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MONTANA DEPARTMENT OF FISH AND GAME
FEDERAL AID IN FISH RESTORATION SECTION
HELENA, MONTANA

JOB COMPLETION REPORT
INVESTIGATIONS PROJECTS

State of Montana

Project No. F-23-R-3

Job No. III

Name Fishery Investigation Laboratory

Title A Study of the Relationships Between Total Dissolved Solids and Trout Growth Rate

Period Covered: May 1, 1959 to April 30, 1960

Abstract:

Brook, brown, rainbow and cutthroat trout age and growth data representing 51 streams and 37 lakes were tabulated and ranked according to average calculated total length at the second annulus. The samples depict trout growth rates in a wide variety of habitat types in 15 of the 17 major Montana drainages. Average total length at the second annulus roughly ranged from 5 to 10 inches but the extreme variation was from 4.5 inches for brook trout in a small mountain stream to 16.8 inches for rainbow trout in a prairie lake.

Total dissolved solids content will be determined in 1960 for all waters represented by growth data. A portable resistivity meter will be used to make the dissolved solids readings in the field. A statistical method of rank correlation will then be employed to decide whether dissolved solids can be used as an aid to classification of waters into broad productivity types.

Objectives:

In the management of trout lakes, it is desirable to classify the waters according to various readily assessed factors. For example, the number of trout needed to adequately stock a 20-acre cirque lake in a wilderness area is quite different from the number needed to stock a 20-acre pond in the fertile lowlands of more populous areas in Montana. Relative ease of access or proximity to population centers, presence or absence of spawning ares, relative abundance and size of predators or competitors, and relative size and shape of the lake basin can usually be determined accurately enough for management purposes during one or two days of observing and collecting at the lake. Another important factor, potential productivity of catchable game fish, is not so easily assessed.

There is available evidence to indicate that dissolved mineral content can be used to classify lakes into broad categories that are somewhat indicative of potential productivity. 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) are quoted as follows: " In applying our findings to a scheme of lake typology for British Columbia, we would consider only the overriding significance of total dissolved solid content as in index of production. Bearing in mind that T.D.S. (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."

Recent developments in portable conductivity meters (Edmondson, W. T., 1956) make the electrolyte method of determining T.D.S. appear very attractive to fishery workers. Lennon (1959) reported on the wide applicability of electrical resistivity meters to fishery work and presented data that illustrated a close relationship between resistivity and T.D.S. Electrolyte measurements eliminate the problem of varying contents of suspended matter. This was a factor in rendering T.D.S by evaporation useless as in index to lake productivity in Minnesota (Moyle, 1946). Moyle also stated that the wide carbonate-suphate ratio of Minnesota waters presented further difficulties in the use of T.D.S. While this will undoubtedly also be a factor in Montana, much chemical analysis data is already available to indicate where the high sulphate waters are located. High T.D.S. readings due to sulphates and other nonproductive minerals can therefore be given less importance particularly if biological data is available to support interpretations.

A tremendous volume of age and growth data from scale analysis has been accumulated in Montana during the past decade. Age and growth data on portions of the Gallatin drainage was published by Purkett (1951) and on the Missouri River by Kathrein (1951). Most of the growth data however, was collected and analyzed by Fish and Game Department biologists for use in management of the sport fishery; such data has appeared previously in Completion Reports for federal aid projects. Growth of trout can be limited by certain factors such as overstocking which are not reflected in T.D.S. readings, however, Reimers et al (1955) found a fair degree of correlation between trout growth and dissolved solids content of 10 alpine lakes. It is proposed that available growth data and chemical analysis be used to supplement T.D.S. readings as an aid to the classification of Montana waters into broad fertility or potential productivity types.

Techniques Used:

Whitney and Carlander (1956) stated that "For general surveys and many management purposes growth approximations using the direct proportion computations are probably sufficiently accurate....". The direct proportion method of back calculation of total lengths at each annulus was used in all age and growth work with fish scales at the Bozeman fishery laboratory. For the purposes of this study, only those samples were considered in which there were at least 25 calculated lengths available to determine average length at the second annulus. The average calculated total length at the second annulus was then used to rank the various waters according to trout growth rate. There is a wide variation in average length of trout at their second annulus and size of fish at this age have very significant management implications. It is at this age that the majority of trout attain catchable size (6 inches or larger). It is sometimes difficult to obtain adequate samples of older fish so that average size at the third annulus would often be based on too few length calculations.

Preliminary tests were made with a resin chloride exchange method of determining T.D.S. but this method was abandoned in favor of the electrolyte method which is becoming standard among fishery workers and which will yield accurate readings in the field. The meter was not purchased in time to make T.D.S. determinations in 1959 so that this part of the investigation is scheduled for the 1960 summer season. The meter to be used is the Bouyoucos BN-2 moisture meter modified for fishery workers. Streams as well as lakes will be tested for T.D.S. content as preliminary study indicates a positive correlation between trout growth and T.D.S. of streams. A great deal of seasonal fluctuation in mineral content of certain Montana waters has been observed (F-13-R Comp. Reports). Therefore, all T.D.S. readings to be used as fertility indices will be measured during the main trout growing season which occurs after the spring or early summer spates.

The method of rank correlation described by Snedecor (1956) will be used to determine whether T.D.S. rankings of trout waters are in agreement with rankings by calculated length of trout at the second annulus.

Findings:

Average calculated lengths at the second annulus were determined for brook, brown, rainbow and cutthroat trout samples taken from 51 streams and 37 lakes in 15 of the 17 major Montana drainages. Average lengths at the second annulus roughly range from 5 to 10 inches for all species. The brook trout samples (Table I) show a range in average length at the second annulus of 4.5 - 8.5 inches in streams and 5.2 - 10.0 inches in lakes. Apparently the full range of habitat types inhabited by this species is fairly well represented in these samples.

The brown trout samples (Table 2) show a similar range in average lengths for streams, 5.7 - 10.3 inches but a range of only 8.4 - 10.9 inches for lakes. All of the brown trout lake samples were from the Madison-Missouri series of reservoirs and adequate samples from other habitat types would be desirable for this study. Actually, few Montana lakes contain large numbers of brown trout.

The range of average lengths for rainbow trout (Table 3) in streams was 4.8 - 10.4 inches and the range in lakes was 6.2 - 16.8 inches. Many high mountain lakes in Montana have rainbow trout populations but none were represented by adequate scale samples according to criteria used in this study. The 14.5 inches and 16.8 inches average lengths for Kipp Lake and Duck Lake respectively are of great interest in that recently developed lake planting tables fell far short of the former stocking rates for these or similar lakes. This investigation into potential trout productivity of lakes may yield much needed information on the classification and management of such highly productive lakes.

The cutthroat trout samples (Table 4) appear to represent the full range of habitat types available to this species. The range in average length for cutthroat trout in streams is only 4.6 - 6.3 inches but this is to be expected since this species is found in large numbers only in the headwater portions of Montana drainages (Hanzel, 1959).

Total dissolved solids content will be determined in 1960 for each of the 51 streams and 37 lakes represented in these tables. Rank correlation will then be used to determine whether T.D.S. can be used as an aid in classifying waters into trout productivity types.

Recommendations:

Growth data representing a wide range of habitat types occupied by brook, brown, rainbow and cutthroat trout have been tabulated. It is recommended that the total dissolved solids content of these waters be determined in the field by use of an electrical resistivity meter so that the study of relationships between trout growth rate and mineral content of water can be completed.

TABLE 1

Brook trout samples ranked by average calculated length at second annulus (inches)

Water	Drainage	Year	Number of fish aged	Number of lengths Calculated	Average lengths at 2nd annulus
			Streams		
Bloody Dick Cr.	Beaverhead	1953	42	37	4.5
Placid Cr.	Clark Fk.	1950	293	172	4.6
Trail Cr.	Big Hole	1959	52	32	5.6
O'Brien Cr.	Kootenai	1950	258	94	5.7
Big Hole Riv.	Big Hole	1959	50	27	5.7
Clear Cr.	Milk	1957	107	45	5.9
W. Fk. Rock Cr.	Yellowstone	1950	105	28	6.3
Taylor Cr.	Beaverhead	1952	31	30	6.4
Bridger Cr.	Gallatin	1948	86	53	6.6
Rock Cr.	Clark Fk.	1959	62	26	6.8
Elkhorn Cr.	Missouri	1952	28	26	7.2
Smith Cr.	Flathead	1951	57	53	7.3
Gallatin R.	Gallatin	1948	71	63	8.5
			Lakes		
Browne L.	Big Hole	1959	32	32	5.2
Silver L.	Clark Fk.	1958	55	55	5.5
Kilbrennan L.	Kootenai	1956	47	44	5.6
Sept. Morn L.	Yellowstone	1949	38	37	6.4
Slide Rock L.	Yellowstone	1949	28	28	6.5
Miner L.	Big Hole	1959	25	25	7.1
Reservoir L.	Beaverhead	1959	59	41	7.2
Moore L.	Clark Fk.	1958	46	27	7.3
Holiday L.	Musselshell	1958	71	57	8.8
McDonald Pond	Beaverhead	1955	64	34	9.8
Widows Pool	Beaverhead	1955	100	48	10.0

TABLE 2

Brown trout samples ranked by average calculated total length at second annulus (inches)

Water	Drainage	Year	Number of fish aged	Number of lengths calculated	Average length at 2nd annulus
		Streams			
Little B'foot R.-Upper	Clark Fk.	1959	117	91	5.7
W. Boulder R.	Yellowstone	1958	65	28	5.7
W. Rosebud Cr.	Yellowstone	1948	51	51	5.8
Bluewater Cr.	Yellowstone	1952	47	34	6.5
E. Boulder R.	Yellowstone	1958	56	27	6.7
W. Fk. Stillwater	Yellowstone	1952	44	37	6.7
Rock Cr.	Yellowstone	1952	68	39	6.8
Stillwater R.	Yellowstone	1948	51	47	6.9
Boulder R.	Yellowstone	1948	37	33	6.9
Shields R.	Yellowstone	1950	176	95	7.2
Big Elk Cr.	Musselshell	1951	118	51	7.6
Prickley Pear Cr.	Missouri	1949	570	269	7.8
Little B'foot R.-Lower	Clark Fk.	1959	99	31	7.9
Ruby R.	Beaverhead	1953	44	30	8.5
Madison R.	Madison	1950	163	144	8.7
Gallatin R.	Gallatin	1949	102	97	8.8
Missouri R.	Missouri	1949	127	103	8.9
[illegible]. Fk. Madison	Madison	1950	53	53	9.1
Rock Cr.-Lower	Clark Fk.	1959	115	93	9.9
Odell Cr.	Beaverhead	1951	89	39	10.0
Blaine Spring Cr.	Madison	1951	56	23	10.3
		Lakes			
Willow Cr. Res.	Madison	1955	55	55	8.4
Ennis L.	Madison	1950	32	32	10.1
Canyon Ferry Res.	Missouri	1958	67	67	10.4
Hebgen L.	Madison	1950	101	97	10.6
Hebgen L.	Madison	1950	135	135	10.9
Holter Dam	Missouri	1948	39	28	9.0

TABLE 3

Rainbow trout samples ranked by average calculated total length at second annulus (inches)

Water	Drainage	Year	Number of fish aged	Number of lengths calculated	Average length at 2nd annulus
			Streams		
E. Boulder R.	Yellowstone	1950	134	80	4.8
Rock Cr.	Big Hole	1959	37	33	5.1
Big Sandy Cr.	Milk	1958	47	26	5.1
Clear Cr.	Milk	1957	33	27	5.2
W. Fk. Rock Cr.	Yellowstone	1950	225	116	5.3
Flint Cr.	Clark Fk.	1953	64	52	5.3
W. Fk. Stillwater	Yellowstone	1950	40	30	5.5
Judith River	Missouri	1951	53	33	5.5
E.Rosebud Cr.	Yellowstone	1948	40	38	5.6
W.Rosebud Cr.	Yellowstone	1948	30	29	5.7
Boulder R.	Yellowstone	1948	84	68	5.9
Ruby R.	Beaverhead	1953	55	40	6.1
Prickley Pear Cr.	Missouri	1949	333	170	6.4
Eagle Cr.	Missouri	1958	41	27	6.5
Bridger Cr.	Gallatin	1948	98	77	6.6
Rock Cr. Lower	Clark Fk.	1959	47	41	6.6
Sheep Cr.	Missouri	1951	188	66	6.8
Sun R.	Sun	1952	94	89	6.8
Smith R.	Missouri	1952	35	25	6.9
Rock Cr. Upper	Clark Fk.	1959	166	138	6.9
Blackfoot R.	Clark Fk.		48	36	7.1
W. Gallatin R.	Gallatin	1948	65	50	7.2
Gallatin R.	Gallatin	1949	142	126	7.4
Stillwater R.	Yellowstone	1948	49	47	7.7
Missouri R.	Missouri	1949	478	371	7.9
Sheep Cr.	Beaverhead	1953	56	31	8.2
Madison R.	Madison	1950	201	148	9.4
Blaine Spring Cr.	Madison	1951	92	32	10.4
			Lakes		
Willow Cr. Res.	Yellowstone	1959	56	56	6.2
Francis Lake	Marias	1948	40	39	8.2
Holter Dam	Missouri	1948	238	145	8.6
Ennis Lake	Madison	1950	114	105	8.8
Hebgen Lake	Madison	1950	112	112	9.1
Willow Cr. Res.	Madison	1955	69	69	9.1
Dailey L.	Yellowstone	1955	141	141	9.2
Hebgen L.	Madison	1950	272	272	9.4
Georgetown L.	Clark Fk.	1950	93	93	9.7
McDonald Pond	Beaverhead	1955	72	44	10.4
Kipp Lake	Marias	1959	46	32	14.5
Duck Lake	St. Mary's	1955	26	26	16.8

TABLE 4

Cutthroat trout samples ranked by average calculated total length at second annulus (inches)

Water	Drainage	Year	Number of fish aged	Number of lengths calculated	Average length at 2nd annulus
		Streams			
Clearwater R.	Clark Fk.	1957	41	25	4.6
Meadow Cr.	Bitterroot	1952	63	51	4.9
So. Fk. Skalkaho	Bitterroot	1952	28	25	5.0
Rock Cr. Upper	Clark Fk.	1959	102	41	5.0
W. Fk. Rock Cr.	Clark Fk.	1956	43	38	5.0
Upper Willow Cr.	Clark Fk.	1948	58	48	5.1
Mid. Fk. Flathead	Flathead	1956	32	32	5.2
O'Brien Cr.	Kootenai	1950	87	41	5.3
Placid Cr.	Clark Fk.	1950	84	44	5.4
Miller Cr.	Bitterroot	1959	53	33	5.5
Rock Cr. Lower	Clark Fk.	1959	72	70	5.7
Hughes Cr.	Bitterroot	1952	53	34	5.8
Ranch Cr.	Clark Fk.	1959	60	40	5.8
Crooked Cr.	Yellowstone	1950	31	31	6.3
		Lakes			
Weasel Lake	Kootenai	1957	46	45	4.5
Therriault L.	Kootenai	1957	30	26	4.7
U. Elliot L.	Clark Fork	1959	49	49	4.9
L. Fish Lake	Flathead	1956	41	38	5.0
Cedar Lake	Flathead	1956	26	25	5.0
Placid Lake	Clark Fork	1956	29	29	5.0
Mid. Thompson L.	Clark Fork	1956	29	29	5.2
U. Wolverine L.	Kootenai	1957	27	27	5.3
Salmon L.	Clark Fk.	1948	26	26	5.3
Seeley L.	Clark Fk.	1948	52	52	6.1
Inez Lake	Clark Fk.	1948	70	65	6.3
Medicine Lake	Clark Fk.	1956	40	35	6.3
Rainy L.	Clark Fk.	1948	100	75	6.4
Parker L.	Clark Fk.	1959	58	57	6.7
Alva L.	Clark Fk.	1948	76	56	7.1
Webb Lake	Clark Fk.	1959	31	31	7.6
Georgetown L.	Clark Fk.	1958	124	119	9.4

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Data and Reports:

The original data and reports are in the Project Leader's file, c/o Z & E Dept., Montana State College, Bozeman, Montana

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