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MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION
HELENA, MONTANA

JOB COMPLETION REPORT
INVESTIGATIONS PROJECTS

State of Montana

Project No.: F-23-R-4 Name Fishery Investigation Laboratory

Job No.: III Title A study of the relationship between total dissolved solids and trout growth rate

Period covered: May 1, 1960 to April 30, 1961

Abstract:

Growth rate of brook, brown, rainbow and cutthroat trout from Montana lakes and streams was studied in relation to dissolved mineral content. Specific conductance measured in the field with a portable meter was used as the index to mineral abundance. Waters were classified as low mineral content (less than 150 micromhos) and high mineral content (150 micromhos or more). Growth rates were classified as slow (less than 7.0 inches average length at the second annulus) and fast (7.0 inches or larger at the second annulus). Of the 100 growth samples, 26 were from low mineral waters. All but two of the latter were in the slow growth category. There were 38 slow growth samples from the good fertility waters. It is suggested that slow growth in these 38 waters may have resulted from short growing seasons, overpopulation or habitat deterioration and that fast growth could not occur in the 26 low mineral waters because of insufficient mineral content.

Objectives:

The present study was undertaken to explore the possibility of using dissolved mineral content as an indicator of conditions favorable for trout growth in Montana lakes and streams. Reimers (1955) found a fair degree of correlation between trout growth rate and dissolved solids content of 10 alpine lakes. Rawson (1951) stated that, "A positive correlation was found between the total solids in the water and the average standing crops of plankton and bottom fauna," and that "Recent studies in lakes of northwestern Canada suggest that the total mineral content of waters provides a rough indicator of edaphic conditions which must in some measure affect the productivity of lakes." Larkin and Northcote (1958) state: "In applying our findings to a scheme of lake typology for British Columbia, we could consider only the overriding significance of total dissolved solid content as an index of production. Bearing in mind that total dissolved solids summarizes aspects of both the substrate and the climate as well as their interaction, it should be the best single indicator of a large portion of the physical environment."

Techniques Used:

Gravimetric determinations of total dissolved solids are time consuming and therefore seldom applied to fishery management problems. Recently developed transistorized portable conductivity meters (Edmondson, 1956) provide a more practical and reasonably accurate index to mineral content of surface waters. Lennon (1959) demonstrated that electrolyte measurements can be used to estimate the total dissolved solid content of water within ± 2 ppm in certain Appalachian streams. Lennon's conversion formula was not applicable to many Montana waters; therefore, we did not attempt to convert electrolyte readings to total dissolved solids equivalents. Anyone using the electrolyte method of estimating total dissolved solids in Montana waters should determine the exact relationship for each drainage involved.

Specific conductance was measured with a model RA-2 conductivity meter manufactured by Industrial Instruments, Inc. of New Jersey. The instrument had a splash proof case with carrying handle and weighed four pounds. In order to avoid difficulties with seasonal variations, the majority of electrolyte readings were made in September and October, 1960. Readings from the Flathead and Kootenai drainages were made in November, 1960. Conductivity in micromhos, water temperature and location were recorded at the lake or stream. The field readings were later corrected to standard temperature (77°F.) for specific conductance. The specific conductance values were then compared directly with trout growth rates.

Age and growth data from approximately 50,000 individual scales have been analyzed for Montana fishes during the period from 1948 to 1960. Most of this growth data appeared previously in federal aid project completion reports. Age and growth data cited in this report includes: Purkett (1951) West Gallatin River rainbow trout, cutthroat trout, brown trout and brook trout; Purkett (1951) Bridger Creek rainbow trout; Kathrein (1951) Missouri River rainbow trout and brown trout; Bishop (1955) Prickley Pear Creek rainbow trout, brown trout and brook trout; Domrose (1960) Big Hole River, Bloody Dick Creek, Placid Creek, O'Brien Creek, Sheep Creek, Trail Creek, Clear Creek, Big Elk Creek and Smith Creek brook trout; Heaton (1960) Boulder River drainage rainbow trout and brown trout; Posewitz (1960) Willow Creek Reservoir rainbow trout and brown trout.

Average calculated total lengths at the second annulus were used as an index of growth rate of brook, brown, rainbow and cutthroat trout. Only scale samples which involved 25 or more calculated lengths were used. A total of 28 lake samples and 72 stream samples satisfied this requirement.

From an examination of the work by Larkin et al (1957 and 1958) it appears that where total dissolved solids is over 100 ppm there is not necessarily a direct relationship between total dissolved solids and either productivity or growth rate but below 100 ppm, productivity is usually low. As an approximate rule of thumb, total dissolved solids in parts per million is about 0.65 of the specific conductivity in micromhos. Therefore, low productivity and slow growth should be expected where conductivity is less than 150 micromhos. For practical fishery management applications, average calculated length of seven inches or less at the second annulus was considered slow growth. The majority of such fish would not be available to the creel until their third summer of life while faster growing fish would enter the creel in significant numbers during their second summer.

Findings:

Average calculated lengths at the second annulus ranged from 4.2 inches for brook trout in the upper Big Hole River to 16.8 inches for rainbow trout in Duck Lake (Appendix). Conductivities ranged from 23 micromhos in Miner Lake to 978 micromhos in Big Elk Creek (Appendix). Of the 72 stream samples (Table 1), 16 were taken from water of low conductivity. All 16 were in the slow growth category. All eight cutthroat trout samples were in the slow

Table 1 - Trout growth rate in relation to conductivity in 72 Montana streams

	High Conductivity		Low Conductivity		
Species	Slow growth	Fast growth	Slow growth	Fast growth	Totals
Brook trout	9	3	7	0	19
Brown trout	6	10	2	0	18
Rainbow trout	17	6	4	0	27
Cutthroat trout	5	0	3	0	8
Totals	37	19	16	0	72

growth classification. This should be expected as pure cutthroat trout populations have been restricted to the headwater portions of Montana drainages (Hanzel, 1959).

Of the 28 lake samples (Table 2), 10 were in the low conductivity classification. Two of the latter, Miner Lake and Reservoir Lake had fast growth. Average calculated length at the second annulus was 7.1 inches for Miner Lake and 7.2 inches for Reservoir Lake.

Rainbow trout lakes were inadequately represented in this study. All nine were in the high conductivity-fast growth category. Although Montana has many high mountain lakes containing slow growing rainbow trout populations, none were included in the tabulations because of inaccessibility during the time available or because of inadequate growth data.

Table 2 - Trout growth rate in relation to conductivity in 28 Montana lakes

	High Conductivity		Low Conductivity		
Species	Slow growth	Fast growth	Slow growth	Fast growth	Totals
Brook trout	0	1	4	2	7
Brown trout	0	5	0	0	5
Rainbow trout	0	9	0	0	9
Cutthroat trout	1	2	4	0	7
Totals	1	17	8	2	28

Similiarly, the brown trout lake samples were also all in the high conductivity-fast growth category and no high mountain lakes were represented. However, brown trout are rare in Montana's mountain lakes.

Slow growth was associated with high conductivity in 37 stream samples and one lake sample. Factors that might restrict growth rate of trout in the presence of an apparent abundance of mineral fertility are: paucity of certain essential minerals, competition with other fish species, overstocked with hatchery trout, high altitude, siltation, pollution, physical habitat destruction, dewatering, etc.

Recommendations:

Specific conductance may be used as an aid to classification and management of trout waters if the limitations are considered. Values of 150 micromhos or less indicate low mineral fertility and slow trout growth. Higher readings do not necessarily mean high fertility or good trout growth. However, where slow trout growth is associated with apparent high mineral content it would be advisable to determine the cause of the poor growth rate. Rehabilitation through removal of competing species or habitat improvement might be indicated in such situations.

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Date April 26, 1961 George D. Holton

Appendix:

Average calculated lengths at the second annulus, specific conductance in micromhos, and locations of 36 rainbow trout samples.

Water	Drainage	Specific Conductance (micromhos)	Average Calculated Total Lengt[h]
East Boulder River	Yellowstone	193	4.9
Rock Creek	Big Hole	103	5.1
Big Sandy Creek	Milk	405	5.1
Clear Creek	Milk	570	5.2
W. Fk. Rock Creek	Yellowstone	79	5.3
Flint Creek	Clark Fork	194	5.3
W. Fk. Stillwater River	Yellowstone	239	5.5
Judith River	Missouri	532	5.5
E. Rosebud Creek	Yellowstone	38	5.6
W. Rosebud Creek	Yellowstone	40	5.7
Boulder River	Yellowstone	275	5.9
Sheep Creek	Missouri	290	6.0
Ruby River	Beaverhead	608	6.1
Gallatin River 3	Gallatin	310	6.1
Rock Creek	Clark Fork	313	6.4
Eagle Creek	Missouri	394	6.5
Gallatin River 2	Gallatin	310	6.5
Bridger Creek	Gallatin	479	6.6
Prickley Pear Creek	Missouri	327	6.6
Sun River	Sun	810	6.8
Smith River	Missouri	479	6.9
Blackfoot River	Blackfoot	275	7.1
Gallatin River 1	Gallatin	381	7.4
Stillwater River	Yellowstone	242	7.7
Missouri River	Missouri	326	7.9
Madison River	Madison	298	9.4
Blaine Spring Creek	Madison	383	10.4
Willow Creek Reservoir	Jefferson	245	7.9
Francis Lake	Marias	359	8.2
Holter Dam	Missouri	315	8.6
Ennis Lake	Madison	275	8.8
Dailey Lake	Yellowstone	620	9.2
Hebgen Lake	Madison	312	9.3
Georgetown Lake	Clark Fork	199	9.7
Kipp Lake	Marias	660	14.5
Duck Lake	St. Mary's River	600	16.8

Appendix:

Average calculated lengths at the second annulus, specific conductance in micromhos, and locations of 15 cutthroat trout samples.

Water	Drainage	Specific Conductance (micromhos)	Average Calculated Total Length
Clearwater River	Blackfoot	165	4.6
Upper Willow Creek	Clark Fork	66	5.1
Middle Fk. Flathead River	Flathead	197	5.2
O'Brien Creek	Kootenai	180	5.3
Placid Creek	Blackfoot	90	5.4
Miller Creek	Bitterroot	229	5.5
Ranch Creek	Clark Fork	40	5.8
Gallatin River 3	Gallatin	310	6.9
Placid Lake	Blackfoot	116	5.0
Salmon Lake	Blackfoot	139	5.3
Seeley Lake	Blackfoot	86	6.1
Inez Lake	Blackfoot	133	6.3
Rainy Lake	Blackfoot	220	6.4
Alva Lake	Blackfoot	163	7.1
Georgetown Lake	Clark Fork	199	9.4

Appendix:

Average calculated lengths at the second annulus, specific conductance in micromhos, and locations of 26 brook trout samples.

Water	Drainage	Specific Conductance (micromhos)	Average Calculated total length
Big Hole River 2	Big Hole	72	4.2
Bloody Dick Creek	Beaverhead	36	4.3
Placid Creek	Blackfoot	90	5.0
O'Brien Creek	Kootenai	180	5.3
Big Hole River 1	Big Hole	51	5.4
Sheep Creek	Missouri	259	5.6
Trail Creek	Big Hole	62	5.7
Clear Creek	Milk	570	5.7
Beaver Creek	Milk	361	5.7
Miner Creek	Big Hole	23	5.8
Big Elk Creek	Musselshell	978	5.9
West Fk. Rock Creek	Yellowstone	79	6.3
Taylor Creek	Beaverhead	270	6.4
Bridger Creek	Gallatin	479	6.6
Smith Creek	Flathead	215	6.8
Rock Creek	Clark Fork	313	6.8
Prickley Pear Creek	Missouri	329	7.0
Elkhorn Creek	Missouri	486	7.2
Gallatin River	Gallatin	381	8.5
Placid Lake	Blackfoot	116	5.2
Browne Lake	Big Hole	64	5.2
Kilbrennan Lake	Kootenai	51	6.0
September Morn Lake	Yellowstone	27	6.4
Miner Lake	Big Hole	23	7.1
Reservoir Lake	Beaverhead	32	7.2
Holiday Lake	Musselshell	324	8.8

Appendix:

Average calculated lengths at the second annulus, specific conductance in micromhos, and locations of 23 brown trout samples.

Water	Drainage	Specific Conductance (micromhos)	Average Calculated total length
Little Blackfoot River	Clark Fork	217	5.7
West Boulder River	Yellowstone	156	5.7
West Rosebud Creek	Yellowstone	40	5.8
Boulder River	Yellowstone	275	5.9
East Boulder River	Yellowstone	402	6.7
W. Fk. Stillwater River	Yellowstone	239	6.7
Rock Creek	Yellowstone	51	6.8
Stillwater River	Yellowstone	242	6.9
Shields River	Yellowstone	413	7.2
Big Elk Creek	Musselshell	978	7.6
Prickley Pear Creek	Missouri	329	7.7
Little Blackfoot River	Clark Fork	309	7.9
Missouri River	Missouri	326	8.1
Ruby River	Beaverhead	608	8.5
Madison River	Madison	298	8.7
Gallatin River 1	Gallatin	381	8.8
Rock Creek	Clark Fork	313	9.9
Blaine Spring Creek	Madison	383	10.3
Willow Creek Reservoir	Jefferson	245	8.3
Holter Dam	Missouri	315	9.0
Ennis Lake	Madison	275	10.1
Canyon Ferry Reservoir	Missouri	344	10.4
Hebgen Lake	Madison	245	10.8