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Title: Ecology of Underyearling Summer Steelhead Trout in Intermittent Streams Tributary to the Rogue River, Oregon

Abstract approved: Redacted for privacy

James D. Hall

Juvenile summer run steelhead trout (Salmo gairdneri) of the Rogue River, Oregon were studied from emergence through emigration from natal streams. Objectives of the study were to describe the emigration process, describe certain characteristics of the environment of the fry, and determine the mechanisms that influence emigration from the streams. The emigration process and characteristics of the environment were examined in Kane and Galls creeks, two intermittent tributaries of the Rogue River. Factors that might influence migratory activity of the fry were examined in Kane and Galls creeks, in a third tributary of the Rogue (Foots Creek), and in the laboratory in aquaria and an artificial stream channel.

Emergence and emigration from natal streams began in April. Emergence ended during June. Emigration continued until July and

August, when movement downstream was halted by intermittent streamflows. Number of emigrants varied by tributary and year and ranged from about 39,000 to 106,000.

Emigrants were of two fairly distinct size groups: 26-33 mm and 38-87 mm long. Movement downstream by the smaller fry occurred only during darkness, was predominantly passive, and was usually at or near the water surface. Smaller fry did not school; they maintained positions in the substrate and pools during the day and at the water surface immediately along the shoreline at night. Movement downstream by the larger fry was predominantly active and appeared to be directed. Early in the emigration the larger fry migrated individually and only during darkness, but later they also migrated during daylight, often in schools. Movement downstream was usually at or near the surface during darkness and near the bottom and at intermediate depths during daylight. Larger fry maintained positions throughout the streams during daylight and darkness.

During the emigration periods, average daily stream temperatures ranged from 6.5 to 19.7°C and stream discharges decreased from about 280 to less than 12.5 liters/second. The lower rate of discharge was insufficient to maintain continuous surface flows in the lower reaches of the tributaries.

Factors that influenced the migratory activity of recently emerged fry and larger fry differed. Emigration by most of the recently emerged fry was associated with vertical movement away from the substrate during darkness. Upon apparent loss of visual and tactile orientation during darkness, recently emerged fry were carried downstream by the current. Disturbances such as rain striking the water surface and low intensity agonistic behavior among fry congregated along the shoreline at night were associated with movement downstream. Movement downstream by the larger fry was probably influenced most by their requirements for food and space. As fry size increased and habitat area decreased, fry that had apparently become resident emigrated from the tributaries. Stream temperature did not appear to be an influential factor in the fry migrations. Comparisons of behavior and migratory activity of fry of three stocks of steelhead indicated that the summer run stock of the Rogue River does not possess unique innate characteristics that trigger or influence emigration from natal streams.

Ecology of Underyearling Summer Steelhead Trout
in Intermittent Streams Tributary to
the Rogue River, Oregon

by

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ECOLOGY OF UNDERYEARLING SUMMER STEELHEAD TROUT IN INTERMITTENT STREAMS TRIBUTARY TO THE ROGUE RIVER, OREGON

INTRODUCTION

Most tributaries of the Rogue River where anadromous summer steelhead trout (*Salmo gairdneri*) reproduce are unsuitable rearing areas for juveniles (Everest 1973). Tributaries that accommodate intensive spawning activity in winter become intermittent or completely dry in summer. Water temperatures in most of those tributaries that do maintain intermittent flows throughout the summer reach levels lethal to salmonid fry. To avoid lethal temperatures in the intermittent tributaries and keep from being stranded in the dry tributaries, the fry must move within 60 to 90 days after emergence to favorable rearing areas in larger tributaries and the main river.

The purpose of my study, conducted during 1970 and 1971, was to describe the ecology of underyearling summer steelhead from emergence until emigration from natal streams. Specific objectives were to (1) describe the emigration of underyearling summer steelhead from two tributaries to the Rogue River; (2) describe certain characteristics of the environment of underyearlings during natal stream residence; and (3) determine the mechanisms that control or influence emigration from natal streams.

Directed migrations of salmonid fry have been studied extensively. The studies have demonstrated that a thorough understanding of the mechanisms that trigger and control fry movement is essential for effective management and enhancement of salmonid stocks. They have also revealed the variability in migratory response that is displayed by different species and even by populations of the same species. For example, Raleigh (1967) found that the time and direction of migration of lake outlet and tributary spawning sockeye salmon (Oncorhynchus nerka) fry was of genetic origin. Northcote (1962), working with Loon Lake rainbow trout (Salmo gairdneri), concluded:

> "Differences in water temperature between outlet and inlet creeks regulate differences in direction of migration through action on behavior associated with downstream movement, maintenance of position, and upstream movement."

Northcote's (1969) study of rainbow trout fry in the upper Lardeau River suggests the existence in Kootenay Lake rainbow of an intrinsic downstream migratory response that is reversed during the later part of the fry migration period by rising water temperature.

Previous studies of salmonid fry migrations have focused on the Pacific salmon (Oncorhynchus spp.), on the freshwater resident rainbow trouts, and on the winter run steelhead trout. My work supplements Everest's (1973) investigations of summer steelhead in the Rogue River and will be useful for management of that stock and protection of its habitat.

DESCRIPTION OF THE FIELD STUDY AREA

The field portion of the study was conducted in Kane, Galls, and Foots creeks in southwestern Oregon, east of the Coast Range in the central inland valley of the Rogue River drainage (Fig. 1). Watersheds of these streams drain directly into the Rogue River between river kilometers 182 and 193. Climate in the area is generally mild. Average monthly temperatures range from 2.6°C for January to 22.0°C for July for a mean annual temperature of 11.7°C.[1] Average annual precipitation for the period 1962-1972 was 52.7 cm. Annual precipitation for 1970 and 1971 was 59.1 and 49.2 cm, respectively. Most precipitation occurs as rainfall during the winter. Only about 12 percent of the annual rainfall occurred from April through August in 1970, and only 20 percent in 1971.

The physical characteristics of the watersheds and surrounding land uses are typical of the major spawning areas of Rogue summer steelhead (Table 1). Tributary watersheds are small with generally steep to rolling hills and narrow valley floors. Predominant vegetation is coniferous at higher elevations and mixed conifer and hardwood at lower elevations. Streamside cover is quite dense and consists primarily of alder, willow, and blackberry. There is logging activity in the uplands and agriculture (cultivated crops, pasture lands, and fruit orchards) and suburban development in the lowlands.

[1] Temperature and precipitation were recorded at the Medford Airport. Mean temperatures are based on the period 1941-1970.

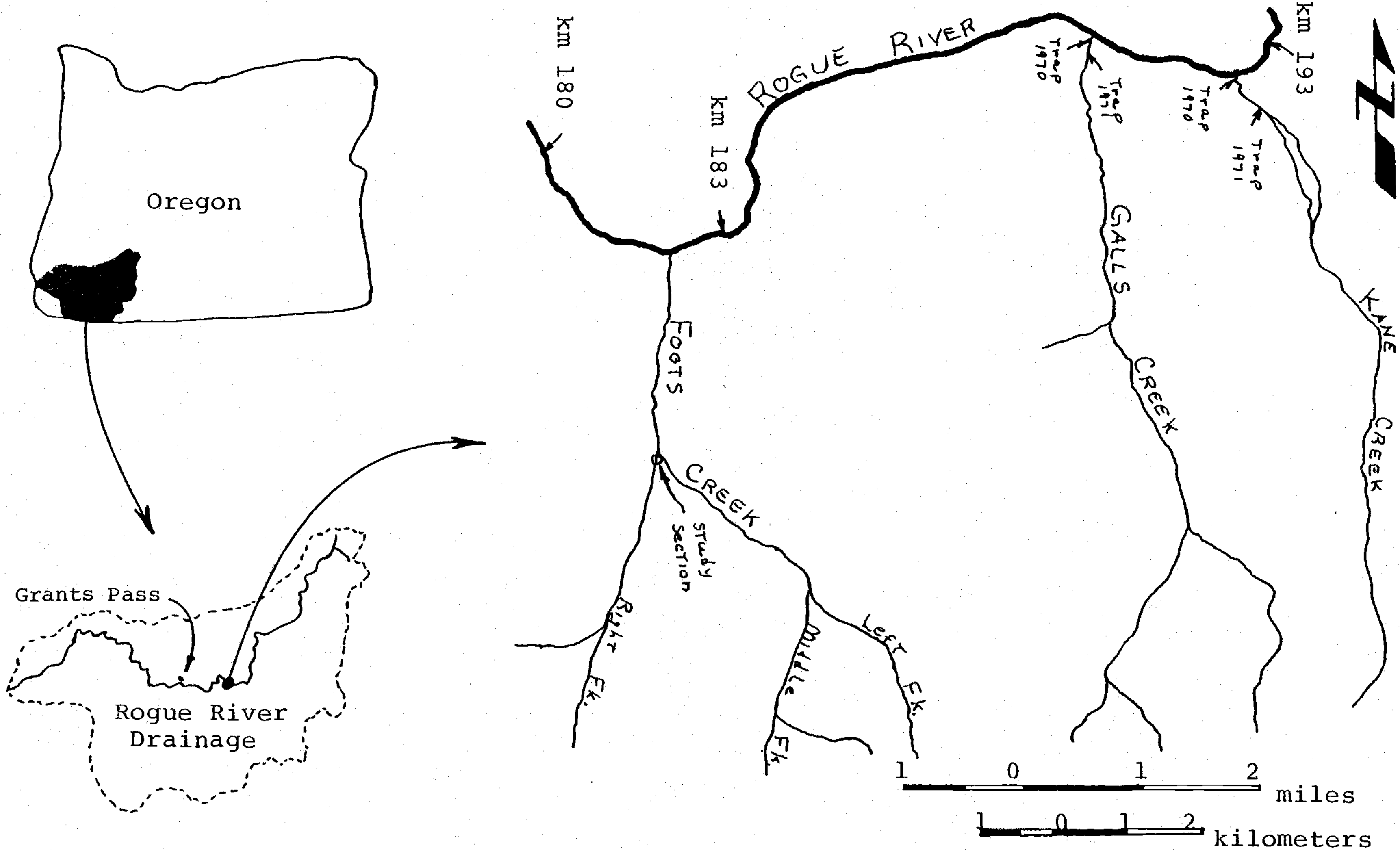

Figure 1. Location of study streams.

Table 1. Some physical characteristics of Kane, Galls, and Foots creeks.

Tributary	Rogue River Kilometer	Kilometers of Steelhead Habitat[a]	Average Gradient (m/km)[b]	Estimated Number of Spawners[c]	Watershed Area (ha)[c]
Kane	192.3	5.6	21.7	>1,000	2,720
Galls	190.3	7.2	25.3	>1,000	3,704
Foots	182.6	8.0[d]	22.7	>1,000	7,097

a) Source: figures for Kane and Galls creeks from Oregon State Game Commission (1971) figure for Foots creek from Michael Jennings, Oregon Department of Fish and Wildlife, Grants Pass, Oregon.

b) Applies only to kilometers of steelhead habitat (distance from the tributary mouth).

c) Everest (1973)

d) Includes 3.2 km of main Foots Creek, 1.6 km of Right Fork, 2.4 km of Left Fork, and 0.8 km of Middle Fork.

Physical characteristics of the streams are similar. Substrate consists of bedrock, sand, gravel, and rocks up to about 60 cm in diameter. Average water temperatures in Kane Creek for the period December 21 through February 17, 1969-70 and 1970-71 were 6.7 and 6.4°C, respectively (Everest 1973). Temperature in Kane Creek during the fry migration periods (April-July) averaged 15.4°C in 1970 with daily fluctuations up to 8.9°C, and 12.8°C in 1971 with daily fluctuations up to 6.7°C. The study streams sustain flows less than 1.5 m^3/s in winter and are intermittent or dry in summer. Irrigation dewatering of the tributaries and irrigation return flows influence streamflows in spring and summer, which in turn influence fish populations.

Summer steelhead fry were not the only fish in the streams during the fry migration period. The tributaries contained substantial numbers of summer steelhead parr and smolts that entered the tributaries during the winter freshets and left during the early part of the fry migration (Everest 1973). Adult steelhead, resident rainbow trout (*S. gairdneri*), cutthroat trout (*S. clarki*), sculpins (*Cottus spp.*), and larval and adult lampreys (*Lampetra spp.*) were also captured in the downstream migrant traps.

METHODS

Fry Enumeration

Timing and size of migrations were determined with trap boxes used in conjunction with temporary weirs. In April 1970, low weirs were constructed on Kane and Galls creeks approximately 70 and 100 m, respectively, from the tributary mouths. The entire streamflow spilled over the weirs and into the traps. Essentially all fish passing downstream were captured. Removable baffles were arranged inside the trap boxes to allow captured fry protection from turbulence and predation by larger fish. The traps were usually checked daily. Fish were removed from the traps, counted, and released immediately below the weirs. Estimates of the number of migrants for days that the traps were not in operation were made by averaging numbers of fry counted on the days preceding and following the days missed.

Midway through the 1970 migration period I discovered that the water level in a nearby irrigation canal was regulated by the periodic spilling of excess canal water into Kane and Galls creeks. In order to avoid influences that the spilling may have had on fry movement and stream temperature and flow in 1970, new trapping sites were established upstream of the canal spillways in 1971. Modifications of the trapping apparatus in 1971 (larger trap box and by-pass of excess water) provided greater trap efficiency and fewer mortalities. Also, a short flume directed the water passing over the weir through a grading device that was situated directly over the trap box. The grader segregated small fry, large fry, and juvenile and adult fish in appropriate wire trapbaskets and effectively eliminated intra- and interspecific (cutthroat and sculpin) predation within the trap.

Fry Size

Samples were taken to determine fry length and stage of development both from the traps and from areas within the study streams well above the trapping sites. Trap catch was sampled periodically in 1970 and daily in 1971. Sampled fry were anesthetized with MS 222 (tricaine methanesulfonate), measured, allowed to recover in fresh water, and released immediately below the trap.

The fry populations approximately 1-2 km above the traps were sampled weekly in 1971 with a backpack electrofishing unit. Sampled fry were returned to the stream area from which they had been removed.

Diel Migrations

Two methods of observation were used to determine the existence of any diel patterns in the migratory activity of the fry. Trapped fry were enumerated several times a day on a number of days (morning to morning) and timed counts of the number of fry passing over the trap weir were conducted. Trap catches were enumerated after 1 to 8 hours of operation. The timed counts at the weir ranged from 5 to 20 minutes and were usually conducted at night. Counts were made during periods of darkness with a military surplus monocular infrared viewer and a 12-volt, 15-watt infrared lamp.

Fry Behavior

Fry behavior was observed periodically at random locations on Galls Creek and more frequently at regular observation areas on Kane Creek. Behavior of Kane Creek fry was observed at the weir and in areas of the stream that had been divided into sections approximately 30-cm square or 30-cm wide. Occurrence of fry, their activity, and their vertical distribution were noted. Observations were made during the day from concealment on the stream bank. I made observations at night from beside, over, and while standing in the stream with the infrared viewer and lamp. I monitored permanence of position and downstream movement of some fry by releasing fish that had been marked with fluorescent granules.

Water Temperature and Flow

Water temperatures were recorded continuously throughout the 1970 and 1971 emigration periods with Partlow 7-day thermographs. Calibration of the recorders was checked periodically with a pocket thermometer. Streamflow was recorded weekly, usually during the morning when withdrawal of stream water for irrigation was least likely to be occurring. Measurements were made either in stream reaches with uniform channels or in weir flumes (1970) and in chutes specifically constructed for this prupose (1971).

Population Density

The relationship between population density and movement downstream by fry was tested in an artificial stream channel (Fig. 2)

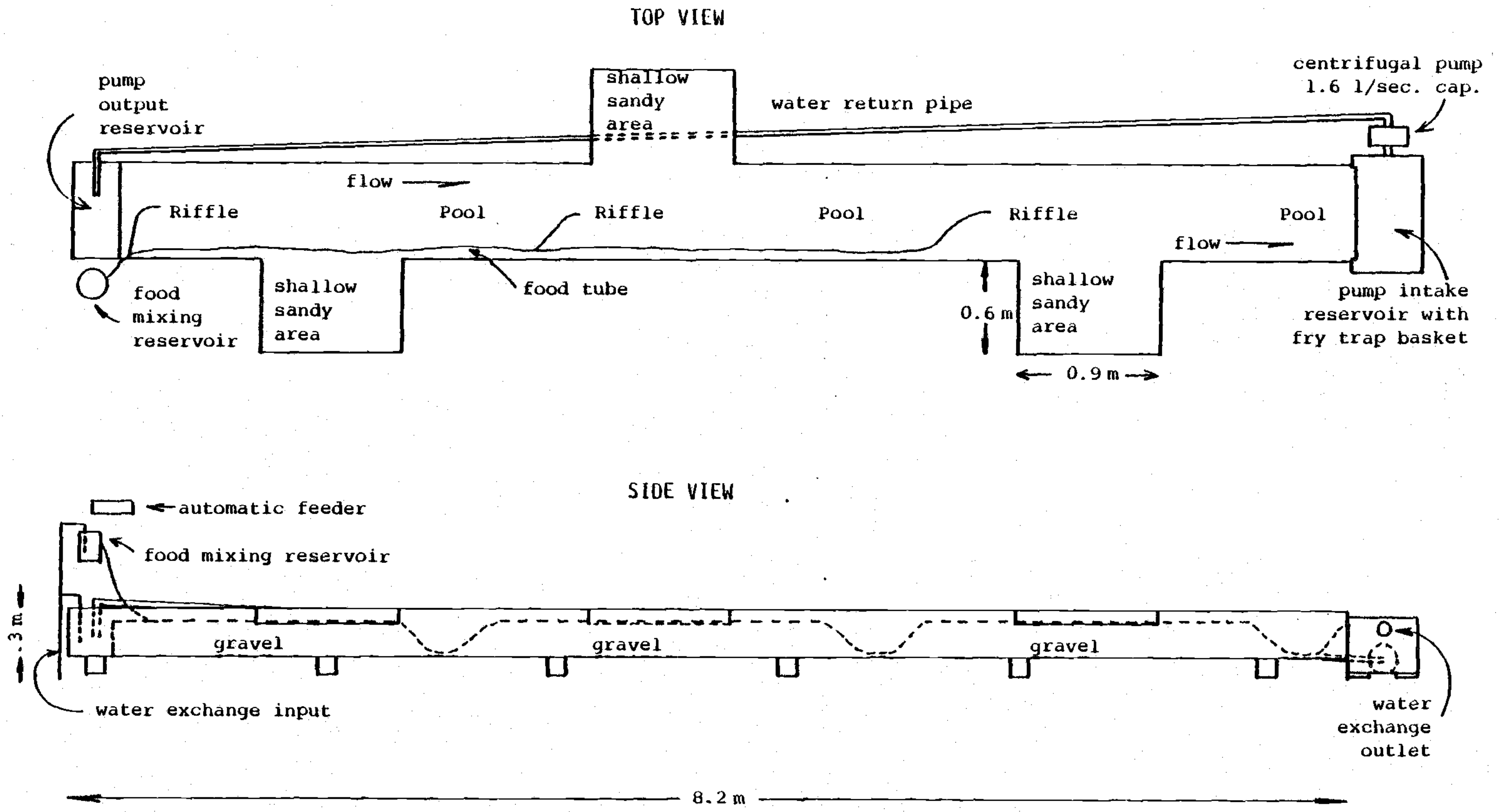

Figure 2. Artificial stream channel. The channel was constructed of 1.3-cm exterior plywood and sealed with a non-toxic light green paint.

and in three plastic aquaria at the Oregon Department of Fish and Wildlife laboratory at Corvallis, Oregon. The apparatus was enclosed on two sides with a black plastic curtain. Three large windows in the south wall and one in the east wall of the laboratory provided a natural light cycle. The artificial channel and plastic aquaria were supplied with nearly constant 12^{o}C well water.

The bottom of the channel was arranged to create an alternating series of three riffles and three pools. Substrate consisted of 1-4 cm diameter smooth gravel, 2-8 cm deep. Large stones up to 18 cm in diameter were randomly placed throughout the channel to provide resting areas and cover for the fry. Three 0.55 m^2 sandbar areas helped simulate a natural environment. Water depth averaged 21 cm in the pools, 7 cm in the riffles, and ranged from 0 to 0.5 cm on the sandbars. Water velocities ranged from 5 to 8 cm/sec and water temperatures ranged from 11.8 to 14.8^{o}C.

While in the channel, fry were fed hatchery mash (Oregon Moist Pellet). An automatic feeder deposited the mash in a food reservoir that drained slowly through plastic tubing into the upper, mid, and lower sections of the channel.

The aquaria were transparent, 41 cm high and 30 cm in diameter and were conical at the base. The bottom of each aquarium contained up to 10 cm of smooth, rounded stones, 2-8 cm in diameter. Black plastic taped to the outside of the base of each aquarium prevented light from infiltrating the substrate laterally and from below. A standpipe at the center of each aquarium maintained water volumes at 19 liters. Exchange water, sprayed at an angle onto the water surface at the perimeter of each aquarium, created a clockwise flow that ranged from 6 cm/sec around the perimeter of the aquaria to near 0 around the standpipe. Water temperatures ranged from 11.9 to 12.3^{o}C. Fry in the aquaria were fed the same diet in a similar manner as those in the artifical channel.

The following races of steelhead were used in laboratory and field experiments: Rogue River (summer and winter), Umpqua River (summer), and Hood River (winter). Eggs from each group were obtained either on the spawning grounds by electrofishing or from upstream traps at hatcheries or dams. Eggs were fertilized when taken, allowed to water harden and transported to the Corvallis laboratory. Incubation of the eggs and development of the alevins were regulated in Heath incubators with 12.2^{o}C and 5.6^{o}C water. Batches of fry that had developed at 5.6^{o}C were placed in trays with 12.2^{o}C water for at least 3 days before test lots of fry drawn from those batches were used for experiments.

The relationship between population density and movement downstream by the fry was measured by the number of fry that left the channel and the frequency of aggressive encounters among individuals in the aquaria. Test lots that contained either 15, 25, 50, or 75 Rogue summer fry were placed in the channel. Lots of either 5, 10, or 25 fry were placed in separate aquaria. Observations during daylight were made through slits in the plastic curtain and through the windows. During darkness, fry were observed from beside the channel and aquaria with the infrared viewer and lamp.

Innate Behavior

The behavior of Rogue summer, Umpqua summer, and Hood winter steelhead fry was observed in the laboratory and in a section of a tributary of the Rogue to determine if Rogue summer steelhead fry displayed racially distinct behavioral characteristics that might account for early emigration from their natal streams. Rouge and Umpqua summer fry that were observed in the aquaria for density responses were observed concurrently for other behavioral traits that might influence downstream movement. In 1971, a study section was established on Foots Creek to test for racial differences in downstream movement by fry of Rogue summer, Hood winter, and Umpqua summer steelhead under field conditions. The study section was approximately 85 m long and averaged 3.7 m wide. The upstream half of the section was shallow riffle and the downstream half deep riffle and pool. Mid-channel depths ranged from approximately 5 cm to 0.9 m. Streamflow ranged from 25 to 2.5 l/sec during the study period. Water temperature ranged from 13 to 16^{0}C. Native fish and fry that remained after successive tests were removed from the study area with explosives. A single string of primacord was laid zig-zag along the stream bottom the length of the study area. The charge was deontated with an electrical blasting cap and flashlight battery. Isolated groups of fry were removed with a blasting cap "gun" (Everest 1978). Reinvasion of the study area by native fish was prevented by a 3.2 mm-mesh galvanized wire fence at the upper end, and by a low weir and trap box at the lower end.

The fry used in the Foots Creek studies were obtained and treated in the same manner as fry tested in the laboratory. They were transported from the Corvallis laboratory to Foots Creek (approximately 4-hour drive) in a 95-liter plastic can. The water was cooled with a floating block of ice and oxygenated with bottled pure oxygen. Prior to being tested, the fry were acclimatized for at least 12 hours in a covered wire basket placed in a quiet area of the stream. Test lots containing either Rogue summer, Hood winter, or Umpqua summer steelhead fry were individually introduced to the study area and downstream movement of the fry observed. Each test lot contained approximately 700 fry that were released in quiet water immediately below the fence. The magnitude and timing of downstream movement by fry of each test lot were monitored by trap catch.

RESULTS AND INTERPRETATION

Description of Emigration

Timing

Emigration from their natal streams by underyearling summer steelhead began immediately after emergence, was characterized by several periods of rapid increase in the rate of emigration, and terminated when streamflows became intermittent. Downstream movement of fry had already begun in Kane and Galls creeks by the third week in April 1970, when the traps were installed. In 1971, the first migrants were captured on April 15 in Kane Creek and on April 25 in Galls Creek. Relatively gradual increases in migratory activity that occurred early in the migration periods were followed by at least two periods of substantial increase in the rate of emigration (Fig. 3). Kane Creek was intermittent at kilometer 3.4 by May 24, 1970 and June 24, 1971 with an approximate streamflow of 20 l/sec. Galls Creek was intermittent 50 m from its confluence with the Rogue by June 18, 1970 and July 22, 1971 when streamflow dropped to approximately 12 l/sec. Periodic spills of excess irrigation water into Galls Creek and occasional rainfall could have reestablished continuous flows that permitted limited downstream movement of fry after those dates. However, by July 12, 1970 and August 5, 1971 both tributaries contained substantial distances of dry streambed and subterranean flow so the traps were removed.

The timing of emigration appears to be influenced by tributary temperature. Everest (1973) reported that spawners began

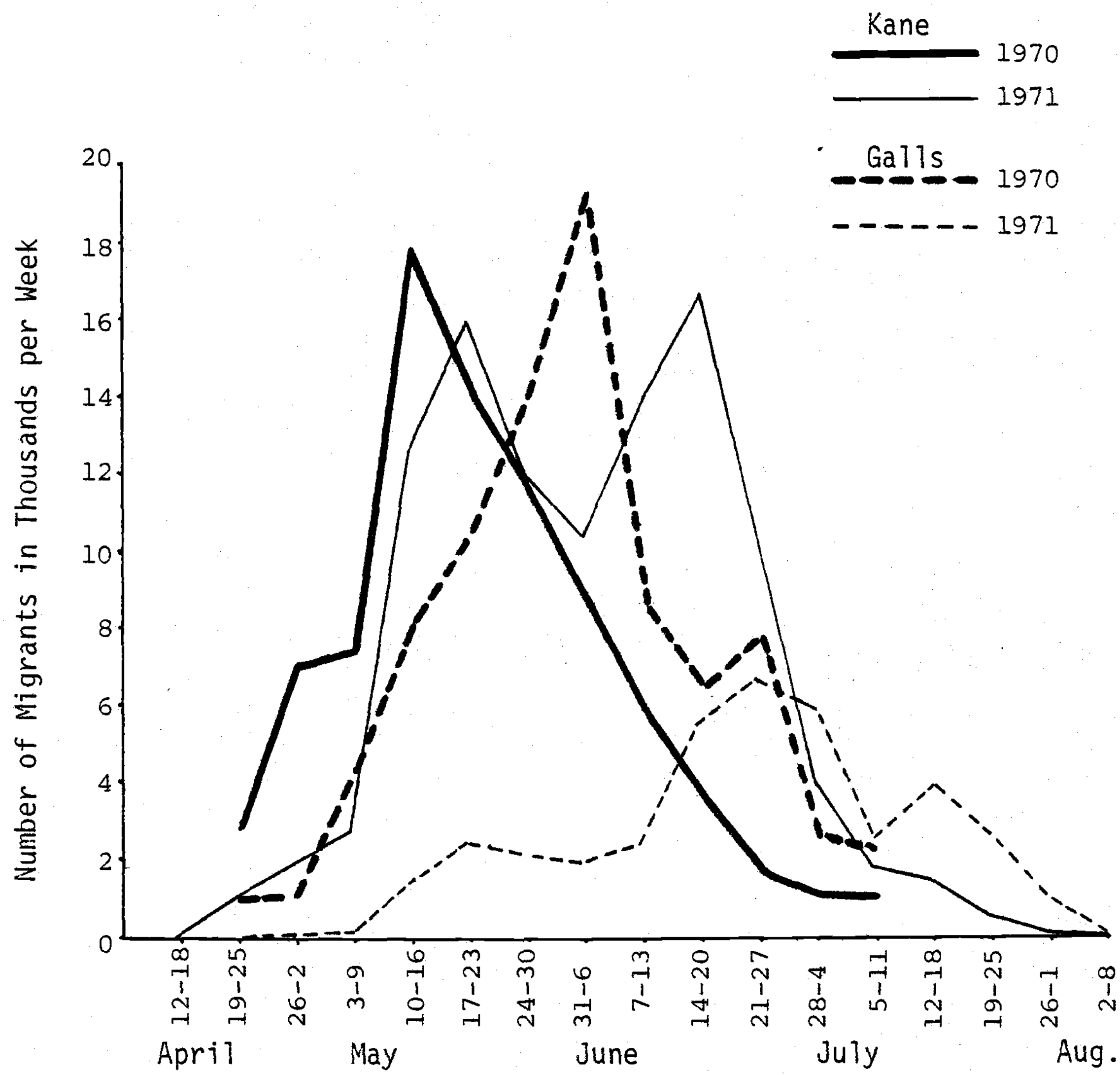

Figure 3. Total (observed plus estimated) number of underyearling summer steelhead that emigrated from Kane and Galls creeks during 1970 and 1971. Migrations were in progress in 1970 when trapping was begun.

entering all of the tributaries simultaneously and that the number of spawning adults in Kane Creek peaked during the same weeks in 1970 and 1971. Yet, based upon the rate of increase in migratory activity during the first few weeks of the 1971 emigrations (Fig. 3), downstream movement of fry probably began 2-3 weeks later in 1971 than in 1970. Colder water temperatures during 1971 (Everest 1973) would have retarded egg incubation and fry emergence and could have caused a later beginning of emigration in 1971. Similarly, colder temperatures in Galls Creek than in Kane Creek prior to and during the first 3 weeks of both emigration periods probably account for the difference between tributaries in timing of initial migratory activity in both years. However, two distinct peaks in Kane Creek in 1971 and several periods of substantial increase in migratory activity in both tributaries in both years suggest that factors other than temperature also influence the intensity of downstream movement of fry once the migrations have begun.

Numbers of Emigrants

More than 83,000 summer steelhead fry from Kane Creek and 86,000 from Galls Creek entered the Rogue River in 1970. The number of migrants from Kane Creek increased substantially in 1971 while the number of emigrants from Galls Creek decreased by more than 50 percent (Table 2).

Table 2. Number of migrants captured and estimated total number of migrants from Kane and Galls creeks, 1970 and 1971.

Year	Kane Creek Migrants Captured	Kane Creek Estimated Total Migrants	Galls Creek Migrants Captured	Galls Creek Estimated Total Migrants
1970	56,458	83,200	51,782	86,200
1971	91,067	106,000	30,981	39,300

Many fish were prevented from entering the Rogue when tributary flows became intermittent. By June 24, 1971, Kane Creek was intermittent about 1,800 m upstream of the trap. From that date until the end of the migration, approximately 12,000 fish that had been distributed throughout the 1,800 m of stream between the trap and the intermittent area, or approximately 6.8 fish/m, emigrated from Kane Creek. If the 3,100 m of known steelhead habitat lying upstream of the dry area (OSGC 1971) also contained 6.8 fish/m, an estimated 21,000 fish were unable to move downstream after the tributary first became intermittent on June 24. The situation was similar in Galls Creek, which was intermittent immediately upstream of the trap by August 5, 1971. Sampling of population density at four locations upstream of the intermittent area (Table 3) yielded an average fish abundance of 5.2 fish/m. An estimated 35,000 fry were prevented from emigrating from the 6,800 m of steelhead habitat upstream of the intermittent streamflow on Galls Creek.

Table 3. Number of underyearling steelhead captured by electrofishing between 0.8 and 7.2 km upstream of Galls Creek trap, August 5 and October 18, 1971.

Date	Distance Above Mouth (km)	Distance Above Trap (km)	Number of Fish	Distance Shocked (m)	Fish per Meter
8/5	7.2	6.8	68	23	3.0
	4.4	4.0	83	31	2.7
	2.4	2.0	89	6	14.8
	1.2	0.8	4	40	0.1
10/18	2.4	2.0	67	15	4.5
	1.2	0.8	8	55	0.1

Some fry that are prevented from emigrating from their natal streams over the summer do manage to survive. On October 18, 1971, two areas of Galls Creek that had been sampled the previous August were again sampled (Table 3); average population density was 2.3 fish/m. By October, air and water temperatures had begun to decrease so many of those fry were probably still alive in November when the autumn rains reestablished a continuous streamflow.

The reasons for the differences from 1970 to 1971 in numbers of emigrants from Kane and Galls creeks are unknown. In Kane Creek, the greater number of emigrants in 1971 may have been associated in part with an increase in spawners. Everest (1973) reported a higher spawning escapement for the Rogue drainage in 1970 than in 1969, and in a 458-m study section of Kane Creek he observed an increase from 81 spawners in 1969 to 97 spawners in 1970. Influences other than escapement that may have accounted for the increase in emigrants from Kane Creek and the substantial decrease in emigrants from Galls

Creek during the same period were probably environmental and occurred after egg deposition.

Size of Emigrants

Emigrant fry were of two fairly distinct size groups that varied slightly between tributaries. Periodic sampling in 1970 and daily sampling in 1971 revealed that all of the emigrants from Kane Creek were from 26 to 33 mm long until the fourth week of the emigration, when fry ranging from 36 to 55 mm also began to move downstream. Both size groups then left Kane Creek until the eleventh week of the emigration. By then, movement of the smaller fry had stopped and the length of the larger emigrants had increased to 83 mm (Fig. 4). In Galls Creek in 1971, most emigrants were from 26 to 33 mm long until the third week of the emigration. From the third to the ninth weeks, two groups consisting of fry that ranged from 26 to 35 mm and 38 to 75 mm, respectively, moved downstream together. Movement downstream by the smaller fry had stopped by the tenth week of the 1971 emigration from Galls Creek.

The relative absence of emigrants 34-37 mm long persisted throughout the emigrations from both tributaries and allowed a size classification of the fry that emigrated Kane Creek as they were enumerated. Fry 35 mm and smaller were classified as "small" and those 36 mm and larger were classified as "large". Approximately 20 percent of the fry that left Kane Creek in 1971 were small fry (Fig. 5). Although few fry 34-37 mm long moved downstream in either tributary, there were fry in that size range present in the streams (Fig. 4).

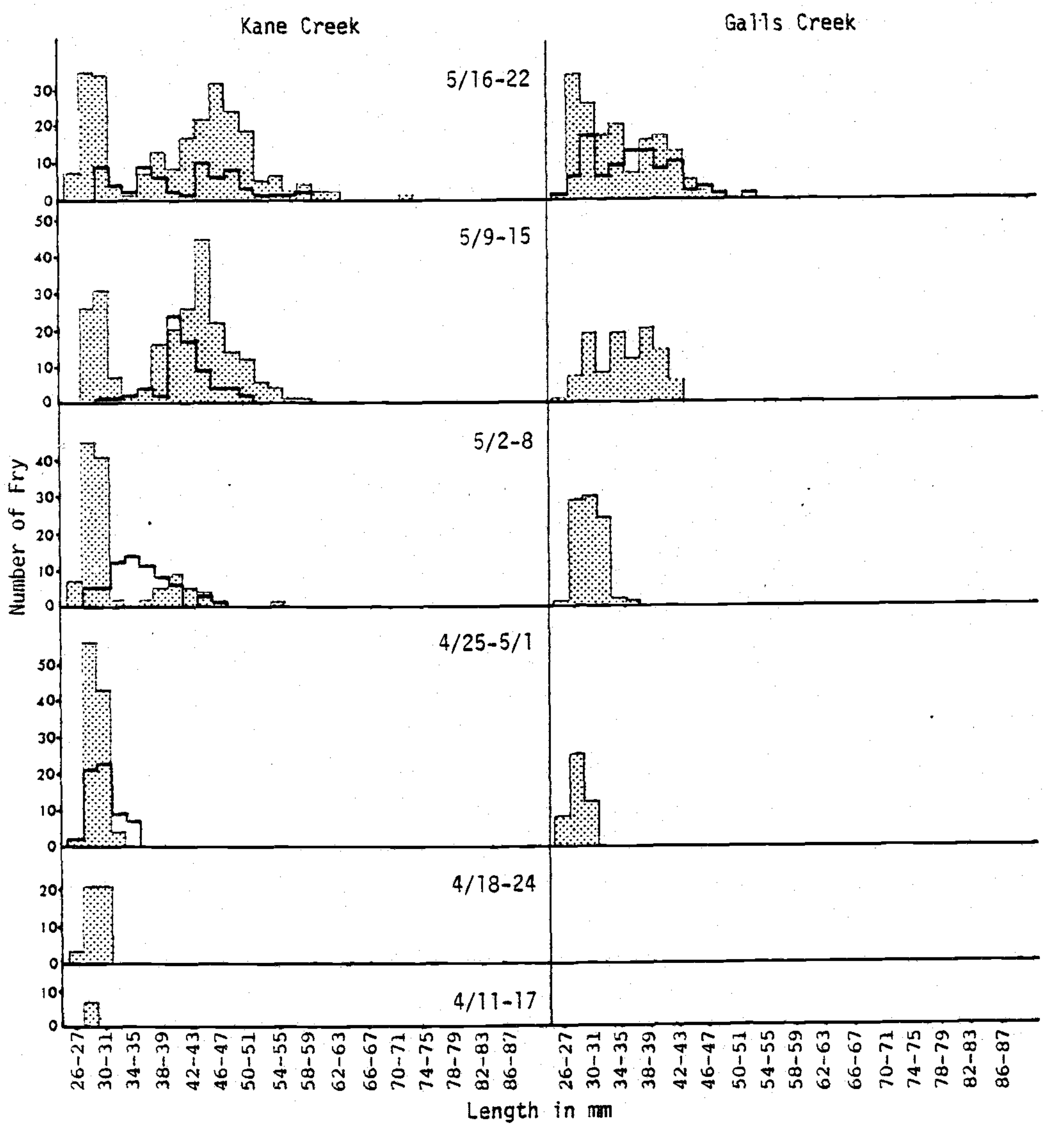

Figure 4. Length frequencies of underyearling summer steelhead sampled from the trap (shaded) and by electric shocker from reaches upstream of the trap (bold line) during the 1971 emigration period. Trap samples were collected daily and combined by week, shocker samples were collected one day per week. Note the size groups of emigrant fry (trap samples) and the presence in the tributaries of fry 34 to 37 mm long that did not emigrate (shocker samples).

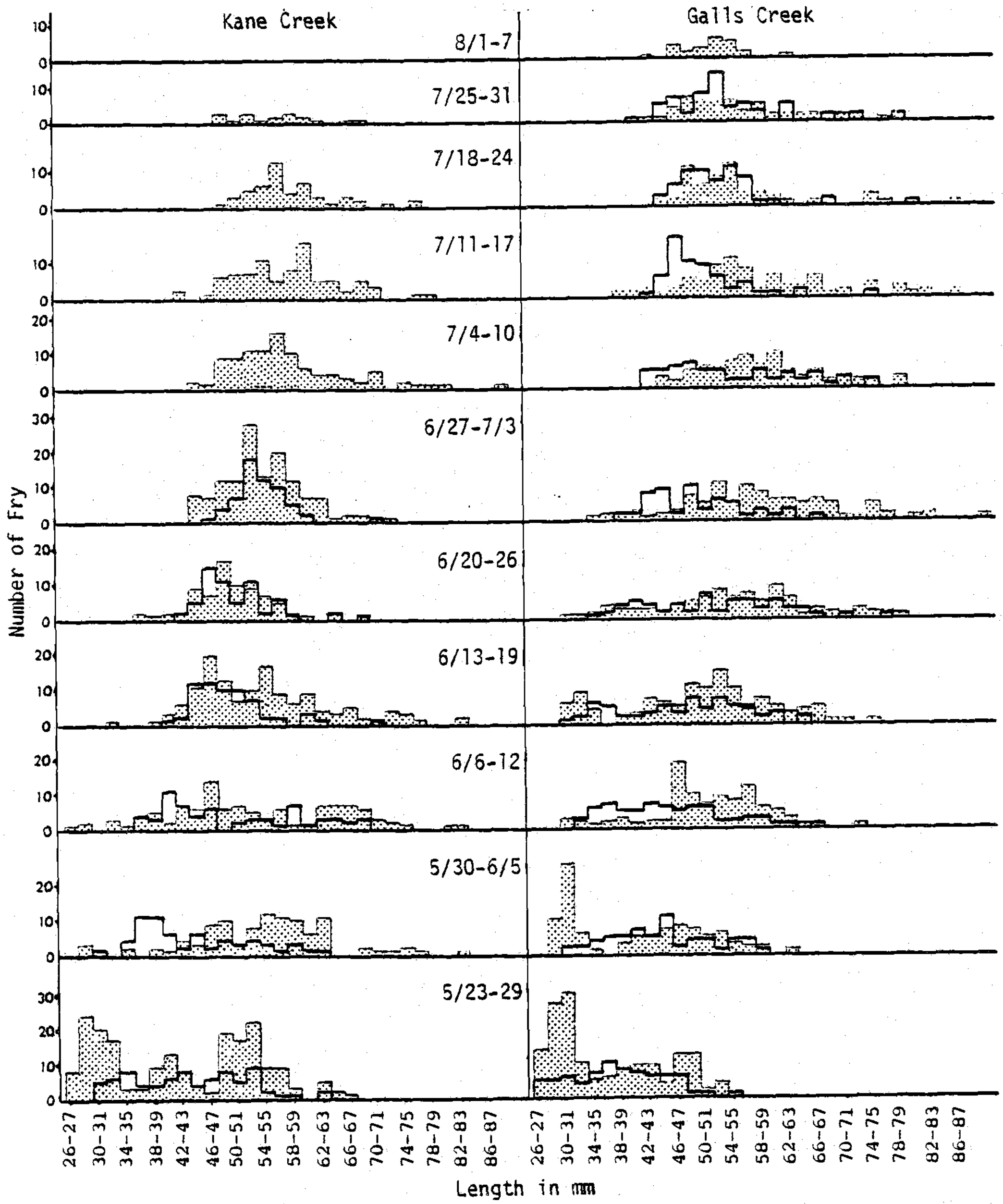

Figure 4. Continued.

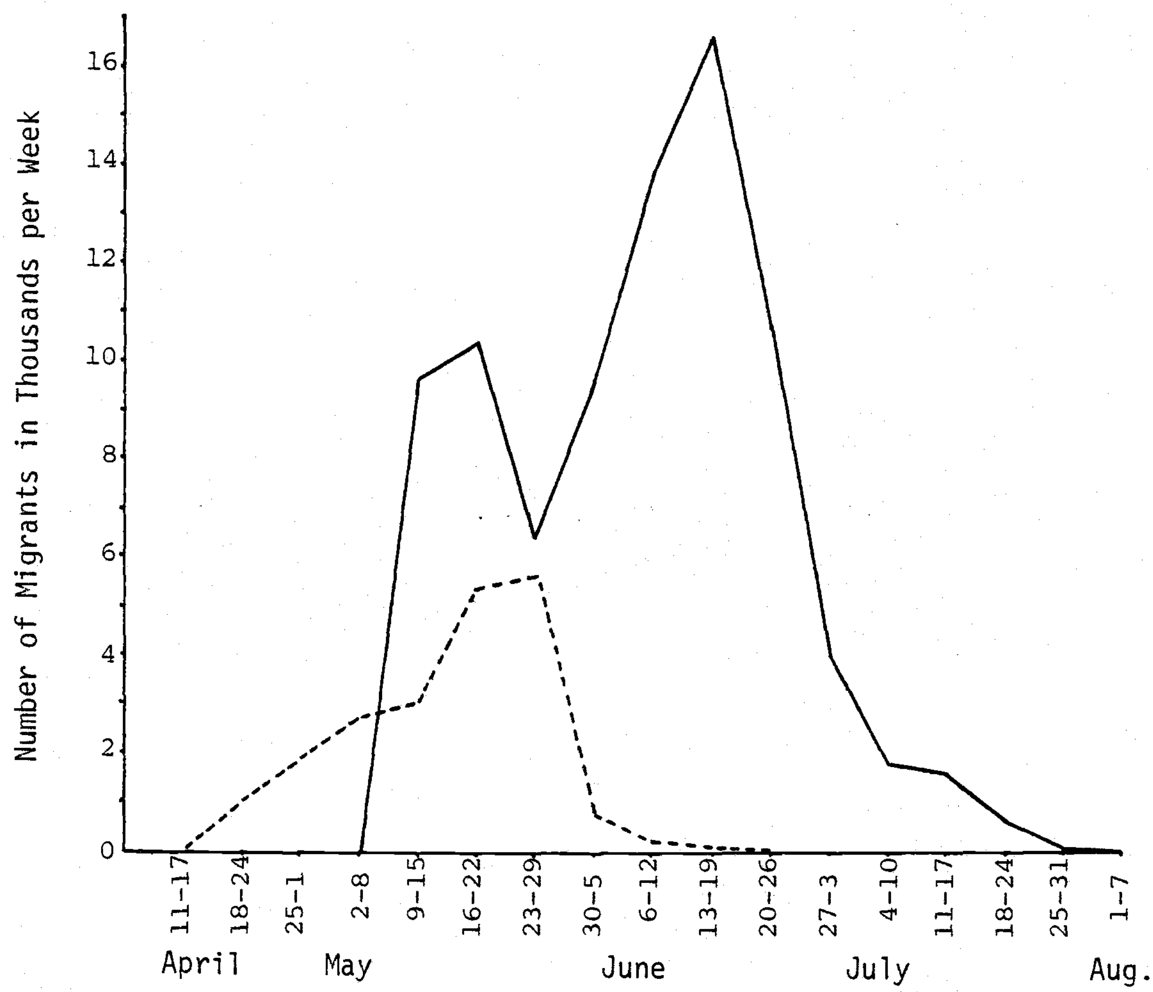

Figure 5. Number of underyearling summer steelhead 35 mm and smaller (broken line) and 36 mm and larger (solid line) that left Kane Creek in 1971. Expressed as total (observed plus estimated) number of migrants per week.

In 1971, apparent rate of growth of underyearling steelhead in Kane Creek averaged about 5 mm per week during the first ten weeks of the migration. Apparent rate of growth, obtained by subtracting the average length of recently emerged migrants captured during the first week of emigration (average length at emergence) from the length of the largest fry captured each week by electrofishing, ranged from 2 to 6 mm per week:

Week	1	2	3	4	5	6	7	8	9	10
Growth (mm)		no data	2	6	6	6	6	5	5	5

Two size groups of emigrants and the timing of their appearance during the emigration period suggest that some of the factors that influence downstream movement are different for small and large fry. The presence of yolk in some small migrants and their size in relation to the average size at buttoning up (when the yolk sac has been absorbed) indicate that emigration by some small fry is associated with emergence. An absence of large migrants until several weeks after the emigration has begun, and a relative absence of migrants 34-37 mm long throughout the migration period, indicate that most fry maintain positions for varying periods of time prior to becoming migratory. Apparently, factors that influence downstream movement of the large fry do not exert their influence until the fry are greater than approximately 35 mm. Small and large migrants differ not only in their migratory activity during the emigration period but also in their migratory activity during the day and night.

Diel Characteristics of Emigration

All downstream movement of underyearling steelhead occurred during darkness for approximately the first month of the emigration periods. Once begun, emigration during daylight increased gradually as the emigration period progressed, but never did become substantial (Fig. 6). Most of the fish that moved at night moved in the first 4 hours of darkness (Fig. 7). Movement during the day was greatest during the first few hours of daylight and again in the early afternoon.

Small and large migrants displayed different diel movement patterns. Downstream movement in Kane Creek during approximately the first 4 weeks in 1970 and 3 weeks in 1971 was by small fry that migrated only during darkness. As the emigration period progressed, large fry also began to move downstream, at first only during darkness but later also during daylight. During the period that both large and small fry left Kane Creek, the proportion of large fry that migrated during daylight was significantly greater than the proportion of small fry that migrated during daylight ($p < 0.01$) (Table 4).

The differing daily movement patterns of the two size groups of fry suggest that some movement downstream of small fry is in response to factors other than those that influence movement of larger fry. The suggestion that some of the regulators of downstream movement of small and large fry differ is supported by behavioral displays characteristic of fry of the two size groups.

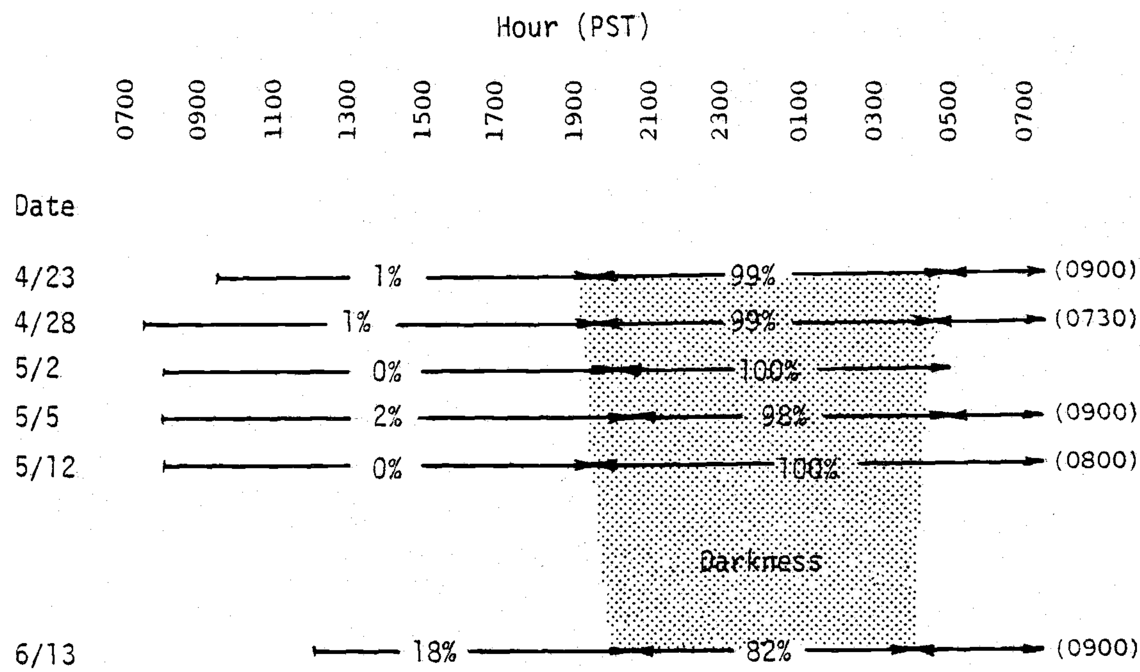

Figure 6. Diel pattern of downstream movement of underyearling summer steelhead in Kane Creek on days indicated, 1970. Expressed as percent of total daily movement that occurred during the hours indicated. The trap was installed on April 20 and removed on July 12.

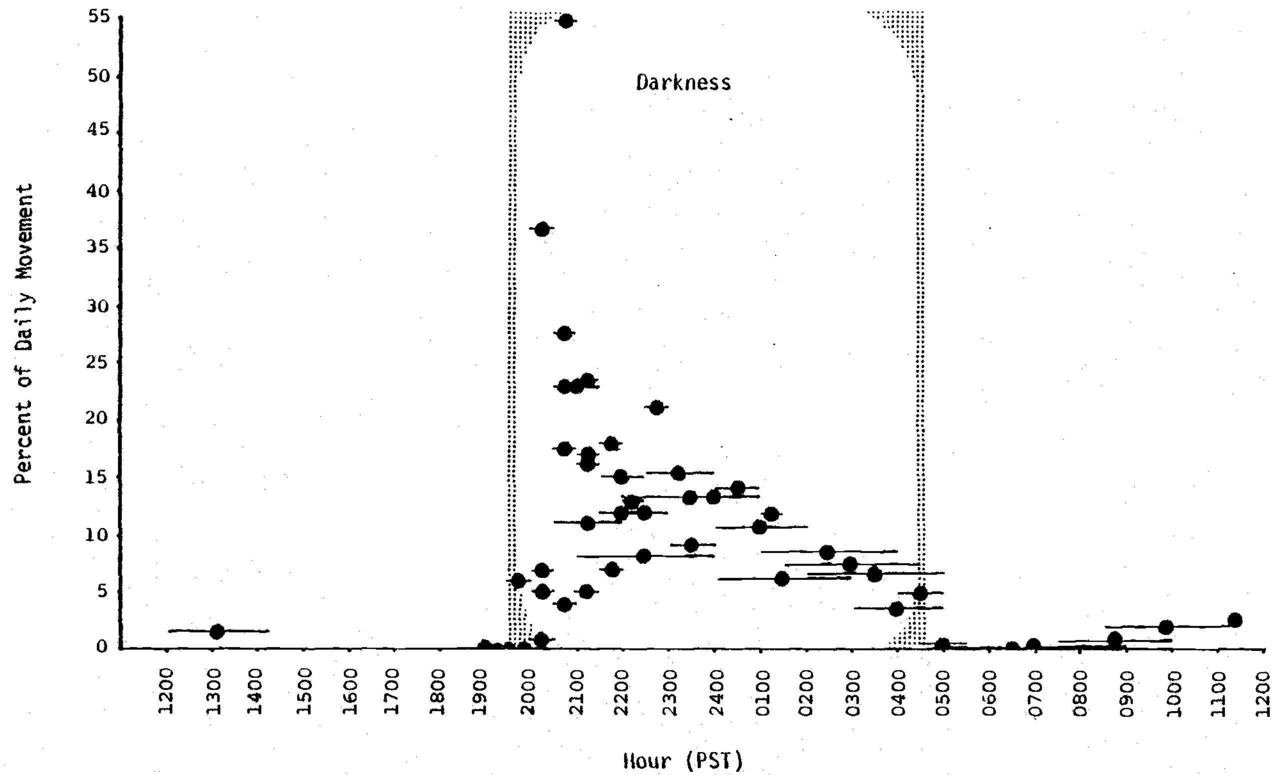

Figure 7. Diel pattern of downstream movement of underyearling steelhead in Kane Creek on selected days from April 23 to June 14, 1970. Downstream movement is expressed as the percent of total daily migrations that occurred during the sample periods indicated (average number of fry per hour/total daily migration). Horizontal lines show length of sample period. Data are tabulated in Appendix (Table A-1).

Table 4. Comparison of the diel timing of downstream movement exibited by large and small migrants in Kane Creek on selected dates, 1971. Comparisons are based on the percent of daily total migrations that occurred during the sample periods indicated.

		LARGE MIGRANTS			SMALL MIGRANTS			
Sample Date	Sample Period (PST)	Number of Migrants per Day	Number of Migrants per Sample Period	Percent of Daily Migration per Sample Period	Number of Migrants per Day	Number of Migrants per Sample Period	Percent of Daily Migration per Sample Period	Test Statistic
5/13-14/71	1045-1415	2,715	154	5.7	560	0	0	32.07**[a]
5/20-21	0930-1430	822	26	3.2	835	2	0.2	19.61**[a]
6/3-4	0820-1620	1,740	218	12.5	100	10	10.0	0.34[a]
6/9-10	0930-2000	2,114	176	8.3	49	3	6.1	0.08[a]
6/10-11	1025-1655	1,741	214	12.3	29	1	3.4	1.34[a]
6/16-17	1030-1530	2,597	214	8.2	7	0	0	0.01[a]
6/17-18	0830-1530	1,956	355	18.2	4	1	25.0	0.08[a]
All Dates Combined		13,685	1,357	9.9	1,584	17	1.1	6.48**[b]

a) Chi-square Test
b) Mantel-Haenszel Test
** = $p<0.01$

Behavior of Fry

Behavior of underyearling steelhead was dependent on size and differed from daylight to darkness. Recently emerged fry remained concealed during daylight. At dusk they began to congregate at or near the surface in the quiet and often very shallow water at the stream edge at densities as high as approximately 500 fry/m^2. The individual fry faced in different directions in areas of no current. Where slight current did exist, individuals faced the current and maintained position by slowly drifting, then swimming several centimeters. The fry fed and investigated drift. Low intensity agonistic behavior was common. An individual that drifted backward into another fry usually received a bump or nip on the tail. Occasionally, a fry behind another swam slowly forward for several centimeters to bump or nip the tail of the individual in front. As the emigration period progressed, small fry continued to use the shore areas at night but some remained visible in the pools and deep riffles, often in groups, during the day. Releases of marked fry approximately 27-32 mm long indicated that some of the same fry moved back and forth from adjacent day and night positions for more than 2 weeks.

Downstream movement by small fry along the stream edges was predominantly passive. In 1971, a total 48 small fry were observed moving along the stream edge during 6 periods of night observation that included 5 nights and totaled 1 hour and 10 minutes. Of the 48 fry observed, 18 (37%) entered or exited observation areas along the shoreline while swimming and 30 (63%) entered or exited while drifting. Similar behavior was often observed throughout the 1970 and 1971 emigration periods. Small fry entered quiet water at the edge of the stream by drifting or swimming from directly upstream or laterally, usually at the surface. They frequently left either by heading toward midstream where they were carried with the current, by slowly drifting downstream backwards or sideways, or by turning and swimming downstream. Movement away from and along the stream edge was usually associated with either aggressive behavior or nearby disturbances, but occasionally occurred for no apparent reason.

Most of the small fry that moved downstream near midchannel were at the surface and either swam or drifted without any apparent orientation (Table 5 and numerous other observations).

Table 5. Night observations of the vertical distribution (subsurface or at surface) and mode of migration (active or passive) of underyearling steelhead as they passed through study sections that encompassed the width of Kane Creek. Data were obtained during 12 observations made during May 18 through 20, June 2, 9, and 10, 1971 that totaled 2 hours and 10 minutes.

Vertical Distribution and Mode of Migration	Large Migrants n=47	Small Migrants n=30
Migrating Actively at Surface	75%	67%
Migrating Actively at Subsurface	23%	3%
Migrating Passively at Surface	0	20%
Migrating Passively at Subsurface	2%	10%

During similar times and days, small fry moved downstream at average rates of approximately 41 migrants/hour through the 0.3-m wide observation areas at the stream edge and approximately 14 migrants/ hour through 0.3-m wide areas throughout the remainder of the stream width. Small migrants neither schooled nor passed through the observation areas during daylight.

Movement from the substrate or intermediate depths to the water surface during darkness is a behavioral characteristic commonly displayed by many fry that have recently emerged and is associated with much of the downstream movement of small fry. Many of the recently emerged fry are displaced downstream by the current at night while apparently disoriented at or near the water surface. However, hundreds of fry either seek out or are carried by the current and their erratic swimming to "night habitat" (areas over sandbars where depth is less than about 5 mm or areas of deeper but calm water against the stream edge). Small fry that have apparently developed resident behavior are able to maintain positions at night by moving into night habitat at dusk. Fry that are unable to find areas suitable for maintaining position during darkness, or for some reason leave such areas, are carried downstream, many from their natal stream into the Rogue River. Movement to night habitat, whether active or passive, tends to delay or prevent emigration from the tributaries.

The large fry remained distributed throughout the stream during daylight and darkness. Marking studies indicated that some fry remained within 4 meters of where they were released for more than 8 days. They usually maintained positions near the bottom or at intermediate depths, never at the surface. They fed or investigated drift during the day and night. Large fry were never observed to display agonistic behavior during darkness, but they aggressively defended territories during daylight. Aggressive displays were usually associated with movement downstream of the subordinate fry.

Nearly all movement during the day and most movement at night by large fry was active and appeared to be directed (Table 5). During daylight, all large migrants moved downstream while near the bottom or at intermediate depths. At night most large fry migrated at or near the surface; only a few large migrants were observed to swim erratically or to be carried passively by the current. As the emigration period progressed, many large fry formed schools of from 5 to 50 migrants during the day, but were never observed to school at night.

Migratory activity of the large fry appears to be associated with intraspecific competition and with other environmental factors, but not with displacement by the current. Fry stop using the upper level of the water column in the shallow or quiet areas along the stream edges at night by the time they have grown to about 33 mm. When fry have attained this size, they likely have sufficient swimming ability that few become disoriented and are displaced by the current. Downstream movement of the large fry is probably influenced initially by aggressive encounters and later also by other stresses related to a deteriorating environment. Several factors that apparently influence downstream movement of fry were examined in the laboratory.

Factors Influencing Emigration

Diel Vertical Movement

Diel vertical movement that was displayed by underyearling steelhead in the natural environment was observed in the laboratory also. During daylight, fry in the artificial channel maintained positions at intermediate depths and near and in the substrate. During darkness many fry moved to or near the water surface, where some maintained positions and others either swam downstream or were carried by the current. Those that maintained positions at the surface remained in the shallow water over the sand bars and in the quiet water of the pools and behind large rocks. Those that moved downstream at the surface either swam erratically or drifted with the current, often bumping along a wall of the channel. Some fry that did not move to the surface at night maintained positions at intermediate depths in the pools and near the substrate in the riffles.

Fish in the aquaria also moved to the surface during darkness. While at the surface, those near the center of the aquaria, where the current was slight, maintained positions. Those near the perimeter in the faster current usually drifted backwards or occasionally turned and swam for short distances, often erratically, with the current. Distribution and movement of the fry not at the surface during darkness was similar to that displayed by the fry during daylight; some maintained positions in and near the substrate and in the intermediate levels of the water column while others continuously swam or drifted with the current. Use of the surface level of the aquaria by recently emerged fry of various stages of development was substantially greater during darkness than daylight (Table 6).

The laboratory studies indicated, as did the field observations, that downstream movement at night of many small fry is associated with their vertical movement away from the substrate. Because use of the surface level of the aquaria was substantially greater during darkness than daylight for fry of various stages of development (Table 6), vertical movement of small fry does not appear to be directly related to the developmental stage of the fry. However, laboratory studies did indicate that an association of aggressive behavior and downstream movement was influenced by population density and by stage of development.

Population Density and Stage of Development

Aggressive encounters between fry in the aquaria usually increased with population density and developmental stage of the fry (Table 7). Incidence of aggression was substantially higher during daylight than darkness. As under natural conditions, encounters at night were subdued bumps or nips exchanged almost exclusively by fry near the water surface. During the day, aggression was vigorous, occurred throughout the water column, and was usually directed at fry that continuously circled the aquaria.

Downstream movement of fry in the artificial channel was also variable with respect to stage of development of the fry and to population density. The percentage of a test group that emigrated

Table 6. Vertical migration during daylight and darkness of underyearling Rouge steelhead in 18.6-liter aquaria. Expressed as the percent of the total number of fish per test period that were observed either at or within 5 mm of the aquaria surface or at some other level in the aquaria during daylight and darkness. Each test group contained 25 fish that were observed at random for periods of from 1 to 15 minutes during a 96-hour test period. Tests were conducted between March 4 and April 9, 1971.

			DAYLIGHT				DARKNESS			
Test Group	Average Length of Fry (mm)	Stage of Development (% Buttoned)[a]	Number of Observation Periods[b]	Total Minutes of Observation	Number of Fry Observed During All Observations	Percent of Total Number of Fry Observed That Were Within 5 mm of Surface	Number of Observation Periods[b]	Total Minutes of Observation	Number of Fry Observed During All Observations	Percent of Total Number of Fry Observed That Were Within 5 mm of Surface
25A[c]	26.3	0	8	34	23	0	6	27	30	60
25B[d]	27.2	0	8	12	44	0	2	20	21	52
25C[c]	27.6	0	6	22	52	0	4	45	64	72
25D[e]	28.3	0	4	8	34	0	3	7	35	29
25E[c]	29.5	77	4	21	55	0	3	21	37	30
25F[c]	28.8	88	5	17	74	0	2	15	38	60
Total			41	114	282	0	20	135	225	53

a) Stage of development is measured by the percentage of the test group that is buttoned up, regardless of the size or age of the fry.
b) Length of observation periods ranged from 1 to 15 minutes.
c) All of the same brood. Spawners were capture in Sardine Creek, tributary to the Rogue River.
d) Spawners were captured in Foots Creek, tributary to the Rogue River.
e) Spawners were captured in Sams Creek, tributary to the Rogue River.

Table 7. Incidence of aggression among underyearling Rogue steelhead at various population densities and stages of fry development during daylight and darkness. Test groups that contained either 5, 10, or 25 fry were held in 18.6-l aquaria for 96 hours and observed at random for periods of from 1 to 15 minutes. Fish-minutes (number of fry X minutes observed) of each observation period are combined for each density and stage of fry development. Tests were conducted between March 4 and May 19, 1971.

			DAYLIGHT				DARKNESS			
Population Density	Stage of Development (% Buttoned)	Number of Test Groups Observed[a]	Number of Observation Periods	Fish-minutes (No. of Fry X Minutes Observed)	Aggressive Displays[b]	Aggressive Displays per Fish-minute	Number of Observation Periods	Fish-minutes (No. of Fry X Minutes Observed)	Aggressive Displays[b]	Aggressive Displays per Fish-minute
5	0	2	11	42	3	0.0714	6	186	1	0.0054
	42%	1	4	12	1	0.0833	3	110	0	0
	67%	1	4	15	2	0.1333	1	25	0	0
	Average					0.0870				0.0031
10	0	1	5	28	4	0.1428	3	260	2	0.0077
	77%	1	10	241	60	0.2490	5	166	1	0.0060
	Average					0.2379				0.0070
25	0	4	26	468	106	0.2265	15	1,134	19	0.0168
	77%	1	4	296	77	0.2601	3	316	0	0
	88%	1	5	254	41	0.1614	2	305	15	0.0492
	Average					0.2200				0.0194

a) Data from test groups of similar stages of development were combined.
b) Aggression is defined as bumping, biting, or chasing.

from the channel increased as the stage of development of a test group increased until all of the fry were buttoned, then decreased (Fig. 8). Although Chi square tests indicated that population density and downstream movement of the fry were not independent ($p < .05$), an increase in migratory activity did not always follow increases in density. At similar stages of development, test groups that contained 25 fry displayed a greater tendency to emigrate from the channel than did test groups that contained 50 fry (Fig. 8).

Population density and stage of development influence downstream movement of small fry primarily through agonistic interactions and possibly through other responses to stress that results from crowding. Although fry appear to be compatible at night, the incidence of coincidental contact among fry, which is often associated with displacement downstream, increases as the number of fry present increases. The requirements of small fry for food and space are greater during daylight than darkness, as is indicated by the substantially higher incidence of aggression during the day. Had there been sufficient area and habitat within the aquaria and channel, subordinate fry might have hidden or formed into groups during daylight, as was observed in the tributaries. Downstream movement by these fry may then have occurred only at night rather than day and night. Migratory activity did not always increase with increases in population density and stage of development, suggesting that there is probably an optimum population density for small fry that may vary with the stage of development.

Handling, in conjunction with the developmental stage of the fry, may have biased the results of the emigration experiments,

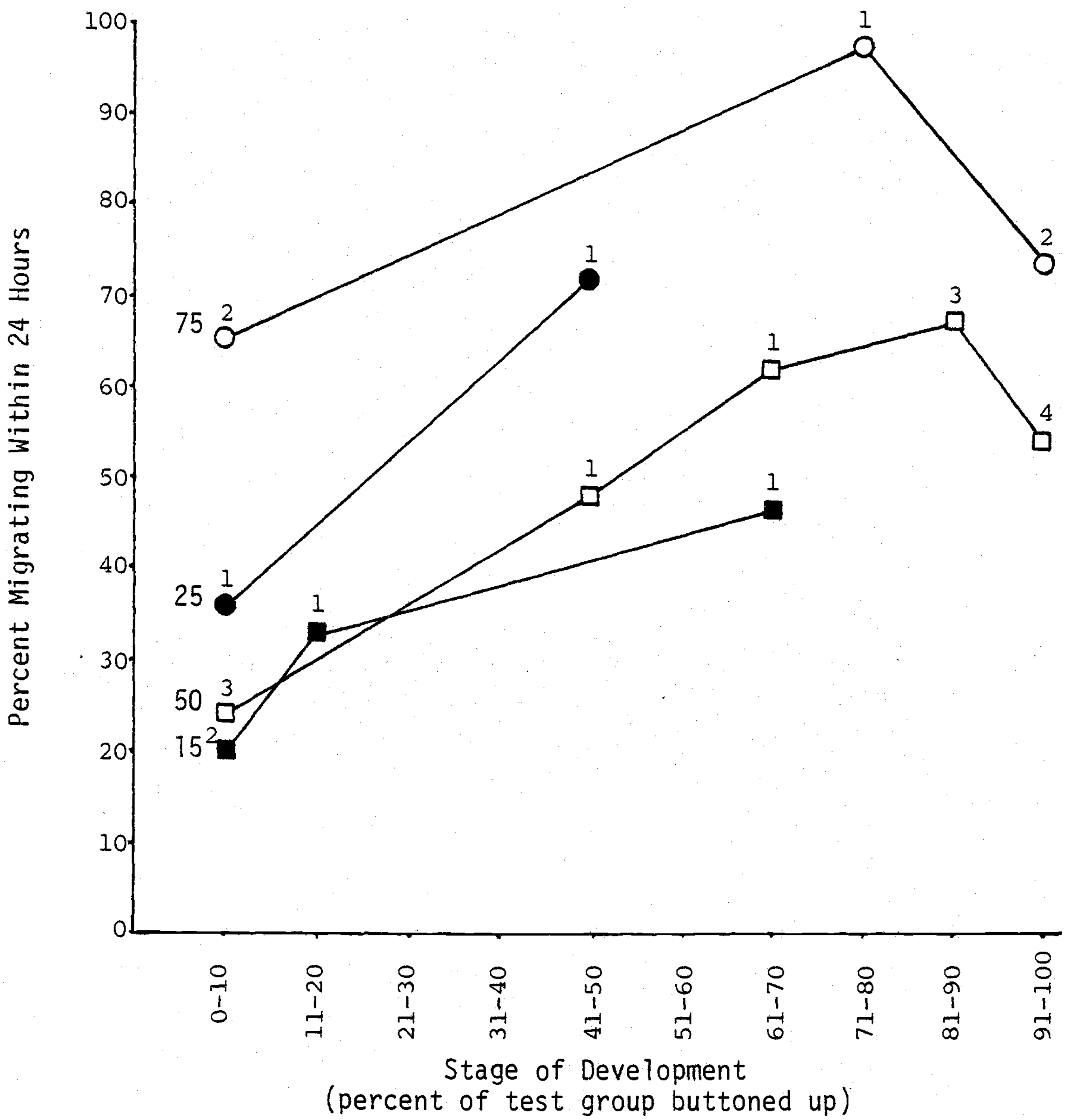

Figure 8. Emigration from an artificial stream channel by underyearling Rogue steelhead of various stages of development at population sizes of 15, 25, 50, and 75 fry. Expressed as percent of test group that migrated within 24 hours after introduction to the channel. Where numbers indicate more than 1 replication, percentage was obtained from an average. Tests were conducted between March 9 and July 21, 1971.

particularly in the artificial channel. Most of the downstream movement during daylight occurred within about 2 hours after the fry were placed in the channel and may have been a response to handling. Upon being placed in the channel, fry of the least developed test groups usually went immediately to the bottom, hid in the substrate, and did not move downstream until dark. Most fry of the more developed test groups remained exposed upon being placed in the channel and many moved downstream before dark.

Influence of Race on Migratory Behavior

Characteristics of behavior of fry were similar for Rogue River and Umpqua River summer steelhead (tributary and mainstem spawning stocks, respectively). In the laboratory, Umpqua fry used the surface area of the aquaria during darkness in the same manner displayed by the Rogue fry. Agonistic behavior of Umpqua fry was similar to, but occurred less often than, that displayed by Rogue fry. Also, incidence of aggression among Umpqua fry was greater during daylight than darkness. That which occurred at night usually was subdued bumps or nips.

Periodicity of downstream migration of fry was similar for three stocks of steelhead tested in the Foots Creek study section, but there was no consistency between stocks in the proportion of each test group that migrated. A significantly greater ($p < .001$) proportion of Rogue fry than Umpqua fry (mainstem spawning stock) left the study section. However, the proportions of migrants and non-migrants in two groups of Rogue fry also differed significantly ($p < .001$) (Fig. 9). The tendency for Rogue fry and Hood River

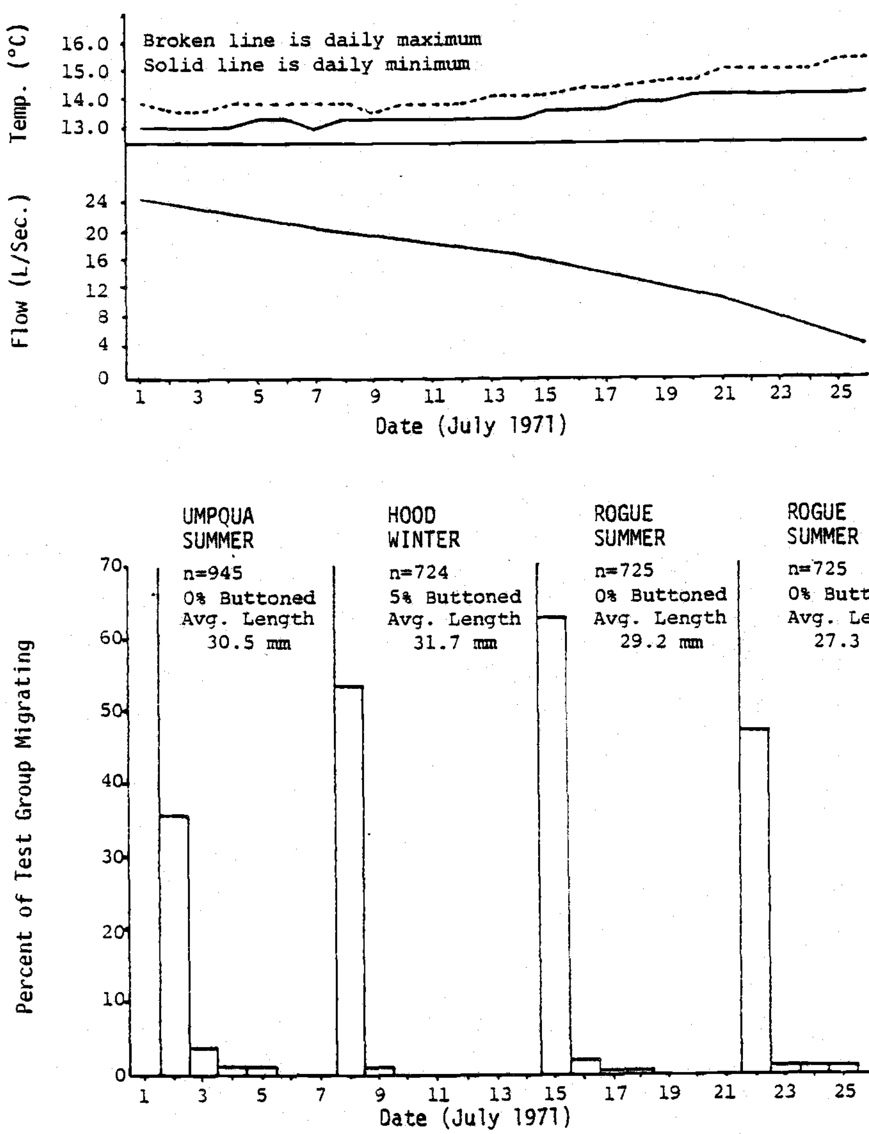

Figure 9. Comparison of daily movement downstream of three stocks of steelhead fry in an 85-meter long study section of Foots Creek, July 1971. Expressed as the percent of each test group that emigrated per 24 hours during 96-hour test periods. Streamflow was measured weekly. Stream temperature was recorded daily.

winter run fry (mainstem spawning stock) to emigrate from the study section did not differ significantly when results of the two test groups of Rogue fry were combined, but when individual test groups of Rogue fry were compared with the group of Hood River fry, one group of Rogue fry (average length = 29.2 mm) contained a significantly greater proportion ($p < .001$) of migrants than the group of Hood River fry. A significantly greater proportion ($p < .001$) of the Hood River winter fry left the study section than did the Umpqua River summer fry (both mainstem spawing stocks) (Fig. 9).

The summer run stock in the Rogue River apparently does not possess a racially unique mechanism that influences emigration from natal streams by fry prior to yolk sac absorbtion. The tests in the study section of Foots Creek were based on an assumption that a stock regularly challenged by drying of its spawning areas (Rogue summer steelhead) would develop a behavioral mechanism to direct all or most fry from their natal streams before the streams became intermittent. Such a mechanism would not be a selective advantage for stocks that do not regularly experience dry spawning areas (mainstem spawners) and therefore might not be present in those stocks. Similarities in behavior of fry of the two stocks of summer steelhead and the periodicity of movement and magnitude of emigrations from the study section by fry of all test groups indicate that the three stocks possess a common innate behavioral mechanism that is associated with dispersal by recently emerged fry. Variability in migratory activity of the test groups may have been due to variation in environmental stimuli present while the test groups were being observed or the size of the fry tested.

Unfortunately, all of the fry available for testing still retained obvious quantities of yolk. Use of fry that were more developed may have produced results that were more conclusive.

Streamflow and Water Temperature

Multiple regression analyses of the relationships of decreasing streamflow and increasing water temperature with downstream movement of Rogue summer steelhead fry indicated that fry movement is significantly more related to streamflow than to water temperature. The STEPWISE and BACKSTEP procedures of the SIPS REGRESS subsystem measured the relationship of the independent variables: Julian calendar date, average daily streamflow, average daily change in streamflow, and daily maximum and average stream temperatures and the dependent variable: total migrants per day in Galls Creek. With the STEPWISE procedure, average daily streamflow entered the model first and is described by the relation $Y = 1496.8 - 10.751\ X_3$ where Y is the number of migrants per day and X_3 is the average daily streamflow. Average daily streamflow accounted for 82 percent of the observed variation in daily migration (t, 41 d.f. = -13.56**). Subsequent entrance of the other independent variables to the model did not account for significant proportions of the remaining variation. The results of the BACKSTEP procedure and the simple correlation coefficients (Table 8) corroborated the results of the STEPWISE procedure. However, reasoning and high intercorrelation of the independent variables (Table 8) suggest that the results of the regression analyses be interpreted with caution.

The correlations may have been confounded by characteristics

Table 8. Simple correlation coefficients of variables analyzed to measure influence of environmental stimuli on emigration from natal streams by underyearling Rogue steelhead. Data were collected from Galls Creek between April 22 and July 2, 1971.

	Date	Average Daily Streamflow	Average Daily Change in Streamflow	Daily Maximum Water Temperature	Daily Average Water Temperature
Daily Number of Emigrants	0.888**	-0.904**	-0.258	0.680**	0.711**
Date		-0.968**	-0.421**	0.811**	0.856**
Average Daily Streamflow			0.353*	-0.747**	-0.778**
Average Daily Change in Streamflow				-0.332*	-0.336*
Daily Maximum Water Temp.					0.966**

* = Significant at .05 level, d.f. = 41
** = Significant at .01 level, d.f. = 41

of the environment and fry behavior. Streamflow in the tributaries coincidentally decreased while fry emergence progressively increased. A progressive increase in emergent fry (many of which would be carried downstream by any flow rate) in conjunction with a progressive decrease in streamflow creates an inverse association of decreasing streamflow with downstream movement of small fry (Fig. 10), at least until late May. Also, many of the fry that do not leave the tributaries shortly after emergence probably migrate later in response to a requirement for space that increases as the size of the fry increases. Downstream movement of the large fry, then, could be in response to insufficient habitat and could therefore occur without a decrease in streamflow. Data upon which the regressions are based were collected during a period when minimum and maximum water temperatures in Galls Creek ranged from 4.7 to 14.7^{o}C and 7.5 to 20.0^{o}C., respectively. The lower temperatures, which occurred early in the migration period, are probably in the preferred range of Rogue summer steelhead juveniles. The higher temperatures are probably easily tolerated by this stock. The analyses and observations indicate that a large proportion of the migratory activity of underyearling Rogue steelhead is influenced by combinations of environmental and innate factors.

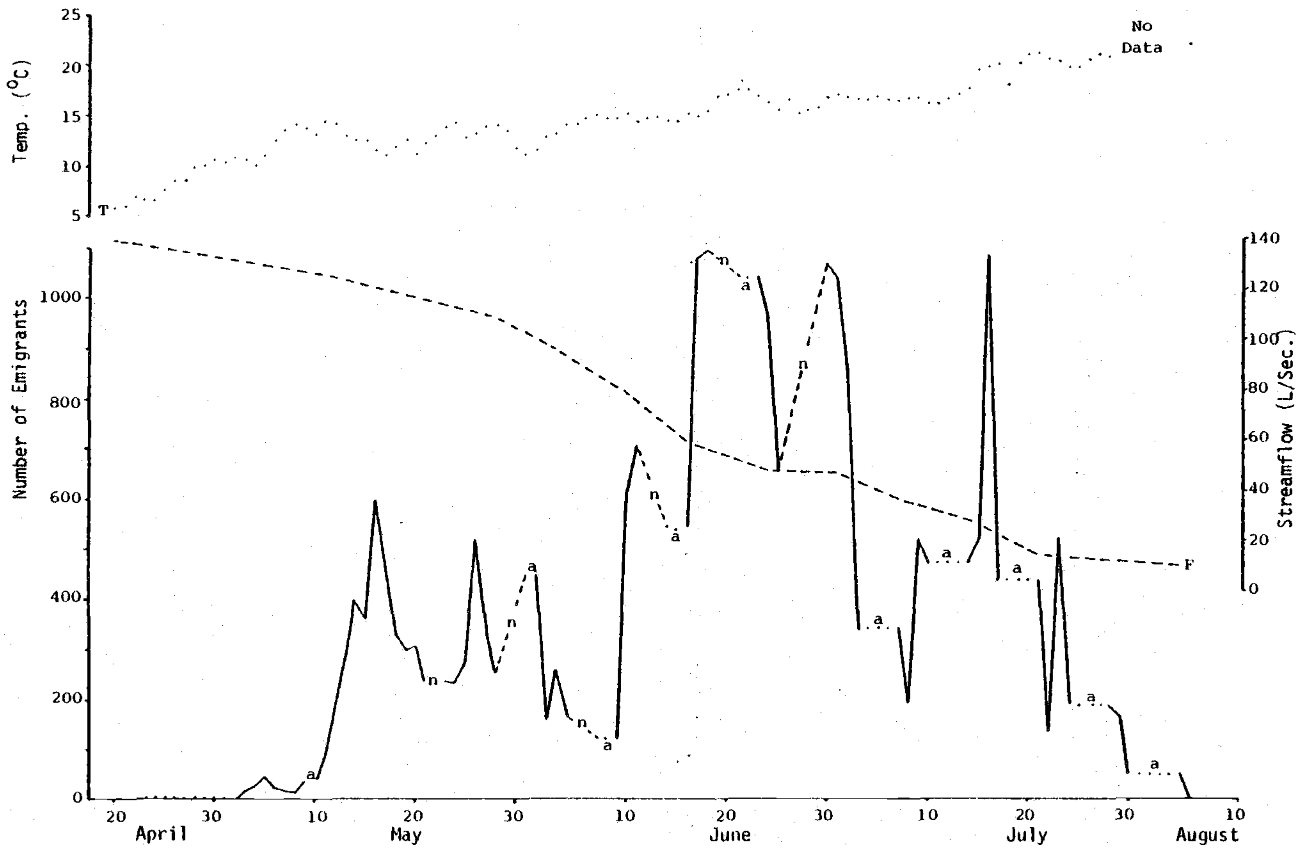

Figure 10. The relationship of number of emigrants per day, streamflow (F), and daily average stream temperature (T) in Galls Creek, April 20 through August 5, 1971. Regression analyses were based on data collected from April 20 through July 1. Periods when the trap was not operating are shown by an n and when the daily number of emigrants was averaged by an a. Streamflow from April 20 to May 11 was estimated by extending the curve by eye.

DISCUSSION

Emigration of Rogue River summer steelhead fry from natal streams is associated with environmental and innate factors. These factors influence downstream movement of fry alone and in combination. The strength of an association of downstream movement with a particular factor or combination of factors varies with the size of fry.

Most downstream movement of Rogue summer steelhead fry that have recently emerged results from displacement by the current and is associated with an innate behavioral characteristic. During darkness, fry move from the substrate and intermediate depths to near the water surface where visual and tactile orientation with the substrate are lost. While disoriented the fry are unable to maintain position and are displaced downstream by the currents.

Vertical migration during darkness by recently emerged fry is not unique to Rogue summer steelhead. Other workers (Hoar 1958; Northcote 1962; Reimers 1971; Au 1972) have observed this behavior in rainbow trout and coho, pink, sockeye, and chinook salmon and associated it with downstream movements by the fry. Reimers (1971) inferred that rapid dispersal of fall chinook fry in Sixes River, Oregon, results from lack of visual orientation and drifting with the currents during darkness. I suggest that a similar mechanism of dispersal is associated with vertical migration of Rogue steelhead fry during darkness and that this behavior might be characteristic of most stream-dwelling salmonids.

The extent and topography of tributary shorelines may be important regulators of the distribution of emerging fry throughout the tributaries. For some unknown period following emergence, even after they have apparently developed resident behavior, many small fry continue to move to the water surface at night and are susceptible to displacement by the currents. Without a mechanism to retard or prevent displacement of fry until they discontinue their vertical movement during darkness, many of them would be carried from their natal streams or at least from the upper areas of spawning. During darkness, large numbers of recently emerged fry are present along the shorelines of the tributaries. Accumulations of fry are greatest in areas that appear to provide the best conditions for fish to maintain visual or physical contact with the shore or bottom while at the same time be at or near the water surface. Sandbars and shore areas with gradual slopes accommodate large numbers of fish; abrupt shorelines accommodate fewer. Use of such night habitat areas by Rogue summer steelhead fry is extensive and probably important in the distribution of the population throughout its nursery areas as the fry move and are carried downstream.

Most migratory activity of recently emerged fry occurs along the shoreline and is associated with factors that move fry out of night habitat. Northcote (1962) attributed much of the migratory activity during darkness by rainbow trout fry in Inlet Creek of Loon Lake to disturbance of fry along the shoreline by other migrant fry. I observed a similar pattern in Kane and Galls creeks. Downstream movement of fry along the shoreline is also often associated with subdued displays of aggression among small fry in night habitat.

When threatened, subordinate fry usually move downstream. Agonistic behavior is displayed by emigrant fry as well as residents that make a diel shift from day to night positions. An association of social interaction and downstream movement of fry during darkness has also been reported by Northcote (1969). Some Rogue fry also left positions in night habitat areas and moved downstream for no apparent reason.

Vigorous defense of territories is displayed by large fry during the day and is often directed toward emigrants. Aggressive behavior of salmonids has been shown by several researchers to have a major influence on population distribution (Chapman 1962, 1966; Reimers 1968). Although I did not observe any responses during darkness that appeared to be associated with social interations that had occurred during daylight as did Reimers (1971), I believe that delayed response does occur and accounts for the predominance of nocturnal movement by large fry early in the emigration period. In fact, most of the migratory activity of large fry at night throughout the emigrations probably is influenced by either daytime social encounters or extremes of the environment.

Water temperature appears to have little direct influence on emigration from natal streams by underyearling Rogue summer steelhead. Temperature is indirectly related to downstream movement of recently emerged fry. It influences initiation of emergence and the period over which emergence extends. Coutant (1977) reported that 18-19^{o}C is the water temperature preference of rainbow trout fingerlings and that the upper avoidance temperatures are higher than approximately 22^{o}C. In 1971, maximum daily water temperatures in Kane Creek did not reach 22^{o}C during the emigration and in Galls Creek did not regularly exceed 22^{o}C until after the first week of July. Water temperature probably would be an influential factor in the emigration from natal streams by Rogue fry if temperatures reached those levels normally avoided by fry before spatial requirements of the fry became limiting.

Requirement for space by Rogue summer steelhead fry and a combination of this requirement and decreasing streamflows are major factors that influence their emigration from natal streams. Chapman (1966) suggests that minimal spatial demands by salmonids are probably fixed, are closely related to the size of the individual fish, and increase as the fish grows. It is likely then, that as the fry continue to grow and streamflows subside, minimal spatial demands are not satisfied and resident fry emigrate from the tributaries in search of adequate space. Density not only affects resident fry but also fry that have recently emerged. As emergence progresses and concentrations of fry in night habitat areas increase, incidence of social interaction between the fry also increases. Night habitat used by recently emerged fry clearly fits Chapman's (1966) description of "desirable" space, which he suggests is a regulator of salmonid populations.

The importance of intermittent tributaries to salmonid production has been poorly documented. Needham (1938) noted that rainbow trout used intermittent tributaries of some lakes in the Sierras of California but did not estimate fish production from those tributaries. Erman and Hawthorne (1976) found that rainbow trout used the intermittent Kiln Meadow Tributary for spawning substantially more than they used permanent tributaries in the Sagehen Creek drainage of the northeastern Sierras. Erman and Leidy (1975) noted that although some fry remained in Kiln Meadow Tributary after flows became intermittent in 1973 and died, in 1974 streamflow in Kiln Meadow Tributary remained permanent and a large number of fry remained in the tributary throughout the summer. Everest (1973) discovered extensive use of the intermittent and small tributaries of the Rogue River by spawning summer run steelhead trout. He also discovered that some underyearlings and yearlings, after emigrating from the tributaries to the Rogue, move back into the tributaries to rear when autumn rains reestablish continuous streamflows. Of 20,047 underyearling summer steelhead in Kane Creek and 338 yearling summer steelhead in Sams Creek (another nearby tributary of the Rogue) that migrated to the main Rogue River in spring 1970, 40 (0.2%) and 19 (5.6%), respectively, were recaptured in those tributaries and five other adjacent streams the following autumn and winter. Although most emigrants from the tributaries remained in the main Rogue River, Everest (1973) has shown that some of the underyearlings and yearlings move back into the tributaries to overwinter.

Everest's work and my study have documented the importance of these streams for production of juveniles. Kane and Galls creeks produced, respectively, an estimated annual average of 94,600 and 62,800 emigrant fry during my study and may be representative of many intermittent spawning streams used by Rogue summer steelhead. A substantial decrease from 1976 to 1977 in the abundance of age 0+ steelhead in the main Rogue River has indicated the importance of this production of juveniles. The decrease in age 0+ fish was believed to be a result of exceptionally low streamflows during the winter of 1976-77, which prevented many adult fish from entering the tributaries to spawn (Cramer and Martin 1978).

Survival and growth of fry that leave the tributaries soon after emergence was not documented but is probably significant. Growth of the large migrants (longer than about 35 mm) during their first period of residence in the main river was examined by Everest (1973) and found comparable to that displayed by Rogue summer steelhead reared at Butte Falls hatchery. The excellent growth of the larger migrants while they were in the main river indicates that food was abundant. Reimers (1971) concluded from his study that downstream movement of fall chinook fry in tributaries of the Sixes River has a survival value because fry rearing in the main river grew better than those remaining in tributaries.

In tributaries of the Rogue River, growth of underyearlings is good before streamflows become intermittent, but only a few of the factors associated with the rapid growth are known. Intensity of interspecific competition for food and space is low. Cottids and cutthroat and summer steelhead trout (age 1+ and older) are present in the tributaries during the spring and early part of the emigration. As predators, these fish undoubtedly have some effect on the steelhead eggs and fry, but nearly all of the larger salmonids leave the tributaries not long after the fry migration begins. Production of food for the fry appears to be excellent and is probably enhanced by fertilizers in the seepage and runoff from agricultural land, terrestrial insects from the dense streamside vegetation along much of the tributaries, and detritus that finds its way from the surrounding forest land.

Substantial numbers of fish are trapped in tributaries until fall rains reestablish continuous streamflow. Growth and survival of these fish during the summer is poor. Brett et al. (1969) have shown for other salmonids that growth efficiency declines at high temperatures. Fish abundance in areas of Galls Creek decreased by nearly 50 percent during the period of intermittent streamflow in 1971. Many fry probably succumbed to extreme temperatures and disease, but more were probably lost to predation by birds, mammals, and reptiles. Throughout the emigration periods, snakes, herons, and kingfishers were observed feeding on fry, and raccoon sign was prevalent. Erman and Leidy (1975) also attributed losses of rainbow trout fry stranded in pools of Kiln Meadow Tributary to predation.

Agriculture, urban development, and timber production are probably the most serious threats to spawning streams of Rogue River summer steelhead. Withdrawal of water from some tributaries begins early in the spring for frost control on orchard lands and continues throughout the summer from most tributaries as a source of irrigation water. The level of Galls Creek was regularly observed to drop about 5 cm during the late morning period of the 1971 emigration and then rise again in late afternoon. At least some irrigation withdrawl occurred on Kane and Galls creeks in both 1970 and 1971.

Destruction of streamside cover, disruption of the tributary substrate and flow, and domestic pollution are significant adverse effects of urban development within close proximity of the tributaries. The importance of the night habitat areas has been documented. Precautions should be taken by fishery and land management agencies to prevent practices that would destroy these areas by scouring, erosion, channelization, etc. Poor timber harvest practices and clearing of forested areas pose a serious threat to the tributaries through siltation and elevated water temperatures from removal of streamside vegetation.

Rogue River summer steelhead either have adapted well or originally possessed characteristics suitable to successful reproduction in small, often intermittent streams. Everest (1973) has noted that the reproductive cycle of Rogue summer steelhead is critically timed to the flow and temperature patterns of the natal streams. Because the tributaries are small and often intermittent, they easily can be overlooked, ignored, or compromised. Even the smallest adverse effect is magnified by the relative size of the streams, making management attention to these important systems a crucial concern.

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APPENDIX

Table A-1. Periodicity of downstream movement of under-yearling Rogue steelhead, Kane Creek, 1970.

Sample Date	Sample Time Period (PST)	No. of Migrants	Average or Estimated No. of Migrants/Hour	Percent of Daily Migration
4/23-24	0930-1830	2	0.2	0.0
	1830-1930	1	1.0	0.1
	1930-2000	24	48.0	5.9
	2000-2030	150	300.0	36.6
	2030-2100	224	448.0	54.7
	2100-2400	202	67.0	8.2
	2400-0300	153	51.0	6.2
	0300-0500	57	29.5	3.5
	0500-0930	6	1.3	0.2[a]
Daily Total Migration = 819				
4/28-29	0730-1900	0	0.0	0.0[a]
	1900-1930	0	0.0	0.0
	1930-2000	1	2.0	0.1
	2000-2030	54	108.0	6.8
	2030-2100	138	276.0	17.4
	2100-2130	128	256.0	16.2
	2130-2230	221	221.0	15.0
	2230-2400	364	242.7	15.3
	2400-0100	223	223.0	14.1
	0100-0130	94	188.0	11.9
	0130-0430	351	117.0	7.4
	0430-0530	8	8.0	0.5
	0530-0730	1	0.5	0.0
Daily Total Migration = 1,583				
5/2-3	0800-1900	2	0.2	0.0[a]
	1900-2000	1	1.0	0.1
	2000-2030	35	70.0	5.1
	2030-2100	187	374.0	27.4
	2100-2130	115	230.0	16.9
	2130-2230	163	163.0	12.0
	2230-0400	794	144.0	10.6[a]
	0400-0500	67	67.0	4.9
Daily Total Migration = 1,364				
5/5-6	0800-2030	10	0.8	0.1[a]
	2030-2100	69	138.0	22.4
	2100-2130	71	142.0	23.0
	2130-2200	54	108.0	17.5
	2200-2230	39	78.0	12.7
	2230-2300	64	128.0	20.8

Table A-1. Continued.

Sample Date	Sample Time Period (PST)	No. of Migrants	Average or Estimated No. of Migrants/Hour	Percent of Daily Migration
	2300-2400	55	55.0	8.9
	2400-0200	131	65.5	10.6
	0200-0500	119	39.7	6.4
	0500-0900	4	1.0	0.2
Daily Total Migration = 616				
5/12-13	0800-1930	1	0.1	0.0[a]
	1930-2000	2	4.0	0.2
	2000-2030	8	16.0	0.8
	2030-2100	38	76.0	3.9
	2100-2130	49	98.0	5.0
	2130-2200	68	136.0	6.9
	2200-2300	234	234.0	11.9
	2300-0100	524	262.0	13.3
	0100-0800	1,044	149.0	7.6[a]
Daily Total Migration = 1,968				
5/21-22	2000-2430	1,359	302.0	18.3[a]
	2430-0730	263	37.6	2.3[a]
	0730-1000	30	12.0	0.7
Daily Total Migration = 1,652				
6/4-5	2000-0830	1,256	100.5	7.6[a]
	0830-1115	67	24.4	1.8
	1115-1130	8	32.0	2.4
Daily Total Migration = 1,331				
6/13-14	1200-1415	41	12.6	1.7
	1415-2030	62	9.9	1.3[a]
	2030-2200	126	84.0	11.2
	2200-0100	300	100.0	13.3
	0100-0400	191	63.7	8.5
	0400-0900	32	6.4	0.8[a]
Daily Total Migration = 752				

a) Sample periods longer than 4 hours were not plotted in Figure 7.

Table A-2. Daily record of parameters examined for influence on migration of underyearling steelhead, Galls Creek, 1971. Multiple regression analysis was performed only with data collected on Julian days 110 through 179.

Date	Julian Day	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
4/23/71	110	0	137.5[b]	-0.5	7.5	5.6	6.6
24	111	0	137.0[b]	-0.5	8.3	4.7	6.5
25	112	2	136.5[b]	-0.5	9.4	5.6	7.5
26	113	6	136.0[b]	-1.0	11.1	5.6	8.4
27	114	13	135.0[b]	-1.0	11.1	5.8	8.4
28	115	7	134.0[b]	-0.5	12.8	6.7	9.8
29	116	9	133.5[b]	-0.5	12.2	7.8	10.0
30	117	3	133.0[b]	-0.5	12.8	8.3	10.6
5/01/71	118	5	132.5[b]	-1.0	11.7	8.9	10.3
02	119	11	131.5[b]	-0.5	12.5	8.9	10.7
03	120	23	131.0[b]	-0.5	11.1	10.0	10.6
04	121	31	130.5[b]	-1.0	10.8	9.2	10.0
05	122	49	129.5[b]	-0.5	13.0	8.6	10.8
06	123	25	129.0[b]	-0.5	15.0	10.0	12.5
07	124	22	128.5[b]	-1.0	16.7	10.6	13.6
08	125	19	127.5[b]	-0.5	16.1	12.2	14.2
09	126	41[c]	127.0[b]	-0.5	15.8	11.4	13.6
10	127	41[c]	126.5[b]	-0.8	16.4	10.0	13.2
11	128	94	125.7	-0.7	17.5	11.1	14.3
12	129	202	125.0	-1.5	15.6	12.5	14.0
13	130	292	123.5	-1.0	15.0	10.8	12.9
14	131	405	122.5	-0.5	15.3	10.0	12.6
15	132	363	122.0	-1.0	13.3	11.7	12.5
16	133	598	121.0	-1.0	12.5	10.3	11.4
17	134	459	120.0	-1.5	13.3	8.9	11.1

Table A-2. Continued.

Date	Julian Day	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
5/18/71	135	331	118.5	-1.0	14.4	9.7	12.0
19	136	300	117.5	-0.5	14.2	11.1	12.6
20	137	310	117.0	-1.0	12.8	9.7	11.2
21	138	244	116.0	-1.0	14.2	10.0	12.1
22	139	240[d]	115.0	-1.5	15.6	10.0	12.8
23	140	240	113.5	-0.5	16.7	10.8	13.8
24	141	235	113.0	-1.0	17.0	11.4	14.2
25	142	285	112.0	-1.0	13.6	12.0	12.8
26	143	520	111.0	-1.0	15.0	11.4	13.2
27	144	326	110.0	-1.0	15.6	12.0	13.8
28	145	259	109.0	-1.0	15.0	12.8	13.9
29	146	354[d]	107.0	-2.0	15.0	12.0	13.5
30	147	354[d]	105.0	-2.0	13.0	10.6	11.8
31	148	450[c]	103.0	-2.0	12.0	10.3	11.2
6/01/71	149	450[c]	101.5	-1.5	12.2	10.6	11.4
02	150	161	99.1	-2.4	14.4	11.1	12.8
03	151	265	97.0	-2.1	15.8	10.6	13.2
04	152	171	93.5	-3.5	16.4	11.7	14.0
05	153	148[d]	91.5	-2.0	17.0	11.1	14.0
06	154	148[d]	88.5	-3.0	17.2	12.0	14.6
07	155	125[c]	86.5	-2.0	17.0	12.8	14.9
08	156	125[c]	83.5	-3.0	17.2	12.2	14.7
09	157	125[c]	81.5	-2.0	16.1	13.3	14.7
10	158	608	79.0	-2.5	17.0	13.0	15.0
11	159	706	75.5	-3.5	17.2	11.7	14.4
12	160	626[d]	72.0	-3.5	16.4	13.0	14.7
13	161	626[d]	68.5	-3.5	16.1	13.3	14.7

Table A-2. Continued.

Date	Julian Day	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
6/14/71	162	547[c]	65.0	-3.5	17.0	11.7	14.4
15	163	547[c]	62.5	-2.5	17.2	11.7	14.4
16	164	547[c]	58.9	-3.6	17.8	12.2	15.0
17	165	1,081	57.5	-1.4	16.7	12.8	14.8
18	166	1,096	56.0	-1.5	17.0	13.6	15.3
19	167	1,070[d]	54.5	-1.5	19.4	13.9	16.6
20	168	1,070[d]	53.0	-1.0	20.6	13.3	17.0
21	169	1,043[c]	52.0	-2.0	21.1	13.9	17.5
22	170	1,043[c]	50.0	-1.5	20.6	14.4	17.5
23	171	1,043[c]	48.5	-0.9	18.9	14.7	16.8
24	172	964	47.6	-0.1	18.9	13.3	16.1
25	173	658	47.5	-0.5	16.1	14.7	15.4
26	174	864[d]	47.0	0.0	18.3	14.7	16.5
27	175	864[d]	47.0	0.0	17.0	13.0	15.0
28	176	864[d]	47.0	-0.3	18.3	12.5	15.4
29	177	864[d]	46.7	0.0	18.9	12.2	15.6
30	178	1,071	46.7	0.0	20.0	13.0	16.5
7/01/71	179	1,040	46.7	-2.7	20.0	13.9	17.0
02	180	861	44.0	-1.0	19.4	13.9	16.6
03	181	344[c]	43.0	-1.0	20.0	13.0	16.5
04	182	344[c]	42.0	-2.0	19.7	13.3	16.5
05	183	344[c]	40.0	-1.5	20.0	13.6	16.8
06	184	344[c]	38.5	-1.0	19.4	13.6	16.5
07	185	344[c]	37.5	-1.5	19.7	13.0	16.4
08	186	194	36.0	-1.5	20.0	13.0	16.5
09	187	518	34.5	-1.5	18.0	15.3	16.6
10	188	473[c]	33.0	-1.0	18.6	13.6	16.1

Table A-2. Continued.

Date	Julian Day	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
7/11/71	189	473[c]	32.0	-1.0	19.2	13.3	16.2
12	190	473[c]	31.0	-1.5	20.0	13.0	16.5
13	191	473[c]	29.5	-1.5	20.8	13.0	16.9
14	192	473[c]	28.0	-1.1	21.7	13.6	17.6
15	193	552	26.9	-2.9	23.0	15.6	19.3
16	194	1,083	24.0	-1.5	23.3	16.1	19.7
17	195	438[c]	22.5	-2.0	23.6	16.1	19.8
18	196	438[c]	20.5	-2.0	19.2	16.7	18.0
19	197	438[c]	18.5	-2.0	23.9	16.1	20.0
20	198	438[c]	16.5	-1.8	24.7	17.2	21.0
21	199	438[c]	14.7	-0.7	25.0	17.5	21.2
22	200	137	14.0	-0.5	24.2	17.0	20.6
23	201	526	13.5	-0.5	23.9	16.7	20.3
24	202	190[c]	13.0	-0.5	23.6	15.8	19.7
25	203	190[c]	12.5	-0.5	23.6	15.8	19.7
26	204	190[c]	12.0	-0.1	24.4	17.0	20.7
27	205	190[c]	11.9	-0.4	24.4	17.5	21.0
28	206	190[c]	11.5	0.0	24.4	17.2	20.8
29	207	171	11.5	0.0	24.8[b]	18.0[b]	21.4
30	208	53[c]	11.5	-0.5	24.8[b]	18.0[b]	21.4
31	209	53[c]	11.0	0.0	24.8[b]	18.0[b]	21.4
8/01/71	210	53[c]	11.0	0.0	24.8[b]	18.0[b]	21.4
02	211	53[c]	11.0	-0.5	24.8[b]	18.0[b]	21.4
03	212	53[c]	10.5	0.0	24.8[b]	18.0[b]	21.4
04	213	53[c]	10.5		24.8[b]	18.0[b]	21.4
05	214	0	No Data		25.3	18.9	22.1

Table A-2. Continued.

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a) Daily minimum temperatures were not included in regression analysis.
b) Data are estimated.
c) Data are averages and were not included in regression analysis.
d) Data are estimates and were not included in regression analysis.

Table A-3. Daily record of parameters examined for influence on migration of underyearling steelhead, Kane Creek, 1971. Multiple regression analysis was performed only with data collected on Julian days 102 through 166.

Date	Julian Day	No. of Small Migrants	No. of Large Migrants	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
4/15/71	102	5	0	5	280.2	0.0	12.2	7.2	9.7
16	103	15	0	15	280.2	0.0	8.3	7.8	8.0
17	104	23	0	23	280.2	0.0	8.0	6.1	7.0
18	105	16	0	16	280.2	0.0	10.0	6.4	8.2
19	106	65	0	65	280.2	0.0	12.2	5.6	8.9
20	107	77	0	77	280.2	0.0	7.8	6.9	7.4
21	108	204	0	204	280.2	0.0	10.0	5.6	7.8
22	109	191	0	191	280.2	0.0	9.4	6.9	8.2
23	110	263	0	263	280.2	-19.2	9.4	5.8	7.6
24	111	239	0	239	261.9	- 9.0	10.0	5.6	7.8
25	112	255	0	255	252.0	-10.0	11.7	7.2	9.4
26	113	273	0	273	242.0	- 9.5	13.9	7.2	10.6
27	114	317	0	317	232.5	- 9.5	13.9	7.2	10.6
28	115	241	0	241	223.0	-10.0	13.9	8.9	11.4
29	116	301	0	301	213.0	-10.0	12.8	7.8	10.3
30	117	227	0	227	203.0	-10.0	12.8	8.0	10.4
5/01/71	118	310	0	310	193.0	- 8.5	12.0	9.2	10.6
02	119	487	0	487	184.5	-10.5	11.7[b]	9.0[b]	10.4
03	120	271	0	271	174.0	- 9.0	11.7[b]	9.0[b]	10.4
04	121	295	1	296	165.0	-10.0	11.4	9.0[b]	10.2
05	122	311	3	314	155.0	- 9.0	12.5	8.9	10.7
06	123	453	2	455	146.0	-10.0	15.0	8.9	12.0
07	124	401	7	408	136.0	+ 1.0	15.8	9.4	12.6
08	125	510	22	532	137.0	+ 1.0	15.6	11.4	13.5
09	126	336[c]	124[c]	460[c]	138.0	+ 1.0	15.8	10.8	13.3
10	127	336[c]	124[c]	460[c]	139.0	+ 2.5	16.1	9.7	12.9
11	128	405	528	933	141.5	- 7.0	17.2	10.6	13.9
12	129	371	1,404	1,775	134.5	- 7.0	15.6	12.2	13.9
13	130	286	1,090	1,376	127.5	- 6.5	15.6	10.6	13.1
14	131	560	2,715	3,275	121.0	- 7.5	15.3	9.4	12.4
15	132	735	3,590	4,325	113.5	- 6.5	13.3	11.1	12.2
16	133	783	3,115	3,898	107.0	- 7.5	12.2	9.4	10.8
17	134	756	2,330	3,086	99.5	- 6.5	13.3	7.8	10.6

Table A-3. Continued

Date	Julian Day	No. of Small Migrants	No. of Large Migrants	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
5/18/71	135	517	1,669	2,186	93.0	- 7.0	14.2	8.9	11.6
19	136	759	1,083	1,842	86.0	- 6.8	14.4	10.6	12.5
20	137	703	702	1,405	79.2	- 5.7	12.5	9.2	10.8
21	138	835	822	1,657	73.5	- 4.0	13.6	8.9	11.2
22	139	1,070[d]	791[d]	1,861[d]	69.5	- 5.5	15.6	9.4	12.5
23	140	1,070[d]	791[d]	1,861[d]	64.0	- 4.0	16.4	10.6	13.5
24	141	1,305	759	2,064	60.0	- 5.0	16.4	11.1	13.8
25	142	1,198	1,283	2,481	55.0	- 4.5	13.0	11.7	12.4
26	143	1,034	901	1,935	50.5	- 5.2	15.3	10.8	13.0
27	144	401	637	1,038	45.3	+ 0.7	14.7	12.0	13.4
28	145	402	936	1,338	46.0	+ 0.5	14.2	12.2	13.2
29	146	258[d]	1,100[d]	1,358[d]	46.5	+ 0.5	14.7	11.1	12.9
30	147	258[d]	1,100[d]	1,358[d]	47.0	+ 0.5	12.5	10.3	11.4
31	148	114[c]	1,264[c]	1,378[c]	47.5	0.0	11.1	10.0	10.6
6/01/71	149	114[c]	1,264[c]	1,378[c]	47.5	+ 0.5	12.0	9.4	10.7
02	150	49	878	927	48.0	- 1.5	13.9	10.3	12.1
03	151	87	1,114	1,201	46.5	- 2.0	15.6	10.3	13.0
04	152	100	1,740	1,840	44.5	- 1.5	15.6	11.1	13.4
05	153	34[c]	2,192[c]	2,226[c]	43.0	- 1.5	16.7	10.8	13.8
06	154	34[c]	2,192[c]	2,226[c]	41.5	- 2.5	16.7	12.0	14.4
07	155	25[c]	1,879[c]	1,904[c]	39.0	- 1.5	16.4	12.8	14.6
08	156	25[c]	1,879[c]	1,904[c]	37.5	- 1.0	16.4	12.2	14.3
09	157	25[c]	1,879[c]	1,904[c]	36.5	- 2.5	15.3	13.0	14.2
10	158	49	2,114	2,163	34.0	- 1.0	16.1	13.0	14.6
11	159	29	1,741	1,770	33.0	- 1.5	16.7	11.4	14.0
12	160	19[d]	2,177[d]	2,196[d]	31.5	- 2.0	14.4	12.2	13.3
13	161	19[d]	2,177[d]	2,196[d]	29.5	- 1.0	14.7	12.5	13.6
14	162	10[c]	2,614[c]	2,624[c]	28.5	- 1.5	15.8	11.1	13.4
15	163	10[c]	2,614[c]	2,624[c]	27.0	- 1.5	16.1	11.1	13.6
16	164	10[c]	2,614[c]	2,624[c]	25.5	- 1.0	16.1	11.7	13.9
17	165	7	2,597	2,604	24.5	- 1.0	15.0	12.2	13.6
18	166	4	1,956	1,960	23.5	- 0.5	15.3	12.8	14.0
19	167	2[d]	2,029[d]	2,031[d]	23.0	- 0.5	17.2	13.0	15.1
20	168	2[d]	2,029[d]	2,031[d]	22.5	- 0.5	17.8	13.0	15.4

Table A-3. Continued.

Date	Julian Day	No. of Small Migrants	No. of Large Migrants	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
6/21/71	169	0[c]	2,103[c]	2,103[c]	22.0	- 0.5	18.0	13.3	15.6
22	170	0[c]	2,103[c]	2,103[c]	21.5	- 1.0	17.8	13.3	15.6
23	171	0[c]	2,103[c]	2,103[c]	20.5	- 0.7	17.0	14.2	15.6
24	172	1	992	993	19.8	- 0.8	16.4	13.0	14.7
25	173	1	614	615	19.0	- 0.5	15.3	13.3	14.3
26	174	0	694[c]	694[c]	18.5	- 0.5	15.8	13.3	14.6
27	175	0	694[c]	694[c]	18.0	0.0	15.3	12.2	13.8
28	176	0	694[c]	694[c]	18.0	- 0.5	15.6	11.7	13.6
29	177	0	694[c]	694[c]	17.5	- 0.5	16.4	11.1	13.8
30	178	0	468	468	17.0	0.0	17.0	12.0	14.5
7/01/71	179	0	637	637	17.0	- 0.5	17.2	13.3	15.2
02	180	0	525	525	16.5	- 0.5	16.7	13.0	14.8
03	181	0	274[c]	274[c]	16.0	- 0.5	16.7	12.2	14.4
04	182	0	274[c]	274[c]	15.5	- 0.5	16.7	12.2	14.4
05	183	0	274[c]	274[c]	15.0	- 0.5	16.7	12.5	14.6
06	184	0	274[c]	274[c]	14.5	- 0.5	16.4	12.5	14.4
07	185	0	274[c]	274[c]	14.0	- 0.5	16.7	12.2	14.4
08	186	0	169	169	13.5	- 0.5	16.7	12.2	14.4
09	187	0	305	305	13.0	- 0.5	14.7	13.6	14.2
10	188	0	208[c]	208[c]	12.5	0.0	15.6	12.2	13.9
11	189	0	208[c]	208[c]	12.5	- 0.5	16.1	12.2	14.2
12	190	0	208[c]	208[c]	12.0	0.0	16.1	12.2	14.2
13	191	0	208[c]	208[c]	12.D	- 0.5	16.7	12.2	14.4
14	192	0	208[c]	208[c]	11.5	- 0.2	17.2	12.8	15.0
15	193	0	250	250	11.3	- 0.8	18.0	14.2	16.1
16	194	0	274	274	10.5	- 0.5	18.0	14.7	16.4
17	195	0	123[c]	123[c]	10.0	- 0.5	18.3	15.0	16.6
18	196	0	123[c]	123[c]	9.5	- 0.5	16.1	15.6	15.8
19	197	0	123[c]	123[c]	9.0	0.0	18.3	14.7	16.5
20	198	0	123[c]	123[c]	9.0	- 0.5	18.3	15.6	17.0
21	199	0	123[c]	123[c]	8.5	0.0	18.9	16.1	17.5
22	200	0	41	41	8.5	- 0.5	18.9	16.1	17.5
23	201	0	28	28	8.0	- 0.5	18.3	15.8	17.0
24	202	0	14[c]	14[c]	7.5	0.0	17.8	15.6	16.7

Table A-3. Continued.

Date	Julian Day	No. of Small Migrants	No. of Large Migrants	No. of Total Migrants	Average Daily Streamflow (l/sec.)	Daily Change in Streamflow (l/sec.)	Daily Maximum Temperature (deg. C)	Daily Minimum Temperature (deg. C)[a]	Daily Average Temperature (deg. C)
7/25/71	203	0	14[c]	14[c]	7.5	- 0.5	17.6[b]	16.2[b]	16.9
26	204	0	14[c]	14[c]	7.0	- 0.5	17.6[b]	16.2[b]	16.9
27	205	0	14[c]	14[c]	6.5	- 0.8	17.6[b]	16.2[b]	16.9
28	206	0	14[c]	14[c]	5.7	- 0.7	17.5	16.7	17.1
29	207	0	3[d]	3[d]	5.0	- 1.5	18.9	17.2	18.0
30	208	0	3[d]	3[d]	3.5	- 0.5	18.6	17.2	17.9
31	209	0	3[d]	3[d]	3.0	- 0.5	18.0	16.7	17.4
8/01/71	210	0	3[d]	3[d]	2.5	- 0.5	18.3	16.7	17.5
02	211	0	3[d]	3[d]	2.0	- 1.0	No Data		
03	212	0	3[d]	3[d]	1.0	- 1.0			
04	213	0	3[d]	3[d]	0.0				

a) Daily minimum temperatures were not included in regression analysis.
b) Data are estimated.
c) Data are averages and were not included in regression analysis.
d) Data are estimates and were not included in regression analysis.

Table A-4. Trap log, Kane Creek, 1970. Figures in parentheses are trapping related mortalities. Mortalities are included in daily totals.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
4/20					Installed trap. A few fry visible in tributary and in Rogue at tributary mouth.
4/21	Totals	171 (7)	23[b]		2 cottid.
4/22	Totals	533 (15)	0	0	1 adult steelhead.
4/23	0930 Totals	784 (153)	11	7	1 cutthroat, 5 cottid, 2 larval lamprey.
4/23	0930-1830	2	0	0	1 cottid.
	1830-1930	1	2[b]		
	1930-2000	24	2[b]		1 cottid.
	2000-2030	150	0	0	
	2030-2100	224 (7)	0	0	Broken overcast, bright moon.
	2100-2400	202 (9)	9[b]		1 adult steelhead.
4/23-24	2400-0300	153 (7)	8[b]		1 cutthroat, 1 cottid. Solid overcast, light rain, no moon.
4/24	0300-0500	57 (4)	2[b]		Daylight (newsprint readable).
	0500-0930	6	0	0	
4/24	0930 Totals	819 (27)	23[b]		1 cutthroat, 3 cottid, 1 adult steelhead.
4/25	Totals	519 (22)	4	2	3 cutthroat, 2 cottid.
4/26	Totals	562[a]	No Data		Trap flooded.
4/27	Totals	562[a]	No Data		Trap flooded and full of debris.
4/28	0730 Totals	605 (3)	5[b]		Nine of 605 fry were substantially larger (40-50mm) than others. 1 larval lamprey, 1 turtle.
4/28	0730-1900	0	0	0	
	1900-1930	0	0	0	Daylight.
	1930-2000	1	0	0	Darkness (newsprint unreadable) at 2000.
	2000-2030	54 (1)	2[b]		Partly cloudy.
	2030-2100	138 (1)	1[b]		
	2100-2130	128	0	0	
	2130-2230	221 (3)	5[b]		
	2230-2400	364 (8)	1[b]		Clear, no moon.
4/28-29	2400-0100	223 (4)	1[b]		

Table A-4. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
4/29	0100-0130	94	0	0	
	0130-0430	351	0	0	First light (newsprint readable) at 0430.
	0430-0530	8	1[b]		
	0530-0730	1	0	0	
4/29	0730 Totals	1,583 (17)	11[b]		
4/30	Totals	1,448[a]	9	12	Discovered hole in trap, corrected. Very heavy predation by large fish in trap. 1 cottid.
5/1	Totals	1,314 (55)	16	12	Heavy predation. 1 cottid.
5/2	0800 Totals	896 (62)	26	52	1 cutthroat, 3 cottid, 4 adult steelhead.
5/2	0800-1900	2	0	0	
	1900-2000	1	7[b]		Darkness.
	2000-2030	35	14[b]		Clear, no moon. 1 cutthroat.
	2030-2100	187 (2)	5[b]		
	2100-2130	115 (2)	9[b]		
	2130-2230	165	4[b]		
	2230-2300	81 (2)	7[b]		Light shining on trap during this period.
5/2-3	2300-0400	713	13[b]		1 larval lamprey.
	0420				First light.
	0400-0500	67 (9)	4[b]		2 larval lamprey.
5/3	0500 Totals	1,366 (28)	63[b]		1 cutthroat, 4 larval lamprey.
5/4	Totals	605 (21)	13	32	3 cottid, 1 crayfish.
5/5	0800 Totals	610[a]	No Data		Trap flooded.
5/5	0800-2030	10	1[b]		Darkness. Solid overcast. 1 frog.
	2030-2100	69	2[b]		1 crayfish.
	2100-2130	71	1[b]		Approximately 7 large (40-50 mm) fry and many smaller fry with large yolk sac.
	2130-2200	54	0	0	Includes 4 large fry.
	2200-2230	39	1[b]		Light shining on trap during this period. 1 cutthroat.
	2230-2300	64	0	0	Three large fry.
	2300-2400	55	0	0	Eight large fry.
5/5-6	2400-0200	131	2[b]		
5/6	0200-0500	119 (2)	0	0	Light at 0430.

Table A-4. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
5/6	0500-0900	4	0	0	
5/6	0900 Totals	616 (2)	7[b]		1 cutthroat, 1 frog, 1 crayfish.
5/7	Totals	1,422[a]	No Data		Trap full of debris, flooded. Closed trap.
5/8	Totals	1,422[a]	No Data		Trap closed.
5/9	Totals	1,422[a]	No Data		Trap closed.
5/10	Totals	1,422[a]	No Data		Opened trap.
5/11	Totals	2,227 (464)	0	3	1 cutthroat, 2 larval lamprey.
5/12	0800 Totals	1,833 (299)	0	4	
5/12	0800-1930	1	0	0	Solid overcast.
	1930-2000	2	0	0	Near darkness.
	2000-2030	8	0	0	Darkness. Broken overcast.
	2030-2100	38 (1)	0	0	
	2100-2130	49 (2)	0	0	About 75 percent of the fry were large (40-50 mm).
	2130-2200	68 (1)	0	0	
	2200-2300	234 (1)	2[b]		
5/12-13	2300-0100	524	2[b]		
5/13	0100-0800	1,044 (6)	0	0	
5/13	0800 Totals	1,968 (253)	4[b]		Mortalities include 242 marking related mortalities.
5/14	Totals	3,227 (965)	0	10	
5/15	Totals	4,030 (299)	3	19	Closed trap. 1 cottid.
5/16	Totals	3,142[a]	No Data		Trap closed.
5/17	Totals	3,142[a]	No Data		Opened trap at 1900.
5/17	1900-2000	1	0	0	Partly cloudy, full moon.
5/18	Totals	2,254 (59)	4	6	
5/19	Totals	1,997 (128)	1	3	1 cottid.
5/20	Totals	1,516 (68)	0	7	
5/21	2000 Totals	1,902 (47)	3[b]		
5/21-22	2000-0030	1,359 (35)	4[b]		Solid overcast.
5/22	0030-0730	263 (4)	2[b]		

Table A-4. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
5/22	0730-0915	0	0	0	
	0915-1000	30 (3)	0	0	Closed trap.
5/22	1000 Totals	1,652 (42)	6[b]		
5/23	Totals	1,748[a]	No Data		Opened trap.
5/24					Trap open but not emptied.
5/25	Totals	3,686 (163)	1	7	Two days data. 5 larval lamprey, 1 crayfish.
5/26	1000 Totals	1,807 (24)	0	4	
5/26	1000-1945	66	0	0	2 snakes.
5/27	0500 Totals	1,417 (26)	0	1	1 cottid, 1 larval lamprey.
5/27	1125-1205	2	0	0	
5/28	1950 Totals	1,656 (5)	4[b]	0	3 larval lamprey.
5/29	0600 Totals	1,654 (11)	0	0	Closed trap. 4 larval lamprey.
5/30	Totals	1,427[a]	No Data		Opened trap.
5/31					Trap open but not emptied.
6/1	Totals	2,401 (30)	0	3	Two days data. 5 cottid, 7 larval lamprey.
6/2					Trap open but not emptied.
6/3	Totals	2,742 (43)	0	3	Two days data. 3 cottid.
6/4	2000 Totals	1,175 (7)	0	0	4 cottid, 1 larval lamprey.
6/5	0830 Totals	1,232 (10)	2[b]		
6/5	0830-1115	67	0	0	
	1115-1130	8	0	0	
6/5	1130 Totals	1,331 (10)	2[b]		1 crayfish.
6/6-7					Trap open but not emptied.
6/8	Totals	3,490 (29)	0	2	Three days data. 4 cottid, 10 larval lamprey.
6/9	Totals	726 (12)	0	0	2 larval lamprey.
6/10	Totals	690 (9)	0	0	1 cottid, 2 larval lamprey.
6/11	Totals	726[a]	No Data		Trap flooded.
6/12	Totals	726[a]	No Data		Trap flooded.
6/12	2330				Trap open but flooded. Water spilling around weir. Replaced stop-log at irrigation ditch spillway.
6/12	2400				Trap operating.

Table A-4. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
6/13	1200 Totals	726[a]	No Data		
6/13	1200-1415	41	0	0	
		(1)			
	1415-2030	62	0	0	Daylight.
	2045				Darkness.
	2030-2200	126	0	0	
		(3)			
6/13-14	2200-0100	300	0	0	Solid overcast.
		(4)			
6/14	0100-0400	191	0	0	Daylight at 0400.
		(5)			
	0400-0900	32	1[b]		Closed trap.
6/14	0900 Totals	752	1[b]		
		(13)			
6/15	Totals	484[a]	No Data		
6/16	Totals	484[a]	No Data		
6/17	Totals	484[a]	No Data		
6/18	Totals	484[a]	No Data		
6/19	Totals	484[a]	No Data		
6/20	Totals	484[a]	No Data		
6/20	2100				Opened trap.
6/20-21	2100-0600	214	1[b]		2 cottid, 1 larval lamprey.
		(4)			
6/21	0600-0630	3	0	0	Closed trap.
6/21	0630 Totals	217	1[b]		2 cottid, 1 larval lamprey.
		(4)			
6/22	Totals	244[a]	No Data		Trap closed.
6/23	Totals	244[a]	No Data		Trap closed.
6/24	Totals	244[a]	No Data		Trap closed.
6/25	Totals	244[a]	No Data		Trap closed.
6/26	Totals	244[a]	No Data		Trap closed.
6/27	2020 Totals	244[a]	No Data		Opened trap and repaired weir.
6/28	1040 Totals	270	0	0	6 cottid, 1 larval lamprey.
6/29-7/11	Totals	145[a]/day	No Data		Trap open but not emptied.
7/11					Streamflow too low to pass over weir. Corrected.
7/12		20	0	0	Streamflow intermittent at several locations upstream of trap. Trapping discontinued.
		(2)			

a) Daily total is estimated.
b) Steelhead smolt and parr are combined.

Table A-5. Trap log, Kane Creek, 1971. Figures in parentheses are trapping related mortalities. Mortalities are included in daily totals.

		Number of Summer Steelhead					
Date	Time (PST)	Small Fry	Large Fry	Total Fry	Smolt	Parr	Remarks and Misc. Species
4/14							Installed weir and trap.
4/15	Totals	5 (3)	0	5 (3)	5	6	1 cutthroat.
4/16	Totals	15	0	15	15	12	2 cutthroat.
4/17	Totals	23 (3)	0	23 (3)	7	2	
4/18	Totals	16	0	16	1		
4/19	Totals	65 (8)	0	65 (8)	6	2	1 cutthroat, 1 native rainbow.
4/20	Totals	77	0	77			
4/21	Totals	204 (20)	0	204 (20)	5	2	1 native rainbow.
4/22	Totals	191 (15)	0	191 (15)	3	0	1 cutthroat.
4/23	Totals	263 (21)	0	263 (21)	4	2	
4/24	Totals	239 (23)	0	239 (23)	1	2	
4/25	Totals	255 (21)	0	255 (21)	8	4	1 cutthroat, 1 adult steelhead.
4/26	Totals	273 (13)	0	273 (13)	26	32	3 cutthroat, 4 native rainbow.
4/27	Totals	317 (11)	0	317 (11)	31	76	3 cutthroat, 3 native rainbow.
4/28	Totals	241 (12)	0	241 (12)	18	67	3 cutthroat, 2 native rainbow.
4/29	Totals	301 (14)	0	301 (14)	11	49	1 cutthroat, 1 adult steelhead.
4/30	Totals	227 (10)	0	227 (10)	6	7	
5/1	Totals	310 (25)	0	310 (25)	11	15	2 cutthroat, 2 native rainbow.
5/2	Totals	487 (22)	0	487 (22)	20	18	1 cutthroat, 1 native rainbow.
5/3	Totals	271 (31)	0	271 (31)	9	54	1 cutthroat, 1 native rainbow.
5/4	Totals	295 (17)	1	296 (17)	6	19	2 cutthroat.
5/5	Totals	311 (9)	3	314 (9)	4	7	1 cutthroat.
5/6	Totals	453 (7)	2	455 (7)	1	7	
5/7	Totals	401 (5)	7	408 (5)	4	15	
5/8	Totals	510 (38)	22	532 (38)	4	72	4 cutthroat, 7 native rainbow.
5/9							Trap open but not emptied.

Table A-5.- Continued.

Date	Time (PST)	Number of Summer Steelhead: Small Fry	Large Fry	Total Fry	Smolt	Parr	Remarks and Misc. Species
5/10	Totals	672	247	919	6	90	Two days data. 1 native rainbow. 7 cutthroat.
		(33)		(33)			
5/11	Totals	405	528	933	1	14	2 cutthroat.
		(24)	(3)	(27)			
5/12	Totals	371	1,404	1,775	1	25	2 cutthroat, 1 large mouth bass.
		(46)	(2)	(48)			
5/13	1045 Totals	286	1,090	1,376	2	2	1 cutthroat, 1 native rainbow.
		(8)	(18)	(26)			
5/13	1045-1415	0	154	154	0	0	
5/14	Totals	560	2,715	3,275	2	29	2 cutthroat.
		(6)	(11)	(17)			
5/15	Totals	735	3,590	4,325	2	14	3 cutthroat.
		(27)	(40)	(67)			
5/16	Totals			3,898	3	17	Small and large fry combined. 2 cutthroat.
				(9)			
5/17	Totals	756	2,330	3,086	0	4	1 cutthroat.
		(15)	(3)	(18)			
5/18	Totals	517	1,669	2,186	0	4	Twenty eight mm fry found in stomach of 59 mm fry. 4 cutthroat.
		(4)	(8)	(12)			
5/19	0700 Totals	759	1,083	1,842	0	2	1 cutthroat.
		(1)	(2)	(3)			
5/19	0700-0730	0	5	5	0	0	
5/20	0910 Totals	703	702	1,410	0	2	
			(1)	(1)			
5/20	0910-1430	2	26	28	0	0	
	1923-1938	0	0	0	0	0	Daylight (newsprint readable).
	1955-2005	0	0	0	0	0	Darkness (newsprint unreadable).
	2045-2055			17	0	0	Small and large fry combined.
	2220-2230			27	0	0	Small and large fry combined.
	2233-2243			19	0	0	Small and large fry combined.
5/21	0745 Totals	835	822	1,657	0	4	Closed trap. 1 cutthroat.
		(1)		(1)			
5/22	Totals	1,070[a]	791[a]	1,861[a]	No Data		Trap closed.
5/23	Totals	1,070[a]	791[a]	1,861[a]	No Data		Opened trap.
5/24	Totals	1,305	759	2,064	0	13	4 cutthroat, 1 native rainbow.
		(3)	(8)	(11)			
5/25	Totals	1,198	1,283	2,481	0	7	5 cutthroat, 1 native rainbow.
		(9)	(2)	(11)			
5/26	Totals	1,034	901	1,935	1	11	3 cutthroat, 1 native rainbow.
		(5)	(2)	(7)			
5/27	Totals	401	637	1,038	0	3	
5/27	1605-1615	0	1	1	0	0	
	2119-2129	9	23	32	0	0	Solid overcast.
	2156-2206	15	14	29	0	0	Broken overcast.
	2235-2245	19	18	37	0	0	Clear, no moon.

Table A-5. Continued.

		Number of Summer Steelhead					
Date	Time (PST)	Small Fry	Large Fry	Total Fry	Smolt	Parr	Remarks and Misc. Species
5/28		402	936	1,338	0	3	2 cutthroat.
		(1)	(2)	(3)			
5/28	0900-0910	0	2	2	0	0	Closed trap.
5/29	Totals	258[a]	1,100[a]	1,358[a]	No	Data	Trap closed.
5/30	Totals	258[a]	1,100[a]	1,358[a]	No	Data	Opened trap.
5/31							Trap open but not emptied.
6/1	Totals	228	2,528	2,756	0	2	Two days data. 1 cutthroat.
		(2)	(9)	(11)			
6/2	0900 Totals	49	878	927	0	0	
			(3)	(3)			
6/2	2055-2105	1	3	4	0	0	Darkness. Bright half moon. Many fry began to enter trap and then swam back upstream.
	2125-2135	2	12	14	0	0	
	2200-2210	2	10	12	0	0	
6/3	0820 Totals	87	1,114	1,201	0	2	
			(1)	(1)	0	2	
6/3	0820-1620	10	218	228	0	0	Stream level lower than afternoon of 6/2. Sunny, hot day.
	2108-2118	3	14	17	0	0	Bright moon.
	2118-2128	2	14	16	0	0	
	2147-2157	0	16	16	0	0	
6/4	0930 Totals	100	1,740	1,840	0	2	1 cutthroat.
		(1)	(2)	(3)			
6/5							Trap open but not emptied.
6/6	Totals	69	4,385	4,454	0	0	Two days data. 2 cutthroat.
			(28)	(28)			
6/7							Trap open but not emptied.
6/8	1730 Totals	59	4,514	4,573	0	6	Two days data.
			(42)	(42)			
6/8	2000						Added plastic to weir to raise water level.
6/9	0930 Totals	15	1,123	1,138	0	1	1 cutthroat.
6/9	1300-1310	0	0	0	0	0	
	1317-1327	0	1	1	0	0	
	1341-1351	0	1	1	0	0	
	1910-1920	0	0	0	0	0	Solid overcast.
	1924-1934	0	0	0	0	0	Daylight.
	1941-1951	0	0	0	0	0	Daylight.
6/9	2000	3	176	179	0	0	
	2128-2138	2	48	50	0	0	Darkness.
	2148-2158	4	38	42	0	0	
	2217-2227	3	25	28	0	0	Solid overcast.
6/10	0936-0946	0	0	0	0	0	
6/10	1000 Totals	49	2,114	2,163	0	0	2 cutthroat.
			(1)	(1)			
6/10	1056-1116	0	2	2	0	0	

Table A-5. Continued.

Date	Time (PST)	Number of Summer Steelhead: Small Fry	Large Fry	Total Fry	Smolt	Parr	Remarks and Misc. Speceis
6/10	1626-1656	0	3	3	0	0	
6/10-11	1656-0900	28	1,527	1,555	0	1	1 cutthroat.
			(3)	(3)			
6/11	0900 Totals	29	1,741	1,770	0	1	Closed trap. 1 cutthroat.
			(3)	(3)			
6/12	Totals	19[a]	2,177[a]	2,196[a]	No Data		Trap closed.
6/13	Totals	19[a]	2,177[a]	2,196[a]	No Data		Opened trap.
6/14							Trap open but not emptied.
6/15							Trap open but not emptied.
6/16	1030 Totals	30	7,843	7,873	0	2	Three days data. 5 cutthroat, 1 bullhead.
			(62)	(62)			
6/16	1030-1530	0	214	214	0	0	Scattered clouds. Bright, hot day.
6/17	0348-0358	0	14	14	0	0	Darkness.
	0401-0511	0	20	20	0	0	Daylight.
	0420-0430	0	60	60	0	0	
6/17	0830 Totals	7	2,597	2,604	0	0	
6/17	0830-1530	1	355	356	0	0	
			(2)	(2)			
6/18	0349-0359	0	20	20	0	0	Darkness.
	0406-0416	0	25	25	0	0	Daylight.
	0420-0430	0	25	25	0	0	Solid overcast with rain.
	0730-1015	1	32	33	0	0	
6/18	Totals	4	1,956	1,960	0	1	Closed trap.
			(4)	(4)			
6/19	Totals	2[a]	2,029[a]	2,031[a]	No Data		Trap closed.
6/20	Totals	2[a]	2,029[a]	2,031[a]	No Data		Opened trap.
6/21							Trap open but not emptied.
6/22							Trap open but not emptied.
6/23	1330 Totals	0	6,308	6,308	0	2	Three days data. 1 cutthroat.
			(34)	(34)			
6/23	1330-1630	0	87	87	0	0	
			(1)	(1)			
	1630-1930	0	43	43	0	0	
6/24	0335-0345	0	6	6	0	0	Darkness.
	0357-0407	0	15	15	0	0	Daylight.
	0417-0427	0	11	11	0	0	
6/24	0800 Totals	1	992	993	0	0	
			(3)	(3)			
6/24	0800-1900	1	178	179	0	0	
	2142-2152	0	7	7	0	0	Solid overcast with rain.
	2155-2205	0	12	12	0	0	
	2216-2226	0	9	9	0	0	
6/25	1115 Totals	1	614	615	0	0	
6/26							Trap open but not emptied.
6/27							Trap open but not emptied.
6/28							Trap open but not emptied.

Table A-5. Continued.

Date	Time (PST)	Number of Summer Steelhead					Remarks and Misc. Species
		Small Fry	Large Fry	Total Fry	Smolt	Parr	
6/29		0	2,764 (10)	2,764 (10)	0	2	Four days data.
6/30		0	468 (2)	468 (2)	0	0	
7/1	0845 Totals	0	637 (2)	637 (2)	0	0	Clear, hot day.
	0845-1945	0	105	105	0	0	
7/1-2	1945-0715	0	420	420	0	0	
7/2	0715 Totals	0	525	525	0	0	Solid overcast.
7/3-6							Trap open but not emptied.
7/7	1040 Totals	0	1,368	1,368	0	0	Five days data.
7/7	1040-1640	0	34	34	0	0	
7/7-8	1640-0800	0	135	135	0	0	
7/8	0800 Totals	0	169	169	0	0	
7/8	0800-1600	0	58 (1)	58 (1)	0	0	
7/8-9	1600-0830	0	247	247	0	0	
7/9	0830 Totals	0	305 (1)	305 (1)	0	0	
7/10-13							Trap open but not emptied.
7/14	0830 Totals	0	1,041	1,041	0	0	Five days data.
7/15	0910 Totals	0	250 (2)	250 (2)	0	0	
7/15	0910-1640	0	37	37	0	0	
7/15-16	1640-0830	0	237 (1)	237 (1)	0	0	
7/16	0830 Totals	0	274 (1)	274 (1)	0	0	
7/17-20							Trap open but not emptied.
7/21	0815 Totals	0	613	613	0	0	Five days data.
7/22	0730 Totals	0	41	41	0	0	
7/23	Totals	0	28	28	0	0	
7/24-27							Trap open but not emptied.
7/28	Totals	0	70	70	0	0	Five days data.
7/29	Totals	0	3	3	0	0	
7/30-8/3							Trap open but not emptied.
8/4	1400 Totals	0	3	3	0	0	Six days data. Streamflow too low to pass over weir. Corrected.
8/5	Totals	0	0	0	0	0	Trapping discontinued.

a) Daily total is estimated.

Table A-6. Trap log, Galls Creek, 1970. Figures in parentheses are trapping related mortalities. Mortalities are included in daily totals.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
4/20	1830				Weir and trap installed.
4/21	Totals	182 (22)	10	0	6 cutthroat, 4 cottid. Sample of 3 smolt and 1 cutthroat with protruding abdomen yielded 76 fry.
4/22	Totals	265 (11)	16[b]		2 cutthroat, 3 cottid.
4/23	Totals	209 (21)	20	4	3 cutthroat, 7 cottid.
4/23	1830	4 (1)	3[b]		
	1830-2130	64 (6)	8[b]		2 cottid, 1 frog.
4/23-24	2130-0530	94 (11)	9[b]		Light rain. 14 cutthroat, 2 cottid, 2 crayfish.
4/24	0530-0900	0	0	0	
4/24	0900 Totals	162 (18)	20[b]		14 cutthroat, 4 cottid, 2 crayfish, 1 frog.
4/25		144[a]	No Data		Trap full of debris, flooded.
4/26		144[a]	No Data		Trap full of debris, flooded.
4/27		144[a]	No Data		Trap full of debris, flooded.
4/28	Totals	127 (1)	9[b]		4 cutthroat, 2 cottid.
4/28	1920	0	1[b]		
	1920-2200	59 (4)	21[b]		Darkness (newsprint no longer readable) occurred between 1930 and 2000. 2 cutthroat, 1 cottid.
4/28-29	2200-0030	65 (14)	39[b]		1 cutthroat.
4/29	0030-0500	63 (9)	10[b]		1 adult steelhead.
	0500-0800	0	0[b]		
4/29	Totals	187 (27)	71[b]		3 cutthroat, 1 cottid, 1 adult steelhead.
4/30	Totals	81 (8)	31	37	16 cutthroat, 1 cottid.
5/1	Totals	138 (23)	80	39	26 cutthroat, 1 cottid.
5/2	Totals	338 (84)	114	136	52 cutthroat, 6 cottid, 3 adult steelhead, 1 crayfish, 1 frog.
5/2	1830	6 (1)	16[b]		1 cottid.
5/2-3	1830-0100	217 (22)	205[b]		17 cutthroat, 9 cottid.
5/3	0100-0600	154 (41)	117[b]		19 cutthroat.

Table A-6. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
5/3	Totals	377 (64)	338[b]		36 cutthroat, 10 cottid.
5/4	Totals	239 (6)	24	60	42 cutthroat, 18 cottid, 1 crayfish, 2 frogs.
5/5	Totals	280[a]	No Data		Trap full of debris and flooded
5/6	Totals	320 (51)	77[b] (16)		23 cutthroat (6 dead), 1 cottid.
5/7	Totals	939 (39)	14	37	Closed trap. 12 cutthroat, 4 cottid, 1 frog.
5/8	Totals	1,072[a]	No Data		Trap closed.
5/9	Totals	1,072[a]	No Data		Trap closed.
5/10	Totals	1,072[a]	No Data		Opened trap.
5/11	Totals	1,205 (37)	1	3	4 cutthroat, 1 cottid, 2 crayfish.
5/12	Totals	779 (29)	0	0	4 cutthroat, 1 cottid, 1 larval lamprey, 2 crayfish
5/13	0200	316 (5)	13[b]		6 cutthroat, 2 cottid, clear, no moon.
	0200-0630	324 (9)	2[b]		
5/13	Totals	640 (14)	15[b]		6 cutthroat, 2 cottid.
5/14	Totals	1,049 (38)	1	12	6 cutthroat, 1 cottid, 1 frog, 1 crayfish.
5/15	Totals	1,426 (113)	0	10	Closed trap. 3 cutthroat, 4 cottid.
5/16	Totals	1,985[a]	No Data		Trap closed.
5/17	Totals	1,985[a]	No Data		Opened trap at 1800.
	2030	3	0	0	Near full moon. Partly cloudy. 1 cutthroat 1 cottid.
	2030-2330	350	5[b]		6 cutthroat, 8 cottid.
5/17-18	2330-0715	2,194 (18)	10[b]		9 cutthroat, 3 cottid.
5/18	Totals	2,544 (18)	15[b]		16 cutthroat, 12 cottid.
5/19	Totals	1,860 (60)	1	9	1 cutthroat, 6 cottid, 1 crayfish.
5/20	Totals	1,142 (31)	1	8	4 cutthroat, 5 cottid, 1 crayfish.
5/21	Totals	804 (11)	0	0	1 cutthroat, 1 cottid, 1 crayfish.
5/22	1115	978 (9)	0	0	
	1115-1145	14	0	0	Closed trap.
5/22	Totals	992 (9)	0	0	1 cutthroat, 1 cottid.

Table A-6. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
5/23	Totals	1,204[a]			Opened trap.
5/24					Trap open but not emptied.
5/25	Totals	2,835 (67)	4	4	Two days data. 3 cutthroat, 14 cottid, 5 crayfish.
5/26	Totals	1,910 (34)	0	2	2 cutthroat, 11 cottid. 2 crayfish.
5/26	0800-1930	45	1[b]		Darkness (newsprint unreadable at 1920). 1 cutthroat.
5/26-27	1930-0540	1,735 (31)	0[b]		5 cutthroat, 2 cottid.
5/27	Totals	1,780 (31)	1[b]		6 cutthroat, 2 cottid.
5/27	1050-1120	1	0	0	
5/28	Totals	2,191 (38)	0	0	
5/29	1330 Totals	2,576 (11)	0	0	Closed trap. 4 cottid.
5/30	Totals	2,686[a]	No Data		Opened trap.
5/31					Trap open but not emptied.
6/1	Totals	5,590 (35)	0	0	Two days data. 2 cutthroat, 6 cottid.
6/2					Trap open but not emptied.
6/3	Totals	5,803 (20)	1	0	Two days data. 22 cottid, 2 crayfish.
6/4	1945 Totals	2,566 (5)	0	0	4 cutthroat, 3 larval lamprey.
6/5	1310 Totals	3,424 (4)	0	0	Stop-log out of irrigation spillway. 2 snakes.
6/5	1310-1325	11	0	0	All large (40-50mm) fry. Closed trap.
6/6	Totals	1,888[a]	No Data		Trap closed.
6/7	Totals	1,888[a]	No Data		Opened trap.
6/8	Totals	353 (1)	0	0	7 cottid.
6/9	Totals	1,748 (21)	0	0	1 cottid.
6/10	Totals	2,008 (27)	0	0	Closed trap. 1 cottid.
6/11	Totals	1,182[a]	No Data		
6/12	Totals	1,182[a]	No Data		Opened trap at 2035. Darkness. Solid overcast.
6/13	1025 Totals	357 (6)	0	0	
6/13	1025-2020	7	0	0	Broken overcast.
6/14	0400				Daylight (newsprint readable). Solid overcast.
6/14	0940	521 (6)	0	0	1 cutthroat.

Table A-6. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
6/14	1100				Removed stop-log from irrigation ditch spillway to increase streamflow at tributary mouth.
6/14	1100 Totals	528 (6)	0	0	Closed trap. 1 cutthroat.
6/15	Totals	992[a]	No Data		Trap closed.
6/16	Totals	992[a]	No Data		Trap closed.
6/17	Totals	992[a]	No Data		Trap closed.
6/18	Totals	992[a]	No Data		Trap closed.
6/18	Totals	992[a]	No Data		Trap closed.
6/19	Totals	992[a]	No Data		Trap closed.
6/20	Totals	992[a]	No Data		Trap closed.
6/20	1945				Opened trap.
6/20-21	1945-0730	1,376 (6)	0	0	Irrigation ditch not spill-spilling. Streamflow subterranean at tributary mouth. 6 cottid.
6/21	0730-0745	37	0	0	
	0748-0803	44	0	0	
6/21	Totals	1,457 (6)	0	0	Closed trap. 6 cottid.
6/22	Totals	1,055[a]	No Data		Trap closed.
6/23	Totals	1,055[a]	No Data		Trap closed.
6/24	Totals	1,055[a]	No Data		Trap closed.
6/25	Totals	1,055[a]	No Data		Trap closed.
6/26	Totals	1,055[a]	No Data		Trap closed.
6/27	Totals	1,055[a]	No Data		Opened trap at 1945.
6/27-28	1945-1000	642 (4)	0	0	
6/28	1018-1148	11	0	0	Tributary flowing at mouth.
6/28	Totals	653 (4)	0	0	Closed trap.
6/29	Totals	326[a]	No Data		Trap closed.
6/30	Totals	326[a]	No Data		Trap closed.
7/1	Totals	326[a]	No Data		Trap closed.
7/2	Totals	326[a]	No Data		Trap closed.
7/3	Totals	326[a]	No Data		Trap closed.
7/4	Totals	326[a]	No Data		Trap closed.
7/5	Totals	326[a]	No Data		Trap closed.
7/6	Totals	326[a]	No Data		Trap closed.
7/7	Totals	326[a]	No Data		Trap closed.
7/8	Totals	326[a]	No Data		Trap closed.
7/9	Totals	326[a]	No Data		Trap closed.
7/10	Totals	326[a]	No Data		Trap closed.
7/11	Totals	326[a]	No Data		Opened trap.

Table A-6. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
7/12	Totals	0	0	0	Streamflow intermittent at several locations and too low for migrants to pass over trap weir. Trapping discontinued.

a) Daily total is estimated.
b) Steelhead smolt and parr are combined.

Table A-7. Trap log, Galls Creek, 1971. Figures in parentheses are trapping related mortalities. Mortalities are included in daily totals.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
4/22					Weir and trap installed.
4/23	Totals	0	1	0	Weir and trap slightly flooded. 4 cutthroat, 1 adult summer steelhead.
4/24	Totals	0	0	0	Weir and trap slightly flooded. 1 cutthroat.
4/25	Totals	2	3	0	7 cutthroat.
4/26	Totals	6	1	1	12 (1 mortality) cutthroat, 1 native rainbow.
4/27	Totals	13	10	5	21 cutthroat, 1 native rainbow.
4/28	Totals	7	1	7	14 cutthroat, 1 adult summer steelhead.
4/29	Totals	9	0	2	13 cutthroat, 3 (1 mortality) native rainbow.
4/30	Totals	3	1	2	7 cutthroat.
5/1	Totals	5	0	0	1 cutthroat.
5/2	Totals	11	0	0	3 cutthroat.
5/3	Totals	23	11	51	13 cutthroat.
5/4	Totals	31	7	17	6 cutthroat.
		(1)			
5/5	Totals	49	4	6	9 cutthroat, 1 adult summer steelhead.
5/6	Totals	25	0	17	
		(2)			
5/7	Totals	22	2	25	10 cutthroat.
5/8	Totals	19	2	29	20 cutthroat.
		(1)			
5/9					Trap open but not emptied.
5/10	Totals	82	5	52	Two days data. 4 cutthroat,
		(6)		(2)	1 adult summer steelhead.
5/11	Totals	94	5	18	5 (1 mortality) cutthroat.
		(29)			
5/12	Totals	202	5	37	Night of 5/11-12 broken
		(39)			overcast with showers. 13 cutthroat, 12 cutthroat fry.
5/13	Totals	292	1	32	2 cutthroat.
		(7)		(17)	
5/14	Totals	405	0	4	
		(11)			
5/15	Totals	363	2	46	3 cutthroat.
		(9)			
5/16	Totals	598	3	17	2 cutthroat.
		(9)			
5/17	Totals	459	0	14	1 cutthroat.
		(3)			
5/18	Totals	331	1	26	4 cutthroat.

Table A-7. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
5/19	Totals	300	1	54	14 cutthroat.
		(1)			
5/19	0800-1930	8	0	0	
5/20	0715 Totals	310	0	35	Examined stomachs of three large fry: 2 contained insects, other contained 1 fry. 13 cutthroat.
		(4)			
5/20	0715-1630	2	0	0	
5/20-21	1630-0645	242	2	15	7 cutthroat.
5/21	Totals	244	2	15	Closed trap. 7 cutthroat.
5/22		240[a]	No Data		Trap closed.
5/23	Totals	240[a]	No Data		Opened trap.
5/24	Totals	235	5	125	18 cutthroat.
		(4)			
5/25	Totals	285	0	70	10 cutthroat.
		(1)			
5/26	Totals	520	1	36	
		(3)			
5/27	Totals	326	0	26	5 cutthroat.
		(1)			
5/28	Totals	259	1	11	Closed trap. 4 cutthroat.
		(7)			
5/29	Totals	354[a]	No Data		Trap closed.
5/30	Totals	354[a]	No Data		Opened trap.
5/31					Trap open but not emptied.
6/1	Totals	899	0	31	Two days data. 3 cutthroat.
		(23)			
6/2	Totals	161	0	6	Overcast morning. Sunny, hot afternoon. 2 cutthroat.
6/3	Totals	265	0	9	3 cutthroat.
6/3	0720-1720	8	0	0	
6/4	Totals	171	0	11	Closed trap. 6 cutthroat.
6/5	Totals	148[a]	No Data		Trap closed.
6/6	Totals	148[a]	No Data		Opened trap at 1000.
6/7-8					Trap open but not emptied.
6/9	Totals	376	0	16	Three days data. At 2000, stream level too low to pass over weir, trap not operating. Corrected. 5 cutthroat.
		(11)			
6/10	0845 Totals	608	0	8	2 cutthroat.
		(13)			
6/10	0845-1845	53	0	0	Stream level about 2.5 cm lower at 1900 than at 0900.
		(5)			
6/10-11	1845-0900	653	0	0	
		(10)			
6/11	0900 Totals	706	0	0	Closed trap. Stream level similar to that of 6/10 morning.
		(15)			

Table A-7. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
6/12	Totals	626[a]	No Data		Trap closed.
6/13	Totals	626[a]	No Data		Opened trap.
6/14-15					Trap open but not emptied.
6/16	Totals	1,640 (123)	0	6	Three days data. At about 1100, stream level suddenly dropped about 2.5 cm which prevented any water from passing over weir. 3 cutthroat.
6/16	1300				Stream level still down.
	1700				Filled around weir to raise level of stream enough to pass over weir.
6/17	0745 Totals	1,081 (3)	0	0	
6/17	0745-1630	147 (3)	0	0	Rain showers throughout previous evening and night.
6/18	Totals	1,096 (7)	0	3	Closed trap. Solid overcast. 1 cutthroat.
6/19	Totals	1,070[a]	No Data		Trap closed.
6/20	Totals	1,070[a]	No Data		Opened trap.
6/21-22					Trap open but not emptied.
6/23	0915 Totals	3,128 (415)	0	2	Three days data. Partly cloudy. 1 cutthroat.
6/23	0915-1645	160	0	0	Stream level about 4 cm lower at 1700 than at 0900.
6/23-24	1645-0645	804	0	1	Stream level about 4 cm higher at 2000 than at 1700.
6/24	0645 Totals	964	0	1	
6/24	0645-1915	142	0	1	
6/24-25	1915-0630	480	0	1	
6/25	0630-1130	36	0	0	
6/25	1130 Totals	658	0	2	Closed trap.
6/26	Totals	864[a]	No Data		Trap closed.
6/27	Totals	864[a]	No Data		Trap closed.
6/28	Totals	864[a]	No Data		Trap closed.
6/29	Totals	864[a]	No Data		Opened trap.
6/30	0715 Totals	1,071	0	0	Clear, hot day.
7/1	0715 Totals	1,040	0	0	
	0715-1615	313	0	0	Clear, hot day.
7/2	0730 Totals	861	0	0	
7/3-6					Trap open but not emptied.
7/7	0830 Totals	1,722	0	0	Five days data.
	0830-1700	160	0	0	
	1800				Stream level too low to pass over weir, trap not operating. Unable to correct completely.
7/7-8	1700-0700	34	0	0	
7/8	0700 Totals	194	0	0	

Table A-7. Continued.

Date	Time (PST)	No. of Summer Steelhead Fry	Smolt	Parr	Remarks and Misc. Species
7/9	0700 Totals	518	0	0	
7/10-13					Trap open but not emptied.
7/14	0745 Totals	2,363	0	0	Five days data.
7/15	0830 Totals	552	0	0	
	0830-1630	258	0	0	At 1630, stream level down. Water barely spilling over weir.
	1930				Stream level below top of weir. Corrected by filling gravel and sand around weir.
7/15-16	1630-0715	825	0	0	
7/16	0715 Totals	1,083	0	0	1 lamprey.
7/17-20					Trap open but not emptied.
7/21	Totals	2,190	0	0	Five days data.
7/22	0845 Totals	137	0	0	Water barely spilling over weir. Corrected by covering stream bed immediately above weir with plastic.
7/23	Totals	526	0	0	
7/24-27					Trap open but not emptied.
7/28	0730 Totals	948 (3)	0	0	Five days data.
7/29	Totals	171	0	0	
7/30-8/3					Trap open but not emptied.
8/4	1430 Totals	318 (5)	0	0	Six days data. Water not spilling over weir. Corrected.
8/5	Totals	0	0	0	Trapping discontinued.

a) Daily total is estimated.