COOLWATER OVERFLOW-DESIGN FOR PONDS, AVOIDS DAMAGE TO TROUT WATERS

By TAYLOR A. ONCALE
Biologist, Soil Conservation Service, Rome Georgia

AND

FLOYD R. FESSLER
Biologist, Soil Conservation Service, Nashville, Tennessee

Construction of reservoirs and floodwater retarding dams on streams, especially those occupied by rainbow trout *(Salmo gairdneri)*, affect temperatures below the dams. This paper reports on the effectiveness of "coolwater inlets" that route the normal overflow from bottom waters (hypolimnion), and makes comparisons with other lakes having the normal flow removed from near the surface (epilimnion).

This study began on the Hightower Creek Watershed Project, located in the Northeast corner of Georgia in the lower Blue Ridge Mountains. It is a project organized by the Hightower Creek Watershed Association in cooperation with the Blue Ridge Mountain Soil Conservation District, to provide protection to valuable bottomlands which frequently suffered inundation. The watershed work plan was made and carried out with technical and financial assistance furnished by the U. S. Soil Conservation Service and other federal and state agencies as provided for in the Small Watershed Act, Public Law 566, 83rd Congress, 1954.

Review of Literature

Previous papers have shown that impoundments will alter the thermal and chemical characteristics of streams whether they be ponds constructed by beavers or larger reservoirs made by man. The alterations may be beneficial, detrimental, or neither depending upon the design of the structure installed and species of fish to be managed.

Shetter and Whalls (1955) reported a pond originally made by beavers was restored on a trout stream in Michigan. The small impoundment, by spreading the water over several times the normal stream channel area, raised the midsummer water temperatures 6.5 to 10.1 degrees F. However, the conditions were still within the physiological limits of the trout population, so no damage occurred.

Churchill (1958) pointed out that deep multi-purpose impoundments, with power intakes deep in the pools, exert greater influences on the oxygen concentrations in the stored and released waters than do shallower single-purpose reservoirs with intakes near the water surface.

Cherokee Reservoir above Knoxville, Tennessee on the Holston River has the power intake low in the pool. When the pool is thermally stratified, water is drawn exclusively from the hypolimnion. Oxygen concentrations in the discharged water drop as soon as stratification develops in the spring, and continue to recede until all the water of the hypolimnion is gone. Oxygen in the hypolimnion is depleted by the residual biochemical oxygen demand (BOD) of materials originally carried by the water into the pool and by the oxygen demand of dead algal cells settling into the lower strata from the epilimnion.

In contrast, Parksville Reservoir on the Ocoee River in Tennessee has a relatively high intake that removed water during the period of thermal stratification from the epilimnion. This resulted in the discharge having high oxygen concentrations all the year.

Methods

In the Hightower Creek Watershed, four floodwater retarding structures were built. The impoundments ranged in size from 2.5 to 4 surface acres. Each was built on a stream suitable for trout. It was recognized that by using the conventional top water overflow on these structures, the character of the stream water would be changed. To minimize this change, the four structures were modified so the sustained normal flow of water would be removed from near the bottom of the storage pools. This modification has been termed as a "coolwater inlet". The four structures were installed and in operation during 1960. During the warm months of 1961 this study was made to evaluate the effectiveness of these inlets.

The two characteristics of paramount importance in managing water for trout are temperature and dissolved oxygen. This study was confined to measuring and evaluating these two items. The temperatures were checked with a Taylor Sixes maximum-minimum registering thermometer. A one degree difference has no significance, since this thermometer has no fractional graduations. Dissolved oxygen content was determined by using the Standard Winkler Method as described by Lagler, 1956.

Oxygen and temperature measurements were made periodically in the Hightower streams before they entered the impoundments and again after the water was discharged below the impoundments made by structures Number 13, 18, and 25 (Table I).

To provide a comparison, similar oxygen and temperature measurements were recorded at structure Number 10 on the adjoining Sautee CreekWatershed and on Unicoi Lake, which is fed by Smith Creek (Table I). The Sautee structure is on a stream containing trout (Merkle, 1961), and Smith Creek is also a good trout stream. Both are equipped with the conventional type outlet where the normal flow is removed from the surface of the impoundment. The temperatures were recorded upstream from the lakes, in the lake surfaces, and below the dams. Both of these sites are approximately fifteen miles south of Hightower.

Three warmwater lakes in Tennessee were similarly checked, one with a coolwater inlet, and two with the normal flow removed from the surface (Table I).

DISCUSSION

Flourishing trout populations are not found in streams exhibiting temperatures in excess of 70 degrees F. for any extended period. "They may however survive exposure to temperatures as high as 87 dgrees F. for short periods." (Schaeperclaus, 1933)

Temperatures below the coolwater inlet impoundments were usually within the desirable temperature range for trout (Table II). The mean downstream temperature was 68 degrees F. The mean dissolved oxygen content was 6.5 parts per million.

In the structures which removed the normal flow from the surface, the downstream temperatures approximated the impounded-surface temperatures—a mean of 73 degrees F. which averaged 6 degrees above the stream temperature before it entered the impoundment. This is above the desirable limits for trout. Although the oxygen in the released water was lower here than with the coolwater inlets there was an abundant supply for trout.

The presence of trout in the streams of Hightower Creek Watershed was indicated when a rainbow was caught in the stream below structure Number 25.

Temperature and oxygen profiles of both types of impoundments were obtained periodically to determine what effect the coolwater inlets had upon the water characteristics at various depths in the impoundments. (Figures 1 and 2)

As can be seen in Figure 1, the temperature of the water downstream from the dam is 72 degrees F. with a rather rapid regression to 67 degrees F. in the pool. A typical temperature curve is not present although stratification is taking place. There are what appears to be two thermoclines which is not unusual according to Evelyn (1957). The biochemical oxygen demand of the residual materials on the bottom has depleted the oxygen in the lower depths to zero. Above the seven foot level there appears to be enough oxygen to supply the needs of trout and any warmwater fish.

At the time of taking the data for Figure 2, the stream flowing into this structure was 70 degrees F. (Table I and III). It can be seen that there is more oxygen in Number 18 below five feet than in Number 10. This is a direct result of the influence of the coolwater inlet. The temperatures of the reservoir water shown in Figure 2 are not the optimum for trout at any depth although with the high oxygen concentrations present, it should support trout.

In order to get a better picture of the extremes experienced in temperature and oxygen in these impoundments, the data gathered are presented in Tables III and IV. This shows that although the outlet

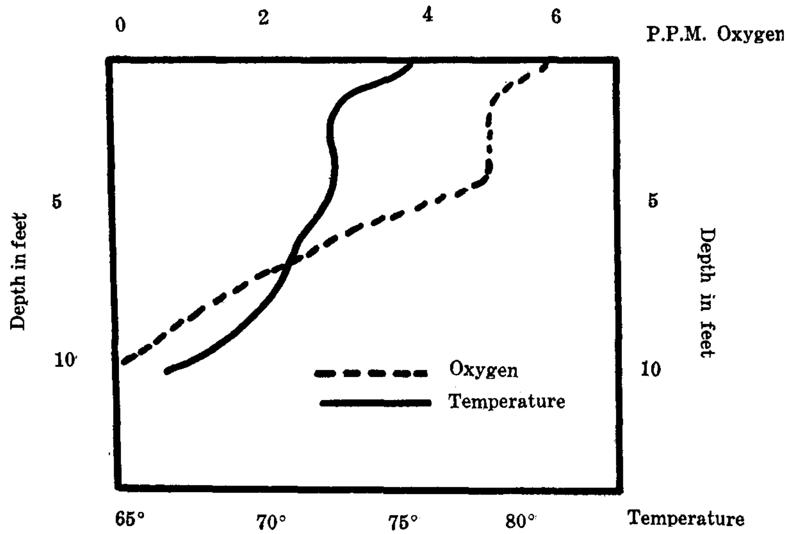

Figure 1. Temperature and oxygen profile of Number 10 Sautee at 3:00 p.m. on September 14, 1961.

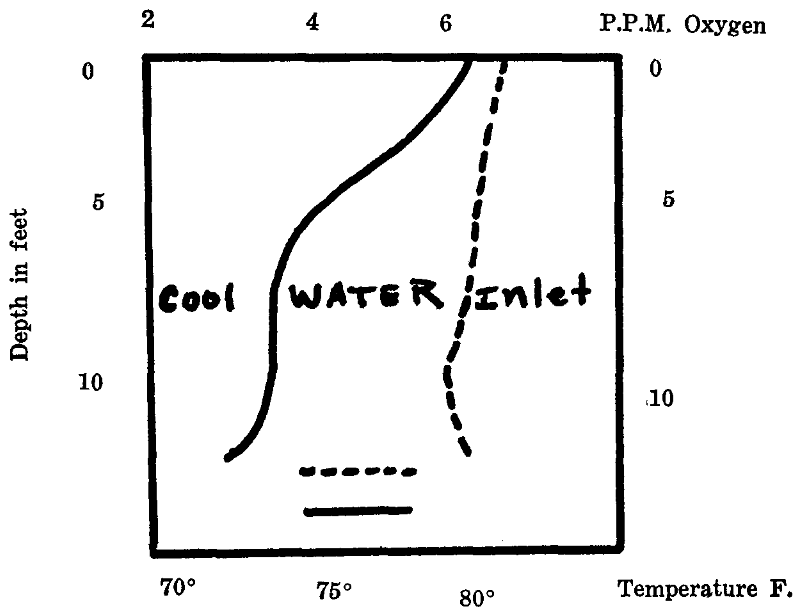

Figure 2. Temperature and oxygen profile of Number 18 Hightower at 3:00 p.m. on September 12, 1961.

temperature of Number 18 is slightly above the maximum desirable limit for trout it would have been even higher had there not been a coolwater inlet present. (Note: The temperatures on Number 10, taken the same week as Number 18, are much cooler, reflecting cool air front which passed over the area while checking Number 10.)

TABLE I.

SHOWING TEMPERATURES AND DISSOLVED OXYGEN IN STREAMS, ABOVE, IN, AND BELOW IMPOUNDMENTS.

			Temperature				*Oxygen*	
Location	*Date*	*Time*	*Air*	*Upstream*	*Pond Surface*	*Downstream*	*Upstream*	*Downstream*
			Coolwater Inlet					
Hightower								
13	7/11	2pm	63	60	66	63	..	..
	8/15	3pm	72	64	72	67	4.5	6.2
18	6/29	2pm	65	62	72	63	7.5	..
	7/12	9am	69	61	67	65	..	..
	7/27	9am	74	64	71	69	..	..
	8/17	9am	60	..	..	67	6.5	8.0
	9/12	11am	84	69	76	72	6.3	6.0
	9/12	1pm	88	70	78	72	7.0	6.5
	9/12	3pm	85	70	80	72	7.0	7.4
	9/12	6pm	76	69	80	73	6.7	6.2
	9/13	6am	69	68	74	74	6.5	5.8
	9/13	9am	72	68	76	73	7.0	7.0
25	6/28	9am		62	67	62	..	..
	7/11	5pm	63	62	69	64	..	..
	7/27	11am	78	66	76	68	..	..
Cheatum, Tenn.	8/10	...	..	78	86	75	5.3	5.0
			No Coolwater Inlet					
Sautee								
10	6/27	9am	68	64	68	68	..	..
	7/26	3pm	82	69	80	82	..	..
	8/16	8am	68	64	69	69	5.5	5.5
	8/16	noon	77	68	75	75	6.5	4.5
	9/14	11am	72	69	73	73	6.3	7.5
	9/14	1pm	72	70	73	73	5.9	6.5
	9/14	3pm	75	70	76	76	6.2	5.4
	9/14	6pm	72	70	74	74	6.8	6.7
	9/15	6am	55	65	72	72	7.4	6.8
	9/15	9am	63	67	73	72	7.3	6.6
Unicoi Lake	6/27	9am	69	62	69	69	..	..
	7/26	5pm	74	69	84	84	..	..
	8/16	4pm	80	66	71	71	..	..
	9/15	11am	63	63	70	70	..	..
Dade Dukes Tenn.	7/26	2pm	..	75	85	..	..	..
Brown Rochell Tenn.	8/2	2pm	..	..	93	93	..	..

TABLE II.

MEAN DATA ON OXYGEN AND TEMPERATURE FOR ALL COLDWATER INLET AND TOP DRAWDOWN IMPOUNDMENTS (NUMBER 10, 13, 18, 25, AND UNICOI LAKE)

	TEMPERATURE			*OXYGEN PPM*		
	Upper Stream	*Pond Surface*	*Below Dam*	*Upper Stream*	*Pond Surface*	*Below Dam*
Coldwater Inlet	65	+8[1]	+3	6.5	—0.4	+0.1
No Coldwater Inlet	67	+6	+6	6.5	—0.2	—0.3

[1] + or — with number shows the variation in the surface or outlet temperature or oxygen from that of the inlet above the impoundment.

TABLE III.

OXYGEN AND TEMPERATURE OF #18 HIGHTOWER AT SELECTED DEPTHS AND HOURS ON SEPTEMBER 12 AND 13, 1961.

Date	*September 12, 1961*						*September 13, 1961*					
Time	*11:00am*		*1:00pm*		*3:00pm*		*6:00pm*		*6:00am*		*9:00am*	
	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*
Air Temp.		85		88		85		79		69		72
Upstream	6.3	69	7.0	70	7.0	70	6.7	69	6.5	68	7.0	68
Below Dam	6.0	72	6.5	72	7.4	72	6.2	73	5.8	74	7.0	73
Surface	4.4	76	5.5	78	6.5	80	7.0	80	6.0	74	7.2	76
2′	7.0	76	..	78	..	78	..	..	..	..	..	76
3′	..	74	..	..	..	..	..	..	..	..	..	..
4′	5.8	74	6.0	78	..	76	..	..	..	..	..	..
5′	..	73	..	..	..	..	..	..	..	..	..	..
6′	..	73	..	..	..	74	..	..	..	..	..	..
7′	..	73	..	..	..	..	..	..	..	..	..	..
8′	5.5	73	7.0	74	5.8	74	6.5	74	6.3	74	7.0	72
9′	..	73	..	73	..	..	..	..	..	..	..	..
10′	..	73	..	72	..	..	..	..	..	..	..	..
11′	..	73	..	72	..	..	..	..	..	..	..	..
12′ (bottom)	2.6	73	7.0	72	6.0	72	7.5	72	6.2	73	6.5	72

TABLE IV.

OXYGEN AND TEMPERATURES OF #10 SAUTEE AT SELECTED DEPTHS AND HOURS ON SEPTEMBER 14 AND 15, 1961.

Date	*September 14, 1961*						*September 15, 1961*					
Time	*11:00am*		*1:00pm*		*3:00pm*		*6:00pm*		*6:00am.*		*9:00am*	
	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*	O_2	*Temp.*
Air Temp.		72		72		75		72		55		63
Upstream	6.3	69	5.9	70	6.2	70	6.8	70	7.4	65	7.3	67
Below Dam	7.5	73	6.5	73	5.4	76	6.7	74	6.8	72	6.6	72
Surface	7.0	73	6.5	73	6.7	76	5.5	74	6.5	72	5.1	73
2′	..	73	..	73	5.5	73	..	..	..	..	..	..
3′	..	72	..	..	..	..	..	..	..	..	..	..
4′	..	72	5.9	72	5.5	73	7.8	73	..	..	..	..
5′	..	72	..	..	..	..	..	..	..	..	..	..
6′	..	72	4.7	72	3.8	72	4.5	72	..	..	..	..
7′	..	71	..	..	..	..	..	..	..	..	..	..
8′	..	70	3.5	70	1.3	71	2.3	69	5.5	72	4.8	70
9′	..	69	..	..	..	..	..	..	..	..	..	..
10′	..	68	..	..	..	..	..	..	..	..	..	..
11′ (bottom)	0.0	67	0.3	68	0.0	67	0.0	67	0.4	72	0.35	68

By comparing Figures 1 and 2, and Tables III and IV, it can be seen that it is very desirable to have the coolwater inlet on any impoundment on a trout stream.

Conclusions are: coolwater inlets on impoundment structures will;

1. Maintain or increase the oxygen content of the downstream water.
2. Increase the temperature of the downstream water only a few degrees, not enough to damage trout waters significantly.
3. Improve the impounded water for fish by removing the low-oxygen water from the lower depths of the pool and providing a larger layer of water with suitable temperature and oxygen characteristics.

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THE USE OF ELECTRICAL STIMULI IN LIVE-PICKING ORGANISMS FROM BOTTOM SAMPLES*

JACK D. BAYLESS
Fish Division
North Carolina Wildlife Resources Commission
Raleigh, N. C.

ABSTRACT

A simple, portable, and effective apparatus for electrically stimulating macrobenthos is described as a material aid for rapid picking of bottom samples in the field.

Experience has demonstrated that the use of electrical stimulation not only shortens the time required, but it also results in recovering many organisms that otherwise would be overlooked.

INTRODUCTION

Picking organisms from bottom samples has long posed a problem in fisheries work. At best, it is a time consuming and tedious task and, too often, a compromise must be made between a desired degree of accuracy and the time required to achieve it. Samples are more quickly and accurately picked at the time of collection when the observer can take advantage of motion directing his attention to an otherwise obscured organism. Even so, unless field time is of no consequence, the period required for even a qualitatively representative picking becomes almost prohibitive. As a consequence, bottom samples usually are preserved in toto for subsequent recovery of the organisms when more time can be devoted to the task. Picking a preserved bottom sample is extremely time consuming if any acceptable degree of thoroughness is desired.

The use of electrical stimuli was tried to obviate the disadvantage of picking preserved samples and yet reduce to a feasible limit the time required for live-picking a sample at the time of collection. The technique proved eminently satisfactory. The worker can cause movement of the organisms at will by applying an electrical stimulation and thereby greatly reducing the time required for picking a bottom sample and correspondingly increasing the accuracy of the individual worker.

MATERIALS AND METHODS

A readily portable apparatus for shocking macrobenthos into movement during the streamside sorting and picking of bottom samples is easily constructed for a negligible cost. The apparatus, including the source of power, may be enclosed in a weatherproof case measuring no more than 15- by 12- by 5 inches. The total weight involved approximates 10 pounds, hence the apparatus easily can be carried to the sampling station along with the other equipment required. The total cost, including the case, should not exceed $20.00.

The apparatus, the wiring diagram for which is shown in the preceding figure, utilizes a six-volt dry cell battery as a power source. The current demand of the apparatus is only 3 to 4 milliamperes, hence the unsual "Hot-Shot" type of electric fence battery will last through an

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