Prepared for
First Annual
North Central States
Snow Conference

Original: Snow Conference
cc, Fish Division
Education-Game

O.N.C.

December 10, 1941

REPORT NO. 709

THE EFFECTS OF SNOW AND ICE ON FISH LIFE [1]

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Introduction

Game animal investigators have long recognized snow and ice may critically limit the production of certain birds and mammals in the temperate zone. Leopold (1936) devotes several pages of his text on game management to discussions of the winter losses of quail, deer, etc. That winter may be an equally critical period in the lives of fishes is indicated for example by the results from fingerling brook trout planting experiments as reported by Shetter (1939). A sharp decrease in the number of wild, unmarked trout as well as marked hatchery fingerlings, occurred early in the first winter following the initiation of the experiment. Also in these experiments less than 2 per cent of the trout planted in the fall as fingerlings survived to the angler's creel. The striking difference in returns to the angler of legal-sized trout planted in the fall as contrasted with the returns from spring planted fish is another indication of severe winter losses of trout. On streams where marked fish were stocked and a check of the catch was maintained, Shetter and Hazzard (1940) found that early spring introductions were 6 times as

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[1] Contribution from the Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan.

effective as fall releases in the case of brook trout, 32 times as great in the case of rainbow trout, and twice as great in the case of brown trout. Other workers, as Cobb (1933), Nesbit and Kitson (1937), Hoover and Johnson (1938) and Smith (1940), have demonstrated similar results. No satisfactory explanation for the over-winter losses indicated is at hand. Our results (Hazzard and Shetter, 1940) from fall plantings of legal-sized rainbow trout in lakes, which showed from 13.8 to 66.0 per cent caught by fishermen, suggest that conditions in lakes may be more favorable to over-winter survival than in streams. These and other winter problems have been cited by Hubbs and Trautman (1935) in a plea for more investigations of fish life during the winter months.

Winter brings many changes in the environment for fish life as well as in the fish themselves. Since the effects of snow and ice are somewhat different in streams and lakes, these two types of habitat will be discussed separately.

Winter Conditions in Streams

Shelter for fish in streams may increase or decrease with the approach of winter. Most aquatic vegetation dies down or at least ceases to grow during the colder part of the year. Deciduous trees and shrubs along the banks lose their leaves. Grasses and weeds, which often form an almost complete cover for the smaller meadow streams in summer, die and become flattened by the snow. However, except in streams which are immediately spring-fed, shelf ice extending from the banks toward the center of the stream or even a complete coating of ice with a layer of snow on top may give as much or more protection than did the aquatic and terrestrial vegetation. It is obvious from this discussion that streams may be most exposed after the leaves have fallen in the fall and before the ice comes and again in the spring after the ice leaves and before new leaves appear.

The extent and duration of the ice cover on Michigan waters determines in a large measure the amount of predation which trout suffer in winter from the feeding activities of fish-eating ducks. As long as the lower river courses and the bays of the Great Lakes are open, American Mergansers and to a less extent Red-breasted Mergansers concentrate there, but when these waters become ice-coated the only available habitat is on the spring-fed trout streams. Leonard and Shetter (1937), Munroe and Clemens (1937 and 1939), and Salyer and Lagler (1940) have shown that considerable inroads on legal and sublegal trout may occur as a result of concentrations of these fish-eating ducks on the upper reaches of such streams. On the basis of extensive studies, Salyer and Lagler (1940) estimated that a single merganser would eat at least one pound of food per day. Stomachs of mergansers from headwater trout streams showed that most of this food consisted of trout averaging about 6 inches in length. They estimated that a flock of 100 mergansers might capture 7,000 trout in a fortnight of which 36 per cent would be over 9 inches in length. It is possible that the sluggishness of trout at temperatures near freezing may contribute to the ease of capture by fish ducks. Their studies also show that during periods of heavy concentration of mergansers there may be from one to two hundred or more per mile of a trout stream such as the South Branch of the Au Sable River. Predation by mergansers may well affect the quality of fishing on certain trout streams the following year. On the other hand, their investigations of the food of mergansers on non-trout waters have shown the dominance of suckers, carp and other fish of little interest to the angler.

The same shelf and surface ice which forces the mergansers to spring-fed areas protects trout in the colder, more sluggish reaches. However, in streams subject to heavy ice formation considerable damage to permanent fish shelter may occur. According to Tarzwell (1936), ice freezes to the stakes which are commonly used to hold in place stream improvement structures such as current deflectors and bank covers. If these structures are at or near the surface, they may also be included in the ice sheet. A rise in stream level lifts the ice and with it the stakes and structures. This may occur several times during a single winter and eventually destroy the improvement devices.

Floods caused by the sudden melting of the accumulated winter ice and snow may also damage or wash out man-made improvements as well as natural shelter either because of the accelerated current or because of the battering effect of ice cakes. Bank and stream bottom erosion may also occur in this way. The ice carried by some streams during the spring break-up may form a jam which dams up considerable water causing new channels to be developed and old stream beds to be abandoned. These new channels are frequently lacking in pools and shelter needed by fish.

The food supply in streams is also affected by snow and ice. Anchor ice commonly forms on the sides and bottom of streams during severe winter weather and when the ice rises may carry with it great patches of gravel and aquatic vegetation both of which contain fish food organisms. The floods mentioned above, together with the gouging action of ice cakes, may damage aquatic fish foods and possibly the fish themselves. Needham (1939) and Moffett(1936) have described the effects of spring floods on trout food organisms.

Winter conditions also limit the available food supply of fish as during this season their diet is restricted to the insects and other forms living in the water. No flight of beetles or swarm of grasshoppers is available to supplement the bottom food supply. Fortunately, winter is the season of greatest aquatic insect abundance since young mayflies, stoneflies, caddisflies and other aquatic forms are numerous and are reaching a size attractive to fish. Also, during the colder months most stream inhabiting fishes, such as the smallmouthed bass, feed little if at all, so that the demand on the food supply is lessened. Hathaway (1927) and Markus (1932) have shown that the rate of food consumption of warm-water fishes such as bass falls off rapidly below a temperature of 50°F. and may stop entirely as the water reaches the freezing point. Fortunately for the fisheries biologist the changes in feeding rate affect the growth rate of fishes which are reflected in the formation of a year mark on the scales. Such marks can be used in studies of growth rate, pollution, parasites, etc., as has been discussed by Creaser (1926).

The same factors which affect the shelter and food supply in streams may also influence spawning conditions. Gravel beds used by trout, bass and other nest building fishes may be disturbed. The eggs of trout are buried deep in the gravel, but those of the brown trout, which do not always select spring-fed areas for spawning, may be smothered by the accumulation of anchor ice. Nests of any of the stream trout may be damaged by floating ice cakes during an early winter or late spring break-up or may be silted in or stranded due to these floods as described by Hobbs (1940).

In 1938 the Michigan Department of Conservation through its Institute for Fisheries Research established a trout fisheries experiment station on the headwaters of Hunt Creek, Montmorency County. One of the primary purposes of this station was to make possible investigations of the winter conditions in trout streams and to determine the causes of suspected winter losses of trout and the methods by which these losses might be lessened (Hazzard, 1940). Snow and ice affect not only fish life but the investigators as well. Location of investigators with adequate facilities in the field increases the efficiency as well as the comfort of winter studies.

Winter Conditions in Lakes

Shelter for fish in lakes also decreases as the aquatic plants die down with the coming of ice and snow. While some of the submerged vegetation may remain green all winter, the great majority of pondweeds (Potamogetons) turn brown almost to the bottom of the stalks and the leaves disintegrate. This decrease in shelter probably exposes the smaller fishes to the raids of predacious forms such as the northern pike, which feeds actively throughout the winter. Although shelter in the lake itself may be reduced, bird and mammal predators are excluded by the ice cover. It is believed that this protection may account at least in part for the higher survival in lakes of fall-planted trout. However, the ice cover exposes the fish to one of their greatest predators--man. Some parts of lakes are difficult or impossible to reach or fish in summer but in winter the fisherman can travel anywhere and by spear or ice line harvest the winter crop. Hazzard and Eschmeyer (1937 and 1938) have analysed the effect of winter fishing and conclude that isolation of many lakes by deep snow and impassable roads, the relatively small take on most lakes, and the dominance of predacious forms in the catch prevent winter fishing from depleting the crop in northern lakes. Clark (Ms.) extended these investigations to southern Michigan "bluegill lakes." Based upon population estimates and creel censuses, he concluded that even though the take in winter on such lakes may be high, only a small percentage of the legal fish is removed by winter fishing and that there is no immediate danger of depleting the stock in these waters.

An advantage to the fisheries investigator of ice cover and a certain amount of snow is found in the facility with which lake mapping can be done. A large number of Michigan lakes, mostly in the northern part of the state, have been sounded and mapped through the Civilian Conservation Corps, working under the direction of technicians of the United States Forest Service or the Institute for Fisheries Research. Brown and Clark (1939) have described a method of lake mapping using a small crew and mechanized equipment. As fish cultural operations are curtailed during the winter months, personnel from hatcheries and rearing stations is available for lake mapping in parts of the state where this work cannot be done by the Civilian Conservation Corps. The ideal condition for mapping work is ice just thick enough to support men and equipment and with several inches of snow to make good footing. Depending upon the depth of snow, sleds or toboggans are used to haul the electric ice drill and storage battery.

As winter progresses, especially on the larger lakes, the weight of the snow causes the ice to crack and forces water up onto the ice, thus adding to the thickness of the sheet as it freezes. Further freezing causes expansion of the ice and the formation of pressure ridges on the lakes which accentuate ice push along the shores. When the ice is very thick, weed beds and other shelter in shallow water may be destroyed. Brush shelters and artificial spawning beds must be installed well beyond the depth of possible ice action if damage to these structures is to be avoided.

A heavy layer of snow reduces or prevents the penetration of light to water below the ice and stops photosynthetic activity of aquatic plants and phytoplankton. Lake productivity is therefore at a standstill until the snow melts or blows away and light can once more penetrate to the water. The ice push along shore referred to above also may crush fish food organisms. Sudden ice formation in a lake following open water conditions may cause a mortality of aquatic insects as they are emerging from the water as described by Leonard (1939).

Probably the most important effect of snow and ice on lakes is upon the oxygen supply. The first complete coating of ice seals the lake from further contact with the air. Until the ice disappears, no oxygen can reach the water except that which is generated by aquatic plants and phytoplankton. Meanwhile, oxygen consumption by decay of organic matter, respiration of animals and plants continues. So long as sufficient light penetrates the ice, photosynthesis may actually build up the oxygen supply, but when the snow becomes deep enough to cut off the light, the oxygen supply diminishes until the snow disappears or a break-up of the ice occurs. A close correlation in dissolved oxygen and depth of snow cover has been demonstrated in studies of the "winterkill" problem by John Greenbank (Ms.), formerly of the Institute staff. If a heavy snow cover is continuous for a long period, the oxygen may be reduced below the minimum requirements of certain or all species of fish in a lake. This results in a mortality of fish which may be more or less complete. Small, shallow lakes having highly organic bottom deposits and lacking inlet streams seem to be most susceptible, but even some of the larger and deeper waters may be affected during unusually severe winters.

Closely related to the "natural pollution" referred to above is that which occurs in lakes or streams during the period of ice cover if the waters receive a large amount of untreated sewage or industrial waste of an organic nature. The added oxygen demand of such waste may result in severe exhaustion of the oxygen supply and the wholesale killing of fish.

Conclusions

From the foregoing discussion it will be seen that snow and ice may have advantages and disadvantages to fish life, to fishermen and to fisheries investigators. The need for more detailed studies of the precise effects of winter conditions upon the environment of fish is apparent. Difficult and uncomfortable as such studies may be, fisheries management in the temperate zone cannot be placed upon a sound basis until more is definitely known concerning the requirements and the hazards of fish life in the winter.

Literature Cited

Brown, C. J. D., and O. H. Clark. 1939. Winter Lake Mapping. Michigan Conservation, February, 1939.

Clark, O. H. 1940. Progress Report ~~on~~ of the Winter Fishing Problem on Several Southern Michigan "Bluegill Lakes". Institute for Fisheries Research Report No. 661, April 2, 1941.

Cobb, Eben W. 1933. Results of trout Tagging to Determine Migrations and Results From Plants Made. Trans. Am. Fish. Soc. 1933, Vol. 63, pp. 308-318.

Creaser, Charles W. 1926. The Structure and Growth of the Scales of Fishes in Relation to the Interpretation of Their Life-history, With Special Reference to the Sunfish Eupomotis gibbosus. Miscellaneous Publications No. 17, Museum of Zoology of the University of Michigan, Dec. 15, 1926, 82 pp.

Greenbank, John. 1940. Progress Report on Winter-kill Studies 1939-40. Institute for Fisheries Research Report No. 624, October 15, 1940.

Hazzard, A. S., and R. W. Eschmeyer. 1937. A Comparison of Summer and Winter Fishing in Michigan Lakes. Trans. Am. Fish. Soc. 1936 (1937), Vol. 66, pp. 87-97.

Hazzard, Albert S. and R. William Eschmeyer. 1938. Analysis of the Fish Catch For One Year in the Waterloo Project Area. Papers of the Michigan Academy of Science, Arts, and Letters, Vol. XXIII, 1937, published 1938, pp. 633-643.

Hazzard, Albert S. 1940. Hunt Creek Fisheries Experiment Station. Michigan Conservation, April, 1940.

Hobbs, Derisley F. 1940. Natural Reproduction of Trout in New Zealand and Its Relation To Density of Populations. Fisheries Bulletin No. 8, New Zealand - Marine Department. 93 pp.

Hoover, Earl E. and M. S. Johnson. 1938. Migration and Depletion of Stocked Brook Trout. Trans. Am. Fish. Soc. 1937 (1938), Vol. 67, pp. 224-227.

Hubbs, Carl L. and Milton B. Trautman. 1935. The Need for Investigating Fish Conditions in Winter. Trans. Am. Fish. Soc., Vol. 65 (1935), pp. 51-56.

Leonard, J. W. and David S. Shetter. 1937. Studies on Merganser Depredations in Michigan Trout Waters. Trans. Am. Fish. Soc. 1936 (1937), Vol. 66, pp. 335-337.

Leonard, J. W. 1939. Mortality of Aquatic Diptera Due to Freezing. Entomological News, April 1939, pp. 107-108.

Leopold, Aldo. 1936. Game Management. 481 pp.

Markus, Henry C. 1932. The Extent To Which Temperature Changes Influence Food Consumption in Largemouth Bass (_Huro Floridana_). Trans. Am. Fish. Soc., 1932, Vol. 62, pp. 202-210.

Moffett, James W. 1936. A Quantitative Study of the Bottom Fauna in Some Utah Streams Variously Affected By Erosion. Bulletin of the University of Utah, Vol. 26, No. 9, Biological Series, Vol. III, No. 3, 32 pp.

Munro, J. A. and W. A. Clemens. 1937. The American Merganser in British Columbia and Its Relation to the Fish Population. Bulletin Biological Board of Canada, No. 55, 50 pp.

Needham, P. R. 1929. A Biological Survey of the Erie-Niagara System. XI. Quantitative Studies of the Fish Food Supply in Selected Areas. New York Conservation Department, Supplemental to Eighteenth Annual Report, 1928 (1929), pp. 220-232.

Nesbit, Robert A. and J. Arthur Kitson. 1938. Some Results of Trout Tagging in Massachusetts. Copeia No. 3, November 19, 1937.

Salyer, J. Clark, II, and Karl F. Lagler. 1940. The Food and Habits Of the American Merganser During Winter in Michigan, Considered In Relation to Fish Management. The Journal of Wildlife Management, Vol. 4, No. 2, April 1940, pp. 186-219.

Shetter, David S. 1939. Success of Plantings of Fingerling Trout in Michigan Waters as Demonstrated by Marking Experiments and Creel Censuses. Transactions of the Fourth North American Wildlife Conference, 1939, pp. 318-325.

Shetter, David S. and Albert S. Hazzard. 1941. Results From Plantings of Marked Trout of Legal Size in Streams and Lakes of Michigan. Transactions of the American Fisheries Society, 1940 (1941), Vol. 70, pp. 446-468.

Smith, Lloyd L., Jr. 1941. The Results of Planting Brook Trout of Legal Length in the Salmon Trout River, Northern Michigan. Trans. Am. Fish Soc., 1940 (1941), Vol. 70, pp. 249-259.

Tarzwell, Clarence M. 1936. Lake and Stream Improvement in Michigan. Proceedings of the North American Wildlife Conference, 1936, pp. 429-434.

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