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PROGRESS REPORT OF BEAVER-TROUT INVESTIGATION

By J. C. Salyer

Research Associate, Institute for Fisheries Research

Intinerary and research stations:

1933	Week of Sept. 7	Preliminary survey with Prof. Bradt.
	Sept. 12-20	Standardizing and securing equipment.
	Sept. 20-28	Gladwin Game Refuge.
	Sept. 28-30	Clare County streams.
	Oct. 3-5	Gladwin Game Refuge.
	Oct. 6-9	Presque Isle and Montmorency counties.
	Oct. 10-21	Upper Peninsula survey.
	Oct. 21-26	Gladwin Game Refuge.
	Oct. 26-30	Grayling and Roscommon districts.
	Nov. 1-3	Pigeon River State Forest district.
	Nov. 4-5	Gladwin Game Refuge.
	Nov. 5-9	Survey of west side streams of Lower Peninsula with Mr. Tarzwell.
	Nov. 9-Dec. 17	Spawning studies, Gladwin Game Refuge.
	Dec. 21-23	Boardman River studies.

The first week of the writer's return to research work for the Department of Conservation was spent in conference with officials directing the survey and in ordering equipment. While awaiting delivery on the equipment, at Mr. Ruhl's suggestion, the investigator went with Mr. Bradt of the State College faculty to decide upon research stations in the Lower Peninsula. This gave the worker the benefit of Mr. Bradt's previous experience in beaver studies and ultimately saved much mispent effort. This preliminary survey was made possible by Mr. Ruhl's interest and thoughtfulness in retaining Mr. Bradt for this very helpful service.

As a result of this early survey, the Gladwin Game Refuge promised the best location for intensive work. On this Refuge was a heavy beaver population, the history of which was well known by the Game Division. So important data was already

available upon some phases of the work. Moreover, the streams of this Refuge were typical brook trout streams. Then Mr. Westerman's extensive knowledge of the past and present condition of the trout population of these streams was another argument for its choice. Mr. Westerman has since supplied some very valuable data in connection with the spawning studies made here this past autumn. Finally, since this property was state owned, long-time experiments could best be conducted here. Consequently the most intensive research performed to date has been at this Refuge. The results show this site to be a very fortunate choice.

It was thought that the study which could be undertaken best at this time of year was the effect of beaver dams on the spawning migration of trout. The writer had to decide at once whether to study head water, spring fed reaches of a stream this season or to study the lower reaches of a stream with their attendant larger dams, the greater stream flow, and fewer spawning tributaries. Lack of time was the deciding factor here. Because of the excellent opportunity for the former study which the Gladwin Game Refuge offered it was decided to make the headwater study. It must be pointed out that because of the intensive nature of such a spawning study, both stream situations cannot be studied simultaneously.

The success of the spawning study would depend upon having a reasonable number of tagged trout planted in such a manner that they would have to attempt to run a series of beaver dams in order to get to suitable spawning grounds. Since jaw-tagging as devised by Dr. Greeley of the Institute staff gave such promise, this method of tagging was adopted. By October 5, some three hundred trout had been tagged and planted in and below the four main series of beaver dams on the various Refuge streams. One hundred twenty of these were adult brook trout breeders supplied by Mr. Westerman. Subsequent seinings and tagging brought the number of tagged fish up to over six hundred by the end of the spawning period.

While awaiting the onset of the spawning run, a general survey of beaver-infected trout streams in both peninsulas was undertaken. This was done not only to secure observational data, but also to locate the best regions for future research

and to select streams to be closed for specific types of research. The act of the Commission in closing the streams selected will be very helpful in enabling research to be continued without fear of the beaver being trapped off before its conclusion.

At this time, several hundred physical-chemical examinations of water changes in beaver dams were made. A great number of trout catches in beaver dams were recorded from the prominent fishermen of each locality visited and cast into catch per man hour for comparison from year to year. This gives startling information concerning the length of time trout fishing endures in beaver dams. In addition to the foregoing, a great mass of data on all phases of the beaver-trout investigation was secured.

The spawning season began in earnest about Nov. 1 at the Gladwin Refuge. From this date on, the investigator spent all his time at this station with the exception of two excursions to the west side of the state to observe the behavior of brown trout towards beaver dams during the spawning fervor. The spawning of the brook trout continued with but slight change in intensity at the Gladwin Refuge until Dec. 7, when it ended almost over night. After this date, a study of winter conditions for trout life in beaver dams was made. Further, a series of dams in various stages of trout depletion and chemical stagnation were blown out in order to initiate studies on the recovery rate of streams from beaver occupancy.

Here follows a brief statement or summary of those facts obtained experimentally in the beaver-trout investigation thus far. They are grouped under their respective phases of the study.

A. Physical-chemical conditions of the water in beaver dams as opposed to the natural stream. New equipment and re-standardization of chemicals was necessary for this work. This is the most laborious phase of field operations. As a result of this method of attack the following facts stand out

1. All beaver dams regardless of age or flow of water definitely lower the amount of dissolved oxygen in the water.

2. This is because they have a very high bio-chemical demand for oxygen due to their high organic content (bottom debris and materials).

3. This lowering of the dissolved oxygen in the water of a beaver dam grades from very slight changes to a drop below fish zero (2 or 3 parts per million) according to the age of the dam. Some dams recently blown had a reading as low as 1 part per million. Needless to say, fish cannot endure such conditions long.

4. The dissolved oxygen content of headwater's dams is more depleted than in dams along the main course of the stream.

5. But a narrow, high, water-tight beaver dam often builds the lower oxygen content of its water up to and above normal as the water falls and breaks over the sticks and logs in the down-stream face of the dam.

6. In a dam not watertight, the water goes through the dam and down the stream below with its lowered oxygen content unchanged.

7. The pH reading of a dam gets lower with the increasing age of the dam. Readings range from almost the normal stream value to as low as 3.2 on the acid side of the scale. This last reading would almost coagulate the mucus on a trout's sides.

8. Three stream systems in the U.P. were found to be in such a physical-chemical state that the trout caught therein were uneatable. The fish were muddy to the taste and gave off a disagreeable odor while cooking. All of these streams had many beaver dams in which a large amount of vegetation was fermenting and decaying.

10. An analysis of stream and dam temperatures obtained thus far is very conflicting. In some cases, the water is actually cooled in going over beaver dams, especially large or rather high dams. In as many other cases, dams on a trout stream definitely caused a rise in the stream temperature. Fall and winter are not good seasons for temperature studies. Effects of beaver dams are on trout stream shade and temperatures will be the major phase of the summer's work on the problem.

11. The physical chemical conditions of a dam grows worse as it becomes older. As a general rule, a dam is at its worst physical-chemically in its first and fourth years.

Several other deductions are possible from the date on hand, but these are the major findings.

B. How long does a beaver dam afford good fishing? An analysis of the data on hand shows that where a series of dams are built in close proximity (usually the case) to each other, the following condition obtains:

1. First year of dam's existence, legal limit caught by almost all in 1 to 2 hours actual fishing time.

2. In the second year of fishing a given dam, the fishing is still good but the time necessary to secure the legal limit or a reasonable catch is practically doubled.

3. In the third year, the fishing is exhausted, the average catch being one fish per 6 man-hours.

4. Nothing but the tradition of the previous years of good fishing is left in the fourth year.

In arriving at the above comparative data, only catches were used where a number of sportsmen fished a given dam for a number of years, the age of the dam being first definitely ascertained. The catch was then expressed in number of fish taken per man hour of fishing in order to apply the data comparatively.

C. Beaver dams as barriers to migrating trout. Before rendering this data a distinction must be made between home dams and transport or subdams. Home dams are the larger and more stable structures from 2-6 ft. high making a pond wherein the beaver winter. Transport dams are smaller and less watertight, being made to facilitate beaver movements and the transportation of food to the home dam. A beaver colony generally has one, sometimes two home dams, with a series of from three to twenty-three transport dams.

1. It is a physical impossibility for trout to go upstream over watertight, winter-conditioned home dams. None of the 500 trout tagged and planted on the Refuge streams were able to do so. They can neither leap over the dams nor work their way through them.

2. Trout can sometimes get over some of the smallest subdams, especially if they are in bad repair. However, this was observed in only one instance.

3. But trout can go downstream over any dam to spawn. Tagged breeders went down

stream out of dams to spawn in all of the 4 series of dams under observation at the Gladwin Game Refuge. One female went down over 5 dams in a series on 2 different occasions. After being trapped below these dams the first time, she was replaced in the dam she originally migrated from only to be captured again eight days later spawning a 1/4 mile downstream.

4. 5.6% of the trout tagged and placed in beaver dams before the spawning season were later recovered on spawning grounds below the dam in which they were planted. There was not a single tagged spawner which went upstream over a dam successfully. This recovery record is very remarkable.

5. Anaerobic conditions prevail in the heart of a beaver dam. There is no oxygen in the heartof a beaver dam. This was revealed in tearing out a series of 4 dams by hand on a stream where the spawning run of trout has disappeared. In each of these dams suckers and trout, which had worked their way up into the interior of the dam base 2-3 feet, were found. Here they were met by an impervious core of earth, clay, sand, and stones which effectually barricaded them against further progress. The suckers were evidently of the preceding spring's run and still preserved their spawning colors. The trout found had worked up into the dams at a time which must have been a year previous to the time of their finding. Their preservation is only accounted for by the absence of oxygen and the low interior temperature of the dam. The flow of water over the face of a tight dam must act as a gigantic aspirator in so far as the inner recesses of the dam are concerned.

6. Trout are quite indifferent to a dam when it bars their up-stream spawning progress. When the spawning season was well under way, there was a definite concentration of trout below each series of dams from several hundred to a thousand breeders. By means of trapping the tagged fish in these groups it was revealed that if there are no feeder streams below the obstructing dam, they will linger in front of the dam several days without trying to run it. Of all the trout observed congested below dams, not a single individual was seen trying to work over a dam.

Finally the trout would spawn here regardless of the suitability of the bottom which in many instances was merely sand or marl. But if there were feeder streams below the dam, the movements of tagged fish showed that the breeders dropped back downstream and went up these lower feeder streams until they found normal spawning beds.

7. Several important phases of brook trout life history had to be worked out before the effect of beaver dams could be fully adjudged. As a result of the studies at the Gladwin refuge this fall, the data is available to show that brook trout in deciding upon a spawning stream are not influenced by the dissolved oxygen content of the water as has been held by some fisheries workers, but rather by the minimal temperatures of the stream and the abundance of gravel in the stream bed. Further, it was found that brook trout have a minimal temperature at which the normal spawning behavior becomes first manifest and below which it immediately ceases. It was additionally discovered that the females are the first to leave the spawning grounds when spent.

D. Latent effects of beaver dams on the spawning of brook trout.

1. Headwater beaver dams when heavily iced over in the event of an early cold snap as occurred this season, lower the water temperature below the spawning threshold of the trout. This spawning threshold seems to be very definitely 37°F. The trout at two stations last a full week of the total spawning period from this source. During this cold water period the trout simply lay inactive below the dams. At 3 other stations 2 to 3 days were lost in the height of the season from this cause again. This, it should be noted, occurred on normal, spring-fed streams.

2. In the case of early and heavy snows during the spawning season, when this water melts and runs off, so much silt and sand is washed out of dams one year old that excellent gravel spawning stretches of 1/8 to 1/4 mile extent below 2 stations were covered with a suffocating layer of silt, and then sand. This happened first in the second week of the spawning season and again in the fourth. Dams 2 years old or older gave no trouble in this respect. Their bottoms had become more compacted.

Fully 2/3 of the suitable gravel spawning areas on the Refuge were destroyed from this cause. A number of nests were staked out in these regions to be dug up later in the eyed stage and checked for survival of the eggs.

3. Due to the combined effects described in topic No. 1 and 2 just above, all spawning areas in the main Cedar River were abandoned after the first half of the spawning season, and the total population of trout in the Refuge waters were forced into Hoister Creek to complete the spawning cycle. This creek afforded a scant 200 yds. of spawning gravel which was, however, of high grade and another 150 yds. of poor gravel much mixed with sand, marl, and muck. Succeeding waves of spawning trout worked and re-worked this gravel. They were seined here and tagged at the rate of 133 per hour in one instance. The investigator frequently caught and tagged 35-50 trout by himself here in an afternoon.

It can be readily seen that if the beaver subsequently elect to throw a dam across the lower reaches of Hoister Creek, there will be no spawning grounds available for the trout in the upper three miles of the Cedar River. If this event happens, the brook trout population of the Refuge will quickly pass out of the picture. This is exactly what has happened in the case of Trout Creek, a dead trout stream in the Gladwin Refuge.

E. Can trout spawn in beaver dams? Twelve nests were found and staked out in beaver dams. These will be dug out in the eyed-stage (about January 20) to see if they were successful. It is very doubtful if beaver dam trout nests are successful. The spawning of the fish here was observed in great detail on two occasions. The normal spawning routine was greatly changed, the males could not defend their nests, and each time the female attempted to issue eggs, she was overwhelmed by the charging-in of from four to a dozen males. As a consequence the whole spawning set-up was overturned. Undoubtedly the intricate grouping of males in the spawning act as worked out by Dr. Greeley of the Institute staff positively depends upon the strong rheotropic sense of the trout. Since a strong current is absent from beaver dams

the normal spawning cycle probably cannot be fulfilled in beaver dams. As a final hazard to the success of beaver dam nests, those nests are invariably covered with a heavy, black silt deposit in from 24 to 36 hours after the trout have left them.

F. Increased predator intensity. On headwater streams beaver dams immediately permit the entry of fish-eating birds which were formerly excluded by the overhanging trees and shrubs. They stay much later on the ponds than on the trout streams proper in the fall. Kingfishers and herons lingered until November 2 this year on the Refuge streams, the latest records I have in all predatory studies.

G. Parasites and disease. I have to date three well authenticated instances where strigeid infestations of trout populations in trout lakes followed a change in the lake ecology occassioned by beaver dams thrown across its outlet.

H. Beaver dams build up the trout fishing in some regions.

1. In many U.P. counties such as Keweenaw, Houghton, Ontonagon, Baraga, and Marquette, the beaver dams make fishing where there was none before.

2. In this same region, water is conserved by the beaver dams which formerly ran off quickly.

3. Periodical droughts hit this region and lower water levels tremendously. At this time beaver dams become a haven of refuge and substenance to the trout.

4. The bad physical-chemical conditions so often observed in lowland beaver dams are largely absent from this region.

5. As a general rule all beaver dams in any district which do not overflow the natural stream banks give better fishing for a definite period of time (2-3 years) after which such productivity falls off.

I. Beaver dams can make trout streams extinct.

1. A number of instances were found in Iron and Dickinson counties where great numbers of beaver dams on lowland trout streams sodded in and became permanent warm-water marshes. The streams all had a good past history for trout. Other streams in the U.P. and in Presque Isle county are on the road to the same fate unless simple control measures are applied soon.

J. An excessive number of uncontrolled beaver dams on trout streams without sufficient cedar-spruce swamp reservoirs cause the water supply to fail through a widespread and increased evaporation rate. This is strikingly demonstrated in the water failure of the Big and Little Rainey river systems of Presque Isle County the past two summers.

K. Whenever a home beaver dam is thrown across the outlet of a trout lake, the lake area is greatly increased, the water warms up, the plant life changes over, and the trout fishing goes progressively downward. Many instances of this phenomenon have come to light.

L. Control measures. The present beaver population on our trout streams are not incompatible with good trout fishing providing a definite system of beaver control is worked out and adopted. Such control measures are beginning to suggest themselves. Happily certain converging factors in the life history of both beaver and trout bid fair to make such control practical. If such control measures are not evolved and adopted, Michigan trout streams are faced with their most serious menace in the uncontrolled occupation of headwaters by the ever-increasing numbers of the beaver.

M. The fishing public has been contacted in each region visited and opinions obtained from this public with reference to beaver dams and beaver dam fishing. The result is an interesting array of critical opinions, prejudices against, and advocation of the beaver.

Miscellaneous findings

In addition to the topics discussed before, a mass of data is being built up on the following topics: Muddy trout; warming of lakes and streams; difference in water condition of occupied and unoccupied beaver dams; fishermen preferences—dams or natural streams; overstocking beaver dams in U.P.; sodding in of dams to make permanent marshes of trout streams; methods of checking damage; fertility of dams vs. natural streams; blowing-out dams for recovery studies; age, time and method of blowing-out dams; timber and shade damage; timber salvage; silt from dams destroying

spawning beds in high water periods; cyclic occurrence of beaver on streams; sustaining trout fishing in beaver dams; dams as barriers to trout; temperature changes; winter conditions in iced-over dams; other activity on dams and natural streams; beaver returning to occupy stream sections too soon after cutting food timber off; ancient beaver workings and effects on streams; beaver dams vs. trout refuges in winter and in times of drought; beaver dams on trout lakes; effect of acid and low oxygen conditions in dams on developmental rate of trout fry; dams increasing food supply on sandy streams; rate of increase in beaver; destruction of deer food by flooding; beaver dams as an ecological factor in lives of other species—as drowning of deer (6 instances) in beaver dams; beaver fertilization of water; parasite and predator increase in beaver dams; plant succession in beaver dams; age dams are abandoned by beaver; ancient beaver-trout relations; correlation of weather and beaver activity on trout streams; new facts in life history of both beaver and trout; and many other phases of the broad scope such a study as beaver-trout relations must have.

The winter months will be largely devoted to studies on

1. Beaver dams as wintering places for legal trout.
2. Physical-chemical conditions in iced-over beaver dams.
3. Comparative study of food production in beaver dams and natural trout streams.
4. The bio-chemical demand of beaver dam bottoms.
5. Growth rate of trout in beaver dams.

Many minor phases of the investigation already under way and well developed had to be omitted from this preliminary report because of the need of further confirmation of the data and the need to confine this paper to a progress report.

In conclusion, this progress report would not be complete without acknowledgment of the time, aid and direction cheerfully accorded the investigator by Mr. Westerman and Mr. Ruhl. Mr. Westerman further supplied data on trout behavior which aided greatly in interpreting certain portions of the findings obtained in the Gladwin

Refuge spawning studies. Mr. A. B. Cook, Sup't of fisheries operations, made helpful suggestions as to localities for investigation and greatly expedited the procuring of special equipment. Mr. De Boer took charge of posting research areas on special streams, thus allowing the investigator to continue the spawning studies without interruption at this important period of the research. Mess'rs Martin, Bush, Beach, Thorson, Wershey, Adair, and Entriken of the law enforcement division gave active field help in many instances. Dr. Greeley of the Institute staff made many interpretive suggestions in the spawning studies. And needless to say, Dr. Hubbs, Director of the Fisheries Institute, is a fountain of inspiration and critical guidance in any type of research.