MOVEMENT AND HOMING OF CUTTHROAT TROUT *(SALMO CLARKI)* IN BRIDGE AND CLEAR CREEKS, YELLOWSTONE NATIONAL PARK

by

GEORGE WILLIAM LABAR

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of

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in

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Approved:

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Head, Major Department

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Chairman, Examining Committee

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Graduate Dean

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VITA

George William LaBar was born in Birchwood, Wisconsin, July 10, 1942 to Mr. and Mrs. W. F. LaBar. He resided on a farm outside Birchwood until he graduated from high school in 1960. In the fall of 1960, he entered Wisconsin State College at Superior and graduated with a Bachelor of Science degree in Biology June, 1964. During the 1964-65 school year he taught Biology and General Science at Crandon Public High School, Crandon, Wisconsin. In September, 1965, he began graduate work at Idaho State University, Pocatello, Idaho and received his Master of Science degree in Zoology June, 1967. While at Idaho State University he held a graduate teaching assistantship. In June, 1967 he started doctoral work at Montana State University. From September, 1967 to June, 1968 he held a graduate teaching assistantship. He was a research assistant on a National Science Foundation grant from 1968 to 1970. In February, 1961 he married Joan Etta McEathron and they have three children; Laureen Ann, George William Jr. and Pauline Helen.

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ABSTRACT

Mature cutthroat trout *(Salmo clarki)* exhibited in-season homing to tributaries and redds in Clear and Bridge Creeks, Yellowstone National Park, in 1967, 1968 and 1969. Of 532 fish displaced from a small stream tributary to Clear Creek, 135 (26.4%) homed, 116 (21.8%) strayed and 281 (52.8%) were unaccounted for. Significantly fewer anosmic and blind fish homed than controls. More blind fish strayed than other groups. Of 190 fish displaced from the North and South Forks of Bridge Creek in 1968 and 1969, 60 (31.6%) homed, 16 (8.4%) strayed and 114 (60.0%) were unaccounted for. Fewer anosmic and blind fish homed than control and non-anesthetized. Mean homing times were shortest for non-anesthetized and progressively greater for control, anosmic and blind fish in both Clear and Bridge Creeks. Mean homing time for all groups from Clear Creek in 1969 was double that of 1968. Twenty-nine (40.9%) of 71 fish displaced from redds in Clear Creek in 1969 homed to the same redd from which they were taken. Eighteen (25.4%) returned to within 2-3 m of the home redd. Ten (14.1%) strayed and 14 (19.7%) were unaccounted for. Homing to redds did not appear to be affected by the distance displaced.

INTRODUCTION

Mature cutthroat trout *(Salmo clarki)* migrate from Yellowstone Lake into the tributary streams to spawn (Cope, 1957b). Ball (1955) reported that they home to particular streams and that only 6 (2.4%) of 280 repeat spawners entered streams other than those used previously. Cope (1957b) found that only 3.2% of repeat spawners entered streams different from those in which they were originally tagged. McCleave (1967) displaced 1908 cutthroat trout from spawning streams to release points in Yellowstone Lake and found that 614 (32.2%) homed, 119 (6.2%) strayed and 28 (1.5%) were taken in the lake by anglers. Of 300 cutthroat trout displaced by Jahn (1969), 116 (38.2%) homed, 30 (10.0%) strayed and 8 (2.7%) were taken by anglers. Platts found that approximately 48% of displaced cutthroat trout in a Utah reservoir homed to the stream of original capture. All these previous studies dealt with homing of mature cutthroat trout from a lake to a stream. The present study concerned homing within Bridge and Clear Creeks, tributaries of Yellowstone Lake. The objectives were to determine: if cutthroat trout home to given tributaries of a stream system and to particular redds within these tributaries; if olfaction and vision have a role in homing behavior.

Cope (1957a) suggested that Yellowstone cutthroat trout may have more than one genetic group within individual streams, and that each group may select a particular part of the stream for spawning. Liebelt

(1969) recognized five distinct populations of cutthroat trout through serological differences between spawning fish from eight streams connected to Yellowstone Lake.

Twenty of 226 displaced brook trout *(Salvelinus fontinalis)* returned to the same spawning beds from which they were taken (Vladykov, 1942). Homing to a particular tributary has been shown for sockeye salmon *(Oncorhynchus nerka)* by Hartman and Raleigh (1964) and for pink salmon *(O. gorbuscha)* by Helle (1966). Brown trout *(Salmo trutta)* and charr *(Salvelinus willughbii)* were found to return consistently to the same spawning grounds after displacement and used these same spawning grounds in different years (Stuart, 1957; Frost, 1963). Natal homing was shown for pink salmon by Clemens, et. al. (1939) and for rainbow trout *(Salmo gairdneri)* by Lindsey, et. al. (1959). An attempt by Ball (1955) to show natal homing for cutthroat trout in Yellowstone Lake was unsuccessful.

The role of olfaction and vision in locating a particular tributary of the Columbia River by adult chinook salmon *(O. tshwaytscha)* was studied by Groves, et. al. (1968). They found that 6 (4.0%) of 152 olfactory occluded, 46 (24.0%) of 192 blinded and 94 (49.0%) of 192 control fish returned to the Spring Creek Hatchery after displacement downstream. Hasler and Wisby (1951) and McBride, et. al. (1964) showed that bluntnose minnows *(Pimephales notatus)* and juvenile sockeye salmon learned to distingish between the waters of two streams by olfaction.

Coho salmon *(O. kisutch)* appeared to use olfaction to choose between tributaries of a river system (Wisby and Hasler, 1954).

DESCRIPTION OF STUDY AREA

Yellowstone Lake is located in Yellowstone National Park, Wyoming, at an elevation of 2358 m and has a surface area of 354 km^2 (Benson, 1961). It receives about 35 tributaries, most of which have spawning runs of cutthroat trout (Cope, 1957b). Two of these, Clear and Bridge Creeks, were selected for study. They each received at least one tributary which contained a spawning population of cutthroat trout and were small enough so that the position and activity of fish could be observed.

Clear Creek enters the east side of Yellowstone Lake approximately 23 km from the lake outlet and is about 15 km in length (Fig. 1). Estimated discharges range from 0.8 to 7.2 m^3/s during June and July (Stober, 1969). Good spawning gravel is found throughout the stream (Cope, 1957a) and fish have been observed spawning in all but the upper 1.5 km. During the three spawning seasons of this study, a fish trap was located 75 m from the mouth.

A tributary (Trib. I) enters Clear Creek about 1 km from its mouth (Fig. 1; Fig. 3). It is approximately 6 km in length, has a mean width of 1.8 m and an estimated maximum discharge of about 0.6 m^3/s. The area adjacent to the lower portion (about 1 km) is heavily timbered, whereas the upper portion meanders through a large meadow covered with tall grasses. Most spawning activity occurs in the lower 2 km. In the 1968 and 1969 spawning seasons, a fish trap was placed 120 m upstream

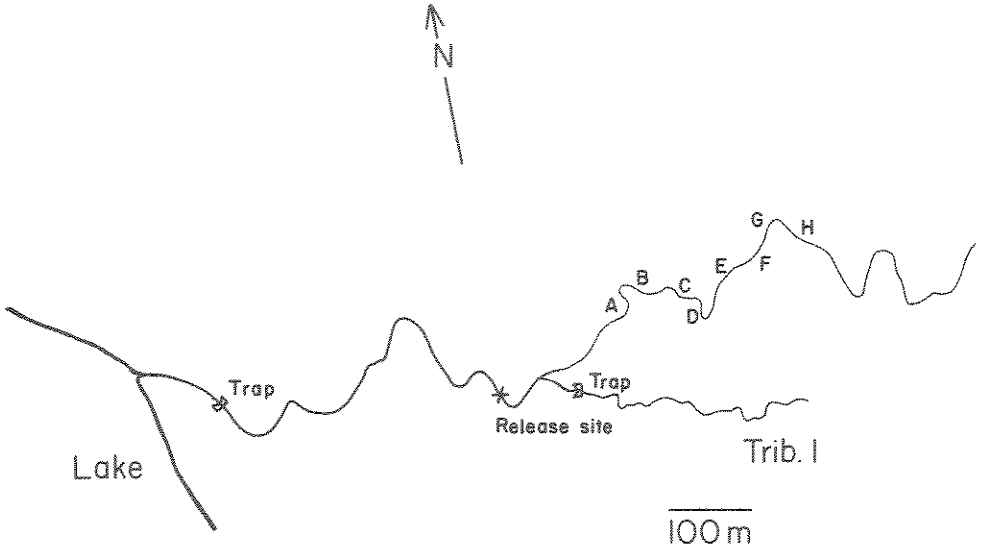

Figure 1. Clear Creek and Tributary I showing trap locations, release site and major spawning areas (letters) used in redd displacement study.

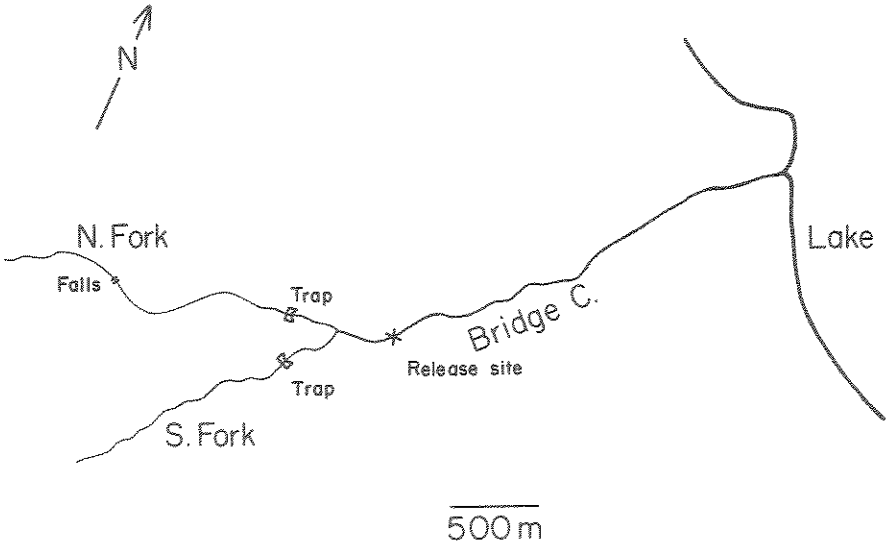

Figure 2. Bridge Creek showing trap locations and release site.

Figure 3. Tributary I (foreground) as it enters Clear Creek.

Figure 4. Trap in place on Tributary I.

from the mouth on Trib. I (Fig. 4).

Bridge Creek enters the west side of Yellowstone Lake about 8 km from the lake outlet (Fig. 2). It is formed by the confluence of two forks at a point 2.5 km from the mouth. The areas studied included: all of Bridge Creek proper; the lower 1 km of the North Fork terminating in a falls which is a barrier to upstream fish movement; the first 0.5 km above the mouth of the South Fork. Bridge Creek and the North Fork have a mean width of about 1.5 m while that of the South Fork is approximately 1 m. During the study (1968-1969), traps were maintained 51 m and 109 m above the mouth of the North and South Forks respectively.

METHODS AND MATERIALS

Fish to be displaced from Trib. I were captured by hook and line and dip net in 1967. Fish traps and dip net were used on Bridge Creek and Trib. I during 1968 and 1969. Fish to be displaced from the redds (Clear Creek) were taken in one of the following ways. Hook and line were generally used to capture fish after a spawning pair was sighted. One person would present a streamer fly to a particular fish and another would observe, to insure that the correct fish was taken. If a fish shocker was used, electrodes were laid on either side of a redd on which a pair of fish was located. This activity caused the fish to move away from the redd. When a pair had returned and resumed spawning activity, the electric current was turned on and the shocked fish secured with a dip net. A large dip net was used to capture some fish by carefully moving into a position directly downstream from an actively spawning pair and quickly scooping them up. This method worked best for capturing females while they were digging. If there was doubt about any specific fish regardless of the capture method, that fish was not used. The fish traps were made of 1.27 cm mesh hardware cloth fastened to a wooden frame 1.54 X 1.54 X 0.63 m (Fig. 4) secured to the stream bottom with metal posts. Sandbags were placed around the bottom of each one to prevent undercutting. Traps were examined daily for captured fish.

Each displaced fish was assigned to one of the following treatment groups: non-anesthetized; control; anosmic; blind. Non-anesthetized

fish were tagged and then displaced. All fish in the other groups were anesthetized in a 1:9000 solution of M.S. 222 (methane tricainesulfonate), three at a time, until they lost equilibrium. Control fish were removed from the anesthetic, tagged and placed immediately in a container with fresh water from the stream in which they were captured. Experimental fish were taken from the anesthetic and either blinded by injecting 0.01-0.15 cm^3 of 3% aqueous benzethonium chloride (Phemerol, Park, Davis and Co.) into the eyeball with a syringe (McCleave, 1967) or made anosmic by filling the olfactory chambers with petroleum jelly (Jahn, 1969). The short-term effect of these operations was determined by placing three different groups of 24 fish each from the Clear Creek trap in a holding net (Marnell and Hunsacker, 1968) in the lake for one week. Each group consisted of eight blind, anosmic and control fish. The net was checked daily. No mortalities were observed. All fish made anosmic retained both olfactory plugs and blind fish had opaque eyeballs.

A few fish were tagged early in 1967 with numbered plastic bird-leg bands around the lower jaw. Thereafter, a modified alligator clip tag (McCleave, et. al., 1967) was used (Fig. 5). This tag consisted of a 10 cm piece of white plastic spaghetti tubing (Floy Tag and Manufacturing, Inc.) coded with symbols and colors for individual recognition attached to an alligator clip (Mueller, type 30). The clip was secured to the posterior base of the dorsal fin. Tagged fish could be seen in the stream up to 30 m and individual tags could be identified

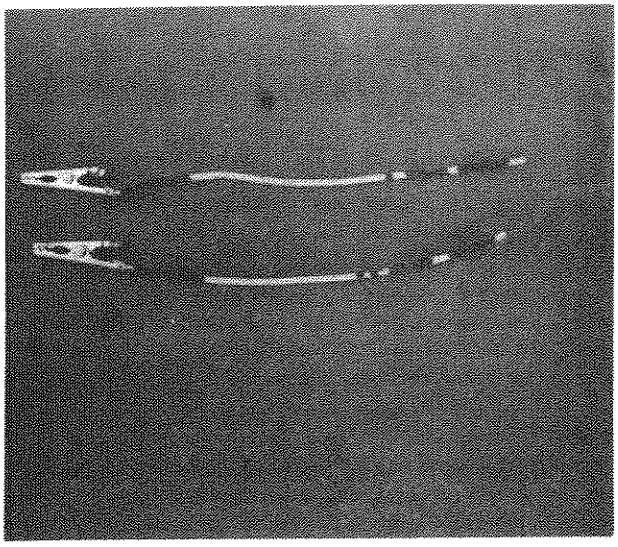

Figure 5. Modified alligator clip tags used to mark displaced fish.

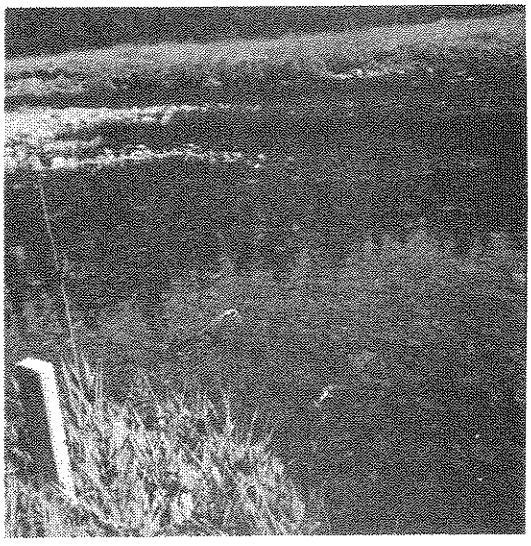

Figure 6. Area B in Clear Creek showing method of marking redds with bank stake and wire stake above redd in stream.

at a distance of 10-15 m with the aid of binoculars. The tags did not noticeably affect either movement or behavior. The maximum observed time that a ~~tag~~ was retained was 34 days.

After tagging, fish from Clear Creek were placed in a 19 liter plastic jug filled with fresh stream water and carried to the release point on a pack frame. A maximum of nine fish was transported at one time to avoid crowding. In 1967, fish from Trib. I were released immediately above the main trap on Clear Creek. In 1968 and 1969, they were released in an eddy behind a tree stump in midstream, 220 m downstream from the mouth of Trib. I. An old galvanized tub containing 20 to 25 liters of water and covered with a lid was used to transport tagged fish from Bridge Creek to the release site which was 235 m below the confluence of the North and South Forks. Data on the location of fish after displacement were secured by: noting their position in the stream; their presence in fish traps; tag returns by fishermen below the study area; finding tags on the stream bank which had presumably been on fish taken by bears. Traps were generally checked for returns at about 6:00 p.m. each day and not again until about 8:00 a.m. on the following day. Very few fish moved upstream during the night and early morning. By checking the traps periodically for returns throughout the day, homing time could be estimated to within about three hours. Chi-square tests (Steel and Torrie, 1960) were used to compare data on homing and straying between groups.

An attempt was made to determine the relative numbers of fish entering Clear Creek which selected Trib. I on their upstream migration. Fish were tagged in groups of 25-50 per day on different days in 1968 and 1969. These were taken from the Clear Creek trap, tagged with alligator clips and placed upstream of the trap. All were non-anesthetized.

Wooden stakes driven into the stream bank were used to identify redd locations; in addition, individual redds were marked by wire stakes with numbered orange fluorescent plastic flags (Fig. 6).

RESULTS

MOVEMENT

Tributary I. Movement of fish after displacement is considered under a number of categories. Those which moved 30 m or more upstream in Trib. I are considered to have homed. Homing fish are of two categories; those which homed directly and those which moved downstream initially and then returned to the home stream. All other fish accounted for are regarded as strays. Movements of fish that strayed are as follows: those that moved downstream from the release site and did not return; those that went directly upstream in Clear Creek past the mouth of Trib. I and did not return; those that moved downstream initially then upstream in Clear Creek past the mouth of Trib. I; those that moved downstream and then upstream, but remained below the mouth of Trib. I; those that remained between the release site and the mouth of Trib. I.

Since the study in 1967 was exploratory and no traps were maintained, data for that year are treated separately. A total of 101 fish was displaced from Trib. I in 1967. All were non-anesthetized. Of 61 tagged with bird-leg bands, eight (14.4%) homed and 53 (85.6%) were unaccounted for, while of 40 tagged with alligator clips, 13 (32.5%) homed and 27 (67.5%) were unaccounted for. Four of the fish tagged with bird-leg bands in 1967 returned to Trib. I in subsequent years—one in 1968 and three in 1969. Fish tagged with alligator clips could

be individually identified without removing them from the stream and this probably accounts for the larger percentage that was observed to home. There was no apparent difference between the percentage of males and females that homed or strayed in any category in any year.

A total of 431 fish was displaced from Trib. I in 1968 and 1969 (Table I). Of these, 114 (26.4%) homed, 116 (26.9%) strayed and 201 (46.7%) were unaccounted for. Most fish that homed (89.5%) moved directly upstream to Trib. I. Of the 12 fish which moved downstream before returning to Trib. I, five were blind and six had originally been plugged. Five of these latter had lost one or both olfactory plugs. Considering all fish displaced in 1968 and 1969, there was no significant difference (Chi-square = 1.32) between the percentage of control and non-anesthetized fish that homed, however, significantly fewer anosmic (Chi-square = 8.3) and blind (Chi-square = 14.7) fish homed than controls (Table II).

Of the 116 fish which strayed, 60 (52%) were observed downstream from the release site and did not return upstream. These included 32 (53%) blind, 16 (27%) anosmic, three (5%) non-anesthetized and nine (15%) controls. Fisherman returns accounted for one blind, four anosmic and one control below the study area. Fish which remained between the release site and the mouth of Trib. I made up 21 (18%) of the strays. Ten (48%) of these were blind, four (19%) anosmic and seven (33%) controls. Eighteen (14%) of 116 strays moved directly upstream in Clear Creek past the mouth of Trib. I. These included nine

TABLE I. Number (percentage in parentheses) of fish displaced from Trib. I in each movement category.

	1968					1969			
Treatment groups[a]	NA	B	A	C	Total	B	A	C	Total
No. displaced	(28)	(56)	(56)	(56)	(196)	(75)	(75)	(75)	(225)
Movement									
Upstream, home	13 (46)	7 (13)	12 (21)	20 (36)	52 (26)	3 (4)	18 (24)	29 (39)	50 (22)
Downstream, upstream, home	0	1 (2)	0	1 (2)	2 (1)	4 (5)	6 (8)	0	10 (4)
Downstream	3 (11)	8 (14)	8 (14)	2 (4)	21 (11)	24 (32)	8 (11)	7 (9)	39 (17)
Upstream in Clear Creek past mouth Trib. I	1 (4)	0	1 (2)	2 (4)	4 (2)	6 (8)	1 (1)	7 (9)	14 (6)
Downstream then upstream in Clear Creek past mouth Trib. I	0	0	0	0	0	3 (4)	1 (1)	1 (1)	5 (2)
Downstream then upstream but below mouth Trib. I	1 (4)	0	0	0	1 (1)	3 (4)	1 (1)	1 (1)	5 (2)
Remained between mouth Trib. I and release site	0	5 (9)	0	3 (6)	8 (4)	5 (7)	4 (5)	4 (5)	13 (6)
Total	18 (64)	21 (37)	21 (37)	28 (50)	88 (45)	48 (64)	39 (52)	49 (65)	136 (60)

[a]NA-non-anesthetized; B-blind; A-anosmic; C-control

TABLE II. Number (percentage in parentheses) of fish displaced from Trib. I which homed in 1968 and 1969.

Group[a]	1968		1969		Total	
	Displaced	Homed	Displaced	Homed	Displaced	Homed
NA	28	13(46)	---	---	28	13(46)
B	56	8(14)	75	7(9)	131	15(11)
A	56	12(21)	75	24(32)	131	36(27)
C	56	21(38)	75	29(39)	131	50(38)
Total	196	54(28)	225	60(26)	431	114(27)

[a]Legend same as Table I.

(50%) controls, six (33%) blind, two (9%) anosmic and one (4%) non-anesthetized. Six (5.2%) strays moved downstream, then upstream and remained below the mouth of Trib. I. Five (4.4%) moved downstream, then upstream in Clear Creek past the mouth of Trib. I. Six of the 11 fish in the above two categories were blind, two anosmic, two control and one non-anesthetized. In all straying categories, there were no apparent differences between non-anesthetized, anosmic and control fish. Significantly more blind fish (Chi-square = 19.1) strayed than other groups (Table III). Blind fish were more readily observed because they congregated in quiet water near the stream bank and were not easily disturbed, while control and anosmic fish preferred swifter, deeper water and were easily frightened into seeking cover. Twenty-eight of the 32 blind fish which moved downstream and did not return were seen in the quiet water immediately above the Clear Creek trap.

TABLE III. Number (percentage in parentheses) of fish displaced from Trib. I which strayed in 1968 and 1969.

Group[a]	1968		1969		Total	
	Displaced	Strayed	Displaced	Strayed	Displaced	Strayed
NA	28	5(18)	---	---	28	5(18)
B	56	13(23)	75	41(55)	131	54(41)
A	56	9(16)	75	21(28)	131	30(23)
C	56	7(12)	75	20(27)	131	27(21)
Total	196	35(18)	225	82(40)	421	116(28)

[a]Legend as in Table I.

One of these remained there for 26 days.

Mean homing times for each treatment group (1968-1969) were: non-anesthetized, 64 hr; control, 108 hr; anosmic, 130 hr; blind, 213 hr (Table IV). All treatment groups in 1968 had shorter homing times than those in 1969. The shortest individual homing times for each group in 1968 were: 1.5 hr for non-anesthetized; 1.6 hr for anosmic; 3 hr for blind; 16 hr for control. Shortest homing times in 1969 were: 8.5 hr for control; 24 hr for anosmic; 68 hr for blind. The longest homing time was 816 hr for a blind fish which was tagged on 7 June 1969 and not seen again until 22 June when it was sighted below the release site in Clear Creek. It remained there until 29 June and was subsequently taken in the trap on Trib. I on 11 July.

based on mean times?

TABLE IV. Numbers and homing times of displaced fish that returned to Trib. I in 1968 and 1969.

Group[a]	No.	Number (percentage in parentheses) Homing time (hr) 1-48	48-96	97-124	125-172	173-816	Mean	Range
NA	13	9(69)	1(8)	0	2(16)	1(8)	64	1-199
B	12	1(8)	4(33)	1(8)	1(8)	5(42)	213	3-816
A	36	5(14)	8(21)	5(14)	10(28)	8(22)	130	2-522
C	49	16(33)	10(20)	6(12)	5(10)	12(24)	108	17-434
Total	110	31(28)	23(21)	12(11)	18(16)	26(24)	126	1-816

[a]Legend as in Table I.

Bridge Creek. Fish displaced from the North and South Forks of Bridge Creek which moved upstream from the release site and into the appropriate (home) fork were considered to have homed. Those which moved downstream and did not return and those which moved upstream into a non-appropriate fork are considered to be strays. A total of 131 fish was displaced from the North and South Forks of Bridge Creek in 1968. Of 103 fish displaced from the North Fork, 43 (42%) homed, two (2%) strayed and 58 (56%) were unaccounted for (Table V). Control and

TABLE V. Number (percentage in parentheses) of fish displaced from the North Fork of Bridge Creek in 1968 which homed and strayed.

Group[a]	Displaced	Homed	Strayed	Total
NA	58	27(47)	1(2)	28(48)
B	15	6(40)	0	6(40)
A	15	3(20)	0	3(20)
C	15	7(47)	1(2)	8(53)
Total	103	43(42)	2(2)	45(44)

[a]Legend same as Table I.

non-anesthetized fish homed with identical frequency (47%). Three (20%) anosmic and 6 (40%) blind fish homed. One non-anesthetized fish strayed into the South Fork and one control moved downstream and did not return. There were no differences in the percentage of males and females that homed in any category in any year. Both fish examined that had originally been plugged retained the olfactory plugs.

see P. 21

In 1969, 54 fish were displaced from the North Fork--seven non-anesthetized, 14 blind, 15 anosmic and 18 control. Eight (18%) of these homed, including one non-anesthetized, one blind, one anosmic and five controls. One control strayed into the South Fork. One non-anesthetized, one blind, three anosmic and two controls were observed downstream from the release site and did not return upstream. Of all fish displaced from the North Fork, 12% fewer were accounted for in 1969 than in 1968. The spawning run was over earlier in 1969 (10 June) than in 1968 (19 June) and this may account for the smaller number of returns in 1969.

Nine (32.1%) of the 28 fish displaced from the South Fork in 1968 homed while six (21%) strayed (Table VI). One non-anesthetized and one

TABLE VI. Number (percentage in parentheses) of fish displaced from the South Fork of Bridge Creek in 1968 which homed and strayed.

Group[a]	Displaced	Homed	Strayed	Total
NA	21	7(33)	5(24)	12(57)
B	2	0	1(50)	1(50)
A	2	1(50)	0	1(50)
C	3	1(33)	0	1(33)
Total	28	9(32)	6(21)	14(50)

[a]Legend same as Table I.

blind were observed downstream from the release site and did not return. Of the 21 non-anesthetized fish displaced from the South Fork, seven (33%) homed and five (24%) strayed. In 1969, five fish were displaced from the South Fork and none of these were accounted for.

Mean homing time was 37 hr for fish returning to the North Fork trap from the displacement area in 1968. Average homing times for each group were: non-anesthetized, 22 hr; control, 34 hr; anosmic, 57 hr; blind, 66 hr. The range was 5 to 119 hr. Ten (8 non-anesthetized, 1 control, 1 blind) fish returned in less than 24 hr. Eight (1 non-anesthetized, 1 control, 3 anosmic, 3 blind) homed in 25-96 hr. One non-anesthetized and one blind fish took more than 96 hr to return.

Displacement from redds in Clear Creek. Only those fish which were paired on redds with the females excavating a nest and the males defending the area were used in these displacement experiments. Homing fish were those which returned and actively spawned on or within 2-3 m of the redd from which they were displaced. All other displaced fish observed were regarded as strays. Movements of fish after displacement were categorized as follows: those that moved directly upstream to the home redd; those which moved downstream and then upstream to the home redd; those that moved upstream to areas other than the home redd (stray); those which moved downstream and did not return (stray).

Seventy-one fish (4 pairs, 35 males and 28 females) were displaced from redds. All were non-anesthetized. Forty-seven (66.2%) of these

homed. Forty-six moved directly upstream to the home redd while one moved downstream to the Clear Creek trap and then upstream to the home redd. Twenty-nine of the 47 fish which homed, returned to the same redd from which they were taken (within an area of about 0.6 m^2), while 15 remained within 2-3 m of the home redd. Three fish were first seen 2-3 m from the home redd where they remained for 1-2 days and then moved directly onto the home redd. Most displaced fish, after returning to the home redd remained there from 2-4 days--maximum eight days. Males and females homed with exactly the same frequency (66.7%). The members of 4 pairs were displaced at the same time. One pair returned to the home redd. The female of another pair returned to the home redd, and the male to a different redd about 0.5 m from the home redd where he spawned with other females. Only one member each of the other two pairs homed and the others were unaccounted for. This particular area (B) had a high concentration of spawning fish and there appeared to be much competition for space.

Of the 71 fish displaced from redds, 4 males and 6 females strayed. Nine of these moved directly upstream and one moved downstream to the Clear Creek trap. Only three of the nine stray fish which moved upstream were observed to spawn.

Homing did not appear to be affected by distance from the release point to the home redd (Table VII). Also, there was no correlation between straying and distance displaced.

TABLE VII. Number (percentage in parentheses) of fish homing to redds after displacement from spawning areas in Clear Creek.

Area	Distance from release point (m)	Number displaced	Number homed
A	500	16	10(62)
B	550	22	15(68)
C	650	4	3(75)
D	700	3	2(66)
E	900	4	3(75)
F	1000	7	4(57)
G	1100	5	3(60)
H	1300	8	7(88)

The mean homing time was 30 (4.4-96) hr. This does not include one fish which took 217 hr to return. Thirty-five of 47 fish homed in 20-26 hr and three took less than 20 hr. All three of the latter were taken from area B at the same time on the same day. Two of these took 4.4 hr to return and moved upstream an average of 125 m per hr.

DISCUSSION

My interpretation of homing follows that of Gerking (1959) which is the return of fish "to a place formerly occupied instead of going to other equally probable places". Evidence from displacement experiments on Trib. I indicates that fish homed to that tributary. More of the fish accounted for were in the homing category than in all other categories combined. A small percentage (0.2%) of fish tagged at the Clear Creek trap entered Trib. I compared to displaced fish (27%) which returned. This difference indicates that displaced fish are not choosing the stream at random. The return in subsequent years of fish displaced from Trib. I in 1967 is also evidence of homing. The homing data for Bridge Creek is much less conclusive. All except one fish which moved upstream after displacement from the North Fork returned to it but almost as many fish displaced from the South Fork choose the North Fork. No explanation for the high incidence of straying in fish displaced from the South Fork is apparent.

Cutthroat trout displaced from spawning sites in Clear Creek homed with a high degree of precision. The percentage (66.2%) that homed to redds is much higher than reported for brook trout (8.9%) by Vladykov (1942). There was a rapid turnover of cutthroat trout on the redds and in most cases, redds vacated by displaced fish were occupied by other fish soon afterwards. This may explain why 38.3% of the fish that homed to redds did not return to the exact spot from which they

were taken, but utilized other redds within 2-3 m of the home redd. Barnaby (1943) expressed the opinion that a large percentage of salmon returning to spawn proceed to the same area where they emerged from the gravel as fry. Although cutthroat trout are not known to home to the redds where they hatched, they do possess the capability of precise homing.

More control and non-anesthetized fish homed than anosmic and blind. Jahn (1969) also found that significantly fewer anosmic and blind-anosmic fish homed than control and non-anesthetized groups, however, McCleave (1967) concluded that blinding and olfactory plugging did not affect the percentage of homing. Homing times were longer for blind fish displaced into the lake from Clear Creek (McCleave, 1967) and from Trib. I into Clear Creek. Homing times for anosmic fish displaced into the lake were about equal to those of controls. In Trib. I, homing times were somewhat longer for anosmic than controls. Fewer blind and anosmic fish displaced from Trib. I were accounted for than control and non-anesthetized in 1968 and 1969 combined, however, the percentage of blind and control fish accounted for was almost equal in 1969. The higher percentage in 1969 resulted from an increase in the number of blind fish which moved downstream from the release site and did not return and the number which moved upstream in Clear Creek past the mouth of Trib. I and did not return. The ability of blind fish to move upstream appeared to be impaired, as evidenced by the higher

percentage of blind than anosmic and control fish which moved downstream and did not return. In the North Fork of Bridge Creek, ~~less~~ about than half as many anosmic fish returned as control ~~and~~, non-anesthetized and blind ~~and almost as many blind as control.~~ The larger percentage of blind fish moving upstream in Bridge Creek than Clear Creek may have resulted from the lower gradient and deeper channel. Blinding and olfactory plugging probably caused a decrease in the percentage of homing. The trauma of the operations may be more important in deterring the fish from moving upstream than the lack of sight or smell. Wisby and Hasler (1954) found that plugging the nares of salmon with cotton or a combination of cotton and vaseline did not hamper their upstream movement. Since some fish in all treatment groups homed, it appears that those returning after displacement use more than a single cue in locating the home stream. Olfaction appears to play a major role in locating the home stream from the Columbia River (Groves, et. al., 1968). In smaller streams, such as Clear and Bridge Creeks, where visual cues are more apparent, olfaction may not be as important. — sight may be more important

be able to use either sight or olfaction ?

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