should be established that the lake contains no [large numbers of] large predator species,

(3) Predators should be stocked at the rate of at least two effective fish/acre and preferably 4 or 5,

(4) Removal of predators by anglers should be either prevented or recorded and compensated. Where such removal can be anticipated, allowance should be made in the original stocking and

(5) The growth rate of the population should be checked annually for 5 years after stocking.

Yearling Production

Yearling muskellunge are raised in Wisconsin for use in certain problem waters, where it is desired to give the muskie an added boost, such as waters which have been invaded by pike and lakes in which pan fish are excessively numerous. These yearlings, when stocked early in their second season, range from 8 to 14 inches in length.

Raising muskellunge to yearling size uses hatchery ponds to advantage instead of allowing them to lie idle over winter. Most of the forage fish for feeding the muskies over winter are added during late fall before the ponds freeze over. It has been found that 193 forage fish per muskellunge fingerling stocked provide enough food to attain a survival rate of 76%, but it is believed that a ratio of 250-300 to 1 would give better growth. Further forage should be supplied in the spring if the yearlings are not to be planted immediately. Suckers, shiners, fatheads and other minnows are the most important forage fishes used.

Rates of stocking fingerling holdovers in ponds ranged from 3,000-8,000/acre. Since the ponds were covered with ice and snow most of the winter, about 80-90 gallons of water/minute was passed through the pond. Hard gravel bottoms further minimized the problem of oxygen deficiency. The only serious problem encountered in yearling production has been loss of water due to muskrats tunneling into the dikes. The most effective remedy for this was heavy trapping during the early part of the winter.

The cost of rearing muskie yearlings on a small scale amounted to $3.69 each in 1947-48 (700 raised), $1.44 each in 1948-49 (2,085 raised) and $1.62 each in 1951-52 (5,000 raised). Oehmcke (1951) said, "If future management findings prove the worth of large-size muskellunge introduction, the cost of $1.50 or $2 per fish will be considered a fair price to pay to redeem a lake over-ridden with pan fish or unwanted species."

He now feels that if large numbers were to be raised the cost could be reduced to $0.40 each.

WISCONSIN WALLEYE PROPAGATION

Since about 1940 Wisconsin has been interested in raising walleyes to fingerling size for stocking lakes for much the same reasons as for muskellunge. It was felt that fingerlings would have a better chance of survival than would fry. The first efforts were made in using natural ponds and lakes as nurseries, usually on a cooperative basis.

Natural Cooperative Ponds

During the period 1942-1948 walleye rearing was carried on exclusively in natural ponds or potholes. This program gave highly varied results. Usually the only preparation given the ponds was clearing of brush and snags for seining. Turbidity, weather conditions and predation cut down production. Usually some fingerlings escaped harvesting and, if the ponds did not freeze out the following winter, the yearling walleyes were serious predators the following year.

Since 1942 Wisconsin has raised over 8,000,000 walleye fingerlings in the natural cooperative ponds. In 1945, 58 of these ponds were used and produced 1,145,000 fingerlings. Many of the ponds had serious difficulties and raised few fish; thus by 1952 only 35 ponds were being used, 15 in the Northeast Area and 20 in the Northwest Area. Production ranged from 1/2 to 1 million fingerlings in each area. The maximum production reached in a natural pond has been 69,528 four-inch fingerlings/acre or 790 pounds/acre. Most of the natural ponds are in the northern part of the state, since southern ponds were so weed-choked that fingerlings could not be removed.

In 1941, when reconnaissance surveys were made to determine which ponds and small lakes could be used for walleye fingerling raising in the Northeast Area, it was discovered that the waters were very soft and fertility appeared insufficient to produce enough plankton for the fish. The production of these ponds has been variable, ranging from 5-105 pounds and 200 to 20,000 fish/acre. The most successful pond in the Northeast Area contains 2.77 acres, and its water tested 3 ppm. bound carbonates at the beginning of operation. In 1942 this pond yielded 15,000 fingerlings from 50,000 fry with no fertilizer added. In 1943 the pond was fertilized with sodium nitrate, phosphates and potash in an 8-8-4 ratio. 194 pounds of fish/acre were removed that year with an average of 48,000 two-to-six-inch fingerlings/acre. In the same year crushed limestone was added at the rate of 500 pounds/acre. In 1944 sheep manure was added at the rate of 1 ton/acre, and water analysis showed the bound carbonates had increased to 10-11 ppm. An increased growth rate resulted in 1944 with 21,028 fingerlings ranging from 6-9 inches.

In the Northwest Area agriculture is carried on extensively, and barnyards are found in the immediate vicinity of many walleye ponds. For this reason many fertile ponds are available and this type has been the most successful. However, even in fertile ponds it is felt that the residual fertility of the bottom will have been removed in 5-7 years, and it will be necessary to replace it.

Artificial Ponds

Wisconsin has felt that they were not getting enough production of walleye fingerlings from natural ponds, many of them being difficult to manage with consistently good results because of infertility, predation, difficulty of harvest and low water levels in certain years. It was felt that Minnesota was making more progress with its controllable or drainable ponds. Beginning in 1947 work with artificial ponds was begun in Wisconsin. By 1948 two ponds were constructed which provided a controllable water supply and also permitted draining. One of 23 acres, in the Northeast Area, is located near Winegar in Vilas County and is known as the "Presque Isle" pond (Figs. 3, 4 and 5). The second, in the Northwest Area, is a 22-acre pond located near Barron in Barron County and is known as the "Maple Plains" pond. A new pond of 43 acres ("Sand Lake") was begun in 1950 in the Northwest Area near Stone Lake in Sawyer County. This one was expected to be in operation in 1952, but it was not completed in time. Another new pond ("Tamarack"), also being constructed in the Northeast Area, is one of 19 acres and is located near Conover in Vilas County. Thus, by 1953 Wisconsin hopes to have four drainable ponds in operation with a total area of 107 acres.

Description of Ponds and Construction

The ponds are constructed by letting contracts, by various other departmental agencies or by assistance from sportsmen. The "Sand Lake" pond was built mostly with assistance from Forest Protection and Forests and Parks Division of the Conservation Department. The bypass and dams of "Tamarack" pond were built under contract with a local construction company and a contract for sloping the sides and leveling the bottoms was let to the Vilas County Highway Department. In building the "Maple Plains" and "Presque Isle" ponds, much assistance was received from the Barron County and Vilas County sportsmen's clubs respectively.

The pond sites were selected where natural gradually sloping basins of 20-40-acres contained year-round streams and where the basin could be dammed at each end and bypassed. If not on state land, the site was either purchased, leased or deeded to the department. A bypass was dug around the basin, an inlet dam and controls were installed at the upper end of the basin and a dam and outlet (Fig. 5) constructed at the lower end. Filter systems (Fig. 3) of crushed rock, similar to those at the Spooner Hatchery, were installed at the inlets of the newer ponds. The sides of the ponds were graded down to gentle slopes with a number of peninsulas dividing the pond into natural seining basins (Fig. 4). The bottoms were leveled and, if it was impossible to remove all of the muck, the bottoms and the sides were covered with a layer of sand. The "Presque Isle" and "Maple Plains" ponds were operated in 1949 without having been graded or leveled, and it was found that full production could not be attained until sloping and leveling was done and the bottoms were made firm. Before this was done, too many pockets of muck and water were left after draining, and seining was difficult. The ponds were intended to be gravity-fed from the streams above the ponds, but at the "Maple Plains" pond in 1950 it was necessary to pump in water because of low water levels. The outlets of the newer ponds are constructed so that, by means of a baffle plate, water may be drawn off the bottom when oxygen depletion occurs in summer. The ponds range from 8 to 12 feet in maximum depth.

Construction costs for these ponds have been $25,000 for the "Tamarack" pond (19 acres) and $50,000 for the "Sand Lake" pond (43 acres). These costs include bypass, upstream and downstream dams, inlet filter, grading, leveling and hardening the bottom.

Rearing Techniques

The ponds are filled and shut off in the spring about a month before the fry are added. As soon as the pond is filled it is fertilized with a commercial fertilizer high in N_2 (10-10-10 was used in 1952) at the rate of 20-30 pounds per acre. Weekly applications are made at the same rate until 4 or 5 applications, and a total of about one ton for each 7 to 8 acres, has been added. Any fertilizer with a high nitrogen content is used, based upon the fertility of the pond. Formerly (1945) it was thought that either an organic fertilizer or a combination of organic and inorganic was best, but at the present time good results are produced by use of inorganic forms alone, and seining is made more pleasant and easier by their use.

Filamentous algae do not often cause trouble in these ponds, but they occasionally appear near shore in the shallow areas. Methods of control used are lowering of the water level (during harvest) to expose this shallow area to the sun or application of sodium arsenite.

The walleye fry are stocked in the ponds at the rate of 87,000-90,000 per acre in both areas. Thus the operation of 107 acres of ponds will require the hatching of nearly 10 million walleye fry.

No forage fish are stocked in the walleye ponds, but instead the walleyes are forced to feed on animal plankton. Since it has been found in Wisconsin ponds that, when plenty of zooplankton is present, the walleyes do not feed heavily on fish until they reach about 3 1/2 inches in length (and most of them are removed before reaching that size), there seems to be little difficulty from cannibalism.

The ponds are cropped beginning in July and usually finishing in August or September. In 1952 the "Presque Isle" pond was cropped for the first time during early July when 100,000 fingerlings were removed. By August 25, when the writer visited the pond, 454,000 had been removed, and the pond was completely drained by the end of August, producing a total of 467,408 fingerlings (20,322/acre). The pond was drained down to a suitable depth for later harvesting, but the earlier harvesting was done while ponds were full so that there was no loss of fertility. Seining was done (Fig. 4) with two 100-foot, 1/4-inch mesh seines fastened together.

If the fish run large (they were 3-6 inches here) seining is done with longer seines of 3/8-inch mesh. The seining was done by four men, two pulling each brail. Considerable effort could be saved by using a lightweight, 3/4 horsepower, pulling engine as described by Rose (1951). A boat, with square bow and stern and an outboard, was used to distribute the seine in an arc and also to hold a tripod for the weighing scales (Fig. 5). As mentioned before the peninsulas of the pond help to make small, individual seining basins or bays (Fig. 4).

Production in the 23-acre "Presque Isle" pond has ranged from 156,000 fingerlings in 1950 to 467,408 in 1952 (6,783 to 20,322/acre). The 1952 figure, resulting from a planting of 2,000,000 fry, comprises a survival rate of over 23%, which is excellent. The production of the "Maple Plains" pond has varied from 216,000 to 344,000 (11,000 to 18,000/acre) or 12% to 20% survival. From "Maple Plains" in 1950 the fingerlings ranged from 3-5 inches, and in 1951 the total of 215,980 fingerlings weighed 1200 pounds (production of 63 pounds/acre).

No costs are available for fingerling production from these artificial ponds, but in 1948 producing 600,000 fingerlings from natural ponds cost about $18,600 or $31/thousand. The same number in 1949 (including an undisclosed number from "Presque Isle" pond) cost $43/thousand or $25,800. In neither of these figures are the cost of the two artificial ponds included. It would be expected that, disregarding the original cost of the artificial ponds, the cost of fingerlings reared in them would be considerably less than in natural ponds because more fish are gotten back with less time, effort and transportation expense.

Selection of Lakes to be Stocked

Wisconsin is of the opinion that stocking has a definite place in fish management but that the important thing is careful selectivity as to where plantings are made. They feel that where stocking can be of value it is important but admit a lack of definite supporting evidence.

The lakes to be stocked with walleye fingerlings are not determined by shoreline seining as in Minnesota but rather on the reputation of the lake and fishing results. From a recent experiment on Escanaba Lake (Vilas County), Wisconsin indicates that when the natural walleye hatch fails stocking could be successful; when the natural hatch is good, stocking is unnecessary.

Once each year, usually in December or January, the Fish Management Area Coordinator organizes a series of meetings by counties. The members of the county conservation congress, the conservation officer, officers and leaders of conservation groups and interested individuals are invited to the area headquarters on a given day for a discussion of the fish-management problems of each water in that county. The area biologist reviews the findings from surveys, and wardens and others add what they know about the water. Fish stocking quotas are then established in keeping with the presumed needs of the waters. These meetings are not primarily intended to see how many fish can be obtained for stocking of the various bodies of water but rather to analyze the need of the waters and try to assign the proper corrective measures.

Stocking Rates

Stocking rates are determined principally by breaking down the total number of fingerlings available to the number of lakes on the stocking lists. This would average out to about 15-20 fingerling/acre, but since stocking is on a 3-year rotation plan they are stocked at the rate of about 45-60 per acre. This stocking of walleyes (as with muskellunge) only once in every three years in a lake allows heavier stocking and presumably greater survival than would be possible if the production were spread too thin over all lakes each year. This practice is also more economical and allows biologists to more readily check planting survival and natural reproduction.

Results of Stocking

Although most, if not all, of Wisconsin's evidence of the value of stocking walleye fingerlings is circumstantial, they believe that if enough cases of improved fishing following stocking occur, this is an indication that stocking is of value.

In Lac Vieux Desert, Vilas County, small perch were presumably keeping down walleye fry with the result that there was a population of only large walleyes. After a period of fingerling introduction, a single day's catch in a fyke net yielded 4,000 small walleye. The writer does not know what the natural walleye hatch during the planting period was.

Anvil Lake, Vilas County, had been stocked with walleye fry every year for 10 years. Beginning in 1948 the lake was to be left unstocked for 5 years to study the effect of natural reproduction.

In some of the Wisconsin walleye lakes which had swung over to crappies, fingerling stocking of walleyes plus heavy ice-fishing for crappies has resulted in considerable improvement in the walleye population. In another lake three years of walleye fingerling stocking apparently resulted in more walleyes.

On several occasions Wisconsin has fin-clipped fingerling walleyes in order to determine at a later date the success of the planting. However, because of mortalities and other reasons, no figures have been forthcoming.

While actually Wisconsin has no definite results based on research, the anglers and resorters (and the department?) are pleased with the fingerling program and are positive it is bettering walleye fishing. This is borne out by the statement of the assistant Superintendent of Fish

Management that "the stocking of fingerling walleyes... and muskies has had excellent results as shown by test netting and hook-and-line returns" (Lloyd, 1949).

MINNESOTA WALLEYE PROPAGATION

Since Minnesota has pioneered the Tri-States' efforts at walleye fingerling rearing, and Wisconsin has more or less borrowed its techniques from them, a few of the Minnesota methods will be reviewed here. Besides the literature cited below some of the information has been gathered from minutes of Tri-State Conferences.

Minnesota proved that fry planting for maintenance of a commercial or sport fishery was ineffective, when no correlation was found between heavy plantings of fry in Lake of the Woods and smaller lakes and later increases in catch (or population) (Smith, 1946). This was one of the main reasons they shifted to a fingerling program. Previous to 1940 an average of about 1/2 billion walleye fry had been distributed annually for 20 years.

Since Minnesota's methods of hatching walleyes does not differ from Michigan's, and Michigan has had no particular difficulty in raising walleyes to the fry stage, only practices relating to fingerling production will be discussed.

Beginning in 1940 mostly natural, undrainable ponds were used, and by 1942 two state drainable ponds and 150 cooperative ponds were used. A third drainable pond was added in 1947 and two more in 1948. By 1951, 17 drainable ponds were in operation and produced over 2 1/2 million fingerlings.

The cooperative ponds used vary from 7 to 100 acres. They are fed with water by gravity or pumps; since the source of gravity flow is limited, pumps often must be depended upon. This raises the costs considerably. It is known that ponds having a sandy-loam soil produce more fish than ponds having silt. As in Wisconsin, these ponds must freeze out every winter, or production is apt to be poor.

Suitable natural ponds were selected, under the cooperative farm program, on the basis of suitable depth, bottom conditions, absence of snags and the probability of winter freeze-out. The ponds can be sponsored by any organization and can be located on private or public property. The sponsoring group makes a reconnaissance survey of the pond, which is later checked by the department. If it is found suitable it is stocked and the sponsoring agency fertilizes, if necessary and also assists with the seining. The agency then has some say in where the fish are stocked.

The majority of the information below concerning Minnesota is about the state's drainable ponds; where natural ponds are concerned, this will be mentioned.

The state ponds are located throughout the state and vary in size from 5 to 53 acres. Maximum depths run from 5 1/2 to 9 feet and the average depth is about 3-4 feet. Depths increase toward the inlets so that fish can be concentrated at the time of harvesting. Banks and pond bottoms may be of sand, muck, clay and even peat. The ponds are of course located so that a water supply is readily available by gravity or pumping. Screens, filters, or both are used on the intake lines so that fish which would be larger or grow faster than the walleyes may be excluded (Miller, 1952).

Fertilization

Considerable experimentation has been done in Minnesota with fertilization of both the natural ponds and the state ponds. A good discussion of fertilization of natural ponds is given by Dr. John Moyle in the minutes of the 1945 Tri-State Conference.

Since pond rearing of walleyes requires an abundant supply of crustaceans (water fleas) and rotifers at, and after, the time the fry are planted, fertilization is aimed at increasing this supply of needed food. In both natural and artificial ponds Minnesota feels that commercial or inorganic fertilizer alone is not sufficient. It should either be used in conjunction with natural manures, or the organic fertilizer should be used alone. Oftentimes ponds with a low basic fertility are fertilized first with manure and then periodically with inorganic fertilizer throughout the season to keep production of organisms up. This is especially true when no forage fish are used, as walleyes can be reared to 4 inches with little cannibalism if animal plankton is abundant.

Ponds which were lightly manured at the rate of 400 pounds/acre gave almost double the production of unfertilized ponds. In the unfertilized ponds little relationship was shown between natural fertility (N_2 and P) and yield, but fertilized ponds did show this relationship. Evidently the manure adds little to the total fertility, as shown by water analysis, but it acts as a catalyst which sets off the proper food chain early enough to be available to walleye fry. This food is then maintained by the addition of a commercial fertilizer (10-8-6 has been used) at the rate of about 100 pounds per acre per month. However, the natural fertility of the ponds varies widely and, other sources of fertilizer such as barnyard drainage, must be considered, when determining how much to fertilize. Most natural ponds with a phosphate analysis over .03 ppm. will produce at least one good crop if animal plankton is available early. Most of the better ponds have a phosphate value of around 0.1 ppm. Over 0.5 ppm. the P may result in excessive plant plankton, bringing on oxygen depletion and fish kills. Only about one-half of the commercial fertilizer appears in the water analysis; this loss must be kept in mind.

Many of the highest yielding ponds are moderately hard (40-80 ppm. total alkalinity) and already contain abundant P. Very hard water usually should not be fertilized with P as insoluble phosphates may be precipitated and the fertilizer wasted.

Fertilization of the state drainable ponds prior to 1951 was based on the earlier experiments in natural ponds. Fertilizers used were barnyard manure, commercial fertilizer (8-8-6), dry sheep manure and superphosphate. Fertilizer was usually applied in 3 or 4 equal portions at 10-day to 3-week intervals beginning 2 or 3 weeks before the fry were stocked and ending about July 1. It became evident after this schedule that, because of the great difference in natural fertility, some of the ponds were not fertilized heavily enough and others too heavily. It also appeared that commercial fertilizer often tended to produce an algal crop rather than the desired crop of animal plankton. Therefore, in 1951, a detailed chemical and biological study was made of the ponds and fertilization was based on this study, using only natural manures on all but one. Dried sheep manure was used at rates of 50 to 724 pounds/acre, and barnyard manure from 400 to 9,000 pounds/acre. Inconsistency of results from these studies suggested that more consideration should be given to the natural fertility of the ponds (Miller, 1952).

Algae control in walleye ponds up to 1952 was effected by the application of copper sulphate.

Food Habits of Walleyes and the Use of Forage Fish

According to Smith and Moyle (1945), the walleye fry first feed on rotifers, copepods such as *Cyclops* spp, cladocera (*Daphnia*, etc.) and midge larvae. Rotifers are not important after the fry reach 10 mm. (2/5 inch) in length. The cladocerans and copepods are important until the fish reach 5-6 inches in length; insects remain common in the diet up to at least 8 inches. Forage fish (in ponds having them) did not become an important part of the diet until the walleyes had reached about 3 inches; even at 6 inches only about 50% of the walleyes were feeding on them. Walleyes themselves were eaten consistently by those over 3 inches but in fewer numbers than forage fish. Thus the presence of the forage fish in the pond no doubt buffers the walleyes to some extent from cannibalism.

At the present time forage fish are not planted in the Minnesota drainable ponds. The explanation given is that the walleyes will do better by themselves, for suckers, in the presence of fertilizer and the increased plankton, will grow too fast. It is also believed that with forage fish present the size range of the walleyes is greater, and with fertilization alone the fish are more uniform. I do not know how they have arrived at this decision concerning their drainable ponds, for they have published information showing that in natural ponds production was greater where forage fish were present. The average yield of 31 ponds supplied with neither fertilizer nor forages was 7.5 pounds or 304 fingerlings/acre. Twenty-four ponds, which received fertilizer but no forage fish, produced an average of 41.6 pounds or 2,784 fingerlings/acre, about 6 times as much as from unfertilized ponds. Eight ponds to which fertilizer and sucker fry were added produced an average of 18.9 pounds and 3,618 fingerlings/acre. Four ponds to which fertilizer and minnows were added averaged 87.3 pounds and 9,129 fingerlings per acre, 12 times as much as when no fertilizer or forage was added and twice as much as when only fertilizer was introduced. (Smith and Moyle, op. cit.). Minnows were usually stocked at the rate of 10,000/acre, while suckers were stocked at about 37,000/acre (1:1 ratio with walleye fry).

Higher numerical yields with forage fish in natural ponds were credited to the buffering effect these forage fish had on cannibalism. Two reasons were advanced for the better yield when minnows (bluntnose and fatheads) were used as compared to the yield when suckers were used. First, suckers tended to decrease in numbers throughout the season while the minnows reproduced and maintained their numbers. Second, suckers often grew faster than the walleyes in algae-rich habitat and thus were unusable as food. It was stressed that if minnows are used they should be stocked in the ponds several weeks after the walleye fry, so they will not prey on the walleyes. If suckers are used every effort should be made to secure those which are late-hatching.

Apparently, however, more recent results from their artificial ponds have led Minnesota to believe that either forage fish do more harm than good, or the increased production is not worth the expense of the forage. Suffice it to say that both Minnesota and Wisconsin formerly used forage fish, but recently Wisconsin has apparently followed along with Minnesota's decision not to use them.

Predator Control

In Minnesota natural ponds, winter hold-overs or resident populations of yearling walleyes, pike, bass, perch and crappies have caused many failures. As few as 50 yearling walleye or bass/acre will greatly curtail the fingerling crop. It is certainly true that bullheads will reduce productinn as they are known to have eaten walleye fingerlings but some ponds have produced very well with bullheads present. Mud puppies are known to eat small numbers of fish and it is suspected that they are oftentimes responsible for failures. The same thing is true of the tiger salamander; some feel they are directly responsible for failures and others feel they are only competitors.

Predacious insects/if present in large numbers, are known to raise havoc with walleye fry and small fingerlings. Leeches also, if abundant, will cause losses. Since invertebrates make up an important part of the diet of walleyes, it is perhaps debatable whether the number of insects should be reduced to avoid predation. In natural ponds it is probable that the pond should be poisoned with rotenone and fuel oil before being put in production for the first time. After this, no poisoning should be done unless it is found that predators are present in large numbers. Artificial ponds should be drained each year, thus removing most of the fish and amphibian predators. Most insect predators can be sufficiently controlled by fuel oil if numerous, for this will not harm the midges which are most important in the walleyes diet. If dragonfly nymphs become a nuisance, they would have to be poisoned after the fish were removed.

Pond Stocking Rate and Cropping

The time walleye fry are stocked in ponds in Minnesota has varied from the end of April until early June but usually is done the first 2 weeks of May. The count of fry stocked is always approximate and is based on the count of eggs when eyed, with allowances for losses.

Natural ponds are stocked with walleye fry at rates ranging from 2,000 to 800,000/acre, but the average is about 44,000/acre. In the artificial ponds, rates have varied between 30,000 and 113,000/acre, with the average around 40,000/acre. Within this range the rate has apparently had no effect on the yield.

Minnesota is convinced, as is Wisconsin, that harvesting can best be done by cropping some of the fingerlings earlier than the remainder. In 1945 in natural ponds it was found, by counting the fingerlings in July and again in the fall, that an average of 50% had been lost by fall. One pond containing 40,000 fingerlings in July was reduced to 500 by fall. It is generally agreed, then, that the ponds should not be harvested only once. Fish would be large, of course, which is advantageous in stocking, but the numbers are correspondingly much less. For natural ponds, Minnesota discovered that the total yield was greatest (only when all were removed at once) when the fingerlings were removed at 3 to 3 1/2 inches in size (approximately 50-80 pounds/acre). It is at this point that the diet of the walleye starts to swing toward fish. At the present time cropping is done in much the same manner in natural ponds as in artificial ponds.

Cropping of artificial ponds is done in July without drawing them down. The inlet is usually opened during cropping, and the fingerlings are seined as they congregate around it. Cropping is done anywhere from 1 to 15 times, depending on the size range of fish, their abundance, the need for fish to stock and other factors. Of the total number of fingerlings produced from all ponds, about 50% of them are removed by periodic cropping and the remainder in the fall. Minnesota has found that if fingerlings are not cropped they tend to grow more slowly and become thin in late summer

Production Rate

Minnesota natural ponds have produced at rates ranging from zero to over 200 pounds/acre, with an average of from 30-50 pounds/acre. The average number of fingerlings has run from 1,000-2,000/acre and has reached over 10,000/acre. Survival rate (from fry to fingerling over 100 days old) has averaged 6 to 9%. As mentioned above, production (from 1941-1943) in ponds with fertilizer and minnows added averaged 87.3 pounds and 9,129 fingerlings/acre; in ponds with fertilizer and suckers production averaged 18.9 pounds and 3,618 fingerlings/acre; in ponds with fertilizer but no forage fish average production was 41.6 pounds and 2,784 fingerlings/acre; and ponds with neither fertilizer nor forage fish produced an average of 7.5 pounds and 304 fingerlings/acre.

The number of fingerlings produced is usually inversely proportional to the weight of the fish. Ponds producing large fingerlings (7-29/pound) produced only 500 fingerlings (33 pounds)/acre, whereas those producing small fingerlings (200-500/pound) produced an average of 11,000 fingerlings (38 pounds)/acre. The best production in pounds/acre seemed to be a compromise where the fingerlings were medium-sized (50-79/pound and 3 to 3 1/2 inches), for an average of 5,300 or 87 pounds/acre was produced. This is also probably a compromise as to what is the best size to which fingerlings should be raised; large numbers of fingerlings are desired but if they are too small there will be greater difficulty in handling and presumably a lower survival rate after planting.

No correlation was found in natural ponds between the size of the pond and the yield. It had been thought that walleyes need large ponds, but evidently any pond over 1/4 acre will produce walleyes if crustaceans and insects (and forage fish) are present.

In the state drainable ponds in 1948, production varied from 5,000 fingerlings (17 pounds)/acre to 31,000 fingerlings (81 pounds)/acre, with a survival rate averaging 20%, and in one pond reaching nearly 40%. Total production of fingerlings in 1949 and 1950 reached about 1 1/2 million, and in 1951 over 2 1/2 million fingerlings. These figures can be broken down as follows:

	1949	1950	1951
Average poundage/acre	45	32	36
Range	13-115	0-59	1.4-121
Average fingerlings/acre	11,400	6,200	7,100
Range	1,900-31,500	0-22,600	190-16,400
Average percent survival	20.0	13.7	19.0
Range	3-59	0-46	1-66

In 1947, when a total of 2 3/4 million fingerlings were produced in Minnesota, 80% were raised in natural ponds and 20% in state ponds. In 1948 these proportions were changed to 72% and 28% respectively (for 4 1/2 million fingerlings), and in 1951 the production of 5 1/2 million fingerlings was divided 55% - 45% between natural and artificial ponds.

No records are available of the cost of rearing walleye fingerlings in Minnesota, but it undoubtedly is very small per fingerling.

Selection of Lakes to Stock

Fingerling walleyes are now planted in waters where they are known to be needed. Minnesota stresses the fact that not all walleye waters need stocking. In many the natural reproduction is so great that stocked fish would be wasted. Therefore, stocking is based on methods of determining what waters need it. Biological surveys have been made on all waters being stocked so that walleyes will only be put where they should do well. Shoreline seining is done every year by special crews in August in lakes up for planting for maintenance. This seining is done at the same place, time and manner year after year so that an index of natural reproduction is thought to be determined. Lakes with poor natural production are stocked heavily every third year to build a dominant year-class that may be recognized later. If a young, dominant year-class is found in a lake, the lake is not stocked again until shoreline seining indicates no abundance of young fish.

Stocking is also done where survey has shown that walleyes should be suited and where there is a stunted, over-abundant population of perch or other pan fish. The greater the problem in the lake, the larger the size of the fingerlingsthat are stocked.

Fry are used for reintroduction to winterkill lakes, for they are cheaper to produce and often give good results under favorable conditions.

If survey recommends walleyes for a lake and the check before planting reveals abundant young walleyes, the biologist and supervisor have the authority to remove the lake from the list.

Stocking Rates

Minnesota stocks walleye fry at a rate of about 5,000/acre. The rate of stocking fingerlings is somewhat determined by the shoreline seining. In problem lakes, fingerlings are stocked as high as 200/acre but usual rates are 50-100/acre. Highest rates used are for problem lakes that are stocked every third year. There has been recent discussion about reducing the time between stocking to two years.

Results from Stocking

After more than 50 years of planting artificially propagated walleye fry in Minnesota waters, research proved rather conclusively that fry stocking for maintenance was of little, if any, benefit. Calculations indicated that less than 1 in 1,000 of the fish caught by anglers was traceable to a hatchery source. At the same time, Minnesota indicated that the justification of fingerling planting remained to be proven by research (Smith, 1946).

Although several instances of improvement in walleye populations and fishing success have been mentioned in Minnesota following stocking of fingerling walleyes, no concrete evidence has been published. In several instances the growth rate of pan fish has increased, and their numbers decreased, following planting of walleye fingerlings. Again there has been no proof that this was due to the walleye plant alone.

In general the public, resort operators and sportsmen seem to feel that fingerling planting has been successful. However, Smith (1950) has the following to say about fingerling stocking of predator fish: "Some states are now embarking on an expansion of hatchery programs designed to rear certain predator fishes such as yellow pikeperch and northern pike to fingerling size for restocking public waters which have had a reputation for production of these species but which now appear to be depopulated. What success will attend these experiments is difficult to predict at this time. Contrary to the public belief in areas where this development is taking place, fishery technicians do not think that waters with an adequate spawning stock will be materially affected or benefited. It is believed that the only practical use of suchreared fingerlings will be to re-establish a population structure favorable to natural reproduction or to produce fishing for planted stock in waters primarily suited to some other species.... New or barren waters can be benefited or possibly pppulation structures may be altered favorably by large introductions of predaceous fish..... The important aspect of this program, however, is the fact that a great development is being made before any critical proof exists that it will in any way accomplish the results desired. It is entirely possible that these states will find themselves with a large hatchery set-up of no value for the maintenance of good fishing but one which for administrative and political reasons they cannot abandon."

REARING PIKE TO FINGERLING SIZE

Neither Wisconsin or Minnesota have been raising pike to fingerling size in large quantities. However, because of the similarity between the rearing and habits of the pike and muskellunge, it is reasonable to assume that the same techniques would apply to both. There has been some questinn raised by Wisconsin as to whether they eat the same food early in life, but Hunt and Carbine (1951) found in Michigan that the first food of pike consisted almost exclusively of the "water fleas". Although smaller types than Daphnia and Polyphemous were utilized by the pike in that study, it may well be that this choice was largely influenced by availability.

The U.S. Fish and Wildlife Service has raised many pike to fingerling size and has gotten a survival of as high as 30% and a production of 23,000 fingerlings/acre (from fry stocked at 75,000/acre). They also discovered that treating developing pike eggs with Malachite Green prevented fungus growth in the jars and increased the percentage of hatch. The material was applied with a constant-flow siphon for one hour at a strength of 1:200,000, and treatment was applied every week or less until hatching commended (Sharp, Bennett and Saeugling, 1952).

CONCLUSIONS

From the above analysis of methods and results of raising muskellunge and walleye fingerlings in Wisconsin and Minnesota, certain conclusions can be drawn;

(1) Stocking of walleye fry has been proved to be of little noticeable value as far as stocking for maintenance or control of pan fish is concerned and probably could be proved for muskellunge fry also. However, fry-stocking can be of value in reintroducing the species to winterkilled lakes or for introduction of the species into new waters that are suited to them.

(2) In muskellunge fingerling rearing certain procedures are of extreme importance, and if done incorrectly or neglected can result in poor production. Most important of these are having the right natural food present at the needed time in sufficient abundance, the control of both vertebrate and invertebrate predators by rotenone and fuel oil, and constant surveillance of the ponds by the same individual throughout the season. Losses can be sudden and drastic if any of these matters are neglected even for a short period.

(3) In walleye fingerling rearing there is little doubt as to the value of such methods as: fertilizing the ponds for increased supply of animal plankton, controlling predators, and cropping the ponds early in the summer. There is some argument as to the value or necessity of using forage fish.

(4) Both walleyes and muskellunge can be produced to the fingerling size in numbers at reasonable cost.

(5) Pike can undoubtedly be raised to the fingerling size in numbers by the same techniques as are used by Wisconsin in rearing muskellunge.

(6) The value of stocking walleye and muskellunge (and pike) fingerlings for maintenance of populations and for control of pan fish populations has not yet been demonstrated by adequate research.

RECOMMENDATIONS

On the basis of the experience Wisconsin and Minnesota have had in rearing predatory game fish to the fingerling stage, and in view of the poor production often encountered in Michigan's attempts at the same program, several recommendations are in order, namely:

(1) Continue and enlarge the program of experimental rearing of fingerling predatory game fish, including walleye, muskellunge and pike, but for the time being limit production only to the present hatchery ponds available. Until the value of the program has been determined and increased space is needed, it is recommended that no construction of the large drainable ponds (for walleyes) be done, since many of our present ponds are essentially of this type and would be satisfactory with a few simple changes in management.

(2) Adopt the more or less standard rearing practices which have been proven successful, including control of aquatic predators, provision of adequate supplies of food, fertilization (in walleye rearing) of ponds,

maintenance of clean, hard bottoms in ponds, daily surveillance of hatchery ponds, harvesting by progressive cropping, etc. as discussed in this report.

(3) Experiment to determine the desirability of some of the unproven or untried practices which other states are discussing, including a better method of obtaining adequate supplies of animal plankton for muskellunge and pike, the need for, or value of, forage fish in the rearing of walleyes, the kind and amount of fertilizer needed in walleye ponds, etc.

(4) Initiate, with the fingerlings reared under the above three recommendations, adequate research to determine the result of stocking these fingerling predators. This will involve many separate problems, such as: the correlation between stocking of fingerlings for maintenance and the increase in adult populations of the species planted and fishing success; the correlation between stocking of fingerling predators for pan fish population control and whether this results in increased growth rate and decreased population of pan fish; the survival rate of stocked and naturally raised predator game fish from the fingerling stage to adults. This would be important and virtually pioneering research, and it would have to be done with extreme care. It is possible that even a small increase in the predatory game fish population of a lake could have widespread and unsuspected results.

(5) If production of fingerling predators on a large scale is determined to be a useful management tool, it will possibly be necessary to build the type of drainable ponds that Minnesota and Wisconsin are using. It is tentatively recommended that Michigan not use natural ponds as the other states have done, for it appears that too many difficulties are involved.

(6) If large-scale fingerling production is embarked upon, research into more refined methods of determining both the lakes that need stocking, and the rate of stocking, will be needed. It would obviously

be important that these predators be used where they are most needed and where the greatest benefit would result

Figure 1. Drained 3 1/2 acre pond at Woodruff Hatchery, Wisconsin, with the outlet structure and seining basin in foreground. Note the hard bottom of the pond and the usual feature of ponds, incomplete draining. Photo taken August 22, 1952.

Figure 2. Drained muskellunge pond at Spooner Hatchery, Wisconsin. Note the rip-rapped sides and the cleanness of the hard bottom. This pond is a very good producer of muskellunge fingerlings. Photo taken August 26, 1952.

Figure 3. Wisconsin's artificially constructed "Presque Isle" walleye rearing pond showing inlet and crushed-rock filter. Pond was partially drawn down for final harvesting and the gradual slope of the hard bottom is visible. Photo taken August 25, 1952.

Figure 4. Seining in progress during the last week of harvesting at "Presque Isle" walleye pond. Note the natural bays (a second is visible in right background) which makes seining conditions ideal. Photo taken August 25, 1952.

Figure 5. The outlet structure of the "Presque Isle" walleye pond and the seining crew ready to start laying its seine with the boat. Photo taken August 25, 1952.

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INSTITUTE FOR FISHERIES RESEARCH

John E. Williams

Report approved by: A. S. Hazzard

Report typed by: M. C. Tait