Winter observations on trout and bottom organisms in Bridger Creek, southwestern Montana
by Sidney M Logan

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management at Montana State College
Montana State University

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High stream flows during the spring reduced the number of bottom organisms in situ and increased the number taken in drift samples. Floating surface ice did not appear to increase the number of organisms collected in drift samples.

The number of marked trout (153) decreased 83 percent over a 10 month period in the study section. Sixty-one percent of the trout within the study section did not travel more than 150 feet from the original place of capture. More trout moved downstream than upstream during each month of study. Trout were observed to move as far as 2 miles upstream from the study section and 55 miles downstream in the Missouri River. During the spring, summer and autumn, trout were mainly found in pools while in winter many were collected in riffle areas under surface ice.

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Abstract

The effects of temperature, ice and fluctuating water levels on numbers of bottom organisms and also on the abundance and movement of rainbow trout were investigated in a 900 foot section of Bridger Creek in Southwestern Montana from October 21, 1959 to September 12, 1960. A total of 96 bottom samples and 27 drift samples was studied. The most abundant group of organisms was Limnephilidae. Surface ice cover appeared to have no effects on the abundance of bottom organisms except for the loss of a small number found frozen in the ice at the water's edge of the stream. High stream flows during the spring reduced the number of bottom organisms in situ and increased the number taken in drift samples. Floating surface ice did not appear to increase the number of organisms collected in drift samples.

The number of marked trout (153) decreased 83 percent over a 10 month period in the study section. Sixty-one percent of the trout within the study section did not travel more than 150 feet from the original place of capture. More trout moved downstream than upstream during each month of study. Trout were observed to move as far as 2 miles upstream from the study section and 55 miles downstream in the Missouri River. During the spring, summer and autumn, trout were mainly found in pools while in winter many were collected in riffle areas under surface ice.

Introduction

Very few winter fishery investigations have been conducted on trout streams. This fact was recognized by Hubbs and Trautman (1935) and Hazzard (1941). The first comprehensive study of winter conditions on trout and trout foods was made by Maciolek and Needham (1952). Anchor ice and its effects on bottom organisms was investigated by Brown, Clothier and Alvord (1953), O'Donnell and Churchill (1954), Benson (1955) and Reimers (1957).

The present study was initiated to determine the effects of temperature, ice, and fluctuating water levels on the number of bottom organisms, and also on the abundance and movement of trout. This investigation was conducted in Bridger Creek, which is a tributary of the East Gallatin River in Southwestern Montana. The first observations were made October 21, 1959 and continued almost daily through June 5, 1960, after which biweekly observations were made through September 12, 1960.

Acknowledgments

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Methods

Air and water temperatures were secured to the nearest 1^{o} F. with maximum-minimum thermometers. Readings were made between 6:30 and 8:30 A.M. daily from October through May except for 11 days and biweekly from June through September. Stream flows were determined with a velocity headrod and turbidities with a Hellige turbidimeter. Determination of alkalinity, dissolved solids, pH and dissolved oxygen followed standard methods (Welch, 1948). Trout were marked by tagging and clipping and were collected with a D.C. electric shocker. Stream bottom organisms were taken with a Surber square-foot sampler and drift organisms with a screen 3 feet wide (20 mesh per inch).

Description of Area

A section of Bridger Creek was selected for study because it was accessible at all seasons and was closed to fishing. This section was located on property of the U. S. Fish and Wildlife Service Fish Cultural Station, 5 miles northeast of Bozeman at an elevation of approximately 4800 feet mean sea level. The water in Bridger Creek, which is a tributary of the East Gallatin River, originates from runoff and springs on the slopes of the Bridger Mountains. Three small warm water springs with a total flow of less than one-half gallon per minute are the only tributaries in the study section.

The climate of the area is characterized by severe winters with frequent and prolonged periods of subfreezing temperatures and heavy snowfall. The mean monthly air temperature was 24.2^{o} F. and the average monthly snowfall was 14.4 inches during the winter of study (November through March).

The study section of Bridger Creek was 900 feet in length with a mean width of 17 feet and an average depth of 15 inches. The mean flow during the year of study was 35.7 cubic feet per second and water velocities were as great as 3.8 feet per second. There are numerous riffles and few deep pools in the study section and the bottom is composed of sand, gravel and rubble. The predominant plants bordering the stream included dense growths of willow, chokecherry and rose with occasional douglas-fir and aspen. These plants provided abundant natural cover in most of the study section. Annual water temperatures ranged from 32 to 65° F. Turbidity ranged from 3 to 18 p.p.m. during low water (July-February) and from 45 to 96 p.p.m. during high water (March-June).

During the study period chemical analysis showed the following ranges: total dissolved solids 205 - 244 p.p.m.; pH 7.6 - 8.2; methyl purple alkalinity 175 - 202 p.p.m. and dissolved oxygen 9.1 - 11.9 p.p.m.

Aquatic vegetation was limited to small patches of watercress and cattails in the spring areas. Rainbow trout (Salmo gairdneri) were common and was the most numerous game fish. A small number of cutthroat trout (Salmo clarki), brown trout (Salmo trutta) and brook trout (Salvelinus fontinalis) were also present. The mottled sculpin (Cottus bairdi) was abundant and the white sucker (Catostomus commersoni) was present in small numbers.

Ice Conditions

Observations were made on ice formation and distribution in the study section and also in a portion of the stream 100 yards upstream. Observations outside the study section provided a comparison of ice conditions in the two areas. This was deemed desirable because a small quantity of relatively warm water from 3 small springs entered the study section.

Surface (sheet) ice, anchor ice and frazil ice are the 3 types known to occur in northern streams. Only surface and anchor ice was found in this study. Surface ice was most common and formed first at the water's edge where stream velocities were lowest. From this initial formation it grew outward toward the center of the stream. Surface ice often began as patches on emergent bottom materials or shelves at the water's edge and completely bridged the stream in certain areas. This ice reoccurred as many as 5 times in the same places. Brown, Clothier and Alvord (1953) reported similar conditions in the West Gallatin River, Montana. The thickest surface ice found in the study section was 2.5 inches while in the area upstream it reached 4.5 inches. This maximum occurred in both places on March 1, 1960. Some differences in ice cover between the study section and the area upstream may be seen in Figure 1. Anchor ice did not form in the study section although it was present in the area above. This type of ice has been described by Barnes (1906), Maciolek and Needham (1952), Brown, Clothier and Alvord (1953), O'Donnell and Churchill (1954) and Benson (1955).

Figure 1. Differences in ice cover between the study section (upper photograph) and the area upstream (lower photograph) in Bridger Creek on March 1, 1960.

Bottom Organisms

A total of 96 bottom samples was collected during the period of study. Six were taken biweekly from the study section during November through April and monthly during October, May, July and August. Three of these were from unit 7, and 3 from unit 20 (Figure 2). Each series of 3 samples was collected at distances of 1, 4 and 7 feet respectively, from the water's edge.

The kinds and abundance of bottom organisms are shown in Table 1. Limnephilidae were the most abundant, constituting 54.3 percent of the total, followed by Hydropsychidae, 15.5 percent; Tenipedidae, 5.6 percent; Rhagionidae, 5.5 percent; and Ephemerellidae, 4.5 percent. Abundance of bottom organisms by months is presented in Table 2. Trichoptera was the most abundant in all months of the study and ranged from 50.5 to 85.6 percent of the samples. Diptera was second with 4.5 to 25.1 percent. The total of all organisms was highest in November when there were 285.0 per square foot and lowest in May with 104.3.

The average monthly water temperatures ranged from 33.5 to 35.0^{0} F. (November through March). During this period bottom organisms were abundant, averaging 243.1 per square foot. Long periods of low water temperatures had no apparent effects on the abundance of bottom organisms (Figure 3). Surface ice covered some of the study section from November through March except for short periods when temperatures rose above freezing. Surface ice broke off under the weight of new snow

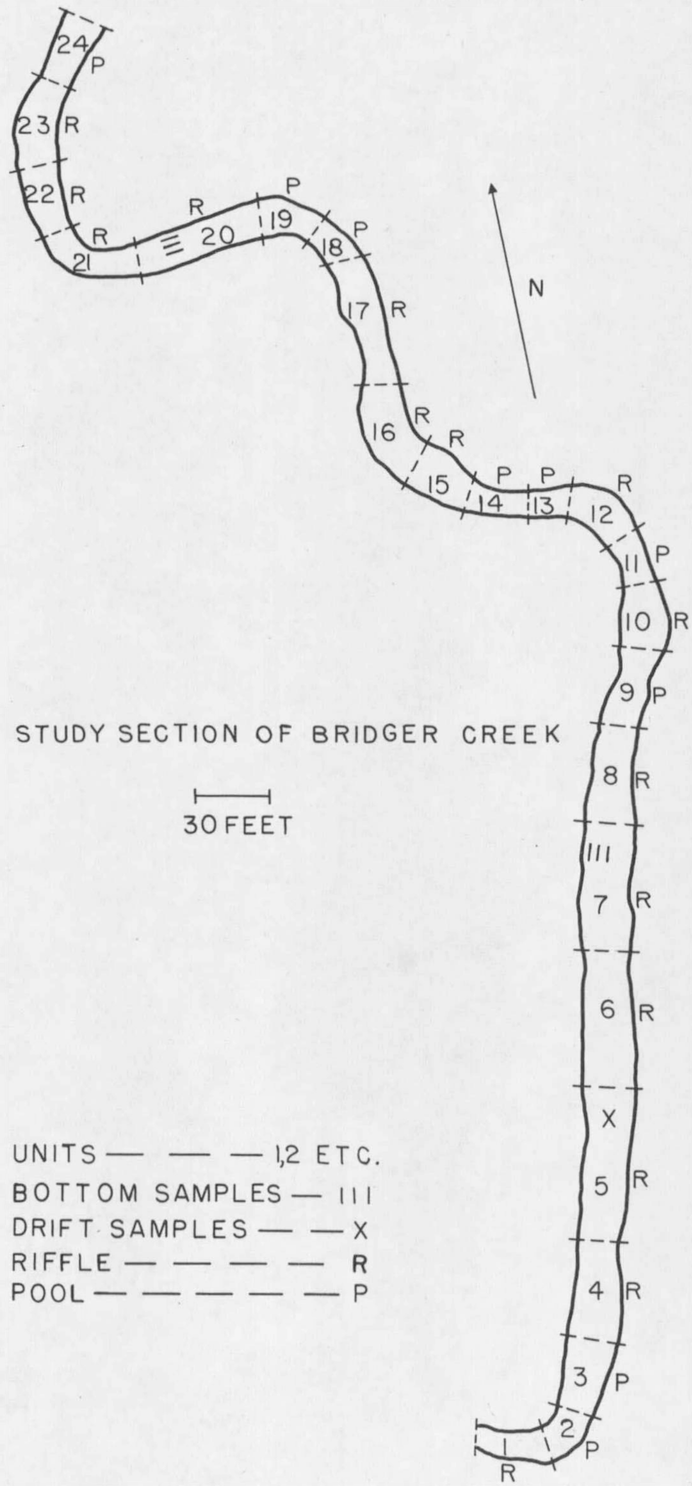

Figure 2. Map of the study section in Bridger Creek showing units, riffles, pools and areas where bottom and drift samples were collected.

Table 1. Order of abundance, total number of organisms and percentage of total number for 96 square foot bottom samples from Bridger Creek, October 23, 1959 to August 15, 1960.

Group of organisms	Order of abundance	Number	Percentage
Tricladia			
Planariidae	22	27	0.1
Ephemeroptera			
Heptageniidae	21	27	0.1
Baetidae	6	610	2.9
Leptophlebiidae	14	137	0.7
Ephemerellidae	5	964	4.5
Plecoptera			
Pteronarcidae	15	95	0.5
Perlodidae	9	236	1.1
Chloroperlidae	19	37	0.2
Nemouridae	17	42	0.2
Coleoptera			
Dytiscidae	20	33	0.2
Elmidae	7	533	2.7
Trichoptera			
Rhyacophilidae	16	47	0.2
Hydropsychidae	2	3225	15.5
Limnephilidae	1	11356	54.3
Helicopsychidae	18	41	0.2
Brachycentridae	8	373	1.7
Diptera			
Tipulidae	13	138	0.7
Psychodidae	12	152	0.8
Simuliidae	23	17	0.1
Tenipedidae	3	1180	5.6
Heleidae	24	11	0.1
Rhagionidae	4	1158	5.5
Acari	11	219	1.0
Gastropoda			
Physidae	10	228	1.1

Table 2. Number of bottom organisms per square foot and percentage (in parentheses) of total number of each group for different months in Bridger Creek from October 23, 1959 to August 15, 1960.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	July	Aug.
Number of samples	6	12	12	12	12	12	12	6	6	6
Bottom organisms per square foot	256.0	285.0	248.1	181.1	283.1	218.2	170.5	104.3	168.0	180.0
Group of organisms					Abundance					
Tricladia	0 (0.0)	1 (0.1)	3 (0.1)	0 (0.0)	5 (0.1)	7 (0.3)	10 (0.6)	0 (0.0)	1 (0.1)	0 (0.0)
Ephemeroptera	78 (5.1)	224 (6.5)	118 (4.0)	235 (10.8)	319 (9.4)	358 (13.7)	81 (3.9)	115 (18.4)	118 (11.6)	93 (8.6)
Plecoptera	23 (1.5)	78 (2.3)	41 (1.3)	46 (2.1)	76 (2.3)	81 (3.1)	32 (1.5)	3 (0.5)	9 (0.9)	21 (1.9)
Coleoptera	22 (1.5)	157 (4.6)	103 (3.4)	63 (2.9)	103 (3.1)	76 (2.9)	40 (1.9)	7 (1.1)	1 (0.1)	15 (1.4)
Trichoptera	1300 (84.6)	2405 (70.3)	2076 (70.0)	1423 (65.5)	2414 (71.5)	1689 (64.4)	1784 (85.6)	316 (50.5)	801 (79.5)	834 (77.4)
Diptera	91 (5.9)	464 (13.6)	574 (19.1)	369 (17.0)	416 (12.3)	386 (14.7)	105 (5.0)	157 (25.1)	45 (4.5)	50 (4.6)
Acari	15 (1.0)	61 (1.7)	37 (1.2)	30 (1.4)	17 (0.5)	12 (0.5)	0 (0.0)	20 (3.2)	11 (1.1)	9 (0.9)
Gastropoda	6 (0.4)	31 (0.9)	29 (0.9)	7 (0.3)	26 (0.8)	11 (0.4)	31 (1.5)	8 (1.2)	23 (2.2)	56 (5.2)

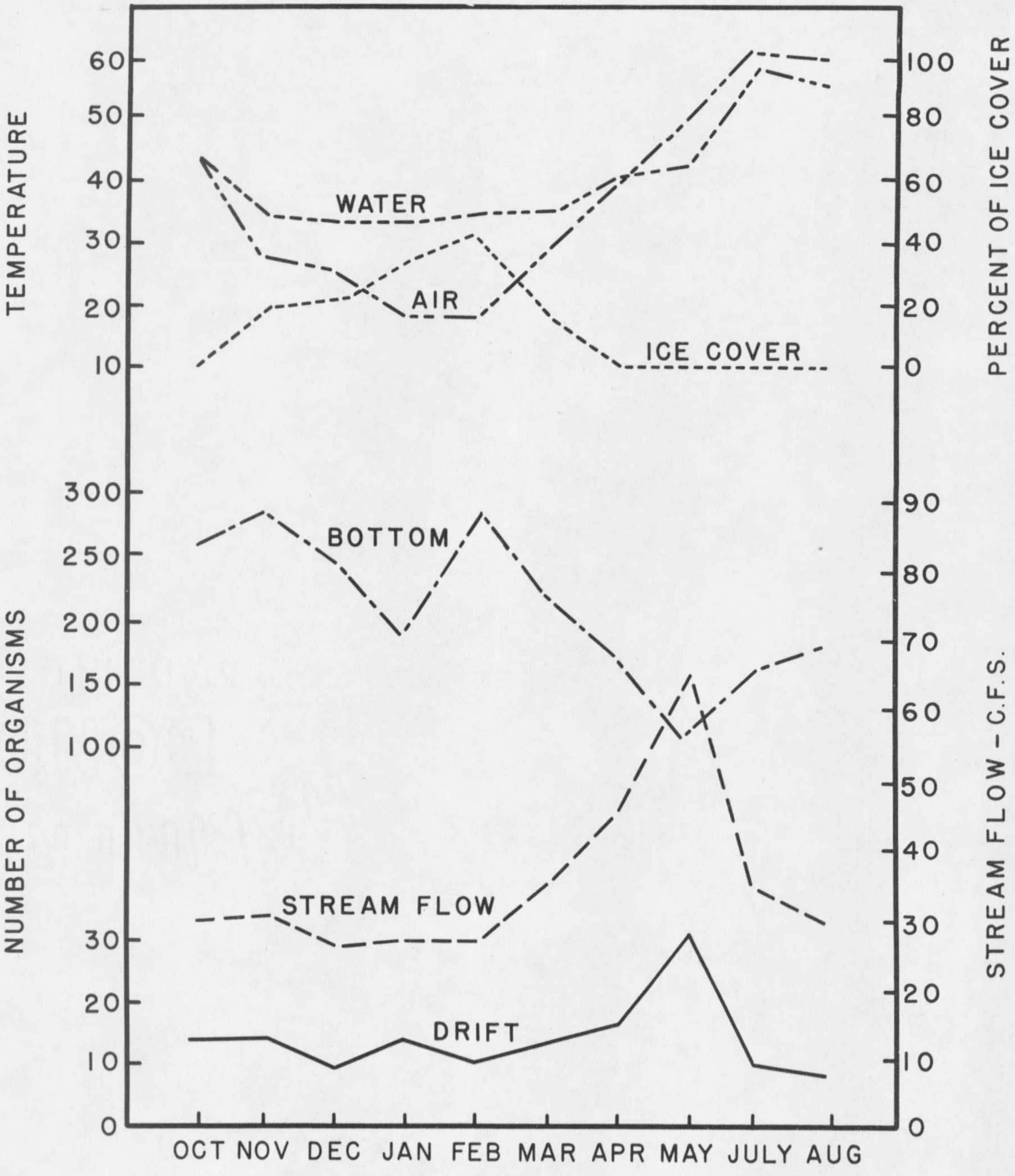

Figure 3. The relationship between the number of bottom and drift organisms and stream flow and between water and air temperatures and ice cover in Bridger Creek.

and a small amount was broken in order to collect bottom samples. Bottom samples taken before ice cover (October) averaged 256.0 organisms per square foot and those collected during the period of ice cover (November through March) averaged 243.1. No marked reduction of bottom organisms was evident as winter progressed (Table 2). During the period of ice cover the effect of surface ice on the abundance of bottom organisms was shown by comparing samples taken at the water's edge (ice cover, 50 to 100 percent) with those collected 7 feet from the water's edge (ice absent). There were no important numerical differences between these areas (Table 3). Nine dead Limnephilids were found where surface ice had frozen to the stream bottom at the water's edge. Although this was only a small loss it may reach substantial proportions when subfreezing temperatures persist throughout the entire winter. Brown, Clothier and Alvord (1953) reported that all bottom organisms succumbed when frozen in surface ice next to the shore. Other than the loss described above, surface ice cover appeared to have no effect on the abundance of bottom organisms. Reimers (1957) reported prolonged surface ice reduced periphytic algae and consequently the grazing organisms important as fish food. He also reported that samples taken under ice bridges showed bottom organisms (36 per square foot) to be scarce as compared to the 1951 winter samples (107

Table 3. Bottom organisms per square foot followed by the percentage of surface ice cover.

Date	Temperature Air Maximum	Temperature Air Minimum	Temperature Water Maximum	Temperature Water Minimum	Distance from water's edge in feet 1 Number	1 Percentage	4 Number	4 Percentage	7 Number	7 Percentage
12/ 5/59	32	8	33	32	278.0	100	274.5	0	289.5	0
12/23/59	32	-16	34	32	223.5	100	190.0	0	258.5	0
1/ 6/60	37	24	34	32	194.0	50	169.5	0	110.0	0
1/18/60	16	-10	34	32	200.0	100	232.5	25	181.0	0
2/ 5/60	36	12	35	32	378.0	50	302.0	0	185.0	0
2/21/60	23	0	35	32	350.5	100	319.0	50	154.0	0
3/11/60	21	-16	34	32	227.0	100	316.0	25	262.0	0

organisms per square foot) of Maciolek and Needham (1952) taken in the same stream. No reduction of bottom organisms in the present study may have been due to intermittent surface ice permitting periphytic algae to thrive as food for bottom organisms.

There was some correlation between the abundance of bottom organisms and high stream flow (Figure 3). During the fall and winter months bottom organisms were abundant (average 244.3 per square foot) when stream flows were low (26 to 34 cubic feet per second). The number of bottom organisms gradually decreased to a low in May (average 104.3 per square foot) when the maximum stream flow (64 cubic feet per second) was reached. The increased stream flow undoubtedly had a scouring effect on the stream bottom and is probably responsible for the reduction in number of bottom organisms. However, some aquatic insects probably emerged during this period and this would account for part of the reduction.

Drift Organisms

A total of 27 drift samples was collected during the period of study. These were taken at 10-day intervals from November through May and at 15-day intervals in October, July and August. All were collected in unit 5 (Figure 2) of the study section. A drift sample was composed of the organisms collected over a 15-minute interval with a screen (20 mesh per inch) 3 feet in width held perpendicular to the stream bottom at midstream.

The kinds and abundance of drift organisms taken are shown in Table 4. Limnephilidae comprised 24.5 percent; Ephemerellidae, 11.3 percent; Hydropsychidae, 10.8 percent; and Tenipedidae, 10.0 percent. Trichoptera was the most abundant in all months of the study period except February and March (Table 5) and made up 13.1 to 63.8 percent of all organisms in the samples. Diptera was second with 12.5 to 39.5 percent. Drift organisms were most numerous in May with 29.3 organisms per sample and lowest in August with 8.0.

Drift samples were taken throughout the winter to determine what effect floating surface ice might have on the number of bottom organisms. Drift samples collected before ice formed averaged 13.0 organisms per sample and those taken during the period of floating ice averaged 12.4. No marked increase in the number of organisms occurred between the fall samples when ice was absent and those taken in the winter when surface ice was floating down the stream although bottom organisms might be expected to be dislodged by such ice. Anchor ice is known to be important and Reimers (1957) noted that it may increase the number of drift organisms by dislodging them from the bottom. Anchor ice in Pigeon River, Michigan dispersed bottom organisms downstream but reduction in the number of organisms was negligible (Benson, 1955). O'Donnell and Churchill (1954) reported an average of 9,480 aquatic organisms per hour carried past a certain point by

Table 4. Order of abundance, total number of organisms and percentage of total number for 27 drift samples from Bridger Creek, October 23, 1959 to August 15, 1960.

Group of organisms	Order of abundance	Number	Percentage
Tricladia			
Planariidae	13	7	2.0
Ephemeroptera			
Baetidae	5	34	8.9
Leptophlebiidae	14	4	1.1
Ephemerellidae	2	43	11.3
Plecoptera			
Perlodidae	7	18	4.6
Nemouridae	15	3	1.0
Coleoptera			
Elmidae	9	17	4.6
Trichoptera			
Rhyacophilidae	16	2	0.5
Hydropsychidae	3	41	10.8
Limnephilidae	1	93	24.5
Brachycentridae	12	10	2.6
Diptera			
Tipulidae	11	13	3.4
Psychodidae	10	14	3.7
Tenipedidae	4	38	10.0
Rhagionidae	6	24	6.3
Gastropoda			
Physidae	8	18	4.7

Table 5. Number of bottom organisms per drift sample and percentage (in parentheses) of total number of each group for different months in Bridger Creek from October 23 to August 15, 1960.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	July	Aug.
Number of samples	2	3	3	3	3	3	3	3	2	2
Drift organisms per 15 minute sample	13.0	15.3	9.6	14.3	10.3	12.7	14.7	29.3	9.5	8.0
Group of organisms					Abundance					
Tracladia	0	0	1	1	0	2	1	2	0	0
	(0)	(0)	(3.6)	(2.3)	(0)	(5.3)	(2.3)	(2.3)	(0)	(0)
Ephemeroptera	6	8	6	9	7	14	10	17	2	2
	(23.1)	(17.4)	(21.5)	(20.8)	(22.6)	(36.8)	(22.7)	(19.3)	(10.5)	(12.5)
Plecoptera	3	5	2	2	1	2	1	4	1	0
	(11.5)	(10.9)	(7.1)	(4.7)	(3.2)	(5.3)	(2.3)	(4.5)	(5.3)	(0)
Coleoptera	2	3	1	2	0	0	3	5	0	1
	(7.7)	(6.5)	(3.6)	(4.7)	(0)	(0)	(6.8)	(5.7)	(0)	(6.3)
Trichoptera	9	21	9	14	10	5	18	41	12	7
	(34.6)	(45.7)	(32.1)	(32.6)	(32.3)	(13.1)	(40.9)	(46.6)	(63.1)	(43.7)
Diptera	4	9	9	14	11	15	9	11	3	4
	(15.4)	(19.5)	(32.1)	(32.6)	(35.5)	(39.5)	(20.5)	(12.5)	(15.8)	(25.0)
Gastropoda	2	0	0	1	2	0	2	8	1	2
	(7.7)	(0)	(0)	(2.3)	(6.4)	(0)	(4.5)	(9.1)	(5.3)	(12.5)

released anchor ice in the Brule River, Wisconsin. Brown, Clothier and Alvord (1953) disclosed little or no depletion of bottom organisms by anchor ice although it did dislodge and carry them downstream.

Stream flow influenced the number of drift organisms (Figure 3). When stream flows were low during the fall and winter months (26 to 34 cubic feet per second), the number of drift organisms was also low (12.5 per sample). Melting snow gradually increased stream flows to a maximum (64 cubic feet per second) in May which was also the period of maximum abundance of drift organisms (29.3 per sample). Reimers (1957), Benson (1955), O'Donnell and Churchill (1954), and Maciolek and Needham (1952) observed bottom organisms being set adrift by surges of water released from anchor ice dams. Stream flow in Bridger Creek was not subject to sudden changes during the winter caused by such anchor ice dams because surface ice continuously bridged the area upstream and prevented anchor ice formation. The most important factor observed to reduce the number of bottom organisms in Bridger Creek was high stream flow during the spring.

Abundance of Trout

The study section was divided into 24 units (Figure 2) to aid in the determination of abundance and winter movement of trout. The objectives were two-fold: first to measure the general movement of trout within the study section, and second, to determine specific movements in relation to the different types of habitat. The units had an average length of 37.5 feet and a mean width of 17.0 feet. Rainbow over 7 inches in total length were jaw tagged and smaller individuals were marked by cutting off the tips of the premaxillaries or clipping the fins. Total length (to the nearest 0.1 inch), date and place of capture were recorded. Trout were collected monthly, with the aid of a direct current electric shocker, in all units of the study section except during May, July and September. After the initial shocking all recruitments to the study section during subsequent shockings were also marked. Limited sampling of fish in portions of the stream adjoining the study section and returns of tags by fishermen provided additional information on movement.

The study section was initially sampled on October 21, 1959 when 125 trout were tagged and 28 were clipped. One month later, after winter had commenced, 61.6 percent of the October population of tagged trout and 42.9 percent of the clipped trout were still present in the study section. Marked trout from the initial sample gradually decreased in abundance throughout the winter (Table 6) and by the following April only 9.6 percent of those over 7 inches and none of the smaller trout were found. By August tagged trout of this lot had increased to 20.8 percent but none of the smaller trout were recaptured. Although trout recaptures in April and June were very low this may not represent the true number present because high water impaired efficiency of sampling.

Recruitment of trout to the study section throughout the year was generally small. This averaged 5.1 trout over 7 inches and 3.4 smaller trout except in August when 54 specimens over 7 inches and 44 smaller individuals were collected.

The total population on August 25, 1960 included 26 of the initially marked trout and 98 unmarked trout. This represents an 83.0 percent loss