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Report 209

FISH CONDITIONS IN IOWA LAKES, WITH RECOMMENDATIONS FOR THE FISH MANAGEMENT OF THESE LAKES

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One of the main objects of the rapid fish survey in Iowa, which we made in the summer of 1932, was to determine what we could regarding the conditions for fish life in the lakes, and from this data to draw up fish management proposals. A general statement regarding the fish problems of the Iowa lakes was included in our report for the Iowa Conservation Plan, and some of our more general suggestions, especially those dealing with legislation and local regulation, have been given in other reports. The nursery lakes and rearing ponds are treated in our Report 208, "Examination of Nursery Lakes, Pike Hatcheries, Rearing Ponds and Minnow Lakes in Present Operation in Iowa".

We offer in this report first a series of general statements regarding the fish conditions, for better or for worse, in Iowa lakes, along with a brief discussion as to methods of control of these conditions when they become deleterious. Following this general introductory discussion, we give what data are available to us on the conditions for fish life in each lake, along with the specific fish management proposals for this particular lake. We have excepted the results of the 1932 survey conducted independently of us by the Department, as this is not all available to us, and as it largely covers smaller waters not personally examined by us.

It will be noted that the material for each lake is started on a new sheet. It is our recommendation that these data be filed alphabetically by lakes, the sheets for each lake in a separate folder, and that any other data on hand (such

as the results of the Department's 1932 survey), or to be received in the future, be filed in the same folders. This will bring and hold together the accumulated information on each lake in a form readily available for examination.

This report will be followed by one on the streams which we examined.

POLLUTION

The problem of lake pollution in Iowa is largely one of the stimulation of obnoxious algae, so far as fish life is concerned. The data we have seen leads us to believe that sewage must contribute heavily to the growths of Aphanisomenon. This point will again be referred to in connection with "Algae Control".

Some general remarks on the problem of pollution will be given in our stream report.

For general reasons, as well as to help keep down the algae, it would seem desirable to remove the solid matter from the sewage immediately, and where possible to divert the sewage from the lake. Thorough treatment of the sewage seems desirable for various reasons, but can not according to present information be expected to hold down the algal growths. Changing the nitrogen to nitrates in fact, probably accelerates algal growth.

Prevention of direct pollution of lakes by farm animals should be continued as the policy of the Board of Fish and Game, on the grounds of sanitation and appearances if not of the effect on fish life.

Slowing up pollution from drainage will in the end probably be the most effective means of holding down the over-richness of the Iowa lakes in fertilizing qualities. This of course means keeping those fertilizing elements in the soil of the farms rather than leaching them into the lakes. This phase of lake management therefore becomes one of farm management, proper handling of soil, erosion control and intelligent planting.

CONTROL OF WATER LEVEL AND WATER CONNECTIONS
(with remarks on lake dredging)

In the conservation and upbuilding of the fish in Iowa lakes, the control of

water levels certainly is of prime importance. This is of course very obvious in the construction of new fish lakes. Most Iowa lakes are dangerously shallow, especially in the winter when the rich organic content of water and bottom tends to deplete the dissolved oxygen reserve. The shallowness is a large factor in making these lakes productive, but it also puts them on the threshhold of continuous danger.

Even though evaporation may be so great as to prevent a lake from overflowing in the fall, a dam may be desirable. The chief source of water for raising the lake levels, according to the best reports given us, is the spring thaw. Raising the outlet dams will catch some of the excess runoff at that season.

Since the spring thaws are usually followed by June rains sufficient to hold up the water levels, the spawning conditions are not likely to be ruined through a drop from a new and higher-than-normal level.

Most Iowa lakes are rich enough now, so that higher water would not imperil their productivity. Added depth, even of a few inches, would often turn the balance onto the side of safety, at times when the water tends to "turn bad". A few inches or feet more depth would usually add materially to the area of the lake, especially to the breeding and feeding grounds. Adding to the acreage of lake and pond level will hold down the runoff, to general advantage.

Erosion control dams will do this to good advantage, and will benefit fish conditions in the waters below, even if the ponds so constructed are too small or muddy for fish. Reclaimed marshes should be made productive of certain kinds of fish.

Connections of lakes with adjoining sloughs will add much to the fish growth and productivity in the main lake. These connections may be established by cutting through the separating ice-ramparts or other isthmuses, or by raising the lake level to overflow the barrier.

In general it is desirable to screen the lake outlets, to prevent fish dropping down the outlet in the fall. Self-cleaning, revolving screens are desirable. The outlet may to advantage be provided with a fish chute, provided there is a run of game fish up to the lake in the spring. In the ~~summer~~ fall the fishway should be

kept closed, to prevent the escapage of young game fish.

Special problems in water connections, as they apply to fish life, arise for individual lakes. Thus the problem of grating off portions of lakes is discussed under "Clear Lake, Cerro Gordo County".

There are of course two ways in which to deepen a lake. By far the simpler and cheaper is to make a higher dam. Dredging seems to us to be excessively expensive. Rather than put $300,000 into dredging a lake, it would seem far more desirable to put $60,000 each into five new artificial lakes, leaving the old one for bullheads or ducks even if it can not continue to support the better fish.

One objection to dredging is that it would greatly stir up the lake, probably rendering it more or less unfit for fish life until the water had time to resettle. Then the alterred bottom might be much less productive of plants and animals. These dangers are great enough to call for the work to be done first on one or a few lakes as a controlled experiment, before adopting a general program or policy of lake dredging. We have no full ~~me~~ assurance that dredging will accomplish the beneficial results which seem generally expected.

Local conditions may cause a dredging project even though costly to be desirable for a few lakes, on account of the benefits to be derived from the improved condition, or on account of the value of the reclaimed land. If the dredging be done to clean up a muddy algae-breeding flat, we would suggest the filling of the flat with mud from the deeper part of the lake, rather than the actual dredging of the shallow area. Or if the dredging be undertaken to produce an overwintering area for the fish, we would suggest that a much smaller area be dredged to the desired depth than has been recommended. The fish will move around and find even a small deep hole. A deep area two acres in size should overwinter the fish of a 100 acre lake. If the oxygen should go low in the one deep area, a large aerator plate could be installed in it to counteract this tendency.

CONTROL OF SILT

Silt is usually a deleterious agent in water, and should be kept out of lakes when-

ever it is practicable to do so. The building of erosion dam in gulleys tributary to lakes should be urged by the Fish and Game Department. Prevention of shore erosion is also desirable, and may often be accomplished by planting willows or by stone or log work.

PUBLIC FISHING RIGHTS

We compliment Iowa on the efforts made to hold the fishing rights in its lakes open to the public. The holding of state property on the lake shores is desirable, from the legal as well as the recreational standpoint. In some lakes, the shores of which are controlled entirely or in part by the state, the operation of one or more boats by the state, for the convenience of the fishing public, would seem legitimate and desirable. In some places this would be done merely as a public service. Elsewhere, as on the minnow lakes and nursery lakes, this should be done to help hold down the predaceous fish. At very much frequented lakes, especially at Storm Lake, the construction and maintenance of a public fishing dock seems desirable. The maintenance could include the building of fish shelters and the chumming of the fish about the pier.

DISSOLVED OXYGEN CONTROL

The very small amount of dissolved oxygen which suffices to saturate water is of course of vital importance to all the fishes and to other aquatic life. Ordinarily by biological balance the oxygen is held in lakes near the saturation point. When plants are abundant, heavy supersaturation may occur as a result of the production of pure oxygen by the plants (either the larger plants or the algae). In such cases, however, the oxygen is apt to fall well below saturation in the dark, when the plants do not replenish the supply.

When the water is otherwise reasonably pure, the fishes will tolerate rather low oxygen values for fairly long periods. They may even go without any oxygen, or with but a trace of it for several hours or even days. However, any really low oxygen determination should be taken as a sign of danger. The conditions preceding any accompanying loss in oxygen are well treated in Dr. Prescott's 1932 report.

There seems to be a considerable production of oxygen beneath the ice, by

the activity of the plants in sunlight. Only this would explain how Diamond Lake remained nearly 150% saturated with oxygen over the winter of 1930-31, or why Diamond and Welch Lake quickly lost most of their oxygen then the ice became covered with the light-interrupting snow.

The problem of using aeration to hold up oxygen loss in the lakes especially the nursery lakes, is a serious one, which as nearly as we can tell from reports is not yet completely solved. The effect of a single air outlet is entirely too local, and involves an excessive amount of labor and trouble for the results obtained.

We recommend that the Department experiment with other mechanisms for reaerating the water. We were told that the custom up to 1932 was to lay a piece of pipe at the end of a 50 foot hose under the ice, circling this so as to spread the air in a circle about 100 feet in diameter. The devices used up to the winter of 1931-1932, from the evidence given us, seem to have been none too successful. Another possible means to consider is pumping the water out on the ice, allowing it to flow off a considerable distance before dropping down through a hole. Such water would return about saturated, and the water channels would tend to cut through the ice, making open cracks where surface aeration would take place. Also some circulation would be established. We heard that a 6 inch pump so used in a 4-foot lake at Worthington proved successful last winter (1931-32). The water flowing over the ice is said to have cleared a channel $\frac{1}{2}$ mile long. Some tests taken by Mr. Speaker are given in Dr. Prescott's report.

We have recently heard from the Carborundum Company that carborundum aerating plates such as used in certain sewage treatment systems were used successfully last winter in Iowa. That of course may be the solution.

At Lost Island Lake in the winter of 1931-32 the mere cutting of many holes is said to have been followed by a rise in D.O. from 1 to 3 p.p.m. up to 5 p.p.m. Possibly this simple expedient will prove satisfactory.

Another scheme possibly worth trying would be to lay pipe with very small holes or with several aerating plates in two or more lines radiating off from the compressor,

so as to cover a considerable area. The pipe could be laid on the bottom in the fall or could be hung from the ice.

Whatever scheme is used, great precaution should be taken not to churn up the bottom mud, for this would likely consume as much or more oxygen than could be added by effective aeration.

There are times when the depletion of the dissolved oxygen calls for rapid remedial treatment before the ice forms. On our visit we met with conflicting claims as to the efficacy of outboard motors in reaerating the water. Some said that in some instances a marked effect was so produced. (See p. 7a). This had been the experience on Jones Lake near Lansing, Michigan. We know that bubbling air through solutions of organic wastes will hold the oxygen up fairly well, even though the wastes have an extremely high and rapid oxygen demand. It was therefore with surprise that we heard of the failure to reaerate the putrescent portion of East Okoboji Lake when it "went bad" in 1930 owing to the death of plankton (Daphnia) following several days of hot, calm weather. We were told that at least 8 motors as well as compressors were used, chiefly at night. The oxygen did not go up for four days, and when it did rise, this was following wind and rain. On questioning, our informer told us that the motors were run as usual, not set to churn. That is probably the explanation for the failure. If our informer was mistaken, and the motors were run half out of water, then we would have to assume that the decomposition had gone so far that a "negative oxygen demand" (following anaerobic decomposition) had developed, so that the oxygen added by the motors was consumed chemically as fast as it was put into the water. A case of the successful use of outboard motors in building up the dissolved oxygen content depleted by excessive animal plankton, in Welch Lake late in 1932, is recounted by Dr. Prescott in his report for that year. We conclude that outboard motors properly set so as to propel the boat at half speed when the motor is churning the water at full speed, can hold up the oxygen above the danger point, when this is being removed by decomposing animal life. Whether this would be true on the decomposition of blue-green

Supplementary Note on Oxygen Restoration by Outboard Motor Operation

Since the section on dissolved oxygen control was written, we have located a field note giving evidence by Department employees of the apparently effective use of outboard motors in replenishing the oxygen supply in an Iowa lake. In August, 1931, the fish in Crystal Lake began to die, and the dissolved oxygen "went out". One outboard motor was used for 20 days and two were used for 12 ~~to~~ or 15 days, one being run as long as 16 or 18 hours a day. The fish deaths stopped and the dissolved oxygen supply was built up again.

algae needs to be learned. The toxic products of Aphanizomenon on composition may kill fish even though some dissolved oxygen is present.

We recommend that outboard motor aeration be used whenever the oxygen gets low (say down to 2 or 3 p.p.m.) in lakes when free of ice. The aeration should be done by night especially for several reasons:

(1) Oxygen production by living plants is stopped then.

(2) Wind aeration of the surface is usually lessened.

(3) The cooling of the surface at night tends to induce circulation, so that the aerated surface water will sink to the bottom.

Dr. Prescott tried out several floats at our suggestion, with the idea that they might simultaneously aerate the water and break up the surface mats of Aphanizomenon. These trials led to no good result, because the floats either sunk under the pull of the motor, or were so deep as to churn up the bottom, which of course is bad. It seems to us that these floats could easily be constructed so as to ride the surface and so to thoroughly break up the surface of the water and any surface mats of algae. A flat device with the front end held up at the right angle by a bridle will dance along on the surface. With some baffles on the lower (or front) surface, the breaking up of the surface can be made very extensive. Careful design should produce a device which would allow almost all the energy of the motor to go into breaking up of the water surface. Such a device could then be tested against the motor used alone, set so as to give the maximum surface churning.

HYDROGEN ION CONCENTRATION (pH)

This measure of the acidity, neutrality or alkalinity of the water is emphasized by some biologists as being a very vital environmental condition. Others, usually with more data, have not found the factor so important. One reason for the discrepancy of opinion is due to the fact that the pH is not a simple factor. The kind of acid or hydroxide responsible for the pH is also important. Usually naturally acid or alkaline waters are not toxic as such. Furthermore the changes

are so gradual that the organisms usually adapt themselves to the change.

Most Iowa lakes, because they contain an abundance of plant growth, either in the form of the higher attached plants or of algae, are very strongly alkaline (pH often around 9.0). This figure would be taken by some to indicate unsuitable conditions, which of course is not true.

The chief value in taking pH is to indicate plant activity and decomposition. A sharp rise in pH reflects excessive growth of plants, while a drop in pH indicates active decomposition already in progress. The drop in pH may be a significant indication of bad conditions, even though it is only to 8.0.

COVER INCREASE

Some of the shallower Iowa lakes are so choked with water weeds as to call for more protection of the fish. It must be remembered, however, that the weeds die down in the winter, while some fish, as the northern pike, continue their predations to some degree over the winter. Properly installed brush shelters supply better protection for the small fish in the summer than do the weeds and also give winter protection.

The larger and deeper Iowa lakes, like Clear, Okobojis, Storm and Spirit would be benefitted by an increase in the shelter for small fish. Brush structures also serve to attract the larger fish to their margins, thus concentrating the fish and making fishing better. The increased replenishment due to the protection of the smaller fish tends to compensate for the increased catch of adults. The catching off of the larger fish makes way for the more rapid growth of the new stock. Thus a more rapid turn-over is induced.

The brush may be added as brush carpets on the bottom, or as definite brush shelters built according to any one of several styles. On the brush can be inserted under docks to shelter young bass and other fish which seek such shade, and to better the dock fishing for the adults which naturally hang around the brush.

Just dumping brush in the water is unsatisfactory.

VEGETATION

The vegetation in the lakes is of utmost significance to the fish life. It is also vital to the support of ducks and other waterfowl, and hence serves a double purpose. In neglecting the waterfowl aspect of the vegetation problem, we do not indicate any idea that this is not of great importance.

The manner in which the "weed beds" affect fish life are numerous:

(1) They supply spawning facilities for such game fish as northern pickerel and such forage fish as golden shiners, which deposit their eggs directly on the stem or leaves, and for other game and pan fish, notably large-mouth black bass, bluegills and sunfish, which clear patches of rootlets to serve as redds or "nests" in lieu of gravel.

(2) They provide cover for the fish from their preying enemies, from the water or from the air. The protection given the young fish by weed beds is of particular significance in maintaining the supply. They also help to provide shelter areas along the shore, where young fish need this shelter.

Abundant vegetational shelter is probably one of the main reasons why Welch and Diamond Lakes produced such a huge crop of pike in 1931 and 1932, while the plant-poor Center Lake produced virtually none.

(3) They greatly increase the food supply. A few fishes, including carp, eat a considerable amount of the higher plants, either directly or incidentally in snapping up the animals living therein. Many of the insect larvae, snails and other animals feed directly on these plants. The plants tremendously increase in the substratum on which animals may live, and thus also lead to a great increase in the production of animal food. The weeds when thick give enough shelter to the food organisms to insure the carrying over of breeding stocks.

(4) They purify the water, by absorbing the carbon dioxide and giving off pure oxygen and perhaps by some other chemical means.

(5) They provide protection to the bottom and shores, lessening the ten-

dency of the waves to churn up the bottom and to erode the shores.

(6) They act as competitors with the obnoxious algae, probably by using up the excess carbon dioxide, nitrogen, phosphorus, etc., which otherwise would be used by the plankton algae in their natural tendency to increase. This is a point of major importance in Iowa lakes. Hart rightly emphasized this relation in these words:

"It has been the experience of the writer to find that the lakes, such as Silver Lake at Lake Park, Clear Lake, Cerro Gordo County, West Okoboji, and Upper Gar Lake, which have an abundance of higher plant form of the submersed types, do not have the troublesome growths of the obnoxious plankton forms which in Storm and Lost Island Lakes where there is almost total absence of these (plant) forms, the plankton algae have the upper hand, and the condition of these two lakes is unsightly and acute during the summer months."

The fact that the obnoxious algae have since become very bad in Silver Lake is a fine confirmation of Hart's idea, since the coming of the algae was accompanied by a tremendous decrease in the growth of the pondweeds in this lake.

In our reports some attention is given to the aquatic vegetation, but time did not permit any really accurate study of the existing beds.

In dealing with the vegetational problems of Iowa lakes, Dr. L. H. Pammel's "Report on the Vegetation of Iowa Lakes" should be kept in mind.

On the other hand, the lakes may become unbalanced on the side of excessive weed growth. In extreme cases, as in some shallow lakes planted to wild rice, this virtually makes a marsh out of the lake. The dying weeds when very thick may cause a serious loss of dissolved oxygen. They accumulate in the bottom to help fill up the lake, and to produce very septic conditions. That is probably what happened in Silver Lake (Dickinson County) where we found just such a foul bottom. Several years of excessive weed growth led to the covering of the bottom with a rotten mess in which the weeds could not grow except here and there in small quantity. The richness of the lake being maintained, the plankton algae

came in; and the blue-green algae being the more tolerant, they took the lead, causing the obnoxious conditions which obtained in 1933.

When too thick, the weeds become a nuisance. Thus in Silver Lake they made either rowing or motoring extremely difficult. And thick weeds are bad for the fisherman's temper, when he catches and often loses his hook.

It is very probable that too thick a weed growth does not provide the optimum conditions for fish life and growth. Certainly fish like to lie in open patches among the weeds.

Again, excessive weed growth is probably deleterious to food production. The theory is that by competition the larger plants hold down the growth of plant plankton, which is basic to the production of animal plankton. This in turn is the main support of young game fish, and a main support of forage fish. The U. S. Bureau of Fisheries has gone so far as to develop chemical methods of killing off the major plants so as to allow the plankton chain to gain the ascendency.

It might be point out that in Silver Lake the pike fishing improved marvellously after the wholesale dying off of the larger plants. But it must be remembered that the pike which furnished this unparalleled fishing developed in the thick weeds.

We are convinced, though opinion may not be unanimous on this point, that a fairly heavy growth of water weeds is desirable in Iowa lakes, but that excessive growth of weeds is inconvenient and dangerous.

The control of vegetation so as to obtain the proper quantity of the most desirable species is a matter of very considerable difficulty. We understand that efforts to introduce or replant the "weeds" in Iowa lakes now deficient therein have in general met with complete failure. The importance of balanced condition is so great, however, as to call for strong efforts to develop methods for reestablishing the weed beds when they have disappeared. Experience elsewhere seems to indicate that a measure of success could be obtained, if the attempts were made by a competent investigator, trained to follow and ~~chek~~ check each attempt as an experiment.

In this connection we emphasize again Iowa's need for at least one trained fishery investigator.

ALGAE CONTROL

Our observations and our study of all the reports available to us, lead us to concur with the conclusions of Dr. C. W. Prescott concerning the control of obnoxious algae in Iowa lakes. We regard his investigations very highly, and believe that he has been very conservative and has used good judgment in drawing his conclusions. To discuss the general aspects of the algal problem here would largely mean the duplication of the summary given by Dr. Prescott on pp. i-iv of his 1932 report.

We do not believe the available data are sufficient to determine what part the sanitary sewage plays in causing the algal nuisance in Iowa lakes, Storm Lake in particular. It is perfectly clear that sanitary sewage is not the only factor responsible, for Lost Island Lake without a sewage effluent is badly affected. However, the drainage from barn yards and from farm soils must contribute the substances necessary to the growth of the algae.

We are led to wonder how much it will help a lake to fence the cattle off. Obviously from the view point of sanitation and appearances this would be worthwhile, but how much would the amount of nitrogen, phosphorus, etc. entering the lake be diminished? If the cattle have access to a stream tributary to the lake, the dissolved excreta will of course pass into the lake. Even if they are kept out of the water entirely, much of the nitrogen in their feces will be washed into the lake. This will hold to some degree for the cattle all over the lake watershed, even miles from the lake. Fencing off the cattle will undoubtedly divert a considerable part of the excreted nitrogen into soil, crops, trees, pasture grass and farm animals - but how large a part should be learned.

Our observations at Silver Lake in Dickinson County, make us believe that a fairly definite ecological succession, perhaps cyclic, may be responsible for a lake "going bad". So long as the larger plants are well established, additional

fertilizers (nitrates, phosphates, etc.) contribute further to the growth of these plants, until they become excessively thick. This process continues in a cumulative way, until the weed beds have become so dense over the lake as to produce very septic conditions in the bottom when they die. Then the seeds or tubers of the plants can not grow, and the new weed growth fails to develop in the following spring. The great abundance of weeds. This has very probably been the history of Silver Lake. There is some evidence that other lakes may have followed the same succession.

Presumably the septic condition of bottom and of the water will in time be remedied by organic action, provided the excess addition of nitrogen, phosphorus, etc., can be avoided. The blue-green algae probably play a leading role in this repurification process. The importance of these algae and sunlight in the process is in need of study. It is probable that the action is much accelerated in shallow water, where the sunlight can reach the bottom in considerable amount. This would help to explain why the Ice House Bay of Storm Lake retains such a fine growth of weeds.

A possibility exists that raising the water in the lakes may so retard the purification of the bottom as to stop the growth of the larger plants, and induce the growth of obnoxious algae. This would be especially likely, if the raised water would cause the erosion of the banks, thus clouding the water and preventing the sunlight from reaching the bottom. Thus raising the level of Iowa lakes may be deleterious. This is all only a possibility, but it illustrates the complexity of the problem of managing Iowa lakes, and the need for competent investigation.

THE GIZZARD SHAD AS A NATURAL CONTROL FOR ALGAE

The proposal to introduce the gizzard shad into some of the Iowa lakes as a means of combatting the algae nuisance has not been well received by some. Mr. S. P. Baur for instance, seems rather firmly opposed, and has raised arguments to indicate the proposal as impractical and valueless.

Mr. Harry E. Hart reflected this view in his report. The points raised by Mr. Hart may be answered:

(1) The gizzard shad can be transported to stock inland lakes, because this has been done successfully in Ohio and Illinois. And we now hear that a supply for experiment use was brought to Dickinson County in 1932.

(2) The gizzard shad can live in shallow, muddy lakes, because it abounds in such lakes and reservoirs in Ohio and Illinois. In Buckeye Lake, Ohio, the bottom is so rich that it veritably boils in decomposition at times, yet the gizzard shad are extremely abundant there, the schools darkening the water like sardines.

(3) While it cannot be proved in advance that the gizzard shad will be of material aid in fighting the algae, there are many reasons for expecting that it will be helpful and may even swing the balance over in favor of less obnoxious plants. The gizzard shad feeds exclusively on plankton, and has such a fine straining apparatus that it takes in the fine plant plankton. In other states, especially Ohio, no trouble is experienced with the blue-green algae where gizzard shad occur. This is strikingly true in Buckeye Lake, Ohio, a large shallow reservoir with a bottom so rich as to actually boil up like a polluted sludge in hot weather. Here gizzard shad are extraordinarily abundant. There is no algal trouble and game fish are very abundant, yielding immense animal catches. Studies there show that the game fish subsist very largely on gizzard shad. In Buckeye Lake Mr. M. B. Trautman of the Ohio Division of Fish and Game estimates a daily catch of 10,000 crappies for many days each year, and these crappies feed very largely on the shad.

Mr. W. S. Albert, Sr., immediately appreciated the absence of algal trouble in the overflow lakes along the boundary rivers, which abound in gizzard shad yet do not develop obnoxious blue-greens.

It must be emphasized that the gizzard shad in the Mississippi River and

in the inland lakes and ponds of Ohio and Illinois is found to be a harmless forage fish, a very effective one. It is the most efficient of the forage fishes, in that it forms a direct and single link between the basic food (the plant plankton) and game fish. Ordinarily the plant plankton must pass through a ~~chia~~ chain of several animals, each feeding on the other, before it enters into the flesh of game fish. Furthermore the gizzard shad goes out into open water to feed on the free plankton which otherwise would mostly die and drop to the bottom.

Since these paragraphs were written, we have had the privilege of seeing Dr. Prescott's 1932 report, in which he recounts experiments proving that the gizzard shad feeds heavily on Aphanizomenon, the real culprit. He also found the golden shiner feeding on this plant, and thought that it too might be a natural control. But he added that some of the golden shiners had fed on animal plankton, and thought that they may have taken to the algae only on the exhaustion of the preferred animal plankton. It is our opinion that the golden shiner does not normally feed on Aphanizomenon, in any quantity, and would not form a control of any consequence. We examined the food of a number of golden shiners taken in Storm Lake during a period of very heavy Aphanizomenon growth, but could find only animal plankton, mostly crustaceans. Dr. Prescott also examined the stomach contents of carp and large-mouthed buffalo adults which we collected in Storm Lake at the same time, and found no blue-green algae therein (see his 1932 report). The buffalo probably got their food near the bottom, where we found by tow-net trial that the plankton was largely crustacean. The carp probably got their food in the rich bottom, as did the carp suckers (Carpiodes spp.) which we took at the same time and place (the latter contained midge larvae almost exclusively). The small large-mouthed buffalo adults of Silver Lake at Ayrshire were feeding in August on animals, mixed with a very few algae (filamentous species, Volox, etc.) . We conclude that the gizzard shad is the only fish in Iowa which would freely consume Aphanizomenon. We repeat our former recommendations that several large truck loads of gizzard shade be introduced

into the most badly affected lakes, particularly Storm Lake.

We withdraw our recommendation that this species be introduced at once into Diamond Lake because we now recommend that the lake be put on an annual cycle with the removal of the larger pike, and because the trouble with blue-green algae did not reappear in 1932. The trial should first be made in lakes which are pestered year after year with Aphanizomenon. Later consideration of the advisability of introducing the shad into one or more nursery lakes should be given.

We can not agree with Mr. Baur that the shad would ruin a nursery lake because they give off so much slime in the seine as to kill the walleyes. In a very dirty slough fished for us by the rescue crew near Lansing in mid-afternoon of a warm mid-summer day (August 5, 1932), even under these conditions, and even though we held the fish in the seine for a long time till we picked out samples for preservation a dozen or more young walleyes lived merrily on, though crowded and jammed around by hundreds of adult and young gizzard shad.

In connection with the introduction of shad into interior waters, whether fishing lakes or nursery lakes, it should be kept in mind that the idea is not only to try another means of holding down the algae, but also to provide food for the game fish. Even young walleyes should eat the shad fry.

It is the policy in Ohio and Illinois, based on both experience and research, to stock new inland waters with gizzard shad before introducing game fish. All the Ohio reservoir-lakes have now been successfully stocked with this fish.

NATURAL FOOD

Any thoughtful consideration of the problem of quantity fish production leads one to realize the importance of the supply of natural food available for the desired species of game fish. And the supply should cover the needs of species which differ in food habits, and should cover the needs of all ages. Thus there needs be plankton for the fry and fingerlings of nearly all species. Several species, as bass and pike, seem to need fish food on which to develop a large adult size.

Like other natural conditions, food may develop to excess. This excess supply may simply affect fishing, inasmuch as the overfed fish will not bite readily. But the overproduction of food organisms may go much farther in such excessively productive lakes as those of Iowa. Two clear-cut examples of recent date may be cited, namely the overproduction of scuds (Hyalella) in Welch Lake in October 1931, and the over-abundance of Daphnia in East Okoboji Lake. In both instances, these little animals suddenly died at a great peak of abundance. Their decaying bodies consumed all the available oxygen, thus causing the death of the fish.

There is of course a balance which should be maintained. The excess production of Hyalella in Welch Lake was presumbaly caused by a disturbance of the balance, after the Hyalella-eating fishes had been consumed by the pike.

Even rather foul bottoms are likely to be very productive of food organisms, such as midge larvae (Chironomidae) and sludge worms (Tubifex). These tolerant forms, however, do not supply all fish with food. But bullheads in particular, and other tolerant grubbing species, find in such organisms an abundant food supply. This circumstance explains the abundance of bullheads in some of the dirtiest of the Iowa lakes.

FORAGE FISHES

The importance of maintaining an adequate supply of forage fishes in our lakes and ponds is becoming widely understood. Fish food is a very important item in the normal diet of most game fishes, and is particularly important in producing good growth. The game species, such as walleyed pike, northern pickerel and black bass, may exist as adults on the insect larvae and other food of their youth, but ordinarily do not

reach on such diets the sizes which are prized by anglers. More often they will turn in the absence or scarcity of normal forage species, to their own young or to the young of other game or pan fishes. In fish culture the practice of cannibalism is well understood, and it also goes on in nature. The destruction of desirable species in the waters where there is a scarcity of minnows is great. Hart cited a case of 17 bluegills found in the stomach of a six-pound walleyed pike.

It is theoretically possible to overturn the balance onto the side of forage fishes, which compete for food to a greater or less degree with young game fishes. Many species of forage fish consume fish spawn, and some of the shiners are capable of eating the young fry of game species. They may also act as intermediate stages in the life cycle of parasites which are deleterious to the game species. An excessive quantity of forage fish may satiate the game fish so they will not bite. Clearly, as Mr. Hart emphasized, a balance needs be struck and maintained. But in the ordinary heavily-stocked Iowa lake there need be little fear of forage fishes becoming too abundant.

In general there is strong circumstantial and historical evidence of the depletion of forage fishes in Iowa lakes. The frequent seining of minnows for bait, and the great losses in the live boxes, together with the heavy plantings of game fish, particularly the voracious walleyed pike, and perhaps changes in condition in the lakes, are all probably contributory factors in the decrease in minnow life. The abundance of minnows in Virgin Lake, which lacks major fish-predators, is evidence for this conclusion.

Hart has emphasized the depletion of minnows in the streams near the fishing lakes, as well as in the lakes themselves. Boatmen from Arnolds Park were forced to journey as far as Rock River to get their bait.

In seining forage fishes from the minnow nursery (Virgin Lake) or elsewhere, for planting in other waters, great care should be taken in sorting the catch. Young carp of course should be eliminated. We also believe that sunfish should be excluded, though this is not so important for natural lakes as for the nurseries.

These sunfishes are voracious little fellows. The orange-spotted sunfish, being a non-useful runt species, would seem to be particularly undesirable for planting, it must be at least a serious competitor against fishes of decent size. Unfortunately this species has been widely spread ~~over~~ over the state from the Mississippi rescue operations, and it is abundant in Virgin Lake.

Very probably the gizzard shad will prove to be the most valuable forage fish for the inland lakes of Iowa. The problem of introducing this fish into the lakes is discussed above under "Algae Control".

SPAWNING INCREASE

In managing Iowa lakes, much thought should be given to increasing the natural reproduction. The first step logically would be to make an accurate study of the breeding habits of the important species of game fishes, rough fishes, predator fishes and forage fishes. It is tacidly assumed through much of Iowa that marshes or weedy bays are the spawning grounds of the fish in the lake. This is undoubtedly true of some species, like the northern pike, but is probably not true of a considerable number of other species.

Increase in natural spawning of lake fishes may be brought about by flooding marshes, by digging connections with adjacent sloughs, by introducing gravel (especially for small-mouth bass) and by putting in flat slabs (for certain forage fishes).

PREDATOR CONTROL

Predator Fishes

The gars (two species) and dogfish are almost universally detested and outlawed as useless, destructive wolves. They are of course very little used and are predacious, and their removal without restriction seems justified. Some anglers look on these fish as gamy on a hook. Others here and there eat them. Hart even claimed that the almost universal detesting was a matter of psychology rather than of taste, "as local people in some places prefer them during the spring months to almost any other fish and are considered a delicacy (sic) by many".

The damage done by gars and dogfish is probably less than generally supposed.

The dogfish is a heavy crayfish eater and the gars have such a small throat that most of their prey is small. Pike and pickerel are likely more predatory than either gar or dogfish. However, the gars eat large numbers of other fish, including young game fishes, and start to eat fishes when only an inch long. And of course their uselessness is a prime argument for the control of their numbers.

Hart claims that during their spawning period, as many as 500 gars a day have been taken by seining crews. Floating nets are used in Michigan, and should be tried in the Okobojis if not already proved valueless or dangerous (Some pike will be caught). Spearing parties under warden supervision have proved very effective in some Michigan lakes during the spawning season.

The gars and the dogfish abound in the boundary rivers and the lower courses of the tributary rivers in Iowa. The gars (both long-nose and short-nose) abound in the Okoboji lakes, and gars also occur in Spirit Lake, but probably not in Clear Lake (despite Hart's statement to that effect).

The dogfish seems to be absent from the glacial lakes of Iowa. Mr. Tennant, the very well-versed fisherman of Arnold's Park, says that in all his seining experience in Iowa lakes he has never caught a dogfish. There are always some things to be thankful for!

Other Predators

Our observations in Iowa indicate the need for more predator control about nursery lakes and rearing ponds. Here fish eating birds, snakes and turtles were found to be entirely too numerous.

Whether control of fish-destroying animals in public fishing waters is justified involves a weighing of different values and interests. The amount of harm done to fish life in Iowa lakes should be determined accurately, as a basis for a rational approach to this problem.

ROUGH FISH CONTROL

We discriminate between the coarse or rough fish and the obnoxious or predaceous outlaws (gars and dogfish).

There can be no question that any of the rough fishes may become abundant enough to interfere with the proper growth of the game species. There is some degree of competition between each species of game fish and each species of coarse fish. The adult of the coarse fish may not eat the same food as the adult of the game species, but it will eat the food which should be reserved for the young of the game kind, or for the forage fishes which form the natural food of the adult game fish. That sort of indirect competition is often overlooked, but may be more important than direct competition or predation.

The overabundance of sheepshead in Storm Lake, or of carp and buffalo in Silver Lake in Palo Alto County, constitutes a deleterious lack of balance. A delicacy of balance seems to be a price to pay for the great richness of Iowa lake waters. The balance is easy to topple over, and careful management is required to re-attain and then to maintain a balance.

Thus while a moderate quantity of coarse fish in a given lake will not likely be a serious detriment, a great abundance of them calls for a policy of removal. Whether this job be done by commercial licencees or by the state is a matter of governmental policy. Whatever way it is carried out, every effort should be made to insure that removal be carried out honestly, without engendering local illwill and without harming the lake from the standpoint of the game fishes or of ducks. A copy of the contract form used in Michigan is attached hereto.

It is quite possible that in some instances more vegetation is destroyed in the seining operations than would be destroyed by the carp caught. At times considerable quantitites of game fishes are destroyed, especially in enormous hauls involving up to 100,000 pounds of fish in a single haul.

Most of the possible harm is done by seines. Bill-nets of the proper mesh are almost entirely harmless. The mesh should be large enough to catch carp and large buffalo but to allow virtually all game fish to escape. In the lakes where the coarse fishes grow large, like the Okobojis, the mesh seems satisfactorily fixed at 4 inches

square or bar measure (8" stretched measure).

In lakes like Storm, where sheepshead are excessively abundant and dwarfed, seining is called for. To avoid a heavy death toll of game fishes smothered in the huge catches, the length of seine should be reduced to a safe limit until the population of sheepshead and other coarse species is reduced, so that the larger seines will not make such excessive catches (incidently with a bad effect on the market).

In lakes like the Okobojis, where the sheepshead grows large, tastes good and meets with at least partial local favor, there is some doubt as to whether it should be classed as a coarse fish. It would seem sufficient in such cases to remove the large ones, such as would be caught in 4" nets, as these are the most predaceous and most prolific.

Buffalo should not be regarded as undesirable except where very abundant. They provide a fine animal crop of forage fish (their own young), but are essentially non-predaceous. In fact they feed largely on algae and ooze. Our recommendations are that buffalo only be removed where abundant, and that in general the removal be done by coarse-mesh gill-nets. There will need to be exceptions to this policy, as for example in Silver Lake in Palo Alto County, where buffalo are excessively abundant and mature under a foot in length. Here of course seining is in order.

We were apparently mistaken in a provisionally conclusion that the buffalo feed on blue-green algae, for laboratory studies (by Prescott and by Hubbs) fail to confirm this idea. Hence our verbal suggestions that only very large buffalo be removed are retracted. Prescott found that the adult buffalo we caught in Storm Lake, during a period of over-abundant growth of Aphanizomenon, were feeding almost entirely on animal life, and we have found this true for the carp suckers (Carpiodes) in the same lake and for buffalo in Silver Lake, Palo Alto County.

It is theoretically possible for buffalo or other fish to become so abundant in shallow lakes to seriously affect the dissolved oxygen content of the water, especially following drowths and over winters of heavy snowfall. We would regard this as a serious menace, however, only under very extreme conditions.

Buffalo of two species (Megastomatobus cyprinella and Ictiobus bubalus) are abundant in the boundary rivers and naturally abounded in the larger inland lakes, as Spirit, West and East Okoboji, Clear and Silver lakes (the Silver Lake in Dickinson County), and also occur in many other lakes. A larger species, Ictiobus niger probably also occurs.

For purposes of administration we would recommend that the small relatives of the buffalos, the quillbakes or carp suckers (Carpiodes species) be classed with the buffalos. We found no evidence that these are especially abundant in any inland waters of Iowa. (In this connection, it should be pointed out that Mr. Hart seemed to have confused the true carp, Cyprinus carpio with these native suckers, Carpiodes carpio and other species.)

The common sucker is another rough fish which is the source of much controversy. In the inland lakes it seems to be commonest and largest in Clear Lake, Cerro Gordo County, and is probably not generally abundant enough to cause much concern. In this lake, Hart reported as much as 5000 pounds of suckers being taken in the gill-nets set for spawning pike, in a single season.

The sucker is especially maligned as a spawn eater, and it probably is such in inland lakes (see our report on Clear Lake). This proclivity may or may not be overestimated. It is generally overlooked that the young suckers are a very important forage fish, which circumstance should balance a considerable amount of harm.

It is a serious question whether or not the bullhead should be considered as a more or less obnoxious rough fish, especially where very abundant. The capacity of the bullhead to become a dominant is known. Examples in Iowa are Lost Island Lake as a natural lake and Center Lake as a nursery lake. The bullheads are a spawn eaters and to a degree a competitors of better species. To what degree they prey on other fishes is a problem. They feed almost entirely by sense of smell and touch, but might get young game fish or forage fish at night, when most species other than the bullheads sleep. They readily eat small fish when crowded in the

seine (finding fat-head minnows in the stomachs of bullheads seined in Center Lake led Salyer and the others to regard this as proof of the bullheads predatory capacities, but Hubbs found the minnows to have been just swallowed, no doubt in the net).

In connection with the problem of rough fish removal, one important value of such fish to the Department should be kept in mind. A technique of feeding ground goldfish to fingerling and brood bass in Ohio has been developed. The results have been excitingly successful. There would seem to be no reason why this practice could not be followed in Iowa, with any of the rough fish. For instance suckers caught in Clear Lake, or carp or buffalo or sheepshead could be seined and kept in cold storage, later to be power-ground and fed to bass and perhaps other species being propagated in nursery ponds. This material might also be used to "chum" fish into public fishing docks or floats, if these are built on Clear and perhaps other lakes.

BIRGE LAKE, EMMET COUNTY

This lake was not studied by us. Mr. Hart grouped it in his lake group 5, distinguished as follows:

"Group 5. A good many of these lakes are dry at the present time, but in case there is an abundance of rainfall they will afford good feed and cover for birds. Many of our lakes and sloughs, that could be a great deal of value in that they will provide good hunting, can be improved to advantage, thus rounding out the program of the department considerably. This last group is not satisfactory for the propagation of fish and stocking of them should be discontinued."

Recommendations

From what we know of this lake, from Hart's Report and other documents, we see no reason to doubt his recommendation that stocking be discontinued.

BLUE LAKE, MONONA COUNTY

(An oxbow lake in Missouri River valley between Onawa and the river.)

Water Supply. - There is a limited water supply and much fluctuation in water level.

Use of Water. - Fishing, and bathing at the State Park, are principal uses. Mr. Schuenke reports that migratory birds use the lake by the thousands.

Size: 918 acres in 1916 (according to 1916 Report).

Depth. There was up to 17 feet of water in northeastern part in 1916, according to the report of that year. Since then, the lake has filled in a great deal. Hart reported "at present, one can safely see that the actual water to be found in the lake has dwindled down to one-half to one-third the amount found in the previous survey, and the deepest water that can be found in the lake is in the neighborhood of $4\frac{1}{2}$ to 5 feet, and this only in a small area out from the water house at the state park."

Fish. This lake is said by Hart to contain "more fish now than the lake can support."

Recommendations

General Policy.- We agree with Mr. Hart that any plan to reclaim this body of water as a lake would be unjustified, on account of the large expenditure involved and the probability of its filling up again.

BROWN LAKE, WOODBURY COUNTY

(This is a Missouri River ox-bow lake.)

Water Supply. - Very limited. Possibilities of river flooding exist.

Depth.- Never has been very deep. As Hart pointed out in his report, there is danger of the lake being filled up with silt if the river overflows into it.

Algae. - Not a problem, according to Hart.

Vegetation. - Hart listed this lake as one shallow enough to contain vegetation attractive to migratory waterfowl.

Recommendations

Stocking. - We concur in Hart's report that this lake is adapted to large-mouth bass, bluegills, crappies, bullheads and perch, and suggest that it be well stocked with these species - preferably from rescue work along the Missouri River if this can be established.

LAKE CAIRO, HAMILTON COUNTY

Information on this "lake" was furnished ~~by~~ to Salyer by Dr. Lundell of Webster City, (July 31, 1932).

Fluctuation in Level. - Now dry, run through by a drain; some of the bed farmed. We were told that the Secretary of State sold this lake bed under the "Swamp Lands Act" to his brother. It is held that the proper draining of the land is an engineering impossibility like Union Slough in Kossuth County.

Dam. - It is claimed that a dam to reclaim this lake could be put in for $300. (This sounds fishy).

Size. - About 1600 acres (formerly)

Use. - It is claimed that reclaiming this lake would make a wonderful wildlife refuge and provide some fishing.

Recommendation

We have none to offer, as we did not examine the situation.

CENTER LAKE, DICKINSON COUNTY

(Since this lake is now used as a "Pike Nursery Lake", it is discussed in our Report 208, "Examination of Present Fish Hatcheries and Nurseries in Iowa".)

CLEAR LAKE, CERRO GORDO COUNTY

Examined by Salyer on July 15, 1932, and by Hubbs on August 10, 1932, on both dates in company with Mr. Orel Hoel, from whom most of our general information on the lake was obtained.

Clear Lake is described in the 1916 report on Iowa lakes. Other features are shown on the map which accompanies this report.

Water Supply and Level.-Clear Lake is largely fed by surface drainage, though some spring water must enter too. It maintains its level well. On July 15, 1932, when many Iowa lakes were still low, Clear Lake was discharging in a stream 3 to 5 inches deep over a spillway 15 feet wide (roughly cu. ft./ sec.). We were told that the outlet would flow all summer if a normal rainfall continued.

Pollution.- Most of the cottages have cess pools, from which a seepage reaches the lake.

Shore.-The shore varies greatly, being high in places and low elsewhere, but is in general suited to cottage development.

Water.-The water seems to be of the productive sort. It is very clear. Dissolved oxygen at the surface on July 15 was 8.7 p.p.m. We were told that the D.O. stays up over the winter, except at times west of the bar. Ice averages 15 inches thick.

Bottom.-The bottom varies likewise, being of sand with some mud and gravel along the village, of soft mud in the thicker weed beds and of stones about the island at Bayside. As a whole the shoreward bottom is sand or gravel.

Cover.-Little outside of weed-beds. Very little opposite town and opposite cottages.

Vegetation.-The aquatic vegetation is well developed which is fortunate, as this is valuable to fish life in several ways. Bulrush beds are generally thick, from Reely Pt. to the bridge, and in the head of Grim's Bay where there is a patch of about 10 acres. Thinner rush patches (about 20 acres) occur in Clausen's Bay, and a few small

patches exist in Tanglefoot Bay and off the Methodist Camp. In the arm west of the Narrows, on the north shore, the rushes are thick, intermixed with floating-leafed weeds (lilies and pondweeds) and submerged plants (coontail, bladderwort, pondweeds heterophyllus,interior, etc.). In his report, Mr. Hart fave a list of the plantshe found in the lake.

Algae.-This lake is said never to ~~pp~~ produce an obnoxious growth of blue-green algae. Last year (1931) there was a slight scum of algae on the lake.

Natural Food.- Forage fish seem to be decreasing. Crayfish are very rare (Hoel says he has seen 3 only). Mussels are common.

Predators.-- Some fish-eating birds are present. The flocks of black terns probably do little damage. Painted turtles are abundant, and soft-shelled and snapping turtles are common.

Game Fishes.--According to Mr. Hoel, the fishing in the spring of 1932 was the best experienced in years.

Pike (Walleye) are among the leading fish of the lake. They are caught in spring about the weeds near the rushes west of the Apple Orchard, and elsewhere, and some are caught through the season. On July 15 we learned, the pike were being caught on balls of worms, fished on the bottom. The ripe pike are taken early in the year around the open shores of the lake, away from the rushes; from Reely Pt. around to Dodge Pt. The big females (some as large as 10 pounds) largely monopolize the stony bottom right off the island and off Dodges Pt. They are sometimes taken running-ripe (in one haul, spring of 1932, 7 females all fully ripe were obtained). Such ripe fish are also taken on sand bottom. The spawning fish are generally caught near shore, on dark nights, the darker the better, in water up to 8 feet deep.

Northern Pike (Esox) occur, and are said to be caught successfully on "Dare-Devil" spoons.

Muskallunge.- A 19 pound musky was seined sometime ago and kept at the hatchery; the only record for interior Iowa according to Hoel. This fish was presumably introduced with others from the Mississippi. This fish was held for some time on exhibit and was seen by Mr. Hart, who gave the date of capture as April of 1931.

Small-mouth bass are not very abundant, though some breeding fish are taken off the stony points (Bayside Pt., the Island and Dodge Pt.), according to Mr. Hoel. Mr. Hart reported more enthusiastically, declaring that the introduction of this fine game fish was proving remarkably satisfactory, and that there is now good small-mouth bass fishing at times.

Large-mouth bass are commoner (next in abundance to the walleyes) and are taken along the weedy shores. Hart indicates Clear Lake and West Okoboji as the two best lakes in Iowa for large-mouth bass fishing.

Silver bass (Lepibama) are rather common. Some say this is the best silver bass lake in Iowa.

Yellow bass or "streakers" (Morona) are rather few but seem to be increasing. Hoel says they were not seen up to 4 or 5 years ago, but that last year a few were taken, and more have been caught this year, off the stony points.

Perch are thought to be increasing in numbers and size again. (This may be only an apparently increase in numbers, as a consequence of the pike removing the surplus of small perch.)

Rockbass are unknown in the lake.

Pumpkinseed Sunfish are reputed to be few but large. Green sunfish are few. Orange-spotted sunfish occur.

Crappies of both species occur, but the black crappie is the common species, according to Hoel. Some claim this is the best crappie lake in the state.

Bluegills are abundant and reach a large size. Hart listed the lake as one of the best for bluegills and crappies in the state.

Channel catfish are caught in numbers off the stony points according to Hoel. Hart wrote hazily of "a good many" yellow catfish (whatever that might be) as being present though rarely caught on hook (a few taken each year in pike nets).

Bullheads are now reported to be few. Mr. Harry Tennant of Arnold's Park informed us that when the pike hatchery was established, bullheads were frequently caught on the "pike" spawning grounds, and that these were "full of pike" spawn,

distinguishable from sucker spawn by size.

Coarse Fishes

Carp are abundant. Hoel says there was a huge hatch in 1930, giving rise to many two-year olds in 1932 (some caught this year in pike-nets, for first time).

Buffalo are also present, and fairly common. They also had a good hatch in 1930. In relation to the food habits of the buffalo, Hoel relates that a warden who kept buffalo in a pond fed them when hungry on grass mowed from a golf course, and that the buffalo fed readily on the grass. Hoel reports very few quillback (Carpoides carpio) and few redhorse.

Sheepshead do not occur according to Hoel, although Hart listed them for the lake. We would suppose Hoel's information to be the better.

"Black suckers" (=that is, white or common suckers) are rather common, according to Hoel, who says that they reach 6 pounds and average 3 pounds in weight. He says they are taken on the pike spawning ground in the spring, and that he has seen a sucker sucking in perch eggs laid on a gill-net. If these habits are general, the sucker might be classed as an obnoxious fish in this lake. They give trouble by being caught in the nets, and are ruthlessly destroyed.

Mr. Hart reported observing the hog sucker ("Catostomus Nigricans" = Hypentelium nigricans) once in Clear Lake, in April, 1931, but Hart was likely misled by the circumstance that Hoel refers to the common suckers as "black suckers."

Predaceous Fishes

No dogfish or gar are known to occur in the lake, according to Hoel and others; yet Mr. Hart reported them as very common (probably in error).

Predaceous birds are not very abundant. Black terns are common along the rushes, but probably feed most on food other than fish. Mr. Hoel says he has found only "worms and bugs" in several shot at the nursery pond.

Forage Fishes

Minnows are said by Hoel to be getting scarce. Late in July, 1932, about 500 large golden shiners were brought in from Lansing, but there were a few golden shiners

here previously. We seined a considerable number of golden and other shiners, minnows and top-minnows.

Fishcultural activities

The fishcultural 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 prior 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 one 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 onto 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 mud, screened, and put into the hatching jars. Using this method, almost no fungus loss is experienced.

Recommendations

Refuges.--The present opening date for bass, crappie and bluegill fishing in Clear Lake, June 15, seems about right provided some provision is made for closing certain refuges until a later date. Mr. Hoel reports that bass and crappies are off their beds in this lake by June 8, some bass as early as May 26. This is not so true of bluegills (which are of great importance in this lake); for instance in a catch of bluegills taken in the rushes near the "Apple Orchard" on June 16, all the females were still full. We would expect a few at least to be on their beds in July.

We follow Mr. Hoel in recommending a zoning of the shore, to consider the interest of fish and resorter alike:

The upper arm, above the bridge, should be maintained as a refuge until July 15, or whatever date the obstruction to fish migration is removed (but not earlier than July 1.)

The west arm, between bridge and the narrows, should be held as a refuge on the north side only, since spawning conditions and shelter for fry are much better here than on the south side, and since the south side is more heavily built up by cottagers.

The north shore of the main body of the lake (east of the Narrows has good spawning grounds east as far as Reely Pt., but it would hardly be practicable or necessary to put all this stretch into a refuge. Mr. Hoel's ideas of running the refuge from The Narrows to the "Apple Orchard" would seem about right, and would include what he has found to be particularly good bluegill spawning grounds. If the state park near the Narrows goes in, it would be well to have the refuge start just east of the Park.

The east shore, from Reely Pt. to the present State Park in Grim's Bay is too open, too regular and too much built up to make a refuge here seem desirable.

On the south shore east of The Narrows there seem to be just two logical refuges, and both are needed to scatter the refuges properly. One in need of closing is Clausen's Bay, from Lone Tree Pt. to the road which comes down to the lake 1 1/2 miles SE of that point. The other refuge proposed for the south shore is Grim's Bay or South Bay, from the present State Park westward to the point where the bluff touches the shore,

that is, when the cottages come in. Other parts of the south shore are heavily built up and too open for good summer refuges. Hoel has seen no bluegill beds along the open shores. There are good spawning grounds for pike and small-mouth bass off Bayside Pt., and Dodge's Pt., but these fish are through spawning before June 15.

The location of these refuges is indicated on our sketch map. Running the refuges from shore out to 150 feet beyond the rushes seems to be a satisfactory arrangement, from the standpoint of fish protection and of law enforcement.

Pollution Control.--No pollution harmful to fish life appears to exist.

Cattle-Wading should be abolished on this lake, for sanitary and esthetic reasons if for no other.

Stocking.--The continued heavy stocking of this lake with wall-eyed pike is recommended. If plans for a successful rearing pond or lake can be made and carried out, it would be desirable to replace the fry-planting with fingerling planting. In the meantime fry-planting is in order. Not to exceed 20,000,000 pike fry or 1,000,000 fingerlings is our estimate.

Small-mouth bass fingerlings should be planted in large numbers, up to 50,000 a year if available, at least until the species becomes really abundant or until experience shows the results not worth the effort. Our suggestion is to use the Clear Lake Nursery alternate years for small-mouth and for large-mouth bass. The greater part of the annual yield of this nursery should go to Clear Lake.

A heavy stocking of the lake with rescued fish (up to about 100,000) from the Mississippi is recommended, with emphasis on bluegills, crappies, silvery bass, large-mouth bass, catfish and perch. Stocking with bullheads is not recommended, until the large yellow bullhead (A. natalis) is cultivated. Then an effort should be made to establish this species in the lake.

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 operations of the hatchery. Until (or unless) a suitable rearing lake

is developed for pike fingerling rearing, we can only suggest that the planting of fry be continued. 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, to make a good enough pond for rearing bass fingerlings to be used for that purpose. The rather large expenditures here ($20,000 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 out of 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 was 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 in the state, we would believe it wise to move it. Then when the water approaches a

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[1] Mr. Baur's records for 1930 indicate a planting of 1,000,000 fry in the spring, and the recovery of only 36,000 4 1/4" fingerlings (0.36%) in the fall. No record is given for 1931.

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 winters, 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 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.

Coarse fish.-- The removal of carp of any size and of buffalo larger than 6 pounds, seems to meet with official sanction and with public approval and to be very desirable from all viewpoints. Fixing the limit of 6 pounds on the buffalo, in agreement with Mr. Baur's ideas seems good. This will allow holding down this somewhat desirable species without badly depleting the stock (would allow about 30,000 pounds a year to be caught according to Mr. Baur). So far as the fish and the sport-fishing conditions are concerned, the removal of the coarse fish by seining could be done satisfactorily in later fall before the lake freezes over, or through the winter under the ice, and (or) in the early spring (March and April).

Two objections have been raised against winter seining by certain local residents (as Mr. Goodson). The first claim is that the price for carp is low at that time, the second objection is that many game fish are killed in the winter fishing. The

first objection would automatically care for itself if the seining is done by contract. The second objection (killing game fish) merely calls for strict and intelligent supervision. There is no reason why fish can not be safely handled in under-ice seining, if this is carefully done.

Mr. Baur points out an objection to spring "spot seining", namely that the carp are already spawning when "spotted".

The seining, whether done by contract or by the state, should be confined to the open lake outside of the weed beds. The larger plants are of great importance to the lake, and should be preserved wherever possible. Even the cutting of the weeds in front of cottages should be discouraged. The objection of certain local residents (as Mr. Knutson) that the open seining would do harm by "scattering the moss" (referring to some weeds growing on the bottom in the deeper water of the eastern part of the lake), seems poorly founded. The increase of these bottom plants should be beneficial rather than deleterious.

We do not appreciate the reason for restricting the seining to the road grade, as has recently been required. It would seem wise to allow landings to be made only at certain specified points, both to save vegetation and to make the control of contract seining simpler. Probably points for landing would be (1) the grade; (2) both sides of the Sand Bar across the Narrows; (3) some point on the southside west of the narrows; (4) one or several points along the east arm of the lake, from Reely Point to the present State Park.

The destruction of suckers in Clear Lake may or may not be justified. While it may well be true that the suckers are destructive to pike spawn, it is certain that the suckers contribute heavily to the diet of the pike, and that an abundance of forage fish is a necessity for a good pike lake. We recommend further study of this problem in Clear Lake. In the meantime, the best policy would seem to be to destroy only those suckers caught in the pike nets on the pike spawning grounds, and to make a further effort to remove the suckers.

Grate in bridge opening.--The practice of 5 years, of installing a grid in the bridge opening on the road grade, appears to have been a desirable one, primarily to keep carp out of the fine spawning waters for that species in the thick weed beds of the upper arm. In order to catch as much as possible of the spawning run of the carp, the grid should be installed immediately when the ice goes out, or if possible as early as February 15.

Mr. Baur's plans for the grating seem good. These are to place rods or pipe across the opening, holding the bars apart and permanently aligning them by running the bars through holes bored in timbers. We believe it would be best to put the bars close together, not over an inch apart, so as to hold crappies and bluegills up in the refuge. Unless it be for some legal technicality, it would seem inadvisable to us to use a strip of net in the middle of the barricade, or other special provision to allow boats to pass through. The slough above should be a refuge until the grating is removed in the summer.

There seems to be little doubt as to the desirability of removing the grid some time during the fishing season, from the viewpoint of carp removal as well as of fishing. But there is marked divergence of opinion as to the proper date of removing the obstruction. The 15th of June was the date used in 1932. June 1 is recommended by many, so as to let the fish back to be caught early in the season. (That does not seem to me to be a point of particular importance, from the standpoint of fish increase). Others, including Commissioner Getters, we understand favor August 1, so as to prevent carp from entering, to eat spawn or fry. July 15 has appealed to me as the most satisfactory date for removing the grating. Up to the date it is removed, the upper arm should be closed to fishing.

The practice of putting adult game fish seined in the spring over the grating, as carried out in 1932, seems desirable up to a certain pdn t, but could be overdone. The spawning conditions seem none too good or certain above the grade, especially on account of the very soft mud bottom over most of this arm of the lake (which is scarcely more than a wet marsh). It is probable that spawning conditions are as good

or better for most species in the main lake as in the upper arm. We would recommend that the seiners working the west end of the lake be required to put over all black bass, crappies and bluegills, but only until (or unless) 2000 of any one kind have been put over. Thereafter, the game fish should be liberated directly into the big lake. Conditions are poor in the upper arm for, small-mouth bass, but it would seem unnecessary to specify that only large-mouth bass be put over, because, according to Hoel, very few of the small-mouth (2 or 3 in his experience) are taken in the western part of the lake proper.

Replacing the grating with a fine meshed trap net set in the bridge opening, so as to catch all fish heading up into the slough, needs consideration. Offhand this would seem to be an effective aid in removing carp and in getting game fish above the bridge.

Gill-netting.--We see no reason why gill-netting for carp and large buffalo with 4-inch bar-measure gill-nets should not be allowed in Clear Lake as well as in the Okobojis. This seems to be a desirable way to get carp, especially as it very seldom catches or injures any game fish. Use of a 4" square-measure gill-net fits in nicely with the provision that buffalo may be taken only over 6 pounds in weight. The method of carp removal, according to Mr. Orel Hoel, is less likely to stir up local prejudice than the personnel employed. He thinks that a man like Mr. Cook, who enjoys local confidence should superintend the work.

Predator Control.--is not considered to be required. Vigilance should be exercised to prevent gar being introduced in bait buckets.

Food Increase in Lake.--To increase the depleted supply of minnows in the lake, we recommend the annual importation of about 2000 golden shiners from the Mississippi, until young shiners appear in abundance in the weeds in late summer. We also recommend that spawning slabs be added in shallow water around the fairly open shores, to the number of 500 or more, to be placed where they will not interfere with swimming, carp seining, etc. Brush shelters should add some to the food also.

Brush Shelters.--Clear Lake would be improved by the addition of more and better shelter for young fish. Incidently this would also tend to make catching of fish

somewhat more easy, at the same time protecting the small fish so they will grow up to offset the increased catch. Loosely filling the space below docks with brush would give wonderful shelter, to young bass especially and would also improve dock fishing.

Public Fishing Dock.--The suggestion we heard of maintaining a state owned or controlled public fishing dock on this much-fished lake appeals to us as a desirable feature. We would suggest a three sided dock (the shore completing a square, with plenty of room for fishing; with much brush underneath for sheltering small fish and for attracting large ones, and with places for chumming the fish so as to attract enough to make fishing somewhat worthwhile (as is done on private fishing docks in the ocean).

Public Park.--Providing a state tourist camp, with swimming and boating facilities, on the lake shore, seems laudible to us. The site near the Narrows, or the north side, looked good.

Screen in Outlet.--It would seem quite practicable to install self-cleaning screens in the outlet. The operating suggestions for a grid or trap-net in the opening under the bridge have already been given.

DIAMOND LAKE, DICKINSON COUNTY

Since this lake is now used as a "Pike Nursery Lake", it is discussed in our Report 208, "Examination of Present Fish Hatcheries and Nurseries in Iowa".

EAGLE LAKE, HANCOCK COUNTY
(three miles east of Britt)

Examined by Salyer July 16, 1932

Use of water.--Chiefly for hunting. "Perhaps one of the most ideal duck lakes to be found in the state" (Hart).

Water.--Mr. Hart studied this as an example of a slough-like lake. He found a very fluctuating dissolved oxygen profile. On January 22, 1931, Hart found the pH to be only 7.2 (very nearly neutral, instead of strongly alkaline like most Iowa lakes). The fish in this lake are said to be frequently winter-killed.

Cover.--Good, in form of rushes for ducks.

Vegetation.--Abundance, especially of species suitable as duck food. All the usual species.

Depth.-- Too shallow for better game fishes.

Recommendations

Classification.--We agree with Hart that fishing in this "lake" is primarily a thing of past ages. It should be treated as a water-bird lake. We would suggest it be made a wildlife refuge.

Stocking.--Bullheads and a limited number of panfish.

EAST TWIN LAKE, HANCOCK COUNTY

Examined by Salyer July 16, 1932

Dam.--We found two rods of the retaining wall adjacent to dam and spillway, broken loose so that the water was escaping. No screen.

Temperature.--This is a warm-water lake: temperature 79° F when air was 88F at 3:00 P.M. July 16.

Size.--About 1½ miles long, ½ mile wide and 3½ or 4 feet deep.

Bottom.--Sandy near shore.

Vegetation.--This lake is a meadow of fine-leaved pondweeds, especially P. interior and P. pectinatus.

Game Fishes.--We seined bluegills, green sunfishes, orange-spotted sunfishes, many bullheads and some perch. Walleyes and crappies are reported to occur in the lake.

Forage Fishes.--A couple of bushels seined out of pool below spillway (fatheads, golden shiners, blunt-nosed minnows and other species).

Recommendations

Stocking.--Panfish.

Dam and Screen.--This lake would merit the repair of the dam, and the installation of a screen, preferably a revolving self-cleaning screen.

FOUR MILE LAKE, DICKINSON COUNTY

This lake was not studied by us. Mr. Hart grouped it in his lake group 5, distinguished as follows:

"Group 5. A good many of these lakes are dry at the present time, but in case there is an abundance of rainfall they will afford good feed and cover for birds. Many of our lakes and sloughs, that could be a great deal of value in that they will provide good hunting, can be improved to advantage, thus rounding out the program of the department considerably. This last group is not satisfactory for the propagation of fish, and stocking of them should be discontinued."

Recommendations

From what we know of this lake, from Hart's Report and other documents, we see no reason to doubt his recommendation that stocking be discontinued.

FOUR MILE LAKE, EMMET COUNTY

This lake was not studied by us. Mr. Hart grouped it in his lake group 5, distinguished as follows:

"Group 5. A good many of these lakes are dry at the present time, but in case there is an abundance of rainfall they will afford good feed and cover for birds. Many of our lakes and sloughs, that could be a great deal of value in that they will provide good hunting, can be improved to advantage, thus rounding out the program of the department considerably. This last group is not satisfactory for the propagation of fish and stocking of them should be discontinued."

Recommendations

From what we know of this lake, from Hart's Report and other documents, we see no reason to doubt his recommendation that stocking be discontinued.

GOOSE LAKE, GREENE COUNTY

Information given Salyer on July 31, 1932, by Dr. Lundell of Webster City

Fluctuation in Level.--Now an unsuccessfully drained lake, - "a jungle of weeds." "By stopping tile a lake 8 or 9 feet deep would be restored."

Use.--Useless now. Owned by state (Department Tree Nursery on east bank). The restoration of the lake would provide good fishing it is thought, because the lake was once a great fish producer.

Recommendations

We merely pass on this information.

GOOSE, KOSSUTH COUNTY

This lake was not studied by us. Mr. Hart grouped it in his lake group 5, distinguished as follows:

"Group 5. A good many of these lakes are dry at the present time, but in case there is an abundance of rainfall they will afford good feed and cover for birds. Many of our lakes and sloughs, that could be a great deal of value in that they will provide good hunting, can be improved to advantage, thus rounding out the program of the department considerably. This last group is not satisfactory for the propagation of fish and stocking of them should be discontinued."

Recommendations

From what we know of this lake, from Hart's Report and other documents, we see no reason to doubt his recommendation that stocking be discontinued.

GRASS LAKE, EMMET COUNTY

This lake was not studied by us. Mr. Hart grouped it in his lake group 5, distinguished as follows:

"Group 5. A good many of these lakes are dry at the present time, but in case there is an abundance of rainfall they will afford good feed and cover for birds. Many of our lakes and sloughs, that could be a great deal of value in that they will provide good hunting, can be improved to advantage, thus rounding out the program of the department considerably. This last group is not satisfactory for the propagation of fish and stocking of them should be discontinued."

Recommendations

From what we know of this lake, from Hart's Report and other documents, we see no reason to doubt his recommendation that stocking be discontinued.

HOTTES LAKE, DICKINSON COUNTY
(T. 100 N., R. 36 W.)

Examined by Salyer, August 1, 1932

Tributary to.--Spirit Lake, through cut in roadway on the west side of the main lake.

Water Supply.--Surface drainage (see 1916 Report).

Use of Water.--This slough is now a duck reserve. It looks like good duck water.

Shores.--High, well defined banks; timbered hills (1916 Survey).

Size.--312 acres (1916 Survey).

Depth.-- 5 to 7 feet (1916 Survey).

Vegetation.--Dense (Salyer).

Natural Food.--Must be very good.

Spawning Grounds.--This lake furnished or should furnish spawning facilities for some of the Spirit Lake fish.

Fishing.-- Not a fishing lake; now a duck reserve.

Recommendations

Refuge.-- We have no data to offer as to the desirability of this lake as a duck refuge, and whether it should be made in all or in part a spawning refuge for fish requires further study.

Stocking.-- May well be used for planting of fish desired for Spirit Lake.

Vegetation Increase and Cover.--Not considered vital now.

Control of Coarse Fish.--If carp and buffalo removal seems advantageous, we recommend that this be done by 4" bar-measure gill nets. Nets one-fourth mile long and 3 to 5 feet deep would enable the operator to make excellent sets across the narrower places and between the island and the shore.

Channels.-- The recommendation of the 1916 Survey, that an open channel between Hottes and Spirit Lakes be maintained is a very important one. Such sloughs are very valuable to a large open lake, as feeding and spawning grounds. Probably a connection should be maintained with Marble Lake as well as with the main lake.

IOWA LAKE, OSCEOLA COUNTY

This lake was not studied by us. Mr. Hart grouped it in his lake group 5, distinguished as follows:

"Group 5. A good many of these lakes are dry at the present time, but in case there is an abundance of rainfall they will afford good feed and cover for birds. Many of our lakes and sloughs, that could be a great deal of value in that they will provide good hunting, can be improved to advantage, thus rounding out the program of the department considerably. This last group is not satisfactory for the propagation of fish, and stocking of them should be discontinued."

Recommendations

From what we know of this lake, from Hart's Report and other documents, we see no reason to doubt his recommendation that stocking be discontinued.

MORRIS LAKE, WRIGHT COUNTY

See Twin Sisters Lake, Wright County.

PINE LAKE, HARDIN COUNTY

The state park lake, formed by draining Pine Creek, a tributary of Iowa River near Eldora, was examined by Salyer on July 12, 1932.

Water.-- Somewhat turbid when examined; said to clear up somewhat more, but to be always more or less turbid.

Size.-- 1 mile long, 86 acres.

Depth.-- 20 feet.

Fishing.-- Better fishing grounds of lake are not accessible to public by road. These are at upper end and sides of lake. Fishing would probably have been better, had the lake not been opened until an adequate supply of brood fish had developed.

Natural Food.-- Rather poor.

Recommendation

Stocking.-- It is advisable to keep walleyed pike and northern pickerel out of this lake, as the food is rather poor. Bass, crappie and panfish should be vigorously favored. Stocking should be heavy, the stocking budget to be based on the annual catch.

Access to Fishing Grounds.-- An auto trail should be constructed to the upper part of the lake, where the best fishing grounds exist. We would suggest that the trail be built around instead of through the natural grove of trees on left side of lake (looking up stream).

Screen.-- Many young crappie get caught in the screen. Likely a new revolving (self-cleaning) screen is desirable.

TRUMBULL LAKE, CLAY COUNTY

Examined by Salyer, July 18, 1932 (Sta. 89). Other information from Hart's Report.

Water supply.-- From the circumstance that this lake has open water at almost all times during the winter, Mr. Hart considered whether some spring water enters it. He found little or no evidence however, of springs in the portion of the lake which stays open, and questioned the cause of open water. As explained to us, it seems more likely that a stretch of ice midway between the two points "heaves" each winter (on account of lateral pressure), thus opening up a narrow channel of water. The high summer temperatures are enough to show that no large amount of spring water comes in. In July 1932 the water level was said to be about average. In the summer, some water flows in from the drainage ditch on the east side.

Pollution.--Cattle were found all around lake, coming from 8 farms and numbering about 15 to 40 per herd.

Temperatures.-- This is a very warm water lake. July and August (1931) surface temperatures ran as high as 29°C (= 84.2 F) and 31°C (= 87.8°F). We found 79°F when air was only81.5°F. at 11:30 A.M. (sky overcast), July 18, 1932.

Water.-- The condition of the water in this very shallow lake must be fair, for Hart reported that it "weathered very favorably" over the winter of 1930-31, and that conditions were very satisfactory in the winter of 1931-'32 until January 5. After that date a continuous blanket of snow over the ice caused the oxygen to diminish gradually to below the "fish zero". Many fish were left in the lake after the "rescue" work of the previous fall, and these wintered through. The removal of part of the fish population was thought by Hart to be a possible reason why the remainder did not die. It is reported that turtles did "freeze out". He was of the opinion that "pumping" would not be successful in so shallow a lake (why?) .

As explained to us, the current from a drainage ditch, averaging 15 feet wide and 3 feet deep in the winter, comes into north end of lake, runs about 3/4 mile and discharges on the west side over the present dam. This current is said to keep

the water aerated under the ice (14 inches last winter, normally 16 inches). Speaker is probably right in assuming that this current saved the fish.

Dissolved oxygen values from January 1 to February 4, 1931, varied from 5.9 to 11.4 p.p.m. (5 stations, 6 dates). From June 28, 1931 to January 5, 1932, the D.O. varied from 5.8 to 13.0 p.p.m. (1 station, 24 dates). Two tests early in February showed a reducing amount (5.5 and 5.0 p.p.m.), as mentioned. Coupled with this drop in oxygen, was a drop in pH to 7.0 (neutrality). Other pH values were 7.6 to 9.2).(on July 18, Mark got a reading of 8.4).

Presumably later tests the same winter, as reported to Salyer, indicated that the D.O. dropped to 1 p.p.m. in the shallow parts of the lake, though it held to 3 p.p.m. in the deeper areas.

Size.-- 1190 acres; about 1 1/2 miles long and 1/2 mile wide.

Depth.-- The bottom of this lake is very flat; the depth was "never more than 4 feet in 1931 or 1932" (Hart), but Salyer found the average to be about 5 feet, with 7 feet reported at deepest point. The depth had decreased to such an extent that the fish were "rescued" in the fall of 1931. During the next winter the greatest depth was slightly more than 30 inches, and generally less.

Bottom-- Sandy and silty near shore, with a few stones.

Shade.-- Little.

Vegetation.-- "The main body of water does not carry a great deal of vegetation. Along the west side of the lake, and extending out into the lake for some distance, are to be found large beds of Carex filiformis. This is the predominant form found at this lake". Salyer noted extensive weed beds along that shore, not by any means confined to the sedge. He found very compact beds of fine-leafed pondweeds (pectinatus and interior) over the western and central parts of the lakes; also some cattails on the southwest shore, in addition to round-stemmed rushes which fringed the lake discontinuously.

Algae.-- Hart reported that this lake, although the shallowest of any of the ten "type lakes" studied by him, is not troubled with blue-green algae. The answer, according to Hart, lies in ~~it~~ the nature of the bottom, which is of mud, accumulated perhaps in greater amount than in any other lake in the state, yet poor in nitrogen. Very likely this is a sound reason.

Natural Food.-- A few crayfish.

Predators.-- Black and common terns numerous. A bittern seen.

Game Fish

Northern Pickerel.-- Hart characterizes Trumbull as perhaps the best lake for northern pike fishing in the state. He regards this as the predominant game fish of the lake. We seined many yearlings, and general evidence leads us to support Hart's view. The pickerel are said to spawn in Mud Lake, which is ordinarily a marsh except in spring; many get trapped.

Pickerel fishing here this spring (1932) was very good.

Large-mouth Bass.--Few or none (Hart).

Perch.--"A good many" caught (Hart). We seined many yearlings.

Crappies.--"Few if any" or "not so many" (Hart).

Bluegill.--"Not so many" as in the better bluegills lakes of the state (Hart). "A few" (Speaker).

Sunfish.-- Only one seined was the orange-spotted.

Bullheads.--Are caught, but no catfish (Hart). Hundreds of black bullheads were seined by us. The 30 bushels of "yellow bullheads" put in by Speaker in the spring of 1932 were probably A. melas.

Buffalo.--"Some" (Hart). We seined large-mouth buffalo and suckers. Carp are abundant.

Obnoxious Fish.-- "No gar".

Forage Fish.--We seined many golden shiners and fathead minnows, and one blunt-nosed minnow.

Recommendations

Law Enforcement.-- Warden reports much illegal seining. This should be stopped.

Stocking.-- Plant heavily with large-mouth bass; also pan fish.

Rough Fish Removal.-- Carp seining is recommended.

Dam and Level.-- We recommend that dam be repaired at once, to prevent the present seepage showing on either side. We recommend that the dam be raised one foot. This would open up areas in center of lake and would make winter-holding safer. If investigation shows probable damage to farm property through flooding farm drains, arrangement to reimburse the farmers affected might need to be made.

Vegetation Increase.-- Plant broad-leafed pondweeds.

Cover Increase.-- Low bottom brush piles are needed.

Screen in Dam.--Badly needed, as many fish go over the present spillway to perish or starve in the muddy pool or prairie stream below (we seined out 1800 emaciated bullheads here, and saw some northern pickerel). Indications are that many pickerel went over the dam last spring (1932).

TUTTLE LAKE, EMMET COUNTY

Examined by Salyer, July 29, 1932.

Tributary to.-- East Branch of Des Moines River, which heads in the lake.

Water Supply.-- Surface drainage, mostly from Minnesota. We understand the water comes in from Clayton and Bright Lakes in Minnesota after a rain to the north, while the flow is reversed after a rain in the south.

Water Level.--This lake is subject to considerably fluctuations. During July it dropped about one foot. About time of World's Fair (1893) it is locally reported that one could walk across the lake dry-shod, on the state line. In 1931 the lake was very low. In the winter of 1931-'32 there was only 3 feet of water under the ice on the Iowa side.

Pollution.--Cattle, horses and hogs wade in and pollute the water all around the shore.

Dam in Outlet.--Yes.

Use.-- A considerable amount of fishing is carried on in this lake. A State Park is located on the east shore.

Temperature.-- This is obviously a warm-water lake. Our only record is 77.5°F. at 11:30 A.M. on July 29, when the air was 79.5°.

Water:--We found the water a dirty gray green.

The oxygen occasionally "goes out" during the winter, causing a "freezing out" when the whole lake is so affected. Catfish were said to have "frozen out" more than 20 years ago, and the lake was said to have frozen out again five years ago, for the second time in 30 years. Last winter (1931-'32) the oxygen is said to have become depleted in the west end of the lake, but to have staid up to 3 or 4 p.p.m. on the Minnesota side, where the lake is slightly deeper. Such incomplete oxygen depletion allows the fish to seek the safe waters.

The pH on July 29 was 8.44.

Size:-- Locally the size of the lake is given as 2500 acres, of which 980 are in Iowa.

Depth.--The present depth (July 29, 1932) was said to be only 6 feet on the Iowa side, but up to 7 feet across the Minnesota line. In our testing, we found the depth to be generally about 5 feet, and we could hardly find 6 feet.

Bottom.-- The general bottom is largely of silty sand, from the shore outward as much as 150 yards from shore according to report. However, our bag-seine filled with mud so it could not be used, only 250 feet out. The shallows are generally sandy, with patches of gravel. The Minnesota north shore is gravelly.

There are at least two rocky reefs, one about 100 yards long at the state line on the north side, and a long one on the Iowa side.

Cover.-- Sadly deficient.

Vegetation.-- There are some pondweeds (potamogeton interior and P. richardsonii) on the east side. On this side there is only one small clump of bulrushes. On the Minnesota north shore there are nice rush and cattail beds, and scattered can brakes (Phragmites).

The bay on the Iowa side of the line, on the eastern shore, is reed-grown.

Algae:--The blue-green algae sometimes become obnoxious in Tuttle Lake. We found the water of the lake more or less green, with a nasty concentration blown into the West Bay, on the Iowa side, by an easterly wind.

Natural Food.--The insect life and other food organisms in the bottom near shore were found to be markedly deficient. A larger production, of course, may take place in deeper water.

Spawning Grounds.--There are two spawning areas on the Iowa side. One of these is a 20 acre slough at the west end of the lake, from which it was found separated by a sand bar. This slough becomes dry during dry years, but there was a good pickerel hatch there in 1932. When the wind raised a little bar along the shore of the slough, the young pickerel were trapped in the cow tracks. (The Park Overseer rescued some, until a rain came to save them).

The other spawning area in Iowa is a reed-grown bay on the east side, just south of the state line.

Predators.--We found a number of bird predators around the lake, including the following species of birds: great blue heron, black crowned night heron and kingfisher. These doubtless do some harm, in consuming forage fish and fingerlings of game fish.

Fishing.--The lake enjoys a fair fishing reputation, said to be better on the Minnesota than on the Iowa side. Whether this belief is based on real fact or just "human nature" is a natural question.

Game Fish

Walleyed Pike.--Some pike occur here. In fact we seined some.

Northern Pike or Pickerel.--There is said to be "lots of pickerel" now, more this year (1932) than for several years past, and though many were caught through the ice (where this is allowed on the Minnesota side) the season in 1932 was extended through March, because it was feared the fish might winter kill anyway.

The pickerel spawning in the slough at the west end is referred to above.

Large-mouth Bass.--are fairly common. We seined many fingerlings in the rushes at the inlet.

White Bass are reported to be absent.

Perch.--Perch fishing in this lake is said to be good, and lots of young were found by us in 1932. We seined perch in the rushes at the inlet. One 5 1/2 inch perch was found to be empty.

Crappies.--We were informed that crappies were stocked two years ago (1930), and that the species may be taking hold, as two were caught last year in the commercial seining on the Minnesota side.

Bluegills.--Bluegills must be fairly common, as we seined many on the east shore; also some in rushes at inlet. Two pumpkinseed sunfish were also seined at the inlet.

Catfish are said to have been frozen out more than 20 years ago. Since the dam was put in at Humboldt, in Humboldt County, it is reported that no catfish have come up to the lake.

Bullheads are numerous now, it is reported. We seined some on the east shore. One 6 1/2 inch bullhead had eaten much Chara (muskgrass), very likely for the small insects living thereon.

Rough Fish

Sheepshead are said to be absent.

Buffalo do occur in the lake, but apparently not in any great abundance. We seined a big-mouth buffalo at the inlet.

Carp are reported to be numerous but rather small (we seined some). In commercial seining on the Minnesota side last year, only two boxes of marketable carp were obtained, it is said. It would appear easy to hold down the carp.

Suckers must be common, for we seined many on the east side and some at the inlet.

Predaceous Fish

Gars are reported to be absent.

Forage Fish

We found minnows scarce, although spot-tail shiners are said to be abundant. According to local claims and to descriptions given us of forage fish, the following species also occur: golden shiner, trout perch, blunt-nose minnow, redfins (Notropis umbratilis) and log perch. These records all need verification. We seined only fathead minnows.

Recommendations

General Policy.--It would seem highly desirable that the fishery officials of Iowa and Minnesota get together in the administration of this boundary lake. This applies to law enforcement, stocking, removal of rough fish, etc.

Law Enforcement.--Reports indicate a considerable amount of gill-netting "on the Minnesota side". The two Departments should get together to eliminate such illegal acts.

Pollution Control.--We recommend that steps be taken to prevent farm animals from wading in the lake.

Stocking.--The fact that this lake "winter-kills" occasionally does not call

for its abandonment as a fish lake. On the contrary, this condition makes stocking more essential. Iowa and Minnesota need to get together in the stocking of this lake.

We recommend stocking with fingerlings of wall-eyed pike, large-mouth bass, crappies, bluegills and catfish.

Rough Fish Removal.--A moderate amount of seining to hold down the carp would seem in order. As the carp run small, seining rather than gill-netting would seem called for. We would recommend that only carp be removed, unless or until buffalo become more numerous. As to the interstate problems involved in rough fish control in Tuttle Lake, the remark given under Iowa Lake applies.

Predator Control.--While the herons and kingfishers around this lake must do some damage to the fish supply, we do not consider this sufficient to warrant any control measures. The esthetic and education values of these birds, especially in view of a localpark development, would call for the retention of the wild life about the lake.

Forage Fish.--There seems to be need for increasing the forage fish in this lake. We recommend the introduction of gizzard shad, which may well also help prevent the lake going out of control with obnoxious algae. We also recommend the spreading of tile slabs or other flat objects to the number of several hundred around the shallows (depths 1 to 3 feet at fairly high level).

Vegetation Increase.--Planting of some good weeds would seem desirable, the kinds, numbers and methods to be determined by a qualified employee. More bulrushes for bluegill spawning would seem much worth while.

Cover Increase.--An urgent need of the lake is more shelter. We recommend about 100 brush shelters, to be put in water about 4 feet deep and to miss the surface about 18 inches.

Regulation of Water Level.--We recommend that the level of this lake be raised approximately 18 inches, by heightening the dam (at the same time installing revolving screens). This would make it a much safer lake for wintering fish, and

improve it otherwise. Interstate arrangements would be needed, as a few Minnesota farmers object:

Connection with Other Waters.--The higher level would connect up Tuttle Lake more openly, with Clayton and Bright Lakes in Minnesota, thus making a body of connected waters. The raise should also help spawning conditions in Iowa, especially by connecting the slough at the west end of the lake with the lake. This connection should be maintained, if necessary by ditching through the sand bar which tends to separate the two waters.

TWIN SISTERS LAKE, WRIGHT COUNTY.

(Also known as Morris Lake)

Examined by Salyer on July 17, 1932 (Sta. 85).

Water Supply.--Surface drainage from 660 acres and bottom springs.

Dam.--With 10 foot spillway; no screen.

Shore.-- High and grassy.

Ownership.--Privately owned.

Temperature.--A warm lake. 82°F with air at only 87°F, in cloudy weather on noon of July 17.

Water.--pH 8.4 at same time. The owner, Mr. Box, reported "lots of winter trouble."

Size.--About 90 acres or 100 acres including sloughs.

Average Depth.-- 4 to 6 feet.

Vegetation.-- Scarce in general, but a good growth of Saggittaria in west end; some greater burr-reed.

Algae.-- A heavy growth of blue-greens underway on July 17, making lake strongly green.

Predators.--One green heron seen.

Game Fish.-- Pike and crappie and other panfish have been stocked, but few ever caught. Some "blue cat" reported caught. Essentially a bullhead lake. Many fishermen frequent the lake. It is claimed 2000 were counted, one Sunday, fishing this lake !

Recommendations

Classification.--Mr. Hart was probably nearly right in classing this lake in his group 5, distinguished as follows:

"Group 5. A good many of these lakes are dry at the present time, but in case there is an abundance of rainfall they will afford good feed and cover for birds. Many of our lakes and sloughs, that could be a great deal of value in that they will provide good hunting, can be improved to advantage, thus rounding out the program of the department considerably. This last group is not

satisfactory for the propagation of fish and stocking of them should be discontinued.

"We would put the lake in the bullhead class."

Stocking.-- We do not believe the facts warrant quite so extreme a view as Hart's. We recommend stocking with bullheads and a limited number of panfish. The bullheads can be in part obtained by rescue operations in connected sloughs (this rescuing was found to be needed in 1932). It is claimed that the lake has been much neglected by the state.

Public Access.--We would recommend that an agreement be made with farmer-owner of road into lake, R.B.Box, which will permit public fishing in general. Mr. Box offered to keep road open to public, if he be allowed to exclude disorderly persons. He also offered to gravel two-thirds of the road in, if the state graveled the other third.

Screen.-- Should be installed in outlet and inlet.

Further Study.--This lake deserves further study. The owner is desirous of having winter tests made and this should be done.

June 6, 1933

Supplement to Report 209

ON THE FORAGE VALUE OF GIZZARD SHAD

From another state comes strong evidence of the value of gizzard shad as a forage fish. The May 1933 Bulletin of the Kentucky Game & Fish Commission prominently treats this species as a valuable forage fish in Lake Herrington, a large artificial lake which is now the most famous fishing water in the state. We quote:

"Gizzard Shad fill an important place in nature by serving as food for other more valuable fishes, yet themselves finding their sustenance upon food materials that ordinary fishes could not use. An apparatus of about 340 filaments on the gills (gill rakers) permits the Shad adeptly to strain out its minute food from the water.

".....

"As stated before, the Gizzard Shad's chief usefulness in the economy of nature, as far as man is concerned, appears to be the role it plays as food for the more important food and game fish. The flesh of this particular species is not at all palatable, as the whole make-up of its body is completely filled with small bones.

"The Gizzard Shad may be credited with the marvelous success that has been attained in Lake Herrington, for if it were not for the presence of this species, this body of water would produce but very few bass and crappie. For this reason the supply of this fish, which is an inhabitant of both salt and fresh water, must be maintained.

June 19, 1933

Second Supplement to Report No. 209

THE FORAGE VALUE OF GIZZARD SHAD

In further referenceto the value of gizzard shad as a forage fish in fishing lakes, we quote the following information sent us on date of June 15, 1933, and signed by Mr. Curtis S. Allen, Publicity Director for the Kentucky Game & Fish Commission:

"Referring to your inquiry with reference to the gizzard shad, this species is present in Lake Herrington in countless millions, and I believe that I am safe in saying that for this reason Lake Herrington is producing more bass than any other lake in the United States, with the same area. To give you some idea of the number of fish that were caught in this body of water on June 1st, 1933, the opening day of the season, I am enclosing herewith a copy of a report that I compiled on that date. I will also be very glad to secure some specimen of this species of shad for you the first time I have an opportunity to go to the Lake."

Creel census results for the opening day (June 1) of the 1933 season on Lake Herrington showed the following (summarized from the report furnished):

Number of registered fishermen	1487
Bass	3507
"Crappie"	1820
"Bream"	597
Others	35
Total weight of fish caught	6492 1/2 lbs.

In the conclusion to the report mentioned above, it is stated:

"The above figures reveal the largest number of fishermen registered at Biggerstaff's Camp, with the largest number of pounds weighed, at the Pandora

Boat Co., at which camp there were 17 legal limits brought in; the largest Bass reported caught coming in at Gwinns Island, the weight of this fish being 7 pounds. In completing the survey of the 333 miles of shore-line, counting the fishermen, we find that an excess of 6,000 people fished ~~the~~ in Lake Herrington the first day of June, catching in an excess of 18,000 pounds of fish, principally Bass."

INSTITUTE FOR FISHERIES RESEARCH

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