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DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

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ANN ARBOR, MICHIGAN

April 29, 1933

Report 208

EXAMINATION OF NURSERY LAKES, PIKE HATCHERIES, REARING PONDS AND MINNOW LAKES IN PRESENT OPERATION IN IOWA

By Carl L. Hubbs and J. Clark Salyer

In our studies of fish and fisheries problems in Iowa, in the summer of 1932, we paid particular attention to the nursery lakes, and to the associate pike hatcheries. Some examination was also made of a few rearing ponds in operation, and of the two designated "minnow lakes". The present report embodies the results of these examinations.

This report supplements the general discussion we drew up for the Iowa Conservation Plan. We will not repeat here, the general suggestions as to policy made in that statement. The report is complementary to our Report 202, "Fish Cultural Suggestions for Iowa", and Report 201, "Examination of Hatchery Sites in Iowa".

This report is not a complete discussion of the nursery lakes, pike hatcheries, rearing ponds and minnow lakes. Time did not permit as thorough a field study as we would like to have made. Furthermore, the failure of the hatchery inspection party to materialize decreased the extent and value of this report.

THE NURSERY LAKE PROBLEM

Each nursery lake or rearing pond is a problem by itself. Such management recommendations as we have to offer are therefore given under each unit.

The main problems are those of the nursery lakes. The development of the large nursery lake for wall-eyed pike by the Iowa Fish and Game Department has been a very notable contribution to fish culture. The successes obtained constitute an achievement of which the Department and Iowa may well be proud.

It must be remembered, however, that initial successes in fish culture, may exceed the success later obtained in sustained practice. At first, the fish being propagated

may increase inordinately, just as an introduced animal often over runs its new habitat. The natural checks on increase are at first absent or incomplete.

In time the natural checks on abundance--enemies, parasites, bacteria, lack of food--like war, disease and famine among mankind--come into play. The great concentration of a single species in a small area is itself a factor favoring these checks to abundance. Predators gather; parasites and bacteria causing disease find ideal conditions; the single species in over-abundance consumes its own natural food faster than it can be produced. If the cultivated animal be a predator, like the wall-eyed pike, this eating itself out of food is virtually inevitable, unless the situation is met by adequate management practices.

It is highly improbable that the successes obtained in wall-eyed pike rearing in nursery lakes in Iowa, could even during the initial years be duplicated in more northern waters. The extreme productivity of the shallow Iowa lakes has unquestionably been essential to whatever success has been enjoyed. But the great basic productivity of these nursery lakes is in itself a hazard of real danger. This is not only theory, it is experience. Amphipods ("scuds") have become so excessively abundant in Welch Lake as to kill the pike, through the death and decomposition of these small animals. The rich organic content creates an oxygen hazard over certain winters. The vegetation is so dense as to cause dangerous oxygen conditions in the late summer when the weeds begin to die, or so dense as to interfere with seining or with the production of food organisms for the fish. In Diamond Lake the blue-green algae have abounded to dangerous proportions. The recent history of Silver Lake at Lakepark may be repeated in a nursery lake: (1) a choking with weeds for a year or two; (2) production of septic bottom conditions by the annual decomposition of the weeds; (3) obnoxious and potentially destructive growths of blue-green algae, particularly Asphanizomenon.

The problems arising from the inherent difficulties of maintaining a sustained yield of a predacious animal in entirely abnormal abundance, and from the unstability

of biological conditions in these excessively productive nursery lakes, call for adequate management. Considerable care along this line has been exercized, to good advantage, but we do not regard such management as yet adequate. The absolute minimum requirement in our judgment would be the employment of a full time, year-around man of technical training or experience for the management of the three nursery lakes.

At least weekly throughout the entire year the dissolved oxygen and food conditions in the lakes should be sampled. The food conditions should be determined by (1) sampling and studying the plankton, (2) sampling and studying the bottom organisms, (3) sampling the fish (through the summer at least) to determine their condition, growth and stomach contents.

This man need not be an investigator of extended training, provided the Department maintains one or more men of thorough training to supervise such local technical operations.

The manager of the lakes, among other duties should also:

(1) Maintain an adequate predator control, against fish-eating birds, turtles, snakes, etc.

(2) Install and maintain such minnow-spawning devices or fish shelters as are considered desirable.

(3) Re-stock the lakes as necessary with minnows.

(4) Patrol the lakes to prevent minnow seining or other violations of the law or of the local regulations.

(5) Maintain insect-attracting lights (in summer).

(6) Keep down pollution by keeping cattle fenced off.

(7) Keep down silting by maintaining erosion-control dams in the gulleys.

(8) Plant weeds in Center Lake, as needed.

(9) Keep screens clean in outlets.

(10) Aerating the water when necessary.

(11) Supervise the planting of the "pike" fry.

(12) Supervise the seining operations for fingerling pike and for competitor fish.

Surely these are all desirable duties to have performed, and they surely will require the full time service of one man. Some additional help would of course be required from time to time. During the summer each lake would need be visited morning and evening, unless a resident caretaker were available on each lake. It would be advisable to have such a caretaker present, available to help the manager of the lake in routine or special work, and also to maintain one or a few boats for anglers. It would be helpful to encourage and increase angling in the lakes, to help hold down bullheads, perch, and larger "pike". The resident caretaker might well be a farmer operating his own land and being paid for the part time service, or farming state owned land about the lake and giving the state such service in lieu of rent.

The general management suggestions we offer for the nursery lakes are indicated by the proposed duties of the nursery lake manager, as listed above, and are stated more fully in the recommendations for the management of each nursery.

We repeat again our policy proposals for the nursery lakes: Each of the three main lakes should be maintained as a nursery lake until or unless more experience proves this unprofitable. Center Lake should be given a further trial, as well as Welch and Diamond. We recommend that at least one nursery lake, either one of these three or a new one, be devoted to rearing small-mouthed bass.

We strongly recommend the operation of all the nursery lakes on a one-year basis, planting the fry in moderate numbers every spring, and seining thoroughly in late fall, winter and early spring, to remove the late fingerling to early yearling "pike" as completely as possible--also so as to control competitors and predators more completely. The chances of loss over winter must be great, and will likely continue so. The chances for overwintering safely are probably greater in the fishing lakes.

CLEAR LAKE HATCHERY AND NURSERY

The fish cultural activities for Clear Lake center about the large pike hatchery, the Clear Lake Nursery Pond and the Mason City Bass Rearing Pond. According to Mr. Hoel, 29,600,000, pike fry were planted from the hatchery into Clear Lake in 1932. In 1931, 25,000 and in 1932, 35,000 large-mouth bass fingerlings were brought in from the Mason City Pond.

Mr. Hoel claims that while formerly many pike were lost in the hatchery work, that few are now lost. The breeders are caught in gillnets, 2" and 2 1/4" (square measure" 6 feet deep and 300 ft. long (200 ft. lengths used previous to 1932), set at night, and lifted 4 times (at 9, 11, 1 and 3). The fish are taken to the hatchery in tubs, and kept in the big tanks to ripen, a process which now is claimed to take only 1 to 4 days, as only the fish which are almost ripe are brought in. The fishing is done largely off Bayside and Dodge Pt., though fish ripe or nearly ripe are taken elsewhere off the open eastern shore of the lake. Fish seined at the bar (the Narrows) or to the west are too green to handle safely, as their eggs are not over 3% good.

The method of handling the pike eggs in 1932 (300 quarts taken) proved very successful, according to Hoel. The breeders after being ripened a few days are stripped for eggs and sperm and then released. The eggs of one female are stripped into a fiber cuspidor in 1 inch or so of water. Then the sperm from 1 to 3 males is added, and mixture effected by feathering. The fertilized eggs are then floated into one of two cloth screens, two feet wide and 8 feet long. These cloth screens are floated in the tank, being held in place by wires. The eggs are here hardened, and separated by hand. Floating eggs are removed. The big tank containing the eggs is fed by a full jet of water, and another inlet is put under the cloth net, to insure circulation of water about the eggs. After 18 to 24 hours, the eggs are taken to the hatchery in wash tubs, treated with [illegible], screened, and put into the hatching jars. Using this method, almost no fungus loss is experienced.

Recommendations

Pike Hatchery.--Should be continued in operation, in our opinion, and should be

maintained in a high state of operative efficiency. Our examination gave us no occasion to suggest any new plans for the operation of the hatchery. Until (or unless) a suitable rearing lake is developed for pike fingerling rearing, we can only suggest that the addition of brush shelters to the lake should be of material importance in giving the fry their needed protection.

Clear Lake Nursery

Examined by Salyer on July 16, 1932, and by Hubbs on August 10, in company with Orel Hoel.

In our opinion this 20 or 25 acre nursery pond is not likely to prove any more successful than in the past, as a pike rearing pond.[1] It ought, however, make a good enough pond for rearing bass fingerling, to be used for that purpose. The rather large expenditures here ($25000 we hear) may well prove justified. We would recommend it be used on alternate years for large-mouth bass and for small-mouth bass, provided a source of fry of each can be maintained.

On general principles we are opposed to having the adult bass in the pond with the fingerlings. We were told that about 60 or 100 brood bass were still in lake on July 16. This is especially true of ponds like this one, deficient in minnow life. Under such conditions bass take to cannibalism. As a result, some very fine bass result, but in small numbers. Thus we took a sample of four 4 5/8-inch bass on July 16-- but found all empty. (Mr. Hoel was very proud of the size of these bass.)

Clear Lake appears to be capable of supporting both species of black bass and the bulk of the output would to best advantage be put in that lake.

The vegetation beds in the nursery need control. We found a fine growth, but the rushes were getting too thick, and needed some thinning out. Large quantities of fine-leafed pondweeds (P. pectinatus and P. interior were found), but we would think it better to remove some of these and to foster the broad-leaved pondweeds, of which a good start was found. Chara and Naias were found to be abundant.

The expense and trouble of pumping water when the nursery pond goes down in the fall would hardly seem worthwhile. If the pumping equipment could be used elsewhere

[1] Mr. Baur's record for 1930 indicates a planting of 1,000,000 fry in the spring, and the recovery of only 36000 4¼" fingerlings (0.36%) in the fall. No records given for 1931.

in the state, we would believe it wise to move it. Then when the water approaches a dangerously low level in the fall, the bass fingerlings can be seined out for planting. To facilitate the seining, a better seining basin at the outlet would be desirable.

The pond was not properly selected (or not properly puddled). It starts losing water into the drainage ditch as soon as tile-inlet stops flowing.

Predators were found to be entirely too numerous. On July 16 we observed one great blue heron, 3 or 4 kingfishers, 4 pied-billed grebes, many coots and an abundance of common terns and black terns; also one watersnake. On August 10 we made a similar list of birds, including also several green herons. More vigorous predator control on the nursery is needed.

We suggest closing the gates after the fall seining, so that as much water as possible will stand overwinter in the pond--in order to build up the supply of scuds and insect larvae. If or when the bass appear grubby, however, the bottom should be allowed to freeze dry for a couple of winter, to control the disease.

To give the bass more and better food, and to reduce the heavy cannibalism, we recommend that minnows be seined frequently through the season from the ditch along side, and put over into the pond. This ditch should be closed to public minnow fishing. To increase minnow spawning in the creek and in the pond, 200 or 300 spawning slabs (or pieces of broken tile)--or any object with smooth lower surface, should be added.

SPIRIT LAKE HATCHERY

We believe this establishment should be continued as a walleyed pike hatchery. The elaborate plans to pump lake water into ponds seems impracticable, certainly so for pike fingerling rearing. The expense involved, alsong with dangers involved should the pump break down, appear to outweigh any advantages of this site over others, for bass rearing.

Perch Hatching.-- The idea of hatching perch here does not seem desirable to us. The perch hatching would overlap the pike operations, necessitating an added force and new hatching equipment. Mr. Baur believes a filter would also be required, if perch were to be hatched here. Perch fry planting is of questionable worth and perch fingerling rearing very difficult. Most Iowa lakes are not particularly well suited to perch. In some of these lakes the perch are dwarfed, as is very often true of the species. In the Okobojis, where perch grow fairly well, they are badly parasitized by Argulus. The perch needed for experimental introduction into perch-less waters, and a moderate number for restocking elsewhere could easily be spared from West and East Okoboji lakes. (Here an extra large number of young perch were found on July 26 and 27.) Furthermore, in cleaning Welch Lake of perch, a goodly quantity of very fine fall fingerlings should be obtainable for a few years.

Netting Pike Spawners.--The gill netting of spawning pike-perch, or of near spawners, has become systematized, and our experience is insufficient to warrant any criticism. Offhand, we wonder if methods of seining could not be perfected, which would be more effective and possibly less harmful of fish or eggs. However, reports seem to indicate that pike propagation has been very well perfected in Iowa. A minor advantage in seining would be in lessening the gill-netting now illegally practiced, for the offenders not infrequently steal the state nets. On account of the smaller size of Spirit Lake pike, 2" square-measure gill netting is used in that lake, Hardman reported. This size meshing prevents the catch of the biggest pike, but an insufficient number of spawners can be obtained by use of the

coarser mesh. This possibly indicates depletion, but it may be mean overproduction. An offhand judgment would be dangerous. Likely using two sizes of meshing would prove advantageous.

We understand that 3 gill nets of 300 feet each are run by a crew of 2 men, the nets being set before dark (about 6:30) and lifted at 11:00 P.M., 1:00 A.M. and 3 A.M. (also at 9:00 P.M. according to Warden Ray Butler). The run is stated by Butler to be around April 5 to 10 in the Okobojis lakes. In Spirit Lake, the run is said by Warden Hardman to start April 8 to 10.

Some nets are said to be stolen each year. This is not only a financial loss, but also contributes to violations. The duty of watching the nets is said to fall on the warden on duty, while the net operators return to shelter on shore. In view of the fact that this is a busy season otherwise for the warden, it would seem better to have the net operators stand guard.

Formerly it is admitted that heavy losses were experienced in handling the pike. Mr. Butler said that about 1918 pound nets killed many large pike.

Pike Stripping.--Mr. Baur told us that he usually gets 5 quarts of eggs out of 7 female pike from East and West Okoboji, where the species run bigger than in Spirit or Clear Lake. Warden Hardman agreed that the walleyes run smaller than in West Okoboji Lake, averaging 2 to 2½ pounds. For many years, Mr. Baur reported, only male pike were caught in Spirit Lake, so he used these males to fertilize Okoboji females. This would indicate to us either that the pike spawn later in Spirit Lake, so that only the first of the run was netted, or that the actual spawning grounds had not been located. It is certainly not to be expected that one lake would contain fish of only one sex.

Pike Hatching.--The reports heard indicate that the Spirit Lake pike hatchery has been operated with truly remarkable success, inasmuch as walleyed pike propagation is usually considered very difficult and subject to heavy losses. Mr. Harry Tennant estimates hatching as nearly perfect as 09%, and states that this station has never experienced a failure in the several years of operation. This is a record to be proud of--to the degree it is true.

The idea of Ves Baur, of hatching out buffalo fry to serve as food for the young pike in the nurseries sounds rather good; certainly worth a thorough trial in a small pond. The young buffalo might fee largely on algae, and thus might not compete very seriously with their predators, the young pike.

We understand that Mr. Baur is opposed to the idea of using gizzard shad as a forage fish in the nursery lakes. We are not ready to state with full confidence that the shad would succeed there, and not do serious harm either in depleting the basic food supply or in causing the death of pike during seining operations. But we still think they would benefit the nursery lakes. However, it would be best to introduce the shad into some other lakes first, at least until more experience with the species is gained.

The location of the present pike nurseries is very good from a geographical standpoint. They are central to the best lakes of the state, and the walleyed pike is essentially a lake fish in Iowa. We found relatively few in the inland rivers, and these were in the deepest holes of any particular stream.

The rearing of large numbers of any excessively predacious fish such as the wall-eyed pike must be expected to throw the nursery pond or lake out of biological balance. Even with improved administration, it must be expected that the pike will at times clean up on the available food so as to put themselves face to face with starvation - as happened during our examination in 1932. We do not share the belief of Mr. Baur that the young pike could not be thinned out under such circumstances by planting them in the summer. With improved transportation units, this should be wholly possible, even though it might not be safe with the use of the present equipment. We understand Mr. Canfield of the U. S. Bureau of Fisheries has also expressed the belief that the pike could be moved in the summer.

Proper Age for Planting.--Experience and expectation unite in indicating a very heavy loss of pike in the nursery lakes, due to cannibalism and other factors. If the pike are held over their first winter, the chance for loss due to cannibalism increases, of course. And the yearling pike must be very destructive to the fry or fingerlings of the next year if fry are planted again. If, however, the fry are

not planted that year, or next, as seems to be the present policy of running the nurseries on a three-year cycle, then there is a very inefficient production, as large plants of fingerlings would only be available every third year. Furthermore, there is always the imminent danger of winter loss. The chance for winter loss in the crowded, shallow nursery lakes would be greater than in most fishing lakes. Presumably no growth, or very little, takes place over the winter, whether the pike are in nursery lake or fishing lake. Then circumstances combine, in our opinion, to warrant the policy of seining out the pike as fall fingerlings, preferably after the weeds have died down and growth has been retarded or stopped. If observations indicate starvation, as was discovered in Diamond Lake in August, 1932, thinning out the fingerlings in the late summer may be desirable. Using improved transporting units, this should be possible, whereas now Mr. Baur feels it unsafe. Seining may be advantageously continued under the ice in winter, if any considerable number of the young pike have been left from the fall. Then the seining can be continued in the spring while the water is still cold and before the weeds get thick, in order to insure a fairly thorough clean up of the yearlings before the next crop of fry is introduced. We strongly recommend that pike propagation in all the nursery lakes be put on an annual basis, harvesting a fingerling crop each year.

While the policy of annual cropping of pike fingerlings has not been adopted officially, some of the interested Department's employees, as Butler and Speaker, favor this policy.

Planting the Fingerlings.--In the planting of fingerling or older pike from the nurseries, careful thought should be given to the relative needs of the different lakes. This need depends on the carrying capacity of each lake for pike of each age group, on the present population of each group and on the prospective drain due to fishing. It is entirely possible to plant more young pike than the given lake can support. A qualified man should have the responsibility of examining the various pike lakes at fairly frequent intervals, so as to get some idea of the natural abundance of pike of each age already in each lake. If

he should find such an abundance of young pike as we encountered in Spirit and Silver Lakes (Dickinson County), he would naturally recommend that the fish of the same age be mostly planted in other waters.

Wintering Over the Fish.--H. E. Hart's reports of 1933 go into the problem of maintaining a suitable chemical environment for the fish in the nursery lakes over the winter. We have two suggestions which ought to alleviate this situation: The first is to remove a large percentage of the fingerlings soon before the lakes freeze over; the second is to raise the water level a few feet. In any event, the continuous use of the lakes calls for maintaining the oxygen over the winter. This is important not only for saving such pike (or bass) as were not seined in the fall, but also for holding a breeding reserve of forage fishes and of other food organisms.

The problem of maintaining the dissolved oxygen supply under the ice is discussed under Oxygen in our report on "Field Conditions in Iowa."

CENTER LAKE PIKE NURSERY, DICKINSON COUNTY

Examined by Salyer August 1, 1932, and by Hubbs, August 13, 1932, in company with Mark and Speaker.

Tributary to.--West Okoboji Lake (in high water). The outlet is from the south-west shore.

Water Supply.--Surface drainage from a very small drainage basin (883 acres according to the 1916 survey). Mr. Hart pointed out that this was advantageous from the standpoint of erosion (i.e. silting), but disadvantageous from the standpoint of the water. The wet weather inlet, draining a couple of sloughs, enters the north shore.

Water Level.--When examined, this lake was at least 5 feet below normal and had not overflowed for a considerable time.

Pollution.--We found hogs still running in the water, and even a dead hog thrown in.

Dam in Outlet.--This dam is such in name only - merely a 150 foot line of large boulders not in the least watertight. At period of examination, there was an interval of about 450 feet between lake edge and "dam". We must expect, however, that the lake will again rise to an overflowing stage.

Shore.--A fringe of open woods extends around the lake. At the low level of 1932 there was a narrow to wide sand beach, except for the marshes of cattails, etc.

Temperatures.--Hart's determinations for the period from July 8 to November 18, 1931 showed water temperatures varying from $8^{\circ}C$(= $46.4^{\circ}F$) to $25^{\circ}C$(= $77^{\circ}F$) and from $0^{\circ}C$(= $32^{\circ}F$) to $2^{\circ}C$(= $35.6^{\circ}F$) between December 9, 1931 and February 10, 1932. We found $70^{\circ}F$ at 4:00 P.M. on August 1, when the air stood at 74°.

Water.--The water in this lake is silty, and in the summer a deep green from the algae. The bottom visibility on August 13 was about 1 foot.

Mr. Hart reported in one place that during weekly visits over the summer of 1931, he never found a deficiency of oxygen, nor any offensive smell. Almost always the tests show a supersaturation of dissolved oxygen. In another place he gave somewhat contradictory figures, which we assume to be correct. From August 19, 1931, to November 18, 1931, the pH varied from 8.1 (once) or 9.2 to 9.6; the dissolved oxygen from 6.1 to 12.4. From December 9, 1931 to February 10, 1932, the pH from 8.1 to 8.7 and the dissolved oxygen from 9.0 to 16.7. The amount of dissolved oxygen fluctuated back and forth on either side of saturation. In general there was an increase in oxygen with a decrease in temperature - a point emphasized as peculiar by Hart, - but this was not much more evident than for the other lakes.

On the occasion of our visits, Mark found the D. O. to be 4.4 on August 1.

Size.--264 acres according to the 1916 survey.

Depth.--This lake normally carries about 15 to 18 feet of water, but is now mostly 12 feet deep, at most 15 feet. It is bowl-shaped, and reaching a depth of about 5 feet about 30 feet from shore (more in some places, less in others).

Bottom.--About island off south shore, very bouldery on a soft blue clay base, except on muddy south side; south half of east shore, blue clay with limestone gravel; west shore, lower and grassier; middle of east shore, sandy; north shore, scattered boulders; south shore, mixed sand and gravel. More than 50 feet from the shore-line (of August, 1932) the bottom is mostly mud, becoming soft outward.

Hart was of the opinion that "the bottom of this lake is not as rich as some studied, but is richer than is found in Trumbull Lake." This is likely, but the existing conditions lead us to suspect that the bottom is very rich in organic matter nevertheless.

Cover.--Very slight.

Vegetation.--The higher plants are relatively poorly developed in Center Lake, though we could hardly confirm Hart's report that very few are to be found. In fact, we found five leafed pond-weeds (P. interior and some of what was perhaps P. zosterifolius) Naias, etc., forming a dense stand between the island and the south shore. There may well have been a big difference in the development of the water plants in 1932 (our visit) and in 1931 (Hart's period of observation). Mr. Hart indicated a complete absence of plants of the rush class, and no Elodea, Valisneria or Ceratophylium. He claimed that it was impossible for the plants to get a foothold, on account of the hogs and cattle which tramped in the lake. Hart reported that some of the pondweeds (Potamogeton) which prefer deeper water occur rarely. Salyer found only one pondweed (P. interior), with a few sprays of P. pectinatus and "nest moss" (Naias flexilis). He found a narrow fringe of bulrushes along the middle of the south shore.

Algae.--Mr. Hart reported that quite a heavy growth of blue-green algae developed in this lake in August, 1931. "They did not develop to the extent found in Lost Island and Storm Lakes." Mr. Hart seemed inclined to correlate the development of the blue-green algae with the scarcity of higher plants. During his weekly visits he never found more than what he considered to be a usual or normal number of dead fish along shore. "There never was a time when this lake had an offensive smell, and neither was there ever a time when there was a deficiency of oxygen." Our observations are quite in harmony with Hart's. We got no evidence of algae piling up on shore or becoming really offensive.

Natural Food.--Mr. Hart reported that this lake contained less food than either Welch or Diamond, and that "it was evident that there was not a sufficient amount of food for the pike to develop in the same proportion as in the other two nursery lakes." This was likely true, but whether the condition was and is due to a lesser basic fertility, or to the extreme overabundance of bullheads, can not be said.

Predators.--We found a relatively high abundance of fish eating birds, including about a dozen great blue herons, a somewhat larger number of green herons, many kingfishers and many black terns. There is some doubt as to the number of fish eaten by the black terns, but they certainly take small fish at times (they even caught minnows in midair, as we threw them). Other birds were common. We also found many snapping and painted turtles (one of former was opened but found empty.)

Fishing.--This lake formerly had a good reputation for bass, pickerel (northern pike) and bullhead fishing. It is very little fished now, most residents believing the lake to be closed.

Pike.--As Mr. Hart remarked, this lake is rather large to be used as a nursery lake, and that "it is physically impossible to get all the large pike out". The numbers that are present diminish the percentage of production appreciably.

We took no pike in our seining.

History of "Pike" Production in Center Lake.--From Mr. Baur we obtained a copy of the record of pike production in this lake:

Date	Fry Planted	Est. Loss as Dead Fish	Recovered	Age	Size
Spring 1927	20,000,000	...	...	...	...
Spring 1928	...	...	3,500,000	Yearlings	4½"
Fall 1928	...	...	120,000	Yearlings	8
Spring 1929	...	...	260,000	2 - year old	...
Fall 1929	...	...	10,000	2 - year old	...
Spring 1930	...	...	160,000	3 - year old	...
Fall 1930	...	...	?	?	?
Spring 1931	20,000,000	...	2,750	4 - year old	...
Fall 1931	...	...	300[1]	Fingerlings	...
Winter 1931-1932	...	300[1]	...	Fingerlings to adults	To 18" or 19", or 2½ lbs.

Percentage recoveries:

Age	1927 Planting	1931 Planting
Yearlings	18.10%	.000015%
2-year old	1.35%	...
3-year old	.80%	...
4-year old	.01%	...
Totals (no more to be expected)	20.26%	.000015%

[1] No official record. Data from Hart and Tennant.

The results for the 1927 planting, as reported, are a marvelous record, far surpassing any other achievement in pike rearing. The results for the 1931 plant are in contrast a dismal failure. We believe the dominance of the bullheads in this lake has produced this difference.

Relation of Bullheads to Pike.--Bullheads exist in this lake in excessive abundance.

It is generally reported that up to 112 (or 120) bushels of bullheads were taken out in single drags of 3000 and 3500 foot seines (3/4 inch mesh in wings, $\frac{1}{2}$ inch mesh in centers), this spring (1932). We took hundreds in a single haul of our small bag seine.

It is generally thought by the local officials that this abundance of bullheads is responsible for the recent failure in pike rearing. It is claimed that the bullheads got all the pike in 1931. No doubt bullheads eat fish. This is shown by our examinations:

Size of Bullhead	Date	Food
7"	Aug. 1	1 killifish (Fundulus diaphanus)
$7\frac{1}{2}$"	"	1 fat head minnow
$9\frac{1}{2}$"	"	2 " "
$10\frac{1}{2}$"	"	(Empty)

Most of these minnows were entirely fresh, and had presumably been swallowed by the bullheads in the bag of the seine. However, it is likely that the bullhead can capture the minnows while they sleep at night. Mr. Tennant claimed that bullheads caught in Center Lake in the summer, on hook, contain minnows in varying stages of digestion. He also claimed that in 1928 the big bullheads taken here commonly contained 1 to 4 walleye fingerlings. He also claimed that when the hatchery was established at Clear Lake, bullheads were frequently caught on the pike spawning grounds, and that these were "full of pike spawn", distinguishable from sucker spawn by size.

It seems probable that the bullheads are almost under control, since Mr. Tennant said no young were found this year (1932), indicating that the adults are largely caught off. We took very few adults, no young, but an abundance of yearlings.

(In reporting the bullheads of the nursery lakes and elsewhere in Iowa to be "mostly Ameurus Natalis and Ameurus Melas, the Yellow and Black Bullheads, respectively", Mr. Hart was obviously led astray by the variable color. The common bullhead over most of the state, certainly the common species of the nursery lakes, is the black bullhead, Ameiurus melas, unfortunately the smallest of the northern species.)

Relation of Game Fish to Pike.--We found other competitors of pike. In our seinings we took several each of green sunfish, bluegills, orange-spotted sunfish. These species, probably in the order named are capable of feeding on pike fry and of feeding on the very foods which should be going to the pike.

Carp are fortunately nearly whipped in Center Lake. We caught none in our minnow seines.

Forage Fish.--According to local testimony (Tennant and others), forage fish were common in Center Lake before its establishment as a nursery, but that the successful operation in 1927 to 1929 as a pike nursery resulted in the cleaning out of the minnows. Thereafter minnows from Virgin Lake and elsewhere were reintroduced. According to the official record, the lake has been stocked with minnows since 1930, most heavily in 1931.

Mr. Hart reports that the nursery lakes contained scarcely any minnows until they were planted in the spring of 1931; elsewhere he also indicated that they had been previously present but had been cleaned out by the pike. We did find fathead minnows to be very abundant. We took many very fine breeding specimens, as many as a bushel in a single haul of our bag minnow seine. Practically all adult males were in breeding colors on August 1, and many were still "nuptial" on August 13. There were also smaller numbers of blunt-nose minnows, brassy minnows (Hybognathus hankinsoni, perhaps introduced from Little Sioux River

through Virgin Lake) and golden shiners. The view of Mr. Hart was hardly confirmed by our findings. The breeding male fatheads were apparently too numerous to be the actual fish introduced from Virgin Lake in 1931. Furthermore, they cannot be the offspring of the fish put in then because they had lived through two winters.

Recommendations

As a Nursery Lake.--We hardly believe that the discouraging conditions in this lake (as of August 1932) ~~fe~~ call for its abandonment as a pike nursery lake. True, its size, depth, contour, etc., make it very difficult to seine thoroughly, and Hart was probably correct in regarding it as impossible to get all the larger pike out. This circumstance would argue against using this lake for a bass nursery, as a very few pike in a small lake are capable of making tremendous inroads on bass fingerlings (actual experience).

It is doubtful if this lake can be made to provide the results which can be made to obtain from the other nursery lakes. It will also require very close attention and intelligent administration.

It is possible that lakes easier to control can be found, which will be so superior as nursery waters as to make Center Lake unnecessary as such. It could probably be rebuilt into a good general fishing lake.

Management.--If it proves favorable to restablish Center Lake as a successful nursery lake, we would recommend an annual stocking with about 15000,000 wall-eyed pike fry, and an effort to remove as many as possible in late fall, winter and early spring. We also would recommend careful and continuous observation.

Fishing Privileges.--It would be beneficial to the operation of the lake and to Department good will to make it generally known that hook and line fishing is permitted in this lake, especially for bullheads. Of course strict regulations against seining for minnows should be made and enforced.

Farm Animals.--The state should exercise or acquire the right to prevent farm animals wading in this lake. This should be helpful in rebuilding weed beds which are much needed, and may be helpful in controlling pollution and erosion.

Predators and Competitor Control.--More effort used to be expended in reducing the predators and competitors of pike in this lake. This applies to the shooting or trapping or frightening off of herons, kingfishers and other fish eating brids, and the removal of turtles. We recommend the removal of turtles so far as possible of game or pan fish and bullheads and the planting of these in suitable waters elsewhere.

Forage Fish Culture.--We recommend that every effort be made to increase the fathead minnow supply. In introducing new stock from Virgin Lake or elsewhere, we urge that all sunfish be discarded, as they are capable of eating pike, even golden shiners should be avoided to a degree as they if abundant probably would consume many pike fry.

It may be necessary to plant more minnows in the lake, but so far as possible it would be wiser and cheaper to cultivate those already in the lake. Increasing the spawning by placing several hundred smooth flat objects in the bottom in shallow water would be a means for that desired end. Broken tile is suggested.

Vegetation Increase.--It is strongly urged that the extension of the weed beds in Center Lake be attempted, by cultivational methods.

Cover Increase.--We regard additional cover for the small fish as a prime need of this lake. This would shelter the young pike from their various enemies, and also shelter a brood stock of minnows. Furthermore, the brush shelters should materially increase the insect life. For Center Lake we recommend 15 lines of about 10 brush shelters, each line to be about 1000 feet long on the average and each shelter made of brush hanging from a board frame 20 feet square. The lines would be of 1/2" cable stretched across the various necks of water. The ends of cable would be attached to shore, so that they could be unfastened. The string of shelters would then be drawn into shore by one of the power wenches used for seining, and the shelters put on shore for the winter.

Regulation of Water Level.--Anticipating a rise in the lake, we recommend that a real dam be put in, so that extra height can be built up in rainy seasons.

WELCH LAKE PIKE NURSERY, DICKINSON COUNTY

Examined by Salyer August 1, 1932, and by Hubbs on August 13, 1932.

For several years Welch Lake has been operated unsuccessfully, on account of some set-backs, as a nursery for wall-eyed pike. In order to appreciate the discussion of the lake from a propagational standpoint, a brief description is in order.

Description

Tributary to.--West Okoboji Lake.

Water Supply and Level.--Surface drainage from an area of only 375 acres (1916 Survey) enters this lake, mostly in a tile-fed inlet at northwestern corner. This tile is said to run more in wet weather. During July of 1932 according to the water marks on lake-edge trees, this lake lost 12" to 14" in level. There is a strong possibility that some spring water enters the lake.

Pollution.-- Little, except for soil wash, and annual dying of weeds.

Dam in Outlet.--There is no real dam at the outlet, merely a pile of stone and boulders across the stream bed at the head of the outlet. We understand that farmers in the lake drainage area object to the dam on the supposed grounds that it floods the tile outlets so as to interfere with the drainage of their fields. They are even supposed to have torn out the dam on several occasions. Unless the Survey of 1916 is very badly in error, there can be little grounds for such apprehension, as the 10-foot contour above lake level is indicated as generally only 100 feet back from the shore, and except for the little swale at the southeast corner even in the draws does not extend back more than 300 feet.

Shore.--The east shore is high and wooded, above the bouldery edge. There are no really low shores, and all sides of the lake are well protected. Banks run about 2 feet high. The west side has some mud flats, caused by soil wash from the fields. On these flats the sand bar willow is getting a good hold.

Temperature.--This is obviously a warm water lake. We found:

Water 73°F, air 67°F, 9:00 A.M., August 1, cloudy sky, light rain.

Hart's detailed survey, from July 8, 1931, to February 2, 1932, shows that the temperature varied from 0°C (32°F) to 26°C (= 78.8°F).

Water.--The water is not clear. Dissolved oxygen determinations by Mark and Speaker show a curious condition, the oxygen being often lower at the surface than at the bottom. On August 1, 1932, the difference was extreme, 2.6 p.p.m. at the surface and 5.6 p.p.m. at the bottom (determination by Mark).

On August 13, 1932, the weeds were beginning to break loose, and were starting to decompose and smell. In the weeds an analysis by Mark showed only 2.8 p.p.m. of dissolved oxygen. On August 14, 1932, D.O. determinations by Mark were as follows: 4.6 p.p.m. 18" deep near center of lake; 3.4 p.p.m. 1 foot off bottom near north end; 3.6 p.p.m. in midwater, south end. In consequence of the heavy weed growth, the pH is very high, on the alkaline side (9.3 on August 1).

Mr. Hart made an extended study of water conditions in this lake. In 27 fairly regular samples, the pH varied from 8.2 to 9.5 between July 8 and October 28, and from 8.0 to 8.4 from November 4 to February 10. (On August 13, 1932, the pH in the weeds was found by Mr. Mark to be 9.3.) The dissolved oxygen shifted from 6.0 to 15.6 p.p.m. except on two dates, July 8, when it stood at 5.6 p.p.m., and on December 9, when it dropped to 4.0 p.p.m. recovering to 7.6 p.p.m. the next day. Mr. Hart attributed this we think correctly to the snow of December 3. The effect was probably accentuated by a heavy mortality of plankton algae, caused by the snow blanket. That there was probably a heavy growth of plankton algae just before the drop in oxygen is evident from the rapid increase in D.O. from 10.6 p.p.m. on November 18 to 15.6 p.p.m., a supersaturation on December 3. Only plant action could have produced this supersaturation. The condition of dissolved oxygen in this lake over the winter of 1931-1932 is indicative of a healthy water condition.

The loss of oxygen in October, 1930, as a result of the overproduction of crustaceans, is dealt with under Natural Food.

Size.--57 acres (1916 Survey). This would be but little increased by a 5-foot rise.

Depth.--This lake is almost as deep near shore as toward the center. At the level when examined, 5 feet of water was found about 30 feet from shore.

Bottom.--A bottom sample in 1910 showed 4 feet of silt over 4 feet of black loam, which rested on clay. We found the bottoms of pulpy peat (decaying organic matter), and very foul smelling, except near the shore, where the bottom is of muddy sand. This is an index of richness, but also of danger on account of potential oxygen depletion.

Cover.--Fairly satisfactory, in the form of dense weeds.

Vegetation.--We found the weeds to be generally very thick; a continuous almost solid bed 15 to 25 feet of fine-leafed pondweeds (P. zosterifolius and P. interior), occurred around the shore; with some scattered patches of sago pondweed (P. pectinatus). There were weeds also in the center of the lake. Some cane (Phragmites) in northwest corner. In with the pondweeds was much filamentous algae. A similar condition for 1931 is reported by Hart.

In 1931, Hart regarded this lake as being in the best condition of any of the three nursery lakes, and attributed this circumstance to the abundance of higher plants, which by late August and early September had become so congested that it was impossible to get around the lake in a boat, and to the scarcity of blue-green algae. "Today the oxygen content of the water is up to, or very close to, saturation".

Algae.--We found no indication of an algal nuisance in this lake. Hart in his 1931 studies never found more than a normal number of Cyanophyceae.

However, considerable anxiety may be entertained, that Welch Lake may follow the history of Silver Lake (at Lake Park), namely lose its larger plants and develop blue-green algae in their place.

Natural Food.--Welch Lake is one of the most productive in natural food of any of the lakes we have ever seen. In fact, the productivity has once passed beyond the danger point. Thus crustaceans once become so abundant that they died and dropped to the bottom in untold millions. Reports have it that the crustaceans could be scooped off the bottom by shovel-fulls; that at one point on the north side of the lake, they

covered the bottom to a depth of 1 to 1 1/2 inches. The oxygen naturally was depleted, as much oxygen is required to consume the animal bodies. According to some, fish deaths occurred, although Hart reported that a 22 inch raise in water, following an 8-inch rain, flushed out the lake. Algae were definitely not responsible, it is claimed. The hear-say evidence is conflictory as to the date and type of crustacean involved. Hart in one part of his report gave the date as October 8, 1931, and the crustacean as "various Cladocera, with daphnias predominating". One another page he gave the date as in October, 1930, and the animals as "scuds (Hyalella), and other smaller crustacea". Baur claimed that the deaths occurred in August. Concensus of testimony was ~~the~~ indicates rather clearly that the date was October, 1930, and that the chief organisms was the amphipod Hyalella. The explanation of this great mortality, which depleted the oxygen and killed the pike seems to be correctly given by Hart, as follows: Owing to the high organic content of the water, there is a tremendous production of the crustaceans. Due to the overstocking of the lake with predacious fishes, the forage fishes and other consumers of the crustaceans were eliminated. These then overran normal limits, died and produced the tragedy of unbalanced nature. After the restocking of the lake with minnows, no such overabundance of food has occurred, and no further losses of the sort mentioned.

These crustaceans are prime food for small fishes and for young game fish, pike included. The evidence seems good that Welch Lake has a better food production than either Diamond or Center Lake, though really reliable quantitative information seems lacking.

Hart found insect larvae more abundant in Diamond and Welch than in any other lakes examined.

On August 13, 1932, we found plankton, about 50% animal plankton, to be dense in this lake. Hyalella abounded also, though not approaching the superabundance which caused the deaths on a previous date. Dragonfly larvae, water bugs, beetles, etc., were also very thick; some crayfish also present. Prescott reported likewise (November 1932) on the abundance of animal plankton in Welch Lake. In fact the animal plankton

became so abundant that a major mortality was only averted by Dr. Prescott's observations and timely action.

The forage fishes of course are needed for the young pike. There would seem to be little chance of overpopulating this lake with minnows , owing to the extreme voraciousness and abundance of the young pike. The fears of Mr. Hart that the minnows which were placed in this lake in the spring of 1931 multiplied so rapidly as to produce an oversupply, were seen in our work to be unfounded. The consumption of minnows by the pike is so extensive, that the more logical fear is that they will again clean out the forage fishes to the low point which Hart indicated was reached before the restocking of forage fish in 1931. A few fathead minnows were found remaining on August 13, 1932.

Predators.--Salyer observed on August 1, a number of predators, including 8 black-crowned night herons and 1 kingfisher. He rescued a three-quarters grown coot from an 11-inch snapping turtle. Hubbs cut open a snapper to find it had eaten one crayfish and one water beetle.

Fishing.--"The fishing is only fair" (1916 Survey). At present fishing is said to be allowed, though this is not generally understood.

Pike.--Salyer found the pike in Welch Lake to be "not as large or vigorous as those in Diamond Lake". On our examination only 12 days later, this condition was very strikingly reversed, owing to partial starvation in Diamond Lake. On August 13, the young pike in Welch Lake appeared to be in fine condition, and very uniform in size. This illustrates again how these lakes are unbalanced.

Both of us found a great abundance of young pike.

The pike were reported to have been frozen out last winter (1931-32).

Reports from Messrs. Baur, Hart and others indicate that during the first few years of operation, this lake was noted for the rapid growth of pike. Lengths close to 7 inches were attained in September.

Mr. Baur's official record of "pike" operations copied by us, is as follows:

Date	Fry Planted	Estimated Loss in Dead Fish	Recovered	Age	Size
Spring 1929 (first use)	2,500,000	...	...	...	...
Fall 1929	...	...	12500	Fingerlings	6"
Spring 1930	...	...	750	Yearlings	7"
"August 1930" (other reports Oct. 8)	...	complete	...	Yearlings	...
Spring 1931	No official record given 1500,000 or 2,000,000 (Hart)*		...	...	...
Winter 1931-32	...	loss not officially reported, but occured (Hart)*	...	...	...

Percentage recovery from 1929 stocking:

Fingerlings	0.5%
Yearlings	0.003%
Older fish	None
Total	0.503%

Other Fishes. - We took perch and bullheads. The perch were undoubtedly competing with the pike; they were feeding largely on Hyalella.

Forage Fish. - Salyer found some golden shiners and some fathead minnows.

Recommendations

Policy.--Despite the failures obtained to date (summer of 1932), we recommend that this lake be maintained as a nursery lake, either for pike or for small-mouth bass. We believe it desirable to allow fishing, and even to spread the news and to urge people to fish here. This should help to keep down the bullheads and perch. If large (2- or 3-year old, or even yearlings) pike should be caught, that would be to the good in our opinion, as the larger pike must take a tremendous toll of the small ones. This suggestion is in line with our proposal that the young pike be removed, as far as possible, every fall, winter and spring. This lake is so rich in organic content, that it can not be expected to consistently hold large numbers of fish over winters. We recommend that the seining start as soon as the weeds have died down, and that this should be continued under the ice and if necessary in early spring, to insure the removal of nearly all the pike.

* See also Hart's Supplementary Reports on Nursery Lakes, dated February 25 and Mar. 10, 1932.

We agree with Hart, Prescott and others that this lake will require extreme care in management, but we do not believe it will require less care than the other lakes. We agree also that it can probably be made to produce more fingerlings per acre, than either of the other nursery lakes.

Predator Control.--This lake should be frequently visited to kill or frighten off herons. Numerous kingfisher pole-traps should be kept. The dead bodies could be thrown into the lake to advantage.

Spawning Beds.--Should not be improved (except for minnows).

Food Increase.--We recommend that fathead minnows be encouraged as forage fish, and that other species be avoided. Even golden shiners (as adults) are potentially dangerous to the very small pike. Fatheads are not. Planting fathead minnows now is desirable and may need to be continued. However, a great increase in the stock should result from placing waterlogged slabs, pieces of crock, or other objects with a smooth and flat bottom, on the bottom near shore.

We further recommend that insect attracting devices be installed over the water and be lighted at night. The extra food and extra light should materially hasten the growth of the pike fingerlings.

Vegetation Increase.-- Not needed now.

Regulation of Water Level.--We recommend that a permanent concrete dam be built in the outlet, with a suitable boulder-faced dike wings. The expense would be well justified. We recommend that this be built so as to permit a 5 foot raise in the lake level, but with removable slash boards so the level could be fixed at any point up to the five foot increase. The spillway should be provided with self-cleaning screens, which would used be examined at frequent intervals, especially when the weeds begin to die.

Experience should dictate the most effective level to be maintained over the summer. It might be best to build up the level in the late fall after a large part of the pike were seined out, in order to hold as high a level as possible over the winter.

According to the topographic map accompanying the 1916 Report, a 5 foot raise would do very little flooding. However we understand local farmers are so convinced that even a one foot raise plugs their tile, that they have several times removed the small boulder dam. An arrangement would need be made with these farmers, involving compensation if any damage should result. The advantages of a higher level are so great as to warrant condemnation proceedings if necessary.

Control of Silting.-- Several gulleys around the lake, as on the west side, are carrying in a rather excessive amount of silt from the fields. We recommend that several loose boulder dams be thrown across these gulleys to catch the silt and that the gulleys be suitably planted to avoid further erosion as far as possible. This might require some land purchase or arrangements with owners, but would be justified. The entire watershed according to the 1916 survey is only 375 acres.

Control of Water Conditions.--The excessively rich organic bottom of this lake creates an oxygen hazard. This demands careful and intelligent and virtually continuous administration. Water and food analyses ought to be run at least weekly throughout the year, and oftener in periods of possible danger, as in early fall when the dying weeds pull down the oxygen. Two weeks neglect, experience has shown, may be very serious. The one great mortality in October 1930 due to the

to the decay of over abundant animal life was more costly than several years checking. There can be little question but that it was Dr. Prescott's presence, frequent examinations and realization of another impending mortality which avoided a loss of the 1932 "pike" crop of Welch Lake. One trained man to manage the three nursery lakes is a virtual minimum requirement, if continued success is to be obtained.

DIAMOND LAKE PIKE NURSERY, DICKINSON COUNTY

(T 100 N, R 37W)

Examined by Salyer on July 28, 1932, and by Hubbs on August 13, 1932.

Description

Tributary to.--Sioux River through intermittent outlet.

Water Supply.--Surface drainage (from 1949 acres--1916 Survey). The main supply comes in through wet-weather sloughs on the north side. A tile near the south end carries in the drainage from a half section or so. Two gulleys carry in flood water from the east shore. The one near the middle of the east shore must carry a heavy flow at times, as it has carried in much fine sand.

Fluctuation in Level.--The fluctuation of about one-foot given in the 1916 report was an underestimate. The lake is reputed to have gone dry in the World's Fair year (1893). During July of 1932 alone there was a one-foot drop according to reports confirmed by water marks on lake-edge trees.

Pollution.--A barn yard deep in manure lies on the east shore, on the slope into the lake. It must contribute a very considerable amount of nitrogenous matter to the lake after rains. This source of pollution is mentioned with others by Dr. Prescott in his report of November, 1932.

Dam in Outlet.--A small, leaky one of loose stones and boulders.

Immediate Shore.--The entire shoreline is sandy, with increased silt at the mouth of the draws. There was generally a narrow sandy beach (at level of examination), with sloping shores rising 15 to 20 feet above lake level except opposite the sloughs and near the outlet. The entire north shore is bordered with 4 or 5 year old peach-leaved willows (Salix amygdaloides). The east and south shores have an open fringe of oak and cottonwood. The west shore is rather open and unshaded. On the southwest there is a nice border of black willows.

Use of Water.--This lake has been used as a pike nursery for several years. While open to fishing, it is not generally supposed to be.

Temperature.--This is obviously a rather warm water lake. Our records however were

not taken on very hot days:

Date (1932)	Taken by	Air	Water Temperature Surface
Aug. 1	Mark	19.4°C=67°F	21°C = 69.8°F
Aug. 13	"		21°C = 69.8°F

From July 8 to December 3, 1931, Mr. Hart found surface temperatures varying from 2°C (= 35.6°F) to 28° C (= 82.4°F).

Water.--The water is generally rather roily especially after storms. Some 1932 summer analyses, taken by Mark, follow:

Date	Where	pH	D.O.
Aug. 1	Near shore	8.1	5.0
Aug. 13	Near shore	8.0	2.8
Aug. 14	Clear water, 18" deep, 60' out	-	3.8
	12" off bottom, 60 feet out	-	2.9
	North end, surface	-	3.1

On August 13 we found that weeds were beginning to die. The shoreward weeds had broken away in the previous two weeks, leaving 100 to 150 feet of clear water. This was doubtless accompanied by decomposition, for the pH was found to be low for an Iowa lake (8.0), and the dissolved oxygen down to 2.8 p.p.m. The water was a dirty brown, with bottom visability less than 1 foot. (The color Dr. Prescott found to be due to the abundance of diatoms).

Mr. Hart also made a survey of the water conditions in this lake. In the winter of 1930-1931, despite heavy ice, there must have been lots of plant activity for the water was generally much supersaturated with oxygen.

From July 8, 1931 to December 3, 1931, the oxygen varied from 5.0 to 14.2 p.p.m. except for two analyses of 4.8 and 0.0 p.p.m. at single stations when other tests ran 5.0 or higher. After December 9, when there was a heavy snow, the tests were much lower, averaging only 2.8 to 3.9 p.p.m. for the different stations on each test day, except during a January thaw, even though air compressors were kept in use. (The effect of these aerators is dealt with at some length by Hart).

The pH in Hart's survey varied from 8.0 to 9.4, and was usually more than 8.5

in the summer but less than 8.5 in the winter.

Size.--Main body of lake 111 acres (1916 Report). A raise in water level of two feet would probably connect up the swales to the north and add about 50% to the area.

Depth.--To 6.2 feet according to 1916 survey. Salyer found slightly over 8 feet in deepest part now, and an average of 4 to 5 feet 100 feet from shore.

Bottom.--Near shore everywhere the bottom is sandy, though with increasing silt in places. This is especially true off the draw by the barnyard on the east shore, where the inshore bottom is of very soft muddy sand, almost quicksand. In other places it is of firm sand. The bottom becomes very muddy about 100 feet from shore. There are several boulders larger than a boat, on the bottom.

Vegetation.--This lake was found to support a heavy growth of narrow leafed pondweeds. On July 28, the north third of the lake was practically covered with Potamogeton interior and "blanket moss". That pondweed (P. interior) also grew all around the lake. There is some P. crismus; some scattered beds of P. zosterifolius; quite a lot of P. heterophyllus along the east shore; lots of Naias on the north shore. On August 13, the beds of P. interior and the blanket algae were dense, except where killed near shore.

The marsh north of the lake contains all the usual water plants, submerged and emergent.

Algae.--During Mr. Hart's period of investigation (summer of 1931), he found that Diamond Lake showed the heaviest growth of Cyanophyceae, along with the heaviest growth of higher aquatic plants. "However, the distribution of the Cyanophyceae was not general. Only the northeast portion of the lake was seriously affected. It is in this portion of the lake that the smallest number of higher plants will be found. There have been times, this winter (1931-32), when the drainage from the barnyard on the east side of the lake would rival the sewage from a packing plant. The effects on the lake can be plainly seen".

The very interesting circumstance that diatoms replaced the bluegreen algae in the late summer of 1932 is emphasized in Dr. Prescott's second report.

Natural Food.--Mr. Hart was probably right in placing the food productivity of this lake below that of Welch Lake. So far as we know, however, he had not enough data to prove the point. Early in 1932 it was said that there was an abundance of scuds and other food animals. We found evidence of lots of food up to August 1, especially in the good condition and abundance of pike up to that date. But by August 13, they had obviously consumed nearly all the food and were in a condition of semi-starvation; some being so very badly emaciated as to appear ready to die from starvation. On the latter date we found the same kinds of food organisms as in Welch Lake, but in very much less abundance (this includes animal plankton, Hyalella , aquatic insects, crayfish, etc.).

The starved condition of the "pike" fingerlings on August 13 appeared so critical that verbal recommendations were made to remove some of the fish. Whether some of the fish died we do not know. Obviously, however, the tremendous growth of diatoms which developed as the starvation became evident, must have reestablished food organisms for the young fish, since these later in the season recovered from the starvation in early August.

Hart found insect larvae more abundant in Diamond and Welch than in other lakes examined.

Possibly Diamond Lake is less richly productive than Welch, though the heavier stocking in 1932 may have largely accounted for the greater food destruction on August 13.

Predators.--Salyer found predators apparently too numerous over this lake. On the one visit he counted:

Kingfishers	11
Great blue herons	3
Black-crowned night herons	5
Green herons	3

Pied-billed grebes.....about 12

Black, common, least terns.....many

Snapping and painted turtles... many

Muskrats....."quite a few"

One kingfisher was actually seen to catch two young pike.

The 15 to 20 acre marsh just north of the lake is a wonderful holding basin for predaceous as well as non-predaceous birds. Here were found some black-crowned night herons and bitterns and many grebes and black terns, as well as many yellow-headed blackbirds and coots and some ducks, sandpipers and swallows.

Fish.--On July 28 we found, in addition to numerous young pike, a considerable variety of other fish, which must affect the pike for better or worse as the case may be. At one seining point we took (July 28) a considerable number of forage fish, golden shiners and breeding fathead minnows, 1 young sucker and 1 killifish. Of these the fathead is probably the best species, because the larger golden shiners are quite capable of devouring pike fry. Of real competitors, all capable of feeding heavily on pike fry, we took a green sunfish, two perch fingerlings, a dozen orange-spotted sunfish, many bullheads and some two-year old carp. Young wall-eyes of 3 1/2 inches were found to be very abundant and in fair condition. 54 were taken in two short hauls of a minnow seine and almost a hundred in one haul of a 75 foot bag seine, both on the south shore.

By August 13 we found the minnow population to have apparently been completely consumed, for we could not seine a single specimen in many hauls.

Mr. Hart reported that in Diamond Lake "the predominant species is the Silver Carp, Carpoides Velifer". He was referring we suppose to Carpoides velifer of authors = C. cyprinus, but we believe he may have confused this sucker with the carp (Cyprinus carpio).

Mr. Hart indicated that the lake had been largely cleared of minnows, until it was restocked in the Spring of 1931.

Mr. Baur's official record showed that minnows were stocked heavily in 1930 and very heavily in 1931. The consumption of the minnows in the summer of 1932 is already referred to.

Some food examinations of the other fish taken in the lake on July 28 show that they were eating the sort of food that would support even though it might not be preferred by the young pike:

Bullhead (7 1/2 inches): algae with minute insect remains.

Bullhead (8 inches): full of sand from caddis cases.

Bullhead (10 inches): Scales and remains of a young carp.

Carp (7 inches): crammed with algae (Cladophora)from top of rocks, the algae containing insect remains and amphipods ("shrimp").

Carp (5 inches): pondweed with midge larvae, shrimp and snails.

History of Pike Propagation in Diamond Lake.--From Mr. Baur, we obtained the following record of wall-eyed pike stocking andproduction:

Date	Fry Planted	Estimated Loss as Dead Fish	Recovered	Age	Size
Spring 1929	9,000,000	--	--	--	--
Fall 1929	--	--	3000	fingerlings	3½"
Spring 1930	--	--	365,000	yearlings	4½"
Fall 1930	?	--	?	?	?
Spring 1931	--	--	70,000	2-yr. old	9½"
Fall 1931	--	--	(No seining)	--	--
Winter 1931-'32	--	2700	--	3-yr. old	up to 15"
Spring 1932	3,000,000	--	--	--	--

Percentage recovery from 1929 stocking:

Fingerlings	0.03%
Yearlings	4.06%
Two-year olds	0.78%
Total	4.87%

This is a creditable record.

Recommendations

Policy.--We recommend that Diamond Lake be continued as a nursery lake for wall-eyed pike. We recommend that this lake like Welch be put on an annual fingerling production basis, for the reasons assigned in that report.

Care.--More constant diligence should be exercised to manage this lake wisely and safely for "pike"production. The need for such diligence was evident on August 13, only two weeks after Salyer's visit, for in that interval the "pike" fry had consumed what seemed to be a plentiful supply of food, had become greatly emaciated and unquestionably were in danger of disease or winter killing if not starvation. Whether a considerable loss occurred we do not know, but obviously a new crop of food developed so that the late fall fish fattened up again. It likely was a matter of luck that a new food-chain developed when it did, for two weeks more of starvation would likely have been intolerable for the fish. Dr. Prescott's 1932 report on the basic food conditions in this lake strongly indicates the need for technical management of this and the other nursery lakes. The fertility of the water is great, but as elsewhere in such Iowa lakes leads to unstable conditions. If these lakes are to be operated with any consistent success, the conditions must be controlled, so that desirable instead of undesirable organisms will result.

Algae Control.--We recommend that the pollution of the lake by cattle as determined by Dr. Prescott (1932 report) be lessened. There is a danger that blue-green algae may again become over-abundant.

Level.--We recommend that the level of the lake be increased about two feet, the state to purchase any lands to be flooded or made undrainable, or to acquire flood rights thereon. The advantages of this raise in level are several:

(1) It would greatly lessen the danger of winter killing.

(2) It would apparently add about 50 per cent to the area of the lake available to the pike, and this new shallow, weedy area would be very productive in food.

(3) It would flood the heron and grebe holdouts in the marshes and thus make predator control easier.

If it should be necessary to insure free connection for the fish between the new area and the main lake basin, a considerable portion of the ice rampart separating the two should be dredged out.

If the location of the dam at the lake shore should not prove feasible, the construction could be installed 600 feet downstream. Here a clay and boulder dike running north and south, a few feet to the north of the dam and 200 to 400 feet south of the dam, would serve the purpose.

The dam should have an adequate spillway, with self-cleaning screen, in its outlet.

Predator Control.--This lake should be frequently visited to kill or frighten off herons. Numerous kingfisher pole-traps should be kept. The dead bodies could be thrown into the lake to advantage.

Spawning Beds.--We recommend that fathead minnows be encouraged as forage fish, and that other species be avoided. Even golden shiners (as adults) are potentially dangerous to the very small pike. Fatheads are not. Planting fathead minnows now is desirable and may need to be continued. However, a great increase in the stock should result from placing waterlogged slabs, pieces of crock, or other objects with a smooth and flat bottom, on the bottom near the shore.

We further recommend that insect attracting devices be installed over the water and be lighted at night. Then extra food and extra light should materially hasten the growth of the pike fingerlings.

Vegetation Increase.--Not needed now.

Controls of Silting.--At least one large gulley(near the farm buildings) contributes a large amount of objectionable soft sand into the lake. An erosion-control dam in this gulley is called for.

(One page of original report missing)

in the pond, a good batch of small mouth bass should be obtainable. The bulk of the fry could be shipped to rearing ponds over the state, leaving only a few hundred in the spawning ponds on the island.

The artesian water seems to be good ~~food~~ quality except for the low oxygen content. The bottom is fair. The plant growth is good, in kind and quantity in the present pond.

The dissolved oxygen test in July, made by Mark for Salyer, was only 1.7 p.p.m. After that visit, and the communication of the finding of low oxygen to W. S. Albert, Jr. a triple-decked perforated platform was built to aerate the water. This looked like a well-designed apparatus for the purpose. (Mr. Albert first claimed that he figured this all out, and installed the aerator in early spring, when he found out that I had heard the real history, he corrected himself, stating that by coincidence he had just started the construction "the very day Salyer came" !)

In connection with fish rearing at the Game Farm, it should be mentioned that Big Lake contains a marvelous growth of good aquatic plants, which are available for planting in lakes now deficient in weed beds. The convenience of the supply, from the standpoint of distribution from the Lansing Station is obvious.

SWAN LAKE MINNOW NURSERY, DICKINSON COUNTY

Examined by Hubbs and Speaker Aug. 11, 1932

This lake was raised 2½ to 3 feet last fall (1931) by a new dam with concrete center. It has been designed as a minnow lake, the apparent idea being to supplement the output of Virgin Lake in this way. Minnow seining is prohibited to the public. The main characters of the lake as determined are:

Tributary to: West Branch of Des Moines River.

Water Supply: Surface drainage.

Pollution: None.

Shore: Grassy, with many willows.

Temperature: A warm lake (temperature not taken).

Water: Not very clean, bottom visible at depth of about one foot.

Game Fish.--In the lake we seined several large-mouth bass; two bluegills, a black crappie, a green sunfish and a number of orange-spotted sunfish, and a number of bullheads. Just below the dam we seined a few more bass, a green sunfish and hundreds of bullheads.

Rough Fish.--Carp are present (one seined).

Forage Fish.--Minnows are rather scarce - a few fatheads, two brassy minnows and a few Iowa darters were seined.

Recommendations

This lake was certainly improved for fishing by erecting the dam. But the flooded trees make minnow seining impracticable. Furthermore minnows are not abundant, while bullheads, bass and sunfish are common. We also do not believe the lake will prove very useful or useable as a minnow lake, and recommend that it is regarded as an ordinary fishing lake. (See also lake survey report).

IZAAK WALTON BASS POND, CEDAR RAPIDS

Examined by Hubbs, in company with Warden Sam O'Brien and Mr. E. J. North of Cedar Rapids, on August 16, 1932.

This little pond of about 1½ acre size, is located along McLeods Run in the city limits of Cedar Rapids. From a rpoduction standpoint it is virtually insignificant, though it is of value from the standpoint of education and local interest, and as a demonstration of the possibilities of small-mouth bass reproduction. It is located on a well fenced lot on the hill slope above the Run, and is fed by a spring. This must be small for the temperature at the outlet was found to be 19.4° C = 66.9°F; at the surface in the spring-house in center of pond, 22° C = 71.6° F; 1 foot down in spring house 20.4°C = 68.7°F. This spring house has been elevated and screened in to hold the very nice brood bass, while the fingerlings are free in the pond.

Eight small adults 11 to 13 inches long were put in the pond in the spring (1932). Eight beds were constructed on the gravel which had been introduced. Three beds produced young. On August 16 the fingerlings were about 2 inches long and seemed to be in excellent condition. They were not fed at all. A fine surplus of food remained in August: large scuds (Gammarus), snails, etc. Adult shiners were stocked, but the bass ate them all.

BASS REARING POND AND PITS BY MEDIUM LAKE

This pond, maintained by the local chapter of the Izaak Walton League was examined by Salyer on July 19, 1932. This appears to be a serviceable rearing pond. Bass are also being reared in gravel pits nearby. It appeared desirable, from our examination, to remove the brood bass from the pond and pits after the fry disperse. This would serve not only to save the fry, but furthermore there is not enough food for the older bass. Two year old bass here were only slightly more than 8 inches long. (This was found to be generally true of such ponds and pits in Iowa).

VIRGIN LAKE MINNOW NURSERY, PALO ALTO COUNTY

Examined by Salyer on July 18, 1932, and by Hubbs on August 11, 1932.

This lake has been used for some time as a minnow lake, the idea being to encourage the breeding of minnows for the restocking of pike nursery lakes and other waters depleted of minnows. Minnow seining is of course prohibited to the public.

Water Supply and Level.--Surface drainage; level subject to considerable fluctuation; up to normal when examined, decidedly higher than in 1931. Lake has not overflowed in years.

Dam.--A small dam at north end only 10 or 12 inches high, and without screen.

Shore.--Banks well protected by boulder-walls shoved up by ice. The banks are usually high and strong. Half of shoreline is well wooded.

Temperature.--This is a warm-water lake. 84°F on July 18, at 2:30 P.M. when air was at 92°F.

Water.--Silty; pH 8.4 and D.O. 9.7 on July 18, at 2:30 P.M.

Depth.--6 to 7 feet when examined.

Bottom.--Sandy toward shore, becoming stony at waters edge and soft outward.

Algae.--According to Hart, this lake is not troubled with algae. A considerable amount of blanket moss is present. The water color was yellow green on August 11.

Vegetation.--There is a considerable amount of emergent and submerged vegetation in this lake of value to ducks as well as fishes. Bulrushes, round-stemmed rushes, a few cattails and pondweeds (P. interior, and P. pectinatus) are present. Weed beds are inadequate, and are chiefly restricted to shore line.

Natural Food.--Comparatively good; midges numerous, and some caddisflies.

Predators.--Terns (common and black) are numerous. Turtles are plentiful. Hatchery seiners took out 50 barrels of turtles last spring (1932), we were told.

Game Fish.--Green sunfish, perch, bluegills and thousands of bullheads were seined. Mr. Speaker reported having seen a few northern pickerel and one perch from this lake.

The orange-spotted sunfish has unfortunately gotten a strong hold in this lake, because it is a runt species unfit for game, yet capable of consuming fish fry and of competing with game fish, especially their young. Hundreds were taken in two seine hauls on August 11.

Rough Fish.--An abundance of yearling carps and 46 two-year carp were taken in two hauls of a 15 foot seine on July 18. About a dozen young and half-grown carp were taken in two hauls of a 75 foot seine on August 11. A few buffalos were also seined.

Forage Fish.--Golden shiners and fathead minnows abound, and there are also some blunt-nosed minnows and a few brassy minnows (Hybognathers hankinsoni).

It is reported that minnows were planted in large numbers from here into Center and other lakes. Last year (1931) the stock seemed somewhat depleted in Virgin Lake. Others were brought in from Little Sioux River, etc.

Relation of Game Fish to Minnows.-- Mr. Hart was presumably right in attributing the abundance of minnows in the lake to the absence of bass, northern pickerel and wall-eyed pike. The few perch, crappies and green sunfish were insufficient to hold down the increase in minnows and dwarfed sunfish (orange spotted.)

Relation of Carp to Minnows.-- The carp in Virgin Lake presumably are undesirable. They may eat minnow eggs and fry. The young carp must compete for food with the minnows. Even the older carp compete to some degree with the minnows especially for insect food. The stomach content of 12 two-year old carp taken in this lake in July, were determined (by Salyer) to be:

Carp No. 1. 50% Snails; 50% insects (mayflies).

Carp No. 2. Empty.

3. Caddis larvae and sand.

4. Seeds of water smartwort (Polygonum).

5. Empty.

6. Brownish slime off top of stones, made up chiefly of the colonial diatom Encyonema and associates. The gelatinous cylinder of this diatom is much used by plankton creatures for lodgement and shelter. It is an important item in the food of carp and buffalo and is also used extensively by suckers (in Michigan at least).

7. Algae and caddis larve.

8. Caddis; Encyonema; traces of insects.

9. Empty.

10. Encyonema and insects.

11. Algae and Encyonema.

12. Algae and Encyonema.

Recommendations

Use.--We believe it worthwhile to continue this lake as a minnow nursery at least for a few years to give the experiment a thorough try. Minnows are certainly needed in Iowa, to restock lakes in which they have become depleted, and to stock the pike nursery lakes. For the latter purpose the lake was poorly chosen, on account of the rather long haul.

The following recommendations are made with the idea of managing this lake for the advantage of the minnows.

Fishing Regulations.-- In order to help remove sunfish, bullheads, etc., fishing should be allowed to continue as at present; more than that, encouraged, in Virgin Lake. Of course the seining of minnows should be strictly prohibited.

Stocking.--No plantings of any fish should be made in this lake.

Rough and Game Fish Control.--The carp and buffalo in this lake should be rigidly removed whenever the lake is seined for minnows, and gill-nets of both coarse and fine mesh should be set through most of the year, in order to destroy all fish which prey upon or compete with the minnows. The gill-nets should be small enough to catch adult perch, and the large orange spotted sunfish, but large enough to avoid capturing adult shiners. Bullheads shouldbe removed as far as possible.

Minnow Spawning slabs.-- Various flat and smooth objects should be laid in shallow water around this lake, to the number of at least 1000, in order to provide adequate spawning facilities for the fathead minnows. This species should be especially encouraged, as it appears to be the most desirable one for the nursery lakes.

Vegetation Increase.--We do not recommend planting more weeds here, because the weeds will interfere with seining.

Cover Increase.--For the same reason we recommend that no brush shelters be constructed. Energetic netting and seining should so remove the larger fish that cover for the minnows should not be needed.

Predator Control.--Herons and kingfishers should be shot or trapped on and immediately about this lake. The number of common terns should be kept rather low, and investigation should be conducted to see if black tern do enough minnow eating here to warrant their control. Turtles and water snakes should be destroyed.

Regulation of Water Level.--To anticipate a wet season, and to provide them a somewhat larger water storage, we recommend that a new and permanent dam be constructed, to raise the level a foot or so.

Screen in Outlet.--The spillway should be provided with slots so that a revolving, self cleaning screen could be installed when needed, and at other time be removed for safe storage.

Management.--Really efficient management of this lake would require a full-time resident caretaker, and we recommend that one be appointed. It would be his duties:

1. To act as local game warden, enforcing the anti-seining regulation in Virgin Lake and controlling the hunting and fishing on and about this lake.
2. To provide a small boat-livery and otherwise to encourage game-fishing on and about this lake.
3. To keep nets set almost continuously, so as to hold down the population of fish other than minnows.
4. To install the minnow-spawning slabs and to keep these at the proper depths when the lake level changes.
5. To keep seining grounds clear of weeds or other obstructions.
6. To destroy the fish predators on the lake.
7. To supervise and help the seining of minnows.
8. To serve as extra man in rush seasons, as when pike-spawners are netted.

These several duties, properly handled, should keep the caretaker busy. Keeping a good man on this job would be a profitable investment.