Homing and orientation of cutthroat trout (Salmo clarki) in Yellowstone Lake, with special reference to olfaction and vision
by James David McCleave

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Zoology
Montana State University

Abstract:
The movements of mature cutthroat trout (Salmo clarki) displaced from spawning tributaries to Yellowstone Lake were studied during late May to early August, 1964, 1965, and 1966, to determine in-season homing performance and the role of olfaction and vision in homing and orientation.

Of 1908 trout tagged and displaced from Clear and Cub Creeks to three release points in the lake and to the mouths of the streams, 614 (32.2%) homed, 119 (6.2%) strayed, and 28 (1.5%) were captured by anglers. Recaptures in 1965 and 1966 were higher, and in 1964 lower, than these averages. A greater percentage of Clear Creek trout than Cub Creek trout homed in 1965 and 1966, but a lesser percentage of Clear Creek trout than Cub Creek trout homed in 1964. Only slight differences in homing performance from various release points occurred. Adjusted mean homing times were 16.4 to 111.8 hr in 1964, 45.7 to 105.8 hr in 1965? and 96.0 to 154.7 hr in 1966. An inverse relation between homing times and distance to the release point was apparent only in 1966. Clear and Cub Creek trout homed in about the same length of time. Homing performance and homing times were similar for males and females. The homing performance of blinded, olfactory occluded, control, and non-anesthetized groups of trout were equal, but the length of homing time for blind trout was much longer than that for the other groups. A general east-north-eastward orientation occurred among blind and control trout from Clear Creek in 1965? and among blind, anosmic, and control trout from Clear and Pelican Creeks in 1966, that were float-tracked from an open-water point. Blind, control, and non-anesthetized trout from Cub Creek moved generally northward in 1965? but in 1966 too few Cub Creek trout were tracked to show orientation.

Blind and anosmic trout oriented as well as control trout. The directions of orientation were not in the directions' of the homestream, and orientation was not at a constant angle to the current directions or the sun azimuths.

HOMING AND ORIENTATION OF CUTTHROAT TROUT (SALMO CLARKI)
IN YELLOWSTONE LAKE,
WITH SPECIAL REFERENCE TO OLFACTION AND VISION

by

JAMES DAVID McCLEAVE

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Zoology

Approved:

____
Head, Major Department

____
Chairman, Examining Committee

____
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

March, 1967

Table of Contents

List of Tables

List of Figures

ABSTRACT

The movements of mature cutthroat trout (*Salmo clarki*) displaced from spawning tributaries to Yellowstone Lake were studied during late May to early August, 1964, 1965, and 1966, to determine in-season homing performance and the role of olfaction and vision in homing and orientation. Of 1908 trout tagged and displaced from Clear and Cub Creeks to three release points in the lake and to the mouths of the streams, 614 (32.2%) homed, 119 (6.2%) strayed, and 28 (1.5%) were captured by anglers. Recaptures in 1965 and 1966 were higher, and in 1964 lower, than these averages. A greater percentage of Clear Creek trout than Cub Creek trout homed in 1965 and 1966, but a lesser percentage of Clear Creek trout than Cub Creek trout homed in 1964. Only slight differences in homing performance from various release points occurred. Adjusted mean homing times were 16.4 to 111.8 hr in 1964, 45.7 to 105.8 hr in 1965, and 96.0 to 154.7 hr in 1966. An inverse relation between homing times and distance to the release point was apparent only in 1966. Clear and Cub Creek trout homed in about the same length of time. Homing performance and homing times were similar for males and females. The homing performance of blinded, olfactory occluded, control, and non-anesthetized groups of trout were equal, but the length of homing time for blind trout was much longer than that for the other groups. A general east-north-eastward orientation occurred among blind and control trout from Clear Creek in 1965, and among blind, anosmic, and control trout from Clear and Pelican Creeks in 1966, that were float-tracked from an open-water point. Blind, control, and non-anesthetized trout from Cub Creek moved generally northward in 1965, but in 1966 too few Cub Creek trout were tracked to show orientation. Blind and anosmic trout oriented as well as control trout. The directions of orientation were not in the directions of the homestream, and orientation was not at a constant angle to the current directions or the sun azimuths.

INTRODUCTION

Homing and orientation behavior of mature cutthroat trout (Salmo clarki) following displacement from spawning tributaries to Yellowstone Lake was studied during late May to early August, 1964, 1965, and 1966. The objectives were to determine in-season homing performance of tagged, displaced trout, and the role of olfaction and vision in orientation and homing.

Gerking (1959) used the term homing in a general sense to mean the return of fish, following migratory, accidental, or experimental displacement, "to a place formerly occupied instead of going to other equally probable places." He defined equally probable places as areas "occupied by other individuals of the same species" (Gerking 1964). In spawning migrations of fishes, three types of homing are recognized: (1) the return of adults to spawn in the same location in which they were hatched, i.e. "reproductive homing" (Lindsey et al. 1959), parent stream, or natal homing; (2) the return of adults to spawn in subsequent breeding seasons at the location of initial spawning, i.e. repeat homing; and (3) the return of adults within the same breeding season to the location of initial choice following displacement, i.e. in-season homing. Horrall (MS 1961) refers to all three as reproductive homing.

Ball (1955) validated the parent stream homing theory for cutthroat trout in Yellowstone Lake. Of 460 fingerlings marked at age I on their downstream migration from Arnica Creek to the lake, 94 (20.4%) returned at ages III or IV as adults. Nearly all of these must have been recruit spawners, since the majority of Arnica Creek fish spawn initially at ages IV and V with a few at ages III or VI (Bulkley 1961), and the survival for more than one spawning is usually less than 10% (Ball and Cope 1961). Traps were operated on five other major spawning tributaries during this period, but no stray fish were captured.

Cutthroat trout in Yellowstone Lake also home for repeat spawning. Cope (1957) tagged 18,836 adults as they entered one of five tributaries to spawn. In subsequent years 244 (1.3%) were recaptured as repeat spawners, and only 8 of these were recaptured in tributaries other than the original. Of the recaptures 96.7% homed.

No in-season homing experiments were done in Yellowstone Lake prior to the present study. However, Platts (1959) conducted such experiments in a high altitude reservoir in Utah. Mature cutthroat trout migrating up tributaries were captured, spawned artificially, tagged, and returned 1.6-6.4 km into the reservoir. Of 2,068 such fish 1,096 (53%) reentered tributaries, and 90% of these chose the initial stream, the rest being recaptured in other tributaries as strays. Apparently the homing motivation was not completely suppressed by stripping of the reproductive products.

Scheer (1939) has reviewed the early work on natal homing of the Atlantic salmon (*Salmo salar*), steelhead trout (*S. gairdneri*), and Pacific salmon (*Oncorhynchus* spp.). Most notable among these studies is that on the sockeye salmon (*O. nerka*) (Clemens et al. 1939). More recent demonstrations of natal homing include: rainbow trout (*S. gairdneri*) (Lindsey et al. 1959), coho salmon (*O. kisutch*) and steelhead trout (Shapovalov and Taft 1954), and brown trout (*S. trutta*) (Stuart 1957). Jones (1959) has reviewed the literature on natal homing of Atlantic salmon. It has been shown that transplanted young pink salmon (O. gorbuscha) (Wickett 1958), coho salmon (Donaldson and Allen 1957), and Atlantic salmon (White and Huntsman 1938) will return at maturity to the tributary where released as young rather than to the stream of parental origin.

Repeat homing occurs in Arctic grayling (Thymallus arcticus) (Kruse 1959), brook trout (Salvelinus fontinalis) (Vladykov 1942), charr (S. willughbii) (Frost 1963), lake trout (S. namaycush) (Eschmeyer 1954, Loftus 1957, Martin 1960), brown trout (Stuart 1957), and rainbow trout (Lindsey et al. 1959).

In-season homing has been demonstrated in brook trout (Vladykov 1942), brown trout (Stuart 1957), charr (Frost 1963), sockeye salmon (Hartman and Raleigh 1964), and pink salmon (Helle 1966). Cutthroat trout (Miller 1954), brook trout (Smith and Saunders 1958), and Dolly Varden (Salvelinus malma) (Armstrong 1965) also home following displacement at times other than the spawning season. Gerking (1959, 1964) has recently reviewed homing in non-salmonid fishes.

Griffin (1952) classified migratory behavior into three categories based on the method used in finding the goal. Hasler et al. (1958) modified the classification as follows: Type I - The ability to find home by use of landmarks in familiar territory and search in unfamiliar territory. Type II - The ability to maintain a constant compass direction in the sense of dead reckoning. Type III - The ability to find home by true navigation involving corrective feedback.

Saila and Shappy (1963) and Patten (1964) proposed two mathematical models of salmon migration in which search on the part of the fish could account for the observed returns. Hasler and Wisby (1958) and Hasler (1956a) have evidence that landmarks may be used in familiar territory. Home water odor may be considered a landmark. Bluntnose minnows (Pimephales notatus) (Hasler and Wisby 1951) and juvenile sockeye salmon (McBride et al. 1964) learned to distinguish between two natural waters by olfaction. Migrating adult sockeye salmon showed olfactory recognition of their home waters by their activity in a tank (Idler et al. 1961, Fagerlund et al. 1963) and chinook salmon (O. tshawytscha) by electroencephalographic responses (Hara et al. 1965). Wisby and Hasler (1954) showed that coho salmon use olfaction to choose between tributaries of a river system.

Jahn (1966) showed that Yellowstone Lake cutthroat trout, displaced westward from their upstream spawning migration to a near shore point or a mid-lake point, displayed a general eastward orientation when continuously tracked for up to two hours. The orientation mechanism was not determined, but the sun may have been used as a reference. Hasler et al. (1958) first demonstrated the sun compass (Type II) orientation in white bass (Roccus chrysops), bluegill (Lepomis macrochirus), and pumpkinseed (L. gibbosus). The roles of sun azimuth, sun altitude, and time compensation in the compass mechanism have been investigated (Braemer 1960, Hasler and Schwassmann 1960, Schwassmann 1960, Schwassmann and Braemer 1961, Braemer and Schwassmann 1963, Schwassmann and Hasler 1964). Winn et al. (1964) demonstrated a sun compass in parrot fishes (Scarus spp.) Johnson and Groot (1963) and Groot (1965) have shown celestial orientation of young sockeye salmon. Henderson (MS 1963) examined the celestial cues available underwater.

Hasler (1956b, 1960a,b, 1966) and Brett and Groot (1963) reviewed the roles of both vision and olfaction in homing. Adler (1963) suggested that organisms do not possess sufficient sensory capabilities for true navigation, but certainly do for compass orientation. Barlow (1964) stated that the possibility of an inertial navigation system in animals should be investigated. While no demonstrations of true navigation in fishes have been made, Neave (1964) feels it must exist, at least in the case of Pacific salmon.

METHODS AND MATERIALS

DESCRIPTION OF STUDY AREA

Yellowstone Lake (Fig. 1) has an area of 354 km^2, a maximum depth of 98 m (42 m mean), and lies at an elevation of 2,358 m msl just east of the continental divide in southeast Yellowstone National Park, Wyoming. Benson (1961) has given basic limnological information for this lake.

Yellowstone Lake is well suited for homing studies, since it is large and has enough tributaries (about 35) to provide adequate choice. This is analagous to the migration of mature salmon from the sea into freshwater streams. It also has an endemic cutthroat trout population, and has not been stocked with trout from other waters.

Release points A, B, and C (Fig. 1) were established equidistant on a line from the mouth of Pelican Creek to the mouth of Clear Creek. Distances (km) from the release points to the stream mouths are as follows:

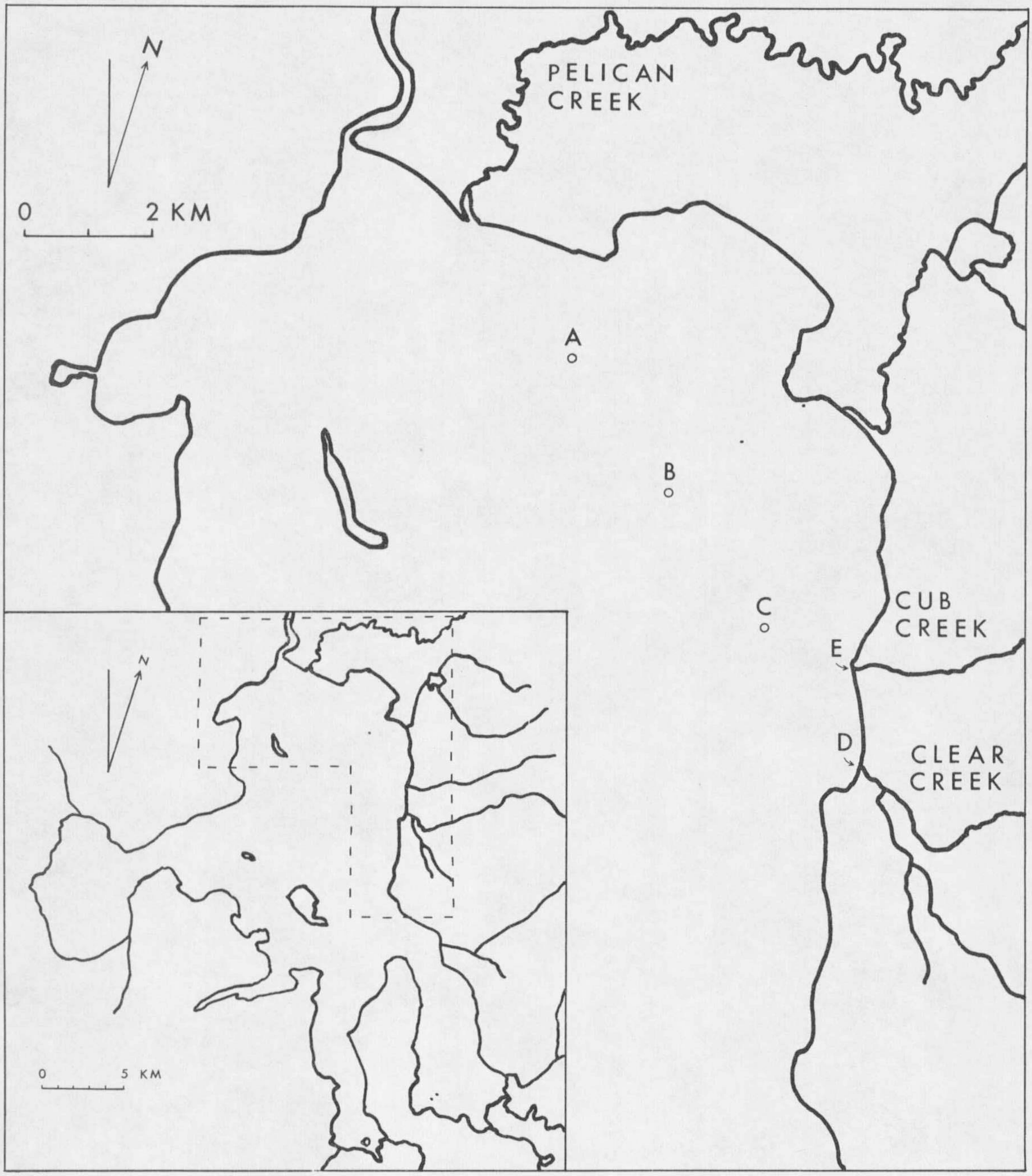

Figure 1. Map of northern portion of Yellowstone Lake showing release points and creeks where experimental cutthroat trout were trapped. Inset shows entire lake and principal tributaries.

	Release Points		
	A	B	C
Mouth of Pelican Creek	2.65	5.30	7.95
Mouth of Clear Creek	7.95	5.30	2.65
Mouth of Cub Creek	6.55	4.00	1.55

In 1964 these points were identified by sighting landmarks with unaided eye each time a release was made. In 1965 and 1966 point B was located with the aid of a sextant and a marker buoy was positioned there. In 1965 points A and C were not used, and in 1966 they were located with the aid of a sextant at the time of each release. Points D and E are in the mouths of Clear and Cub Creeks respectively, and are 1.65 km from one another.

DISPLACEMENT STUDIES

The cutthroat trout used were sexually mature, were moving upstream to spawn, and were collected from the Clear and Cub Creek fish traps. The Clear Creek trap was about 75 m above the stream mouth, and the Cub Creek trap was about 45 m above the mouth in 1964, but about 150 m above in 1965 and 1966, because Cub Creek shifted its course.

In 1964 a few fish at a time were netted from the trap and immediately placed in 15 liters of 1:5000 tricaine methanesulfonate (MS 222: Sandoz Pharmaceuticals) solution. After the fish were anesthetized a numbered monel strap tag (35.0 mm x 3.5 mm) was attached to the posterior edge of the operculum with the aid of a special plier. The total length of each fish was recorded. The sex was also recorded if obvious without extra handling. The fish recovered from the anesthetic after being placed in a covered tub containing 20-25 liters of fresh water. After several fish were tagged the tub was either carried to a boat and the contents emptied into a covered stock tank, or, if the release was to be made at the mouth of the same stream, carried directly to the stream mouth and the fish released. This procedure was repeated until the desired number of fish (10-50) was tagged and either released or placed in the tank. Water was added to make 115-175 liters in the tank. Approximate travel times to release points were as follows (minutes): to point A - 30, point B - 20, point C - 10, and between streams - 8. The maximum time from netting to release was always less than 2 hr, depending on distance to release point and number of fish tagged. Distress of fish at a release point occurred only in two instances. A few fish were not anesthetized and were marked by punching a 6.5 mm hole in the dorsal or caudal fin with a paper punch.

In 1965 and 1966, 5-15 fish were netted from the trap, immediately placed in a covered tub containing 20-25 liters of water, and carried either to the stream mouth or to the stock tank in a boat. This was repeated until the desired number of fish was secured. In 1965, 33-50 fish were released in each group, but in 1966 the number was 25. In addition several extra fish were carried along as spares. It took 16-20 min to reach release point A, 10-13 min to B, 6-8 min to C, and 5-7 min from one stream to the other.

In 1965 and 1966 tagging was done at the release point without anesthetizing or measuring the fish. A 28 mm x 5 mm alligator clip (Minigator: Mueller Co.) was attached to the posterior edge of the dorsal fin at its base with the long axis resting on the dorsal midline of the fish

(McCleave et al. 1967). Release groups were identified in 1965 by a common color code sprayed onto the clips. In 1966 the clips were individually coded by clamping numbered vinyl tubing (Spaghetti FT-4: Floy Tag and Mfg.) inside the prongs which normally clamp a wire. This did not increase the size of the tag but allowed recognition of each fish. Each fish was released immediately after tagging. The maximum time from netting to release was always less than 40 min. Nearly all fish were hauled under relatively calm lake conditions, but occasionally some sloshing of water did occur in the tank.

The fish traps were operated continuously throughout the spawning season except for brief periods of flood conditions. A U. S. Fish and Wildlife Service crew emptied the traps at least once each day, and two or three times when the run was large. All fish were examined for tags. During 1965 and 1966 my colleagues and I usually operated the traps two days each week. Code or tag numbers, date, time, total length, and sex were recorded for all recaptured fish. In addition the U. S. Fish and Wildlife Service periodically electrofished in various portions of the lake and outlet throughout all three summers and all captured trout were examined for tags. A number of tags were returned by anglers although their help was not solicited.

During 1966 releases were also made of tagged blinded, olfactory occluded (anosmic), and anesthetized controls, using the same general procedure as with the previously described 1966 releases.

At release point B, 1-5 fish at a time were anesthetized (1.0-1.5 min) in 1:7500 MS 222 solution. Fish were blinded by injecting 0.10-0.15

cm^3 of 3% aqueous benzethonium chloride (Phemerol: Parke Davis and Co.) into the eyeball. The eye became opaque and turned green immediately, and after several hours changed to white. Plugging of the nares was done with melted distilled acetylated monoglycerides (Myvacet, Type 5-00: Distillation Products Industries, Eastman Kodak Co.) (Bardach and Case 1965). The warmed material (which is liquid above 43° C) was injected from a veterinary syringe using a blunt needle into either the anterior or posterior naris on each side until it began to flow from the other naris. It immediately congealed into a tough, waxy solid which blocked water passage. Each fish was tagged with a numbered alligator clip and placed in a tub containing 25-30 liters of fresh water for a period of 4-7 min, and then released. Time from netting to release was less than 58 min for blind fish, less than 73 min for anosmic fish, and less than 45 min for control fish. Equal numbers of blind and control fish were released on one day, and equal numbers of anosmic and control fish were released on a different day. The heads of all recaptured anosmic fish were preserved for examination of the olfactory plugs.

FLOAT-TRACKING STUDIES

The polystyrene foam (Styrofoam: Dow Chemical Co.) float-tracking method described by Jahn (1966) was used to determine direction of "takeoff" of mature, migrating cutthroat trout displaced from tributaries to point B. The floats were Styrofoam cubes 5 cm on a side wrapped with aluminum foil. Each of these was connected by a 2 m nylon thread to an alligator clip used to attach the device to the dorsal fin. Four experimental groups of trout were tracked: blind (anesthetized and blinded), anosmic (anesthetized and olfactory occluded), control (anesthetized only), and non-anesthetized. Blind, control, and non-anesthetized Cub Creek trout and blind, anosmic, and control Clear Creek trout were tracked in 1965. Blind, anosmic, and control Clear, Cub, and Pelican Creek trout were tracked in 1966.

In 1965, 8-12 trout were netted from the traps and carried in two covered tubs of 20-30 liters water to the boat and either placed in the boat or emptied into a covered stock tank for transportation. Non-anesthetized trout were transported to point B, the floats attached, and 10 individuals released with as little handling as possible. All trout for the olfaction experiment were taken to point B and anesthetized in 1:7500 MS 222 solution. The nares of half of these were plugged using cotton soaked in Phemerol. Trout were allowed to recover in fresh water and then floats attached. Five anosmic and five control trout were released. Trout for the blinding experiments were treated in one of three ways. Most were hauled in tubs or a stock tank just offshore from the collection stream and anesthetized. Half of these were blinded by Phemerol injection and all were allowed to recover during the rest of the trip to point B. On one occasion several Clear Creek trout were hauled to the release point prior to anesthetizing and blinding. On two other occasions Clear Creek trout were anesthetized at the trap site and half of them were blinded. All were placed in a live box for recovery, one group for 91 hr, the other for 19 hr, prior to transportation to point B. Either four blind and four control trout or three blind and three control trout were released for each experiment.

In 1966, 4-10 trout were removed from the Clear, Cub, and Pelican Creek traps and carried to the boat. The Pelican Creek trap, about 2 km upstream from the mouth, was not very effective because of flood damage, but enough trout were captured for float-tracking experiments. Pelican Creek trout were transported in 35-40 liters of water by truck 4.4 km (about 5 min) to the boat, and Clear and Cub Creek trout were transported as in 1965. Just offshore the trout were anesthetized. Some were blinded with Phemerol, some plugged with either white petroleum jelly injected through a needleless syringe or with warmed Myvacet, and some simply placed back in fresh water. All were allowed to recover on the remainder of the trip to point B. Usually six trout (two blind, two anosmic, two control) were released at a time, but on one occasion only one of each kind was released. With the exception of those blind trout held in the live box the time from netting to release was always less than 90 min and usually less than 70 min.

Trout with attached floats were released individually, and sufficient time was allowed between releases to reduce the possibility of the floats becoming entangled. In all but the initial five 1965 experiments a drift drogue (Jahn 1966) suspended at 1 m was released as soon as the last fish had cleared the release area. After experimental fish had been at large for an average of 1 hr, they were picked up as quickly as possible. A large, stable azimuth sighting compass was used to obtain a bearing (to the nearest degree) from the fish to the release buoy. Distance to the buoy was not measured. After each sighting an attempt was made to pick up the trout for length measurement, sex determination, and in 1966 also for tagging with a numbered alligator clip. Nearly all fish were picked up, but a few pulled loose from the float or were not found before the termination of the experiment. A bearing from the drogue to the buoy was taken and the drogue recovered.

In 1965 one control trout, one blind trout and in 1966 one non-anesthetized trout (all from Clear Creek) were float-tracked individually from Point B for longer periods (3 hr 26 min-6 hr 20 min). These fish were subjected to the same treatment as groups in the short term experiments described previously. Sextant sightings of landmarks were used to make position plots at 15-45 min intervals depending on how far the fish moved. All experiments were terminated when the lake surface became so rough that accurate position plots were impossible.

STATISTICAL ANALYSES

Displacement Studies. Chi-square analyses were used to compare the numbers of trout recaptured from various releases. Expected numbers of fish in each cell of the Chi-square computation formula were obtained by multiplying the percent recapture of all release groups in the comparison by the number of fish in each release group.

The time from release to recapture among various release groups was compared using an analysis of variance for unequal sample sizes (Steel and Torrie 1960). Since the distribution of time to recapture (in hours) was skewed toward the longer times, each time value was transformed to its square root. All statistical analyses were performed on transformed data, but the mean time values are presented in hours. The adjusted mean is the square of the mean of the transformed data. If the analyses of variance did not yield significant F values, Bartlett's test for homogeneity of variance (Bartlett 1937a,b) was done as a further check on the assumptions of the analysis of variance model. If more than two release groups were compared in any analysis of variance, Duncan's new multiple-range test (Duncan 1955) was performed on the ranked means of the transformed data to compare all pairs of means.

Float-Tracking Studies. The observed directions from the release buoy to float-tracked trout were represented as points of equal mass on the circumference of a unit circle. An empirical mean vector pointing to the center of mass of the distribution of each group of fish was calculated with polar coordinates *r* (length) and *a* (angle) (Batschelet 1965). The Rayleigh test (Greenwood and Durand 1955) for a significant *r* value was then used. If *r* was significantly greater than zero, the null hypothesis of a uniform circular distribution was rejected. A resultant vector F test (Watson and Williams 1956) was used to compare the mean directions (*a*) of two groups of tracked trout. Another test statistic, R, based on a resultant vector (Watson and Williams 1956, Stephens 1962) was used to determine if the mean direction (*a*) of a group of trout was significantly different from the homestream direction. A concise discussion of all these methods is given by Batschelet (1965).

RESULTS

DISPLACEMENT STUDIES

Tagging and displacement of 1,137 Clear Creek and 771 Cub Creek cutthroat trout were done from 15-27 July 1964, 7-17 July 1965, and 27 June-13 July 1966. A summary of displacement and recapture is shown in Table I, and Chi-square values for certain comparisons are shown in Table II.

Clear Creek trout homed about equally well in 1965 and 1966 and significantly better in both years than in 1964. The same was true of Cub Creek trout. Straying of both Clear and Cub Creek trout was greater in 1965 and 1966 than in 1964, but in the case of 1965 Clear Creek trout the difference was not significant. Straying was about equal among Cub Creek trout in 1965 and 1966, but among Clear Creek trout it was greater in 1966 than in 1965. Total recapture percentages (including angler returns) for both streams were about equal in 1965 and 1966, and were greater than in 1964. The percentage of trout homing was significantly greater than the percentage straying in all three years for both streams.

In 1964 Cub Creek trout homed in significantly greater percentage than Clear Creek trout, but in 1965 and 1966 the reverse was true. In all three years Cub Creek trout strayed significantly more than Clear Creek trout. In 1964 the total percent recapture of Cub Creek trout was greater than that of Clear Creek trout. In 1965 and 1966 total recaptures of the two streams showed a non-significant difference of less than 2%.

In 1966 Clear and Cub Creek trout were displaced to all release points. No significant differences in homing were found among releases at open-water points, or were any trends evident. Trout displaced to the

Table I. Summary of displacement and recapture of Clear and Cub Creek trout during late June and July, 1964, 1965, and 1966. (Percentages in parentheses. Discrepancies in row percentage sums result from rounding numbers.)

Origin stream	Year	Release point	Number released	Number of recaptures: Homing	Straying	Angling	Total
Clear	1964	A	35	4(11.4)a/	1 (2.9)	1 (2.9)	6(17.1)
		B	150	7 (4.7)	1 (0.7)	2 (1.3)	10 (6.7)
		C	158	18(11.4)b/	2 (1.3)	3 (1.9)c/	23(14.6)
		Mouth Clear Cr.	20	3(15.0)	0 (0.0)	1 (5.0)	4(20.0)
		Total	363	32 (8.8)	4 (1.1)	7 (1.9)	43(11.8)
Cub	1964	B	20	4(20.0)	0 (0.0)	1 (5.0)	5(25.0)
		C	106	19(17.9)	5 (4.7)	3 (2.8)	27(25.5)
		Mouth Cub Cr.	10	1(10.0)	1(10.0)	0 (0.0)	2(20.0)
		Mouth Clear Cr.	10	4(40.0)	1(10.0)	1(10.0)c/	6(60.0)
		Total	146	28(19.2)	7 (4.8)	5 (3.4)	40(27.4)
Total	1964	All points combined	509	60(11.8)	11 (2.2)	12 (2.4)	83(16.3)
Clear	1965	B	274	122(44.5)	7 (2.6)	2 (0.7)	131(47.8)
		Inside Mouth Clear Cr.	50	24(48.0)	0 (0.0)	0 (0.0)	24(48.0)
		Outside Mouth Clear Cr.	50	24(48.0)	0 (0.0)	0 (0.0)	24(48.0)
		Total	374	170(45.5)	7 (1.9)	2 (0.5)	179(47.9)
Cub	1965	B	175	57(32.6)	27(15.4)	1 (0.6)	85(48.6)
		Inside Mouth Cub Cr.	25	9(36.0)	0 (0.0)	0 (0.0)	9(36.0)
		Outside Mouth Cub Cr.	25	9(36.0)	2 (8.0)	0 (0.0)	11(44.0)
		Total	225	75(33.3)	29(12.9)	1 (0.4)	105(46.7)
Total	1965	All points combined	599	245(40.9)	36 (6.0)	3 (0.5)	284(47.4)