THESIS

MICROHABITAT OF HATCHERY RAINBOW TROUT

Submitted by

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In partial fulfillment of the requirements

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION

BY Spencer E. Turner

ENTITLED Microhabitat of Hatchery Rainbow Trout

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ABSTRACT OF THESIS

MICROHABITAT OF HATCHERY RAINBOW TROUT

Hatchery rainbow trout, wild rainbow trout, or wild brown trout were introduced into a flume that simulated a natural stream. Fish were observed hourly and parameters of the selected microhabitat locations were measured. Fishes differed in water velocity of microhabitat areas selected, water strata utilized, and degree of thigmotaxis exhibited.

Hatchery rainbow trout selected areas along side of the flume or above a structure and along side of the flume that had a water velocity of 0.9 ft/sec (27.4 cm/sec). They utilized the middle of the water column, were positive rheotactic, and were not thigmotactic.

Wild rainbow trout utilized the same areas in the flume, but the water velocity was 0.7 ft/sec (21.0 cm/sec). They utilized the bottom of the water column, were positive rheotactic, and were thigmotactic.

Resident trout affected only subtle changes in the parameters of the microhabitat selected by nonresident trout. Displacement of nonresident hatchery rainbow trout took place only after resident brown trout had been in the flume for 7 days. Resident hatchery trout displaced nonresident brown trout after 3 days in the flume; thus, indicating faster acclimation to flume.

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INTRODUCTION

Animals have discrete physical and biological requirements that are species specific. Fishes, particularly salmonid fishes, because of their narrow ecological tolerance are susceptible to small environmental changes.

Varied methods have been utilized in studying the ecological requirements of trouts. Chapman (1966), Lewis (1967), and Elser (1968) recognized that alteration of habitat reduced the number of fish and changed species composition. Newman (1956), and Hartman (1963,1965) studied effects of interspecific competition in mixed populations. Gerking (1953), Kalleberg (1958), and Keenleyside and Yamamoto (1962) have studied the effects of territoriality in trouts. Ecological parameters of the microhabitat are currently under study by several investigators.

Microhabitat of an animal is the physical and biological parameters necessary for existence at a given time. A series of microhabitats over time is therefore the home range of an animal. For salmonid fishes, resting, feeding, breeding, and cover microhabitats may be identified (Baldes, 1968). In the lotic community, a discrete set of environmental parameters, especially food, space, and water velocity limit populations. The impact of water velocity on the population increases as stream gradient steepens. Increase in water velocity and the resulting change in bottom composition can reduce the number and size of the microhabitats.

The study of the microhabitat of fishes has been oriented toward several ecological facets. Wickham (1967) studied the microhabitat of brook trout (*Salvelinus fontinalis*) in a natural stream, and Baldes (1968), the microhabitat of brown trout (*Salmo trutta*) in a flume. Both determined the physical environmental parameters of the respective microhabitats. Behavioral aspects of brown trout and rainbow trout (*Salmo gairdneri*) that pertain to the microhabitat were studied by Jenkins (1968) under artificial and natural stream conditions.

It is necessary and desirable to stock some lakes and streams because of high fishing pressure, poor reproductive habitat, or low productivity. Problems inherent in stocking trout in streams are, (1) the effect stocking has on the established population of wild trout, and (2) the effect the wild population has on hatchery-reared fish. Miller (1953, 1958) hypothesized that high stocking mortality of hatchery trout was due to effects of hatchery selection, and interspecific competition. Reactions to natural stimuli by hatchery-reared trout may have been altered. Vincent (1960) found that hatchery brook trout reacted differently to natural stimuli than wild brook trout. The same was also true of hatchery-reared Atlantic salmon (*Salmo salar*) (Male, 1966). It can be hypothesized that the phenotypic and perhaps genotypic selecting and conditioning undergone by a hatchery-reared fish has altered the selection of microhabitat parameters. It may also be hypothesized that prior residence of a wild population of trout, as manifested through interspecific competition, may influence the selection of the microhabitat parameters by hatchery-reared trout.

The purpose of my study is to delineate (1) resting microhabitat of hatchery-reared rainbow trout, (2) changes in the parameters of the microhabitat selected by rainbow trout as a result of hatchery rearing, and (3) changes in the parameters of the selected microhabitat that result from stocking in waters with an established population (prior residence).

METHODS AND MATERIALS

Description of Study Site

The study site was located at the Pingree Park Campus of Colorado State University. Water was diverted from the Little South Fork of the Cache la Poudre River into a flume (Figure 1). Structures in the flume (Figure 2) to form current patterns were the same as described by Baldes (1968) with the following modifications:

(1) A 45° angle of wood was inserted in the juncture of side and bottom to break the eddy created by the 90° angle.

(2) A 45° angle of wood was attached to the flume 6.0 inches (15.0 cm) above the outlet screen (Structure 9).

(3) Two 1 x 4 x 36 inch (2.5 x 10.2 x 91.2 cm) wood strips were placed on the upstream side of the outlet screen to increase the water depth in the lower end of the flume.

Water velocity and depth are not directly comparable between the work of Baldes (1968) and this project. The spring runoff in 1968 was abnormally high, overflowing the stream bank and flume area. Degradation and aggradation around the flume changed the slope.

Bank vegetation surrounding the flume was as natural as possible to provide shade and cover over the flume. To prevent frightening the fish, it was necessary to build observation blinds (Figure 1).

Water volume was maintained at a constant 1.94 cfs (0.05 m^3/sec) by use of a Parshall Flume, control gates, and a Stevens Recorder.

Small marks on the flume floor at 1 ft (30.5 cm) intervals enabled the observer to locate fish to within 0.5 of a ft (15.2 cm) and to make accurate measurement of selected microhabitat parameters.

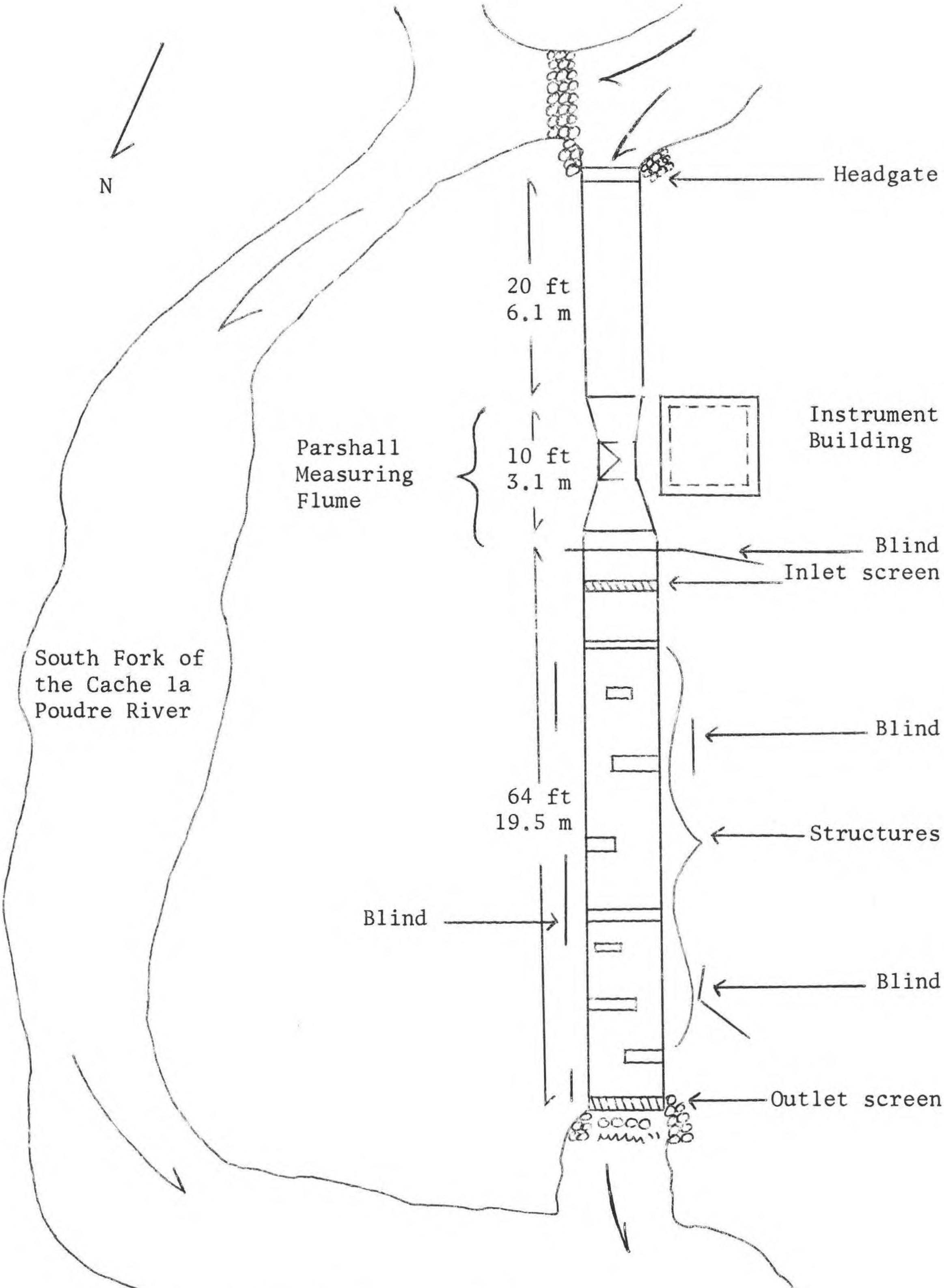

Figure 1. Diagram of flume, instrument building, and Little South Poudre River. Not drawn to scale.

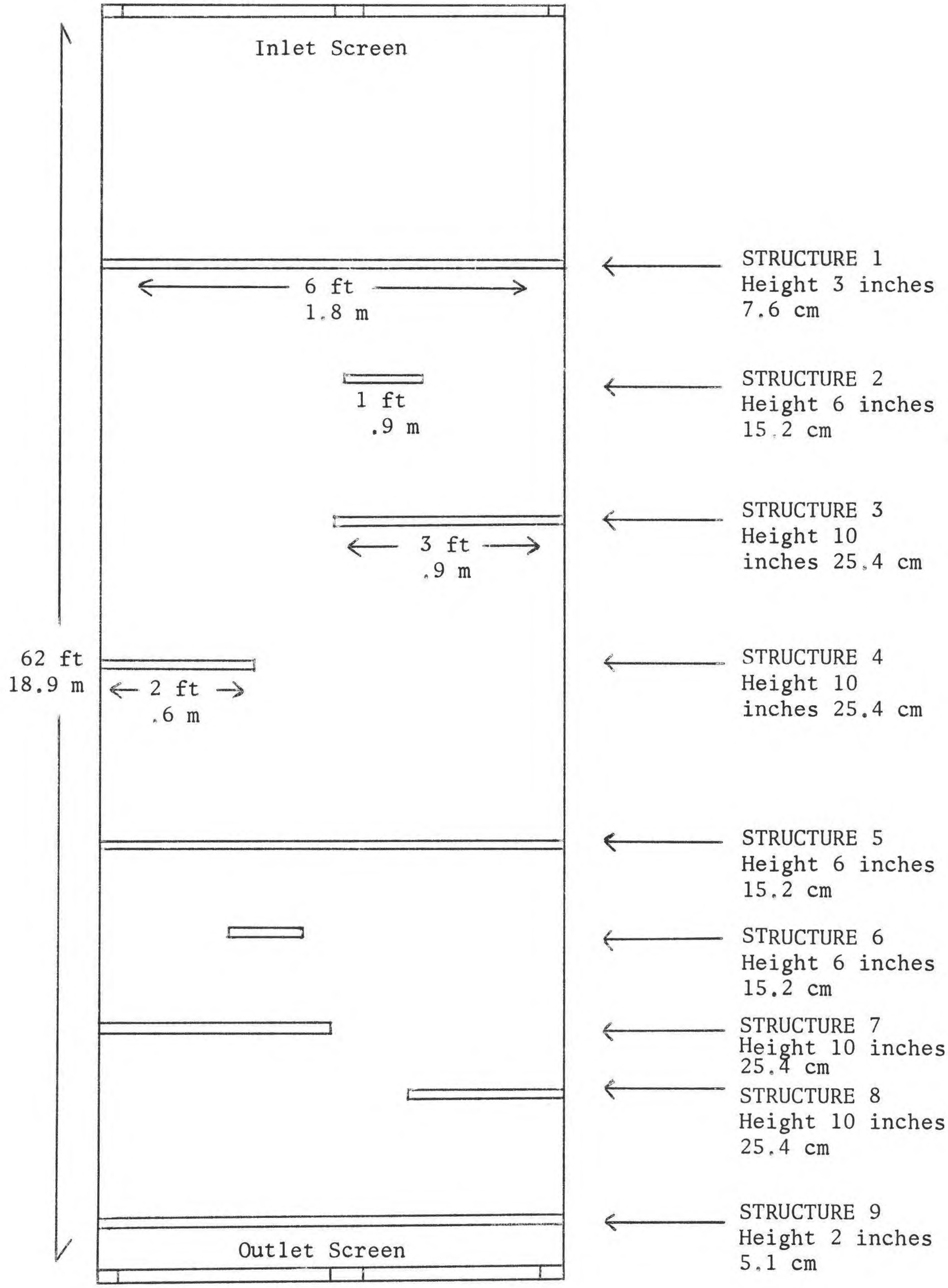

Figure 2. Diagram of location and size of structures in flume. Not drawn to scale.

Experimental Design and Methods

Study fish were from three sources:

(1) Hatchery-reared rainbow trout were from Poudre Ponds Rearing Unit of the Colorado Division of Game, Fish and Parks. Mean total length was 8.6 inches (21.8 cm).

(2) Wild brown trout were electro-fished from nearby Pennock Creek. Mean total length was 8.4 inches (21.3 cm).

(3) Wild rainbow trout were electro-fished from Dale Creek in north-central Colorado. Mean total length was 8.1 inches (20.6 cm).

Fish were transported in a holding tank to the flume where they were placed in holding pens until needed. Transportation time varied from 45 minutes (brown and rainbow trouts) to 5 hours (wild rainbow trout). Holding time varied from 3 to 24 hours. No mortality of the test fish was experienced during collecting, transporting, or holding.

Resting microhabitat of hatchery-reared rainbow trout was determined by introducing 10 trout into the flume, allowing the fish to orient for 12 hours and then making hourly observations from 0800 to 1700 hours. This procedure was replicated three times (300 observations) with experimentally naive fish (Table 1).

Resting microhabitat of wild rainbow trout was determined in a like manner, but only one trial, 100 observations, was conducted because of the difficulty in collecting these fish.

Effect of prior residency was determined by introducing seven rainbow trout or seven brown trout into the flume and allowing them to acclimate for 3 days. Seven brown or rainbow trout were then introduced and permitted to adjust 12 hours before commencing observations. This procedure was replicated three times with experimentally naive fishes.

Table 1. Number of trials, fishes, replicates and total hours of observation for microhabitat and prior residence study.

Test fishes	Number of test fishes per trial	Observations per trial	Number of replicates	Total number of hourly observations
	MICROHABITAT			
(1)				
Hatchery rainbow trout	10	10	3	300
(2)				
Wild rainbow trout	10	10	1	100
(3)				
Brown trout - 4 and 5 days	7	5	2	70
	PRIOR RESIDENT EFFECT			
(1)				
Brown trout - 3 days	7	10	3	210
Hatchery rainbow trout - 12 hours	7	10	3	210
(2)				
Hatchery rainbow trout - 3 days	7	10	3	210
Brown trout - 12 hours	7	10	3	210
(3)				
Brown trout - 7 days	7	10	1	70
Hatchery rainbow trout - 12 hours	7	10	1	70

Exception to this procedure was one trial where brown trout were permitted to orient for seven days before introducing rainbow trout. To determine changes in microhabitat requirements by comparison with Baldes' (1968) study, observations were made of the brown trout at four and five days before introducing rainbow trout.

Data were recorded during each observation period for the following parameters:

(1) Location of fish in flume

(2) Vertical distribution (strata)

(3) Shade vs. sun (presence or absence)

(4) Orientation in flume (upstream, downstream, or parallel to a structure)

(5) Weather condition (clear to cloudy)

(6) Water velocity

(7) Water temperature

(8) Flume utilization (upper or lower section)

Water velocity was measured with an Ott Current Meter with an accuracy of ± 1.5%. Water velocity was measured approximately 1 inch (2.5 cm) from the bottom and at 1 ft (30.5 cm) intervals along the length, and 2 ft (61.0 cm) intervals across the width of the flume. Other measurements were taken at selected locations to define better the velocity patterns. Velocity measurement of preferred locations was taken at the location of the fish's head.

Velocity measurements at each observation point included: (1) minimum, mean of recorded low velocities; (2) maximum, mean of recorded high velocities; and (3) modal, mean of velocities most frequently observed during a 30 sec measurement period.

All water velocity data and conversion to metric units utilized three-place decimal tables. When figures were rounded to one decimal place, the use of three-place tables resulted in differences in the metric equivalent of apparently similar velocity.

Utilized areas were divided into six locations (Figure 3): (1) above a structure and along a side of the flume, (2) below a structure and along a side of the flume, (3) above a structure, (4) below a structure, (5) along a side of the flume, and (6) midstream.

Sun-shade relationship was recorded on a basis of presence or absence of fish in either illumination. Most observations were during periods of cloudy weather.

Vertical position in the water stratum was recorded as (1) bottom - resting on bottom of the flume; (2) middle - floating or swimming to maintain vertical position; and (3) surface - using a portion of water column just beneath the surface.

Orientation to the flume was recorded as (1) upstream, (2) downstream, or (3) parallel to a structure.

Because of differences in mean water velocity and depth, the flume was divided into an upper and a lower section. The lower section appeared to be less desirable habitat and was used to measure preference and displacement resulting from competition.

Changes resulting from competition between resident and nonresident fishes were determined by statistical comparisons of microhabitat parameters. Tables were analyzed by contingency Chi-square and results expressed as ($P >$ or $< .05$). Statistical comparisons between trials and between species were made utilizing Student's T and One-Way Analysis of Variance (Li, 1964).

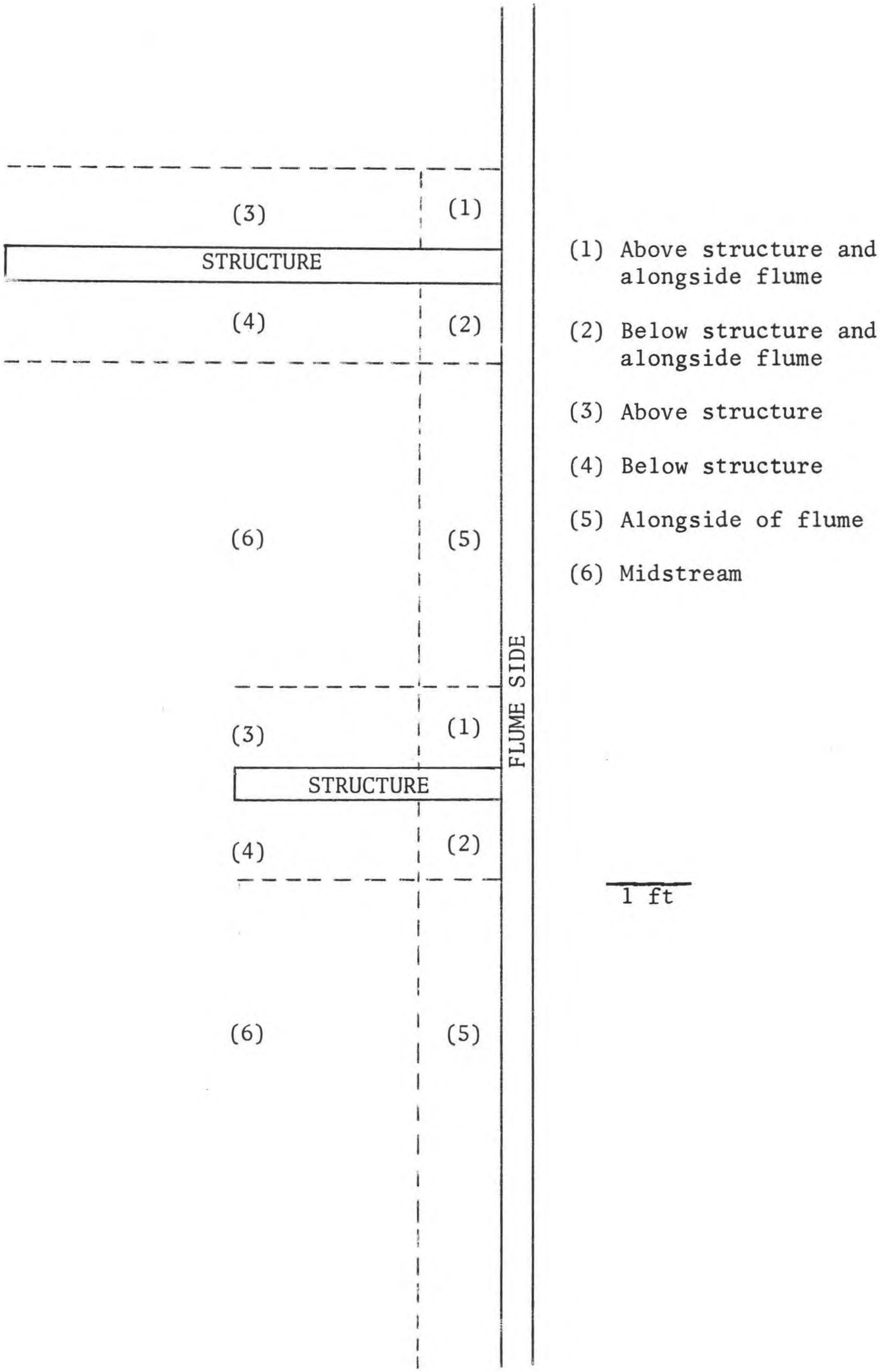

Figure 3. Utilized areas in the flume

Agonistic acts were not quantified in this study, but noted when observed.

RESULTS

Weather during the study varied; 726 observations (53%) were during cloudy periods.

Mean bottom water velocity for the flume was 1.2 ft/sec (37.5 cm/sec) and the mean surface water velocity was 1.4 ft/sec (42.5 cm/sec). Flume sections differed. The upper section had a mean bottom water velocity of 1.0 ft/sec (29.0 cm/sec) and a mean surface velocity of 1.1 ft/sec (33.5 cm/sec). The lower section had a mean bottom water velocity of 1.5 ft/sec (45.1 cm/sec) and a mean surface velocity of 1.7 ft/sec (50.3 cm/sec). Isovels characteristic of the flume are represented in Figures 4 and 5.

Mean water depth in the flume was 6.5 inches (16.4 cm). The upper section had a mean depth of 7.7 inches (19.5 cm). This section had the maximum depth, 10.1 inches (25.6 cm), in the flume. The lower section had a mean depth of 5.2 inches (13.0 cm). Maximum depth was 7.6 inches (19.3 cm). A comparison of water depth and velocity in the flume are presented in Figure 6.

Mean water temperature during the study was 47 F (9 C). Daily fluctuation was 10 F (6 C). A low, 37 F (3 C), was recorded in September and a high, 57 F (15 C), was recorded in August.

Microhabitat

Modal water velocity of areas utilized by hatchery rainbow trout was 0.9 ft/sec (27.4 cm/sec). Surface velocity was also 0.9 ft/sec (26.8 cm/sec). Wild rainbow trout selected areas in the flume with a modal water velocity of 0.7 ft/sec (21.0 cm/sec) and a surface velocity

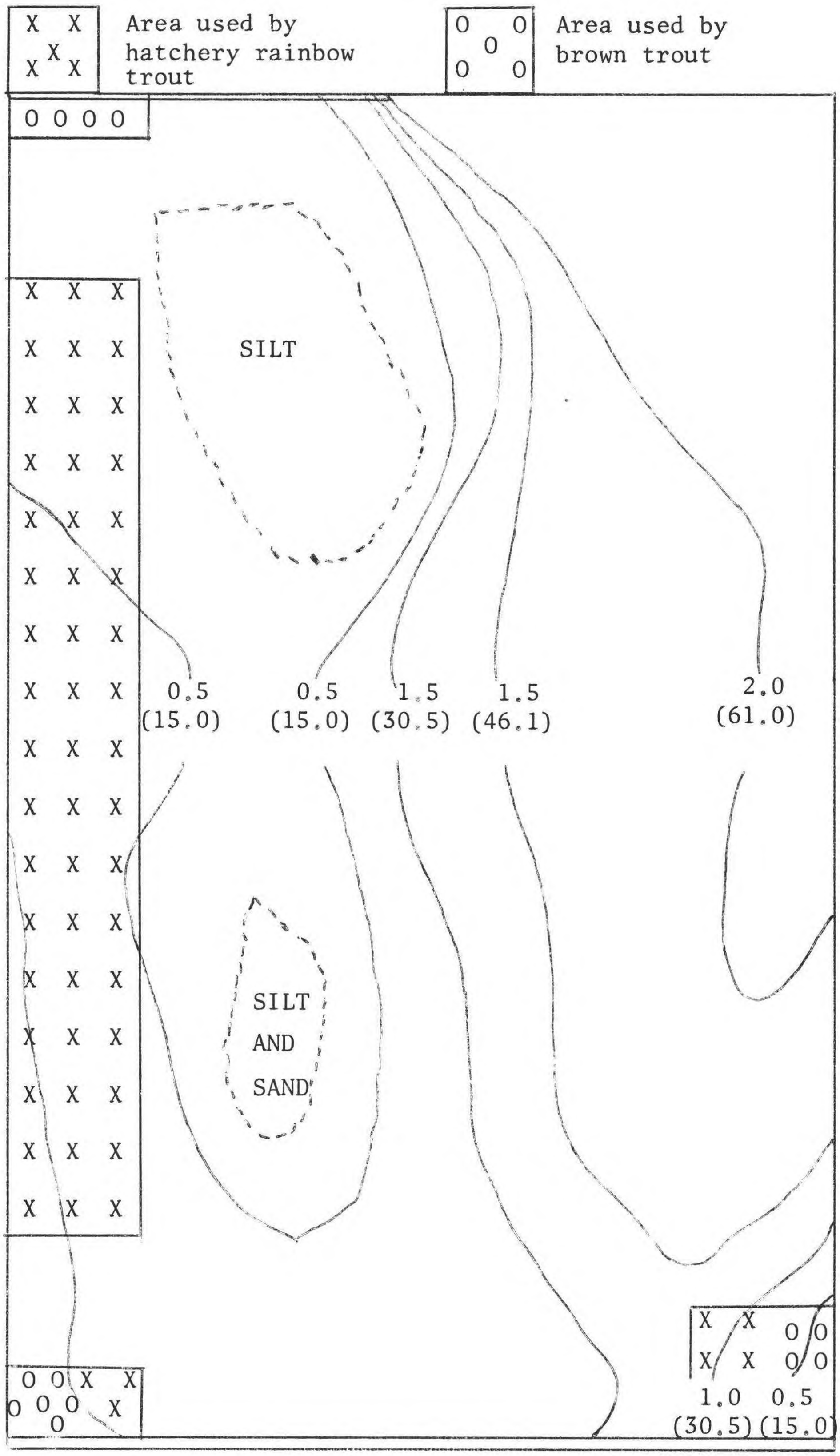

Figure 4. Isovels illustrating bottom velocity patterns characteristic of the flume. Numbers in parentheses ( ) are cm/sec.

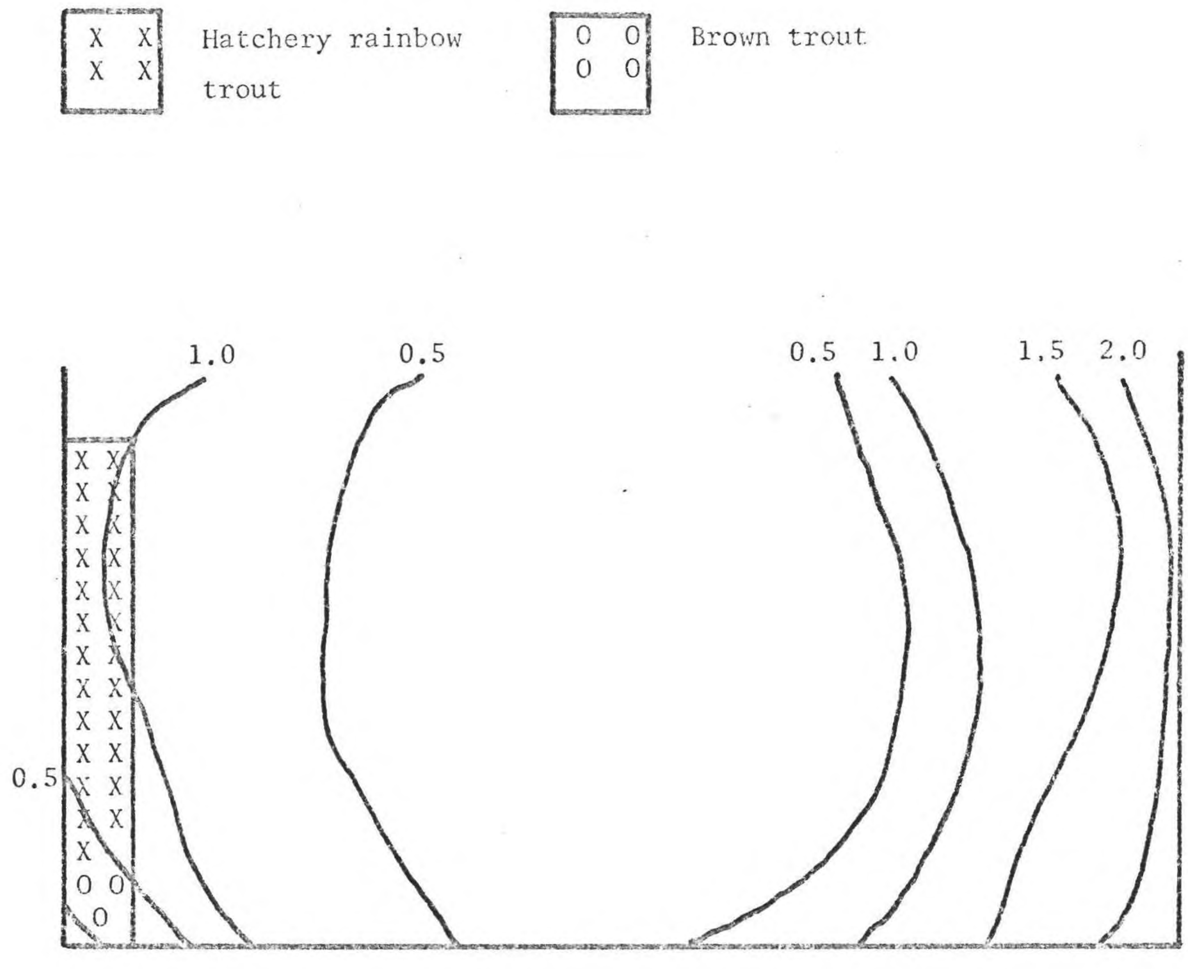

Figure 5. Cross section below a structure of the flume with Isovels illustrating water velocity patterns.

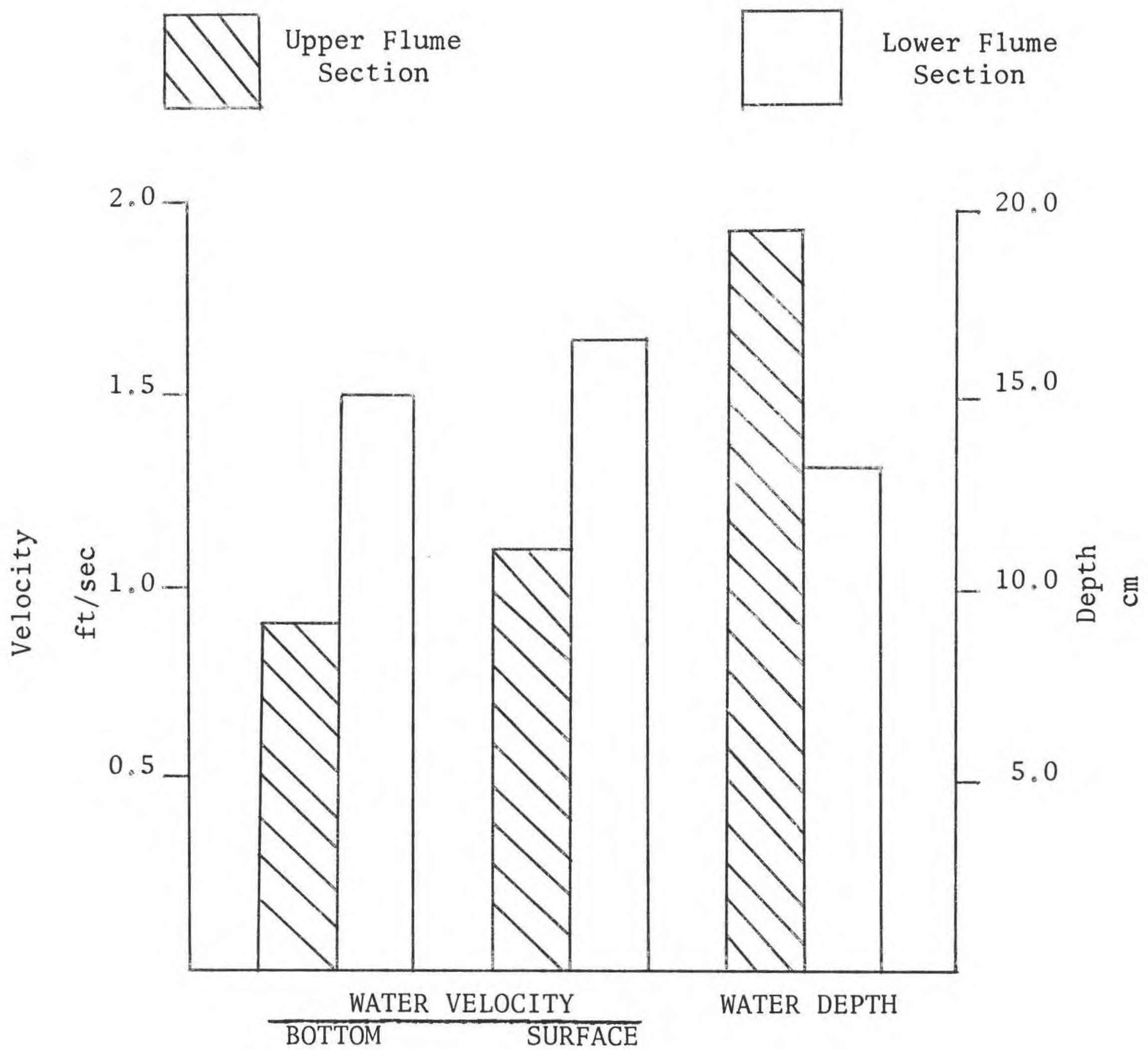

Figure 6. Comparison of water velocity and depth in upper and lower flume sections.

of 1.0 ft/sec (29.9 cm/sec). Hatchery and wild rainbow trout selected areas with a different modal water velocity ($P < .05$). (Table 2 and 3)

Trout were consistent over time in selecting locations of microhabitats. Hatchery rainbow selected areas (5) alongside the flume (47%) and area (1) above a structure and along the side (25%) most frequently; areas (6), (2), (3), and (4), in descending order, were utilized only 28% of the observations. Wild rainbow trout also utilized areas (5) (50%) and (1) (29%) most frequently, but only areas (6) and (2) were utilized of the other four (Table 4).

Water strata utilized by hatchery rainbow trout and wild rainbow trout differed ($P < .05$). Hatchery rainbow trout were observed in the middle portion of the water column 66% of the time. All remaining observations of fish were on the bottom; no fish were observed at the surface. Throughout the study, this relationship held true. Wild rainbow trout were observed on the bottom (66%) most frequently (Table 5).

Water depth of microhabitats selected by hatchery rainbow trout was greater than 3.0 inches (7.6 cm) (Table 6). Mean water depth of microhabitats for all observations was 6.8 inches (17.4 cm). Depth of water frequented most by wild rainbow trout, 7.5 inches (18.9 cm), was statistically similar to depth frequented by hatchery rainbow trout.

Because fish were positive rheotactic, orientation to the flume was directly related to and caused by current patterns at the selected microhabitats. Of the 300 microhabitat observations of hatchery rainbow trout, 64% were oriented upstream; 21% downstream; and 15% parallel. Of the 100 microhabitat observations of wild rainbow trout, 44% were oriented downstream; 33% parallel; and 23% upstream (Table 7).

Table 2. Water velocity (ft/sec) at microhabitat locations selected by fishes within the flume. Numbers in parentheses ( ) are cm/sec.

Trial	Date	Minimum	Maximum	Mode	Standard error of the mean (ft/sec)
		MICROHABITAT			
1		0.7 (22.3)			0.03
Hatchery	July 16, 18, 22		1.1 (34.8)		0.03
rainbow trout				0.9 (27.4)	0.03
2		0.6 (17.1)			0.03
Wild	September 5		0.9 (27.1)		0.05
rainbow trout				0.7 (21.0)	0.04
3		0.8 (22.9			0.06
Brown trout	August 7, 8		1.2 (37.2)		0.07
4 and 5 days				1.0 (29.3)	0.06
		PRIOR RESIDENCE EFFECT			
1		0.7 (20.7)			0.03
Brown trout	July 26, 30, August 3		1.1 (33.8)		0.04
3 days				0.9 (25.9)	0.04
Hatchery		0.6 (18.0)			0.03
rainbow trout			0.9 (28.4)		0.04
12 hours				0.7 (22.3)	0.04
2		0.7 (21.6)			0.03
Hatchery rainbow trout	August 14, 17, 22		1.2 (35.1)		0.03
3 days				0.9 (27.7)	0.03

Table 2. Water velocity (ft/sec) at microhabitat locations selected by fishes within the flume. Numbers in parentheses ( ) are cm/sec (continued).

Trial	Date	Minimum	Maximum	Mode	Standard error of the mean (ft/sec)
2 continued					
Brown	August 14, 17, 22	0.6 (19.2)			0.03
trout			1.1 (32.3)		0.05
12 hours				0.8 (23.8)	0.04
3		0.9 (28.7)			0.05
Brown trout	August 10		1.4 (32.3)		0.06
7 days				1.1 (32.6)	0.05
Hatchery		0.8 (23.8)			0.05
rainbow trout			1.2 (36.6)		0.06
12 hours				1.0 (29.3)	0.05

Table 3. Surface water velocity (ft/sec) at microhabitat locations selected by fish within the flume. Numbers in parentheses ( ) are cm/sec.

Trial	Date	Mode ft/sec	Standard error of mean
	MICROHABITAT		
1 Hatchery rainbow trout	July 16, 18, 22	0.9 (26.8)	0.03
2 Wild rainbow trout	September 5	1.0 (29.9)	0.06
3 Brown trout 4 and 5 days	August 7, 8	1.4 (42.4)	0.07
1 Brown trout 3 days	July 26, 30, August 3	1.2 (37.2)	0.03
Hatchery rainbow trout 12 hours		0.8 (25.6)	0.03
2 Hatchery rainbow trout 3 days	August 14, 17, 22	0.9 (27.4)	0.03
Brown trout 12 hours		1.1 (33.2)	0.06
3 Brown trout 7 days	August 10	1.5 (44.5)	0.05
Hatchery rainbow trout 12 hours		1.1 (32.0)	0.05

Table 4. Frequency of utilization by fishes of areas in the flume. Values presented by total number and by percentage. Numbers in parentheses ( ) are percentage.

Trial		AREAS 1 Above structure and along side	2 Below structure and along side	3 Above structure	4 Below structure	5 Along side	6 Mid-stream
		MICROHABITAT					
1		32	8	5	4	34	17
Hatchery		22	9	5	1	50	13
rainbow trout		20	7	6	2	56	9
	Total	74 (25)	24 (8)	16 (5)	7 (2)	140 (47)	39 (13)
2							
Wild rainbow		29	8	0	0	50	13
trout	Total	29 (29)	8 (8)	0 (0)	0 (0)	50 (5)	13 (13)
		PRIOR RESIDENCE EFFECT					
1		29	30	0	0	11	0
Brown trout		22	19	0	1	20	8
3 days		23	4	0	0	43	0
	Total	74 (35)	53 (25)	0 (0)	1 (1)	74 (35)	8 (4)
Hatchery		0	6	0	3	39	22
rainbow trout		2	12	1	2	30	22
12 hours		10	5	4	0	42	9
	Total	12 (6)	23 (11)	5 (2)	5 (2)	111 (53)	53 (25)

Table 4. Frequency of utilization by fishes of areas in the flume. Values presented by total number and by percentage. Numbers in parentheses ( ) are percentage (continued)

Trial		AREAS 1 Above structure and along side	2 Below structure and along side	3 Above structure	4 Below structure	5 Along side	6 Mid-stream
2		19	1	1	0	44	5
Hatchery		16	10	0	0	40	4
rainbow trout		16	5	1	0	41	7
	Total	51 (24)	16 (8)	2 (1)	0 (0)	125 (60)	16 (8)
Brown		25	14	0	0	29	2
trout		23	14	0	0	33	0
12 hours		12	21	0	3	28	6
	Total	60 (29)	49 (23)	0 (0)	3 (1)	90 (43)	8 (4)
3							
Brown trout		24	1	1	1	43	0
7 days	Total	24 (34)	1 (1)	1 (1)	1 (1)	43 (61)	0 (0)
Hatchery							
rainbow trout		9	15	2	0	39	5
12 hours	Total	9 (13)	15 (21)	2 (3)	0 (0)	39 (56)	5 (7)

Table 5. Water strata utilized by fishes. Values presented by total number and percentage. Numbers in parentheses ( ) are percentage.

Trial		Bottom	Middle	Surface
		MICROHABITAT		
1		31	69	0
Hatchery		38	62	0
rainbow trout		33	67	0
	Total	102 (34)	198 (66)	0 (0)
2				
Wild				
rainbow trout		66	34	0
	Total	66 (66)	34 (34)	0 (0)
		PRIOR RESIDENCE EFFECT		
1		69	1	0
Brown trout		67	3	0
3 days		67	3	0
	Total	203 (97)	7 (3)	0 (0)
Hatchery		10	60	0
rainbow trout		3	67	0
12 hours		0	70	0
	Total	13 (6)	197 (94)	0 (0)
2				
Hatchery		0	70	0
rainbow trout		4	66	0
3 days		0	70	0
	Total	4 (2)	206 (98)	0 (0)
Brown		65	5	0
trout		66	4	0
12 hours		67	3	0
	Total	198 (94)	12 (6)	0 (0)
3				
Brown trout				
7 days		60	10	0
	Total	60 (86)	10 (14)	9 (0)
Hatchery				
rainbow trout				
12 hours		11	59	0
	Total	11 (16)	59 (84)	0 (0)

Table 6. Total water depth (inches) at selected microhabitat locations. Numbers in parentheses ( ) are cm.

Trial	Mean depth	SE
	MICROHABITAT	
1		
Hatchery rainbow trout	6.8 (17.4)	0.1
2		
Wild rainbow trout	7.5 (18.9)	0.1
3		
Brown trout 4 and 5 days	7.0 (17.7)	0.1
	PRIOR RESIDENCE EFFECT	
1		
Brown trout 3 days	7.0 (17.7)	0.1
Hatchery rainbow trout 12 hours	7.2 (18.2)	0.1
2		
Hatchery rainbow trout 3 days	6.7 (17.0)	0.1
Brown trout 12 hours	6.0 (15.1)	0.2
3		
Brown trout 7 days	7.0 (17.8)	0.1
Hatchery rainbow trout 12 hours	6.0 (15.1)	0.1

Table 7. Orientation of fishes to water flow through the flume. Numbers in parentheses ( ) are percentage.

Trial		Upstream	Downstream	Parallel
		MICROHABITAT		
1		73	22	5
Hatchery		57	21	22
rainbow trout		61	19	20
	Total	191 (64)	62 (21)	47 (15)
2				
Wild rainbow trout		23	44	33
	Total	23 (23)	44 (44)	33 (33)
		PRIOR RESIDENCE EFFECT		
1		25	4	41
Brown trout		17	0	53
3 days		41	18	11
	Total	83 (40)	22 (10)	105 (50)
Hatchery		13	37	20
rainbow trout		20	27	23
12 hours		43	19	8
	Total	76 (36)	83 (40)	51 (24)
2		51	15	4
Hatchery rainbow		29	23	18
trout 3 days		38	20	12
	Total	118 (56)	58 (28)	34 (16)
Brown		47	5	18
trout		38	8	24
12 hours		24	16	30
	Total	109 (52)	29 (14)	72 (34)
3				
Brown trout				
7 days		55	1	14
	Total	55 (79)	1 (1)	14 (20)
Hatchery				
rainbow trout				
12 hours		48	6	16
	Total	48 (69)	6 (8)	16 (23)

Shaded areas were utilized by both hatchery and wild rainbow trout when there was a choice, but of all observations, 53% were made during cloudy periods (no choice). Therefore observation datum of sun-shade utilization is not presented.

Because of differences in velocity, depth, and turbulence, the flume was separated into upper and lower sections. Utilization was either by choice or by displacement resulting from competition. Hatchery and wild rainbow trout when alone (no interspecific competition) utilized the upper flume section approximately 2 to 1 over the lower section (Table 8).

Prior Residence Effect

Successful competition in lotic communities is directly related to and enhanced by residency. This residency factor may be an important cause of mortality of hatchery-reared trout that are superimposed upon a wild population.

Modal water velocity of microhabitat areas selected by resident brown trout (Trial 1) was 0.9 ft/sec (25.9 cm/sec). When brown trout were resident for seven days (Trial 3) modal water velocity was 1.1 ft/sec (32.6 cm/sec). Resident hatchery rainbow trout (Trial 2) selected microhabitat areas with a modal water velocity of 0.9 ft/sec (27.7 cm/sec).

Nonresident brown trout (Trial 2) selected areas with a modal water velocity of 0.8 ft/sec (23.8 cm/sec). Nonresident rainbow trout (Trial 3) selected areas with a modal water velocity of 1.0 ft/sec (29.0 cm/sec). Thus, nonresident brown trout were in slower water than resident brown trout, and nonresident rainbow trout in faster water than resident rainbow trout.

Table 8. Utilization of upper and lower sections of the flume by fishes. Numbers in parentheses ( ) are percentage.

Trial		Upper section	Lower section
		MICROHABITAT	
1		69	31
Hatchery		66	34
rainbow trout		63	37
	Total	198 (66)	102 (34)
2			
Wild			
rainbow trout		70	30
	Total	70 (70)	30 (30)
		PRIOR RESIDENCE EFFECT	
1		46	24
Brown trout		46	24
3 days		33	37
	Total	125 (60)	85 (40)
Hatchery		47	23
rainbow trout		62	8
12 hours		48	22
	Total	157 (75)	53 (25)
2		58	12
Hatchery rainbow		26	44
trout 3 days		50	20
	Total	134 (64)	76 (36)
Brown trout		23	47
12 hours		28	42
		15	55
	Total	66	144 (69)
3			
Brown trout			
7 days		35	35
	Total	35 (50)	35 (50)
Hatchery			
rainbow trout			
12 hours		23	47
	Total	23 (32)	47 (68

Modal water velocity of areas selected by resident and nonresident trout was different ($P<.05$). Modal water velocity of microhabitat occupied by hatchery rainbow trout in 3 day residency trials and in microhabitat trials was the same. Modal water velocity of microhabitat occupied by brown trout (Trial 1) was not the same as modal water velocity of microhabitat occupied after 7 days in the flume ($P<.05$).

Orientation is a response to current patterns. Any change in orientation must result from changes in areas utilized. Generally, hatchery rainbow trout exhibited little difference in orientation between microhabitat trials and prior residency trials or between being a resident or nonresident. Brown trout, in all trials, oriented most frequently either upstream or parallel but reversed the order of preference. Resident (Trial 1) brown trout oriented parallel (50%), upstream (40%), and downstream (10%); but as nonresident (Trial 2) oriented upstream (52%), parallel (34%), and downstream (14%). As a resident for 7 days, brown trout oriented upstream (79%), parallel (20%), and downstream (1%) (Table 7).

Flume section utilization varied. Hatchery rainbow trout, in all but the 7 day trial, utilized the upper flume section most whether resident or nonresident (upper 66%, 75%, 64%; lower 34%, 25%, 36%). Resident brown trout were found in the upper section 60% of the observations, but as a nonresident were found in the lower section 69% of the observations. Because of the slight preference for the upper flume section displayed by all trout, the change when brown trout were the nonresident (Trial 2) may have been the result of displacement (Table 8).

DISCUSSION

Microhabitat

Hatchery conditioning and selection have resulted in fish that are different from wild ancestors. The resting microhabitat of hatchery rainbow trout reflects these differences. Hatchery rainbow trout selected areas with a faster microhabitat water velocity, a slower surface water velocity, and deeper water because of extensive use of the middle of the water column. Initially, hatchery rainbow trout formed loose unstable aggregations in the general microhabitat areas; there was no tight thigmotactic response to structures or walls as exhibited by brown trout. Wild rainbow trout under similar conditions reacted like wild brown trout. They selected microhabitat areas with a slower modal velocity, exhibited a thigmotactic response to the flume structures and walls, and utilized the bottom of the water column. Water depth at microhabitat locations selected by wild rainbow trout was similar to depths selected by hatchery rainbow trout and areas selected (5 and 1) within the flume sections were similar.

When frightened, hatchery trout would dash up or down stream, but did not seek shelter as would wild trout. Male (1966) found similar differences between hatchery and wild landlocked salmon parr. Hatchery parr reacted to fright stimuli, by dashing aimlessly, only under fast, shallow water. Wild parr reacted to fright stimuli under all conditions and would seek shelter directly. Male concluded that behavior of hatchery parr had been altered and water depth had definite value as cover. Possibly, one of the reasons for the utilization of the upper flume section by hatchery rainbow trout was water depth as cover.

No stable territories and few agonistic responses were observed. This may be the result of the deliberate attempt to keep the population low, to use similar sized fish, and to minimize intraspecific competition. Loose aggregations dispersed after a short period of acclimation.

Hatchery rainbow trout utilized microhabitat areas with a modal velocity of 0.9 ft/sec (27.4 cm/sec). This water velocity was higher than water velocity of microhabitats of wild rainbow trout and similar to the water velocity of microhabitats frequented by wild brown trout (Trial 3). Essentially all microhabitat and prior residence trials utilizing hatchery rainbow trout, because of the similarity of modal water velocity, could have been considered as replicates. Wild rainbow trout utilized microhabitats with a modal water velocity of 0.7 ft/sec (21.0 cm/sec) that seemed to be midway between wild brown trout (Baldes, 1968) and hatchery rainbow trout. This apparent difference between brown trout and rainbow trout may be a species difference, a residency factor, or a combination of both

Areas selected most by hatchery rainbow trout were the same as those utilized by brown trout (Baldes, 1968) (areas 1 and 5), but of the other four locations, hatchery and wild rainbow trout utilized a mid-stream location more than brown trout (Baldes, 1968). Utilization of area 6 by rainbow trout was more than just a result of movements between areas 1 and 5. Hatchery rainbow trout utilized deep, uniform velocity open-water areas for varying periods of time; thus indicating that thigmotactic response was not strong.

Orientation was always positive rheotactic and was a response to current patterns (or lack of current patterns) at the microhabitat locations. Hatchery rainbow trout oriented upstream (64%), downstream (21%), and parallel (15%). Wild rainbow trout, even though occupying the same general locations in the flume, oriented downstream (44%), parallel (33%), and upstream (23%). This apparent difference was the result of water strata utilized, and thigmotactic response to structures or flume wall.

The upper flume section was utilized by hatchery and wild rainbow trout more than the lower section for several reasons: (1) greater water depth, (2) slower modal water velocity throughout the water column, (3) less current surging at microhabitat depth and at the surface, and (4) larger areas with suitable microhabitat parameters.

Both species utilized small microhabitat areas for long periods; which agrees with Miller (1953, 1958), Wickham (1967), Baldes (1968), and Jenkins (1968). Wild rainbow trout, however, appeared to be more stable at these locations occupying the microhabitats singly as did brown trout (Baldes, 1968) and brook trout (Wickham, 1967). Hatchery rainbow trout were generally found in loose aggregations at the microhabitats.

There appears to be a residency factor in wild fish that has been altered or suppressed in hatchery fish. Wild trout require a longer residency and acclimation period before normal behavioral responses such as feeding, hierarchy, and territory are established. This has been demonstrated by Newman (1956), Keenleyside and Yamamoto (1962), and Jenkins (1968). In my study wild rainbow and brown trouts when introduced into the flume displayed only fright or escape responses. They were extremely thigmotactic utilizing structures, walls, and shade when available as a substitute for overhead cover. They exhibited few agonistic responses and were generally quiescent during the experiments. Contrasting to this, hatchery rainbow trout acclimated rapidly to the flume: utilized open water, exhibited agonistic responses, utilized the middle of the water column, utilized areas with faster water velocity, and generally appeared to accept the flume as a place of residence. Wild brown trout did not appear to accept the flume until after a prolonged period of residency. Only fright reactions were displayed until at least 7 days after introduction. The microhabitat of hatchery rainbow trout, as determined under flume conditions, was probably a resting microhabitat produced by hatchery conditioning.

In streams where trout fishing depends upon "put-and-take" stocking and where a high return to the creel is desirable, this change in microhabitat selection may be beneficial. Stocked fish would concentrate in more accessible areas of the stream: off the bottom and in open water. Competition with resident trout for space may be lessened by this vertical stratification.

Prior Residence Effect

Changes in microhabitat parameters resulting from interspecific competition of prior residence were subtle.

Modal water velocity of microhabitats selected changed little with length of residency. If velocity alone were considered, prior residence trials could have been replicates of microhabitat trials. There are indications that a residency period longer than 3 days is necessary for wild brown trout to become acclimated. Jenkins (1968) found 6 to 7 days were needed to establish a social hierarchy when several species and several age groups were present. In my study, evidence indicating social interactions by brown trout was almost lacking prior to 3 days residence, but increased with length of residency. Surface water velocity of microhabitat locations was species specific and in the case of brown trout may have been a substitute for overhead cover.

Microhabitat locations were, in general, the same as those selected in the microhabitat trials, but prior residence did affect some changes. Hatchery rainbow trout when alone utilized areas 5 and 1 (72%), and 6 (13%). When they were the resident fish (Trial 2), this order again held true, but as a nonresident (Trial 1) use of area 6 increased to 25% of the observations and to second in importance. During Trial 1, resident brown trout utilized areas 5 and 1 (70%) and both species utilized the upper flume section. This crowding (competition) in the upper flume section resulted in increased utilization of the less desirable open water area (6) by nonresident hatchery rainbow trout. The interspecific competition was apparently not great enough to displace the hatchery rainbow trout to the lower flume section, and utilization of area 6 decreased.

The similarity of results from all trials with hatchery rainbow trout suggests (1) prior conditioning and/or selection, (2) limited fright response, (3) an acceptance of the flume as being similar to a hatchery raceway, and (4) possibly a shorter residency period. The residency period is quite real, but the length of time necessary to establish residency appears to differ between species and between wild and hatchery fish. Hatchery rainbow trout appeared to establish residency in approximately 3 days and actively displaced nonresident fish. Wild brown trout apparently take longer to establish residency; between 5 and 7 days. Length of time necessary for residency is further exemplified by increased agonistic behavior and by change in modal water velocity of microhabitat over time. This possibly indicates a change from an escape or fright microhabitat to a resting microhabitat. Hatchery rainbow trout appeared to need a shorter period of residency and the microhabitat outlined was apparently a resting microhabitat specific to hatchery rainbow trout.

Results of the prior residency and microhabitat study support and quantify the conclusions of Miller (1954, 1958). The parameters of the microhabitats selected by hatchery trout have been altered and this alteration affects survival when stocked with a wild population. Prior residency is an important survival factor, but other microhabitat parameters such as water velocity, bank and stream cover, bottom gradient, water depth, and water strata occupied, will also affect survival, especially for trout stocked in a lotic environment.

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