AN ABSTRACT OF THE THESIS OF

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Title EVALUATION OF A LOUVER GUIDANCE FACILITY USED TO SAMPLE SALMON AND TROUT EMIGRANTS

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James D. Hall

The subject of this thesis is an evaluation of a louver facility in the Lemhi River, Idaho. The louver facility was designed to guide juvenile chinook salmon and steelhead trout into a trap in order to sample downstream migrant populations. The study was designed to determine: (1) if the catch in the louver facility was a reliable index of emigrant population size, and (2) if an accurate estimate of the number of emigrants could be obtained through a mark-and-recapture program utilizing louver catches.

The louver guidance facility provided a reliable method of estimating numbers of salmon and steelhead smolts that were emigrating from the upper Lemhi River. The louver facility collected a consistent proportion of the migrating chinook salmon and steelhead trout smolts from the Lemhi River. Approximately 3 percent of the chinook smolts and 21 percent of the steelhead smolts were captured in the trap. Estimates of smolt numbers for both species were derived by expanding the louver-captured proportion. During 1965, an estimated 325,020 chinook smolts and 9,830 steelhead smolts emigrated from the upper Lemhi River. No estimates could be made for chinook fry

emigrants.

An estimated 98.6 percent of the steelhead smolts entering the louver facility were guided into the trap. An estimated 83.6 percent of the chinook smolts were guided into the trap. The guiding efficiency for chinook fry was estimated to be 20.2 percent. The efficiency of the louver system was greatest for large migrants and for periods when water temperature was high.

The upstream migration barrier guided some steelhead smolts into the louver facility but did not guide chinook smolts. The majority of the chinook smolts migrated in the center portion of the stream.

EVALUATION OF A LOUVER GUIDANCE FACILITY USED TO SAMPLE SALMON AND TROUT EMIGRANTS

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EVALUATION OF A LOUVER GUIDANCE FACILITY USED TO SAMPLE SALMON AND TROUT EMIGRANTS

INTRODUCTION

A louver facility was constructed in the Lemhi River, Idaho, to guide juvenile chinook salmon (Oncorhynchus tshawytscha) and juvenile steelhead trout (Salmo gairdneri) into a trap in order to sample downstream migrant populations. The subject of this thesis is an evaluation of the louver facility which was initiated in the fall of 1964 to determine: (1) if the catch in the louver facility was a reliable index of emigrant population size, and (2) if an accurate estimate of the number of emigrants could be obtained through a mark-and-recapture program utilizing louver catches.

The Lemhi louver facility is a part of an upstream-downstream weir installed to enumerate all adult chinook salmon and steelhead trout entering the upper Lemhi River and to sample the juvenile downstream migrants to obtain an estimate or index of the number leaving the stream. This installation captures downstream migrants from approximately 10 percent of the stream flow.

The operation of the louver depends on fish avoiding the change in direction of water flow through the louver bars. When fish approach the louver slats, particularly when water velocities are high, they tend to avoid them and swim away at an angle of about 90 degrees (Bates and Vinsonhaler, 1956). If a downstream migrant avoids the louvers, it eventually drifts into the bypass channel. The louver device was selected ver device was selected for use in the sampling facility because of the wide range of water levels, water temperatures, and amounts of drifting debris encountered in a natural stream. Louvers pass a majority of the debris between the blades, and thus require less maintenance than most trapping devices. Previous studies have demonstrated that louvers are effective over a wide range of stream flows.

The use of louvers to guide the movements of fish was originally studied at the Tracy Pumping Plant near Tracy, California (Bates and Vinsonhaler, 1956; Bates, Logan, and Pesonen, 1960). It was demonstrated that louvers efficiently guided juvenile chinook salmon and striped bass (*Roccus saxatilis*) from a canal having a total flow capacity of 5,000 cfs. Bates and Jewett (1961) reported that young steelhead trout were effectively guided from a canal having a maximum flow capacity of 100 cfs. Ruggles and Ryan (1964) used steelhead trout smolts, chinook fry, sockeye smolts (*Oncorhynchus nerka*), and coho fry and smolts (*Oncorhynchus kisutch*) in test flumes to investigate the use of louvers for screening juvenile salmonids at hydroelectric projects on Vancouver Island, British Columbia.

Description of Study Stream

The Lemhi River is a tributary of the Salmon River and is located in east-central Idaho adjacent to the Idaho-Montana border (Figure 1). The Lemhi weir is approximately 805 river-miles from the sea and approximately one-quarter mile upstream from the mouth of Hayden Creek (Figure 1). Over 90 percent of the spawning of chinook salmon in the Lemhi River occurs upstream from the weir site.

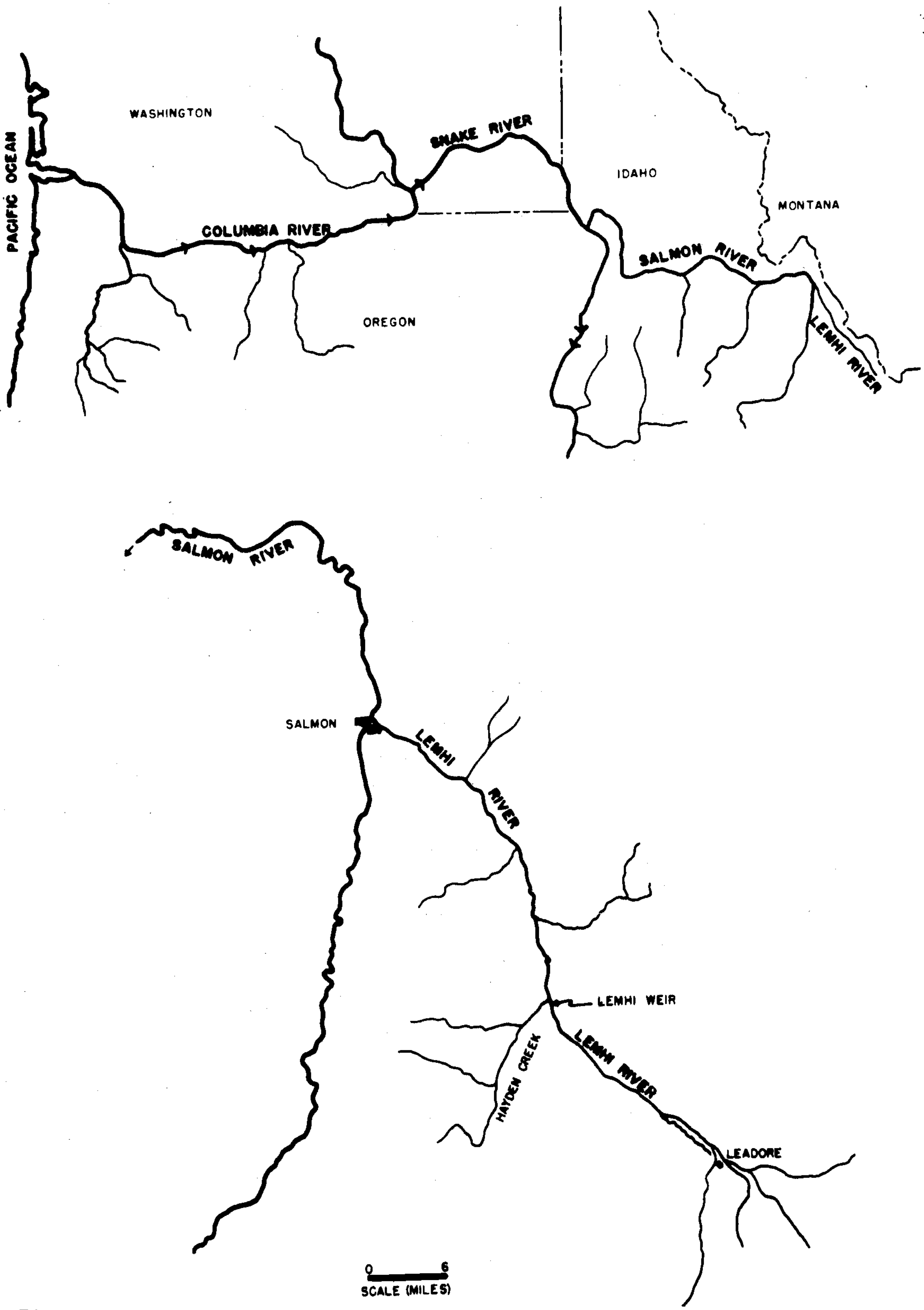

Figure I. (Upper) A portion of the Columbia River drainage showing the location of the Lemhi River.

(Lower) The Lemhi River drainage showing the location of the facility used during this study.

The Lemhi River has a relatively stable flow and temperature. Its water comes primarily from springs on the valley floor near Leadore, Idaho. In some years, snow-melt runoff originating in the Bitterroot and Lemhi mountain ranges enters the stream in late May and early June for a brief period. A maximum flow of approximately 600 cfs was measured at the weir site in June, 1965. The minimum flow measured at the weir site was approximately 75 cfs in July, 1966. The mean flow at the weir site during the study was approximately 150 cfs. The water temperature varied between 32° F and 64° F during the study.

The climate is typical of the Rocky Mountain area. The annual precipitation at Salmon, Idaho (about 28 miles north of the weir) was 10.12 inches in 1965. The air temperature at Salmon ranged from -2° F to 95° F in 1965 (U. S. Weather Bureau, 1966). The elevation at the weir site is 5,180 feet; the city of Salmon is approximately 1,000 feet lower.

METHODS AND MATERIALS

Description of Weir-Louver Facility

The weir portion of the facility consists of an upstream-migrant barrier which is set in the river at a 60° angle to the direction of flow. The barrier is 6 feet high and 58 feet long, and it is constructed of steel bars that are mounted with the narrow edge perpendicular to the direction of the stream flow. The spacing between the bars is 1 5/8 inches. The barrier is constructed in sections and can be removed.

The sampling facility is joined to the downstream end of the barrier rack (Figure 2). Downstream migrants are diverted by the louvers to a bypass channel leading to a trap. The louver section is a series of white vertical bars set with the broad faces at a right angle to the direction of flow. The line of louver bars is 24 feet long and is mounted on a concrete floor at a 19° 30' angle to the stream flow. The individual louver bars are 4 feet high and 3 inches wide. The spacing between the louver bars is 2 inches. The upstream opening of the louver system is 9.5 feet wide and comprises approximately 10 percent of the stream cross section.

The downstream end of the louver is connected to a 6-inch-wide bypass channel that transports the guided migrants to a trap. The trap is constructed of perforated steel plate and has an entrance tube that extends approximately one-third of the distance into the

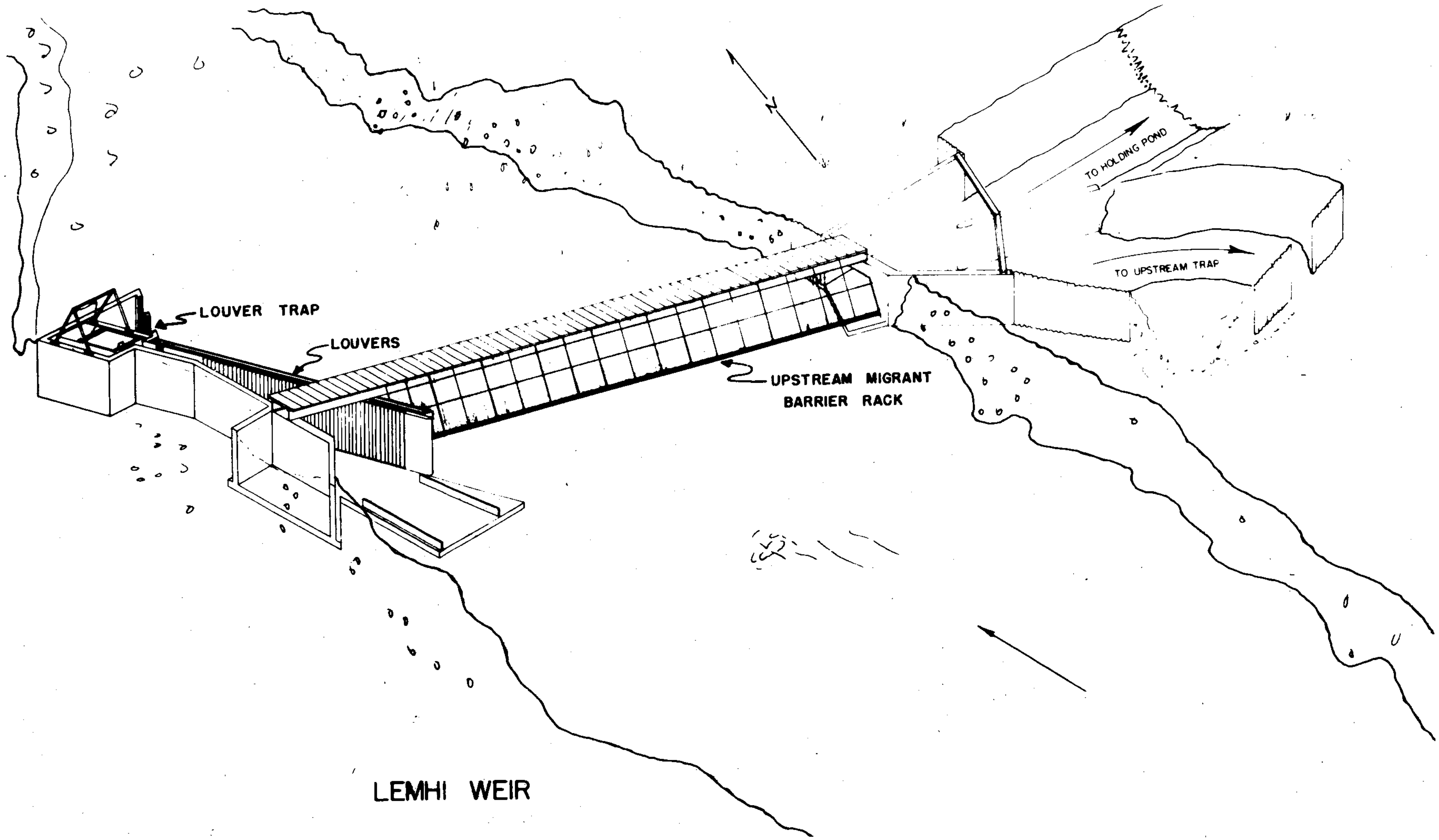

Figure 2. Drawing of the Lemhi weir illustrating the relative position of the major components of the weir.

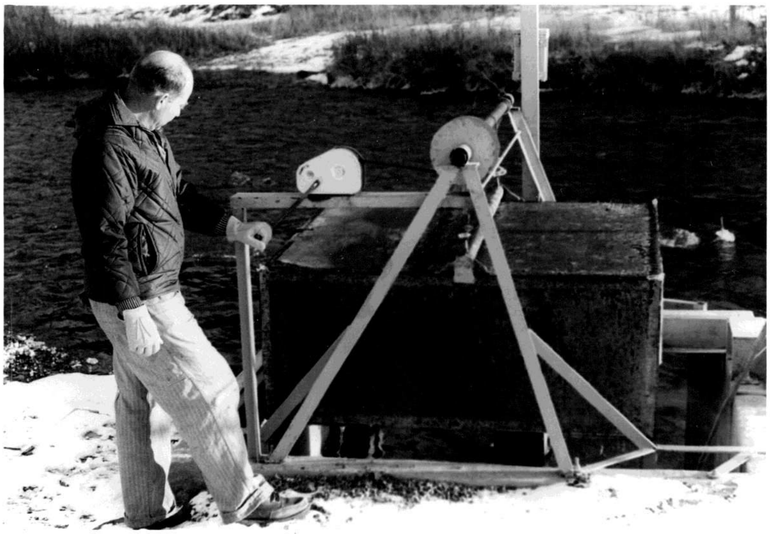

Figure 3. Louver trap in raised position to facilitate removal of the catch.

Figure 4. Net out of the water.

trap. The trap is totally submerged when fishing and can be raised by a hand winch for removal of the catch (Figure 3).

Operation of Louver Facility

The louver facility was operated almost continuously during the course of this study from June, 1964 to June, 1966. Operation of the louver was interrupted during the very coldest part of the winter by large pieces of drifting ice, but this situation occurred infrequently during the two winters involved. During the summer months, the trap was operated continuously; during the remainder of the year, the trap was operated at least five days per week. The catch in the louver traps was normally removed once every 24 hours except when the diurnal patterns of fish movement were being studied. The louvers required cleaning only once per day except for a brief period in the fall when leaves from deciduous trees were present in the stream. The width of the openings between the louver bars allowed the passage of smaller debris and ice particles encountered during most of the year.

Captured juvenile salmonids were enumerated, measured, and examined for marks. The fish were anesthetized in a solution of tricaine methanesulphonate (MS-222).

Determination of Guiding Efficiency

Tests were conducted to determine the effect of changing physical factors on the efficiency of the louver system in guiding emigrants. A net was constructed to strain the water leaving one-third of the louver line at a time (Figures 4 and 5). The net was made of

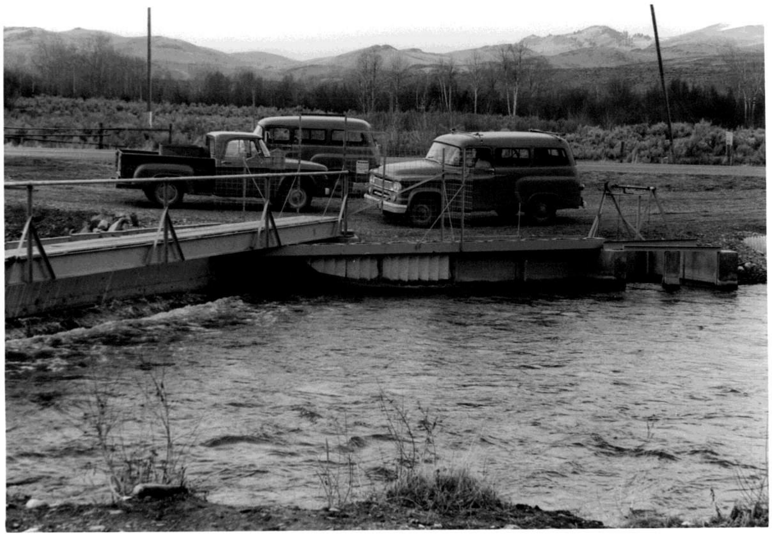

Figure 5. Louver net in place in sample station C.

one-quarter-inch mesh nylon netting and has an opening that was 8 feet wide and 4 feet deep. A livebox constructed of screen was mounted on the terminal end of the net. The net was transferred from one of the three sample stations to the next at the end of each 24-hour sample period (Figure 6). The net was cleaned and the catches removed from the net and the louver trap every 6 hours. The net was fished behind the louvers mostly in the spring and fall when migrant numbers were large and stream conditions varied.

Since the louver net was not fished for the same length of time in each position, the guiding efficiency of the louver facility was determined from data on catch per unit of effort. The net catches and the trap catches were divided by the hours fished. The following formula was used for calculating the guiding efficiency for the louver facility.

Louver efficiency =

$$\frac{\text{Trap catch/hr}}{\text{Trap catch/hr + Net catch A/hr + Net catch B/hr + Net catch C/hr}}$$

where:

Louver efficiency = proportion of fish entering louver facility that are guided into the trap.

$$\text{Trap catch/hr} = \frac{\text{total trap catch while net was in use}}{\text{hours that trap fished while net was in use}}$$

$$\text{Net catch A/hr} = \frac{\text{catch of net behind louver section A}}{\text{hours that net was fished behind section A}}$$

Determination of Degree of Smolt Guidance by Barrier Rack

The upstream migrant barrier potentially could guide downstream

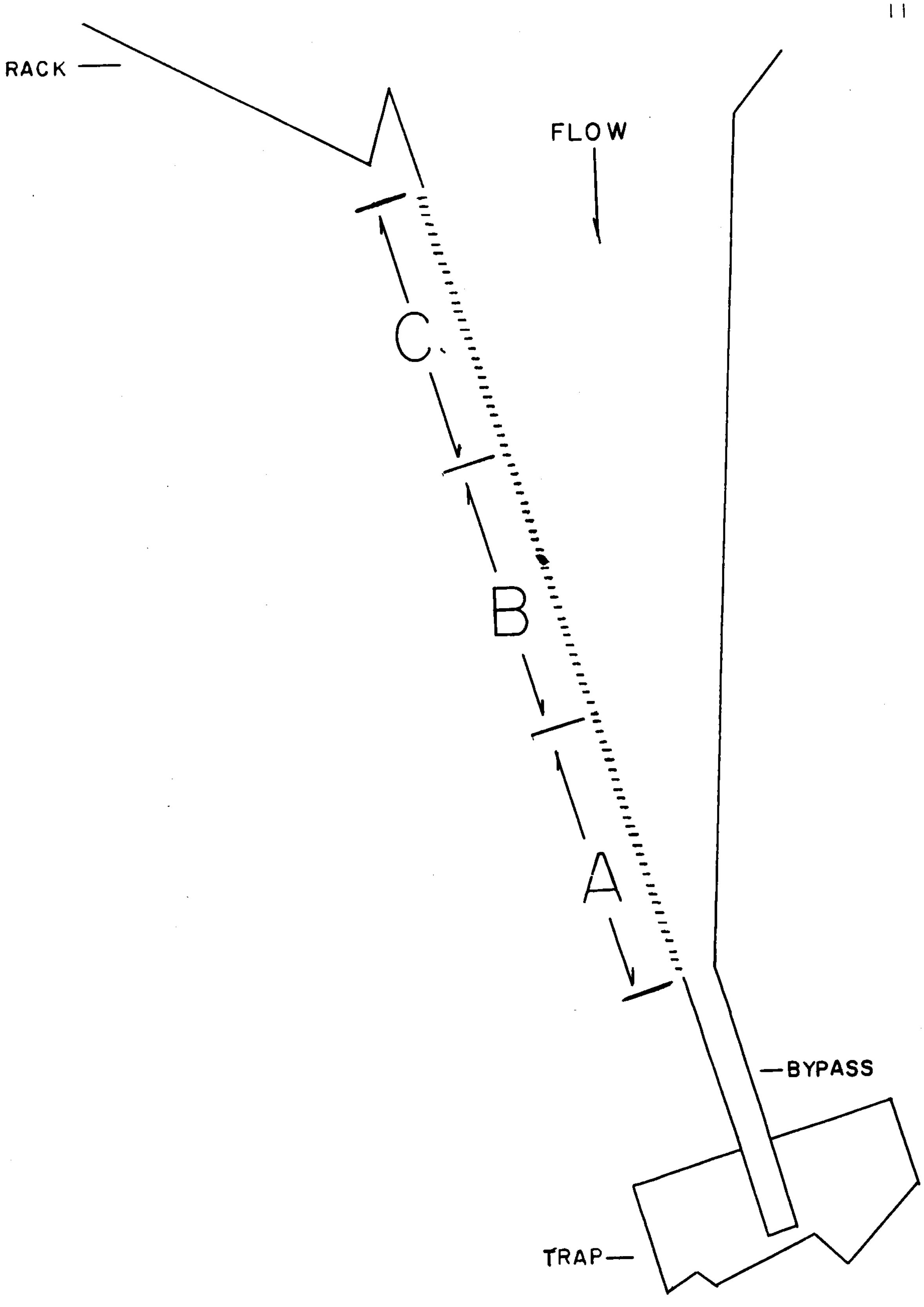

Figure 6. Schematic drawing illustrating the location of the three sample stations for the louver net.

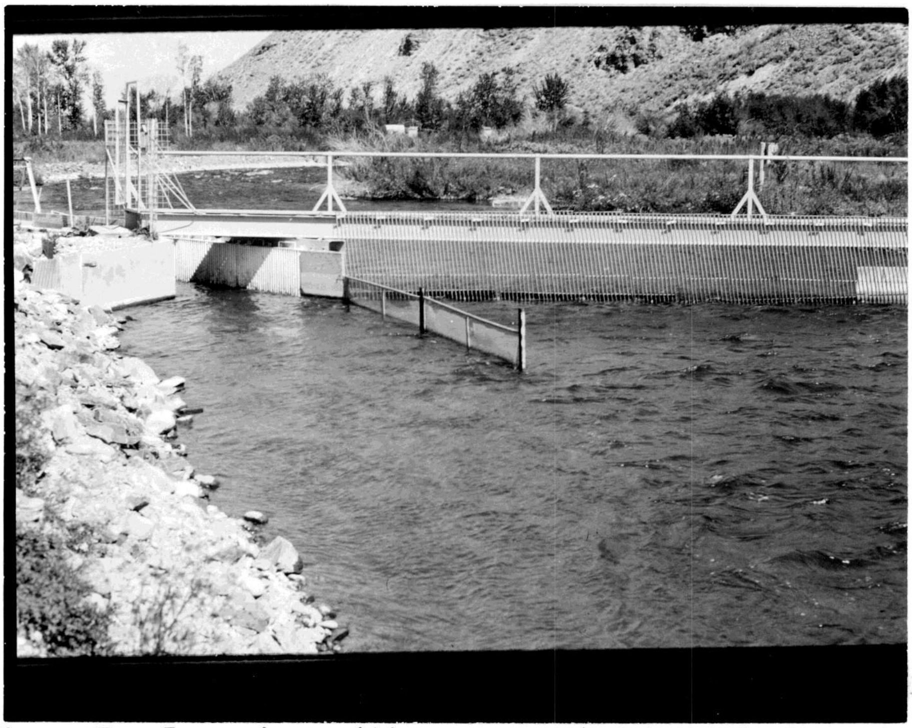

Figure 7. Fence in position, preventing lateral movement of smolts into the louver facility.

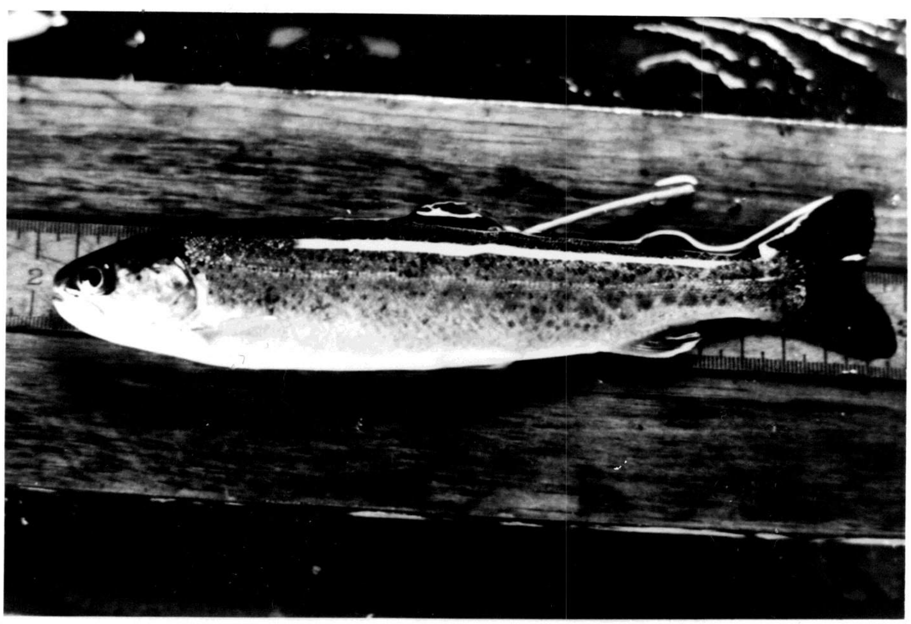

Figure 8. Fluorescent dart tag inserted in steelhead smolt.

migrants from the main portion of the stream into the louver. The reaction of the juvenile salmonids to the barrier was studied by intermittently separating the water that enters the louver from the water that passes through the barrier with a fence of one-quarter-inch mesh screen that was installed parallel to the stream flow (Figure 7). The fence extended 20 feet upstream from the point where the louver system joins the upstream migrant barrier. When this fence was in place, it prevented downstream migrants from being guided laterally into the louver system by the upstream migrant barrier. The fence was installed every other day during a period of smolt migration.

A small, battery-powered spotlight was used to observe the behaior of chinook smolts as they approached and passed through the weir. The steelhead smolts were wary and avoided the spotlight. Ultraviolet light and a fluorescent tag were used to observe the behavior of these fish. The tag used in this study was a small dart, painted with a fluorescent red pigment. It was inserted posterior to the base of the dorsal fin (Figure 8). The stream was lighted with five 40-watt ultraviolet lamps mounted on the weir. Groups of tagged smolts were released approximately 300 yards upstream from the weir. When the fish entered the field of ultraviolet light, tags could be observed and the reaction and movements of the smolts noted.

Determination of Lateral Distribution of Smolts

Efforts were made to determine the lateral distribution of migrating juvenile chinook salmon and steelhead trout, as this distribution pattern could influence the number collected in the louver trap.

Figure 9. A Kray-Meekin trap in operation. In this study, the trap rested on the stream bottom and sampled the entire depth.

Figure 10. Stations for Kray-Meekin traps used to determine the lateral distribution of migrating smolts.

The migrating smolts were sampled with three Kray-Meekin traps approximately 30 yards upstream from the weir, where the physical characteristics of the stream were similar to those at the weir (Figure 9).

The traps were covered with one-quarter-inch mesh screen and had openings that were 34 inches wide and 22 inches deep. They were held in position by dropper cables attached to a suspended cable that was strung between the two banks. The suspension cable was marked with cable clamps so that the traps could be returned to the same location during each sampling period.

Initially, sampling was conducted to determine if the fish migrating through the sampling area preferred one side of the stream to the other. This was accomplished by fishing a trap as close to each bank as water depth would allow. A third trap was fished in the center of the stream. The traps were operated at these sampling locations until it was evident that there was no significant difference between the catches at the two bank stations. The trap from the west bank was then moved to a point midway between the other two traps for the remainder of the study (Figure 10).

The traps were operated during both daylight and darkness, but the majority of the sampling occurred during the hours of darkness, when most of the juveniles migrated.

Determination of Percentage of Smolts Captured by Louver Facility

A mark-and-recapture study was conducted in 1965 to determine the proportions of salmon and steelhead smolts passing the weir site that were captured in the louver trap. This was done only during the spring and fall months to insure that the fish marked were actively migrating and would reach the weir site shortly after release. The louver trap was operated continuously during these periods. The assumption was made that marked smolts would be captured in the louver trap at the same rate as unmarked smolts. The smolts for marking were taken from the louver trap and traps at irrigation diversion screens. Chinook fry were not studied because their small size was not suited to the method of marking.

A thermal marking technique was used to place a visible surface mark on the side of the smolt. The techniques and tools used in this study were as described by Groves and Novotny (1965). Immediately after application, the mark was not distinct. All marked fish that were examined after 24 hours had dark, recognizable marks (Figure 11). For this reason, all marked smolts used in this study were held in liveboxes for 24 hours prior to release. Any handling mortality usually occurred within 8 hours. After the holding period, the smolts were transported to a point upstream from the weir and released. The releases were made during daylight hours at several locations from 1 to 15 stream miles upstream from the louver. All fish captured in the louver trap were anesthetized and inspected thoroughly for marks.

The data from this mark-and-recapture study supplied information necessary for proportion-expansion estimates. Proportion-expansion estimates were made for each month with the following formulae:

$$\text{Estimated smolts captured in full month} = \frac{(\text{Catch for month})\ (\text{Total days in month})}{(\text{Days louver operated})}$$

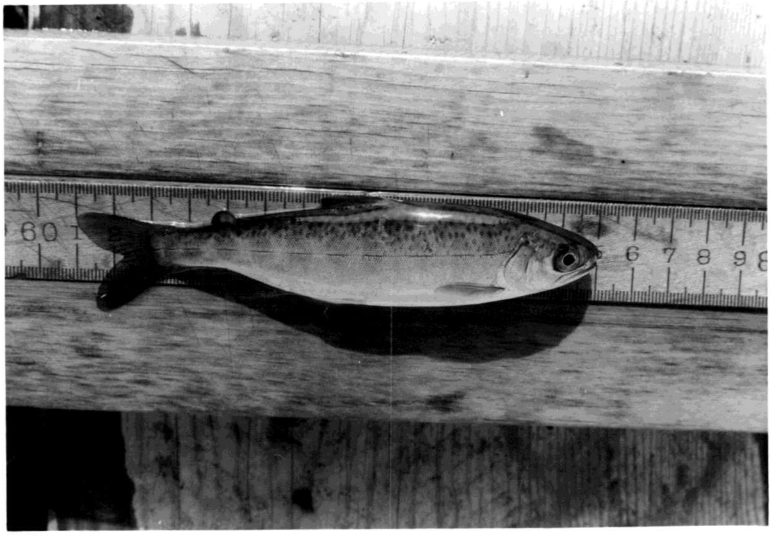

Figure 11. Chinook smolt with a thermal brand below dorsal fin (brand is an inverted T).

$$\text{Estimated total smolts emigrating in month} = \frac{\text{(Estimated smolts captured in full month)}}{\text{(Estimated recapture rate)}}$$

Measurement of Physical Factors

Flow, temperature, and turbidity were monitored during the study. Water level readings were taken daily from a permanently-mounted staff gage at the weir site. Water velocity measurements were made at two locations, the cross section of the stream where the lateral distribution sampling took place, and the weir-louver facility. The velocity measurements were taken with a Gurley pygmy current meter. Recordings of water temperature were obtained with a Moeller thermograph. Turbidity readings were taken with a Hach colorimeter during the portion of the study period when variations occurred in the amount of suspended matter.

RESULTS

Guiding Efficiencies of the Louver Facility

Steelhead smolts were effectively guided by the louvers; an estimated 98.6 percent entering the louver facility were captured in the trap. Chinook smolts were not guided as effectively as were the steelhead, but were guided more effectively than were chinook fry. An estimated 83.6 percent of the chinook smolts were guided into the trap. The majority of the chinook fry that entered the facility were lost through the louver blades; the guiding efficiency for these small migrants was estimated to be 20.2 percent. Size of emigrant was a factor that affected guidance efficiency as evidenced by the differential efficiency values for chinook fry and smolts. More emigrants of all three groups were lost through louver section A than were lost through louver section B or C (Table 1).

Several physical factors affected the efficiency with which chinook smolts were guided. Turbidity readings that ranged from 10 to 20 ppm were optimum, and guiding efficiency declined when turbidity was above or below this range. Efficiency values determined when turbidity readings ranged from 0-10 ppm, 10-20 ppm, and 20-30 ppm were 89, 95, and 66 percent, respectively. As water temperature increased, guiding efficiency improved (Figure 12). The possibility of interaction of water temperature and length of migrant on the effici-

Table I. The catch per unit of effort for the louver net in the three sample stations and for the louver trap. All values are expressed as the number of emigrants captured per hour.

Location of catch	Hours of trapping	Catch per hour		
		Chinook fry	Chinook smolt	Steelhead smolt
Section A	1,107	4.178	0.265	0.00361
Section B	953	1.845	0.472	0.00210
Section C	857	1.051	0.0292	0
Louver Trap	2,917	1.792	1.744	0.401

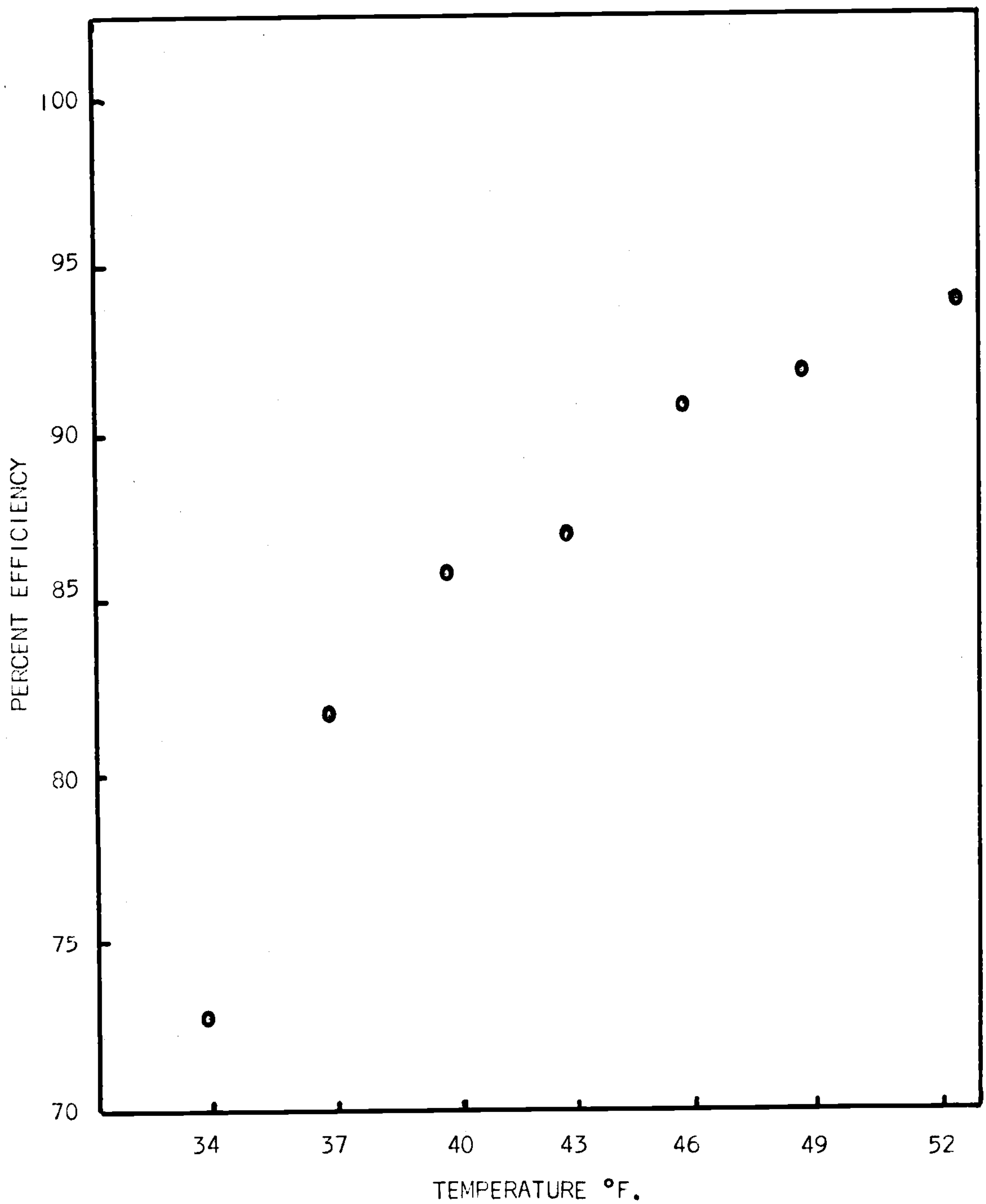

Figure 12. The Relationship of water temperature to the guiding efficiency of the louver for chinook smolts.

ency with which chinook smolts were guided was investigated. During the periods of migration, however, the average length of chinook smolts did not vary appreciably with changes in water temperature (Figure 13). There is little chance that a significant interaction occurred. The effect of light was examined only by comparing night efficiencies to daylight efficiencies, and no appreciable difference was noted. A 1.5 foot change in water level had no apparent effect on guidance efficiencies.

It was possible to relate guidance efficiencies to varying physical factors only for the chinook smolts. Too few steelhead smolts were lost to allow a meaningful analysis for these fish. The duration of the chinook fry migration was relatively short compared to the migrations of steelhead and chinook smolts (Figures 14, 15, and 16). Because of poor guiding efficiency and the short migration period, insufficient data were obtained on chinook fry to investigate the effects of changing physical factors on efficiency values.

Guidance of Migrants by the Upstream Migrant Barrier

Steelhead smolts were readily guided by the upstream migrant barrier. The catch of steelhead smolts in the louver trap was significantly decreased by the placement of the fence between the water approaching the louver and the water passing through the upstream migrant barrier (Table 2). The catch of chinook smolts in the louver trap did not vary significantly with the deflection fence in place, indicating that the chinook smolts were not guided into the louver area by the upstream migrant barrier (Table 2). No data were collected

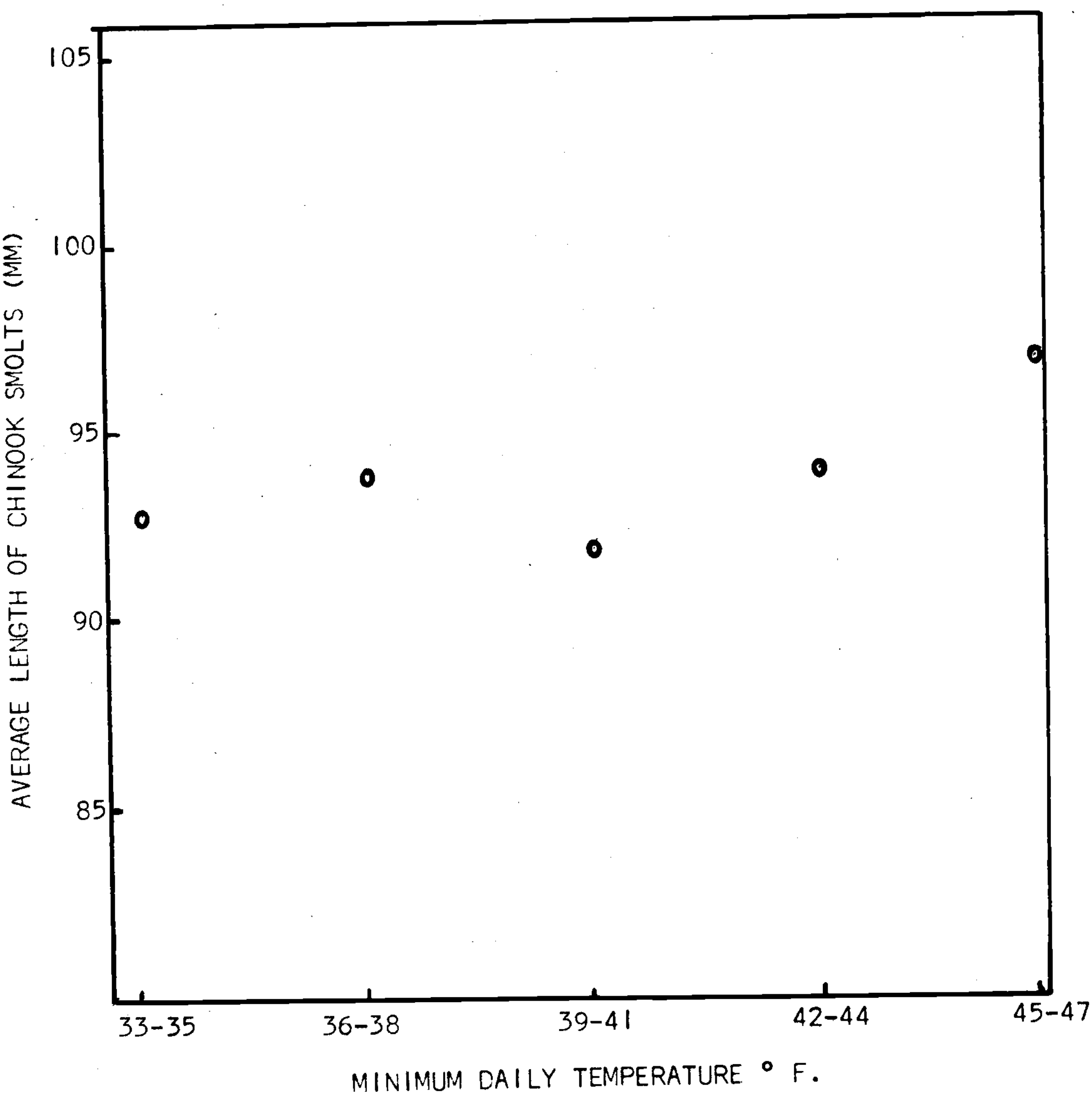

Figure 13. The relationship of chinook smolt size to water temperature during the spring and fall migration seasons in the Lemhi River during 1965.

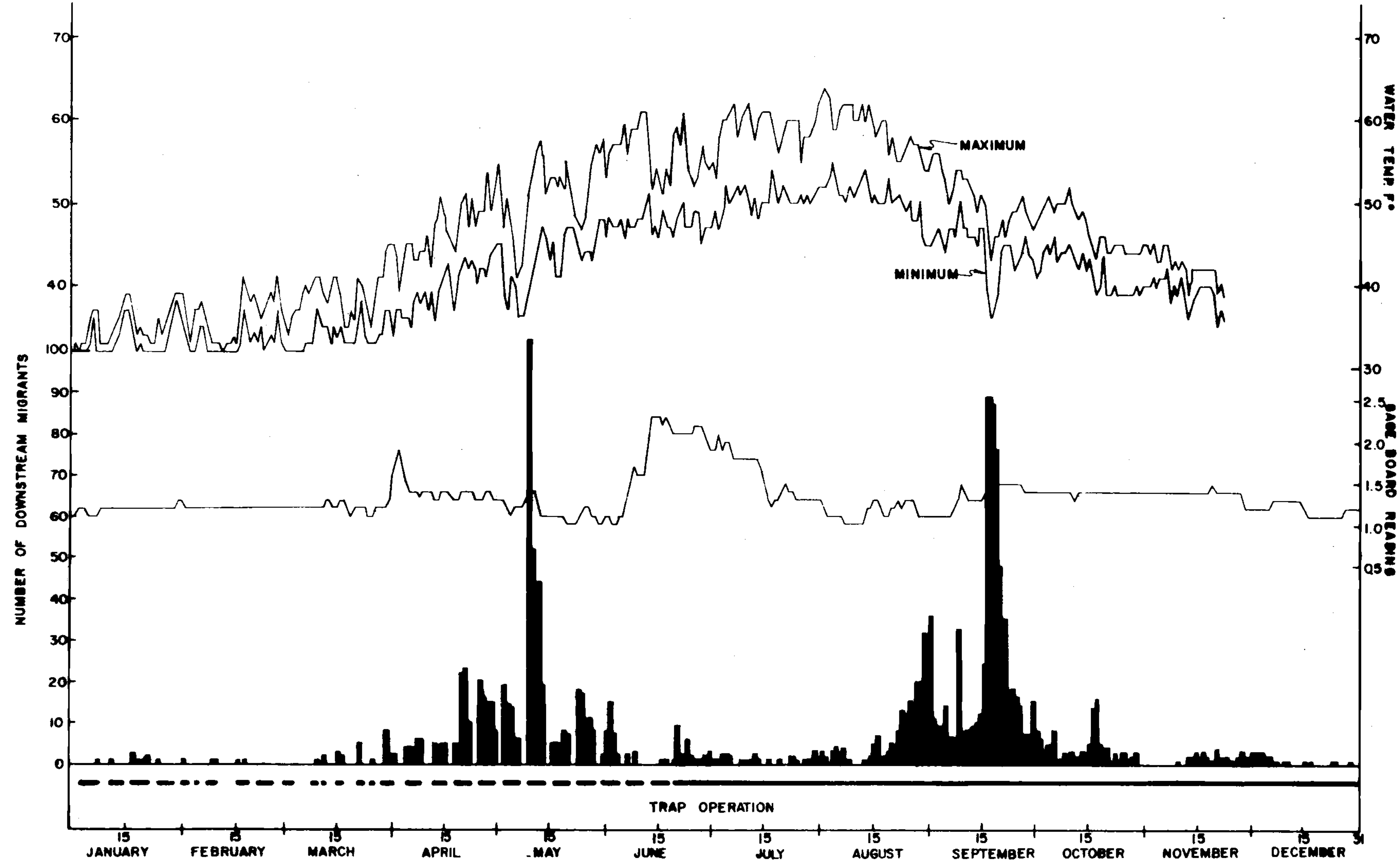

Figure 14. The period of trap operation, daily catch of juvenile steelhead, flow of the Lemhi River (gage board readings), and maximum-minimum temperature of the Lemhi River at the weir site during 1965.

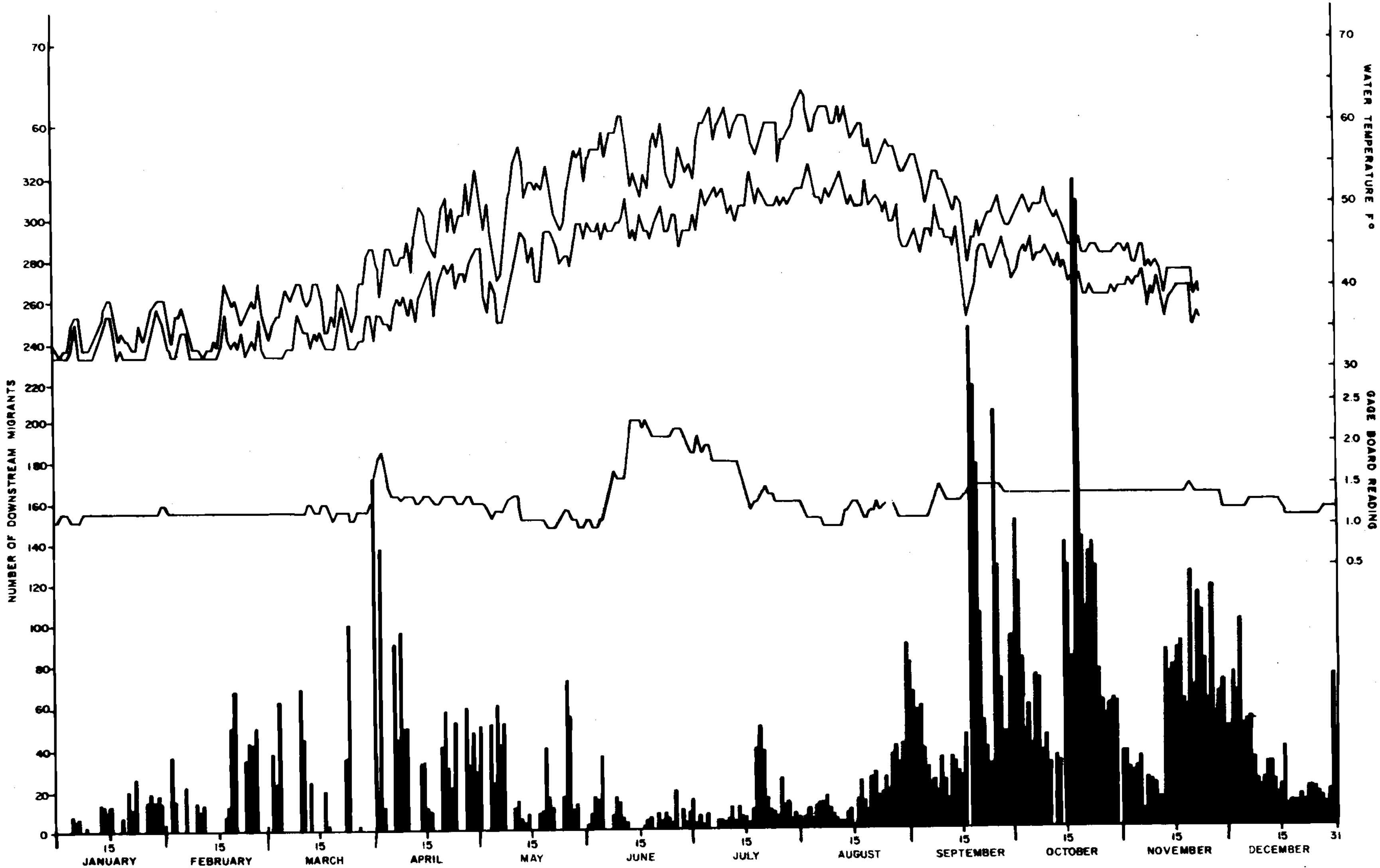

Figure 15. The daily catch of chinook smolts, flow of the Lemhi River (gage board readings), and maximum-minimum temperature of the Lemhi River at the weir site during 1965.

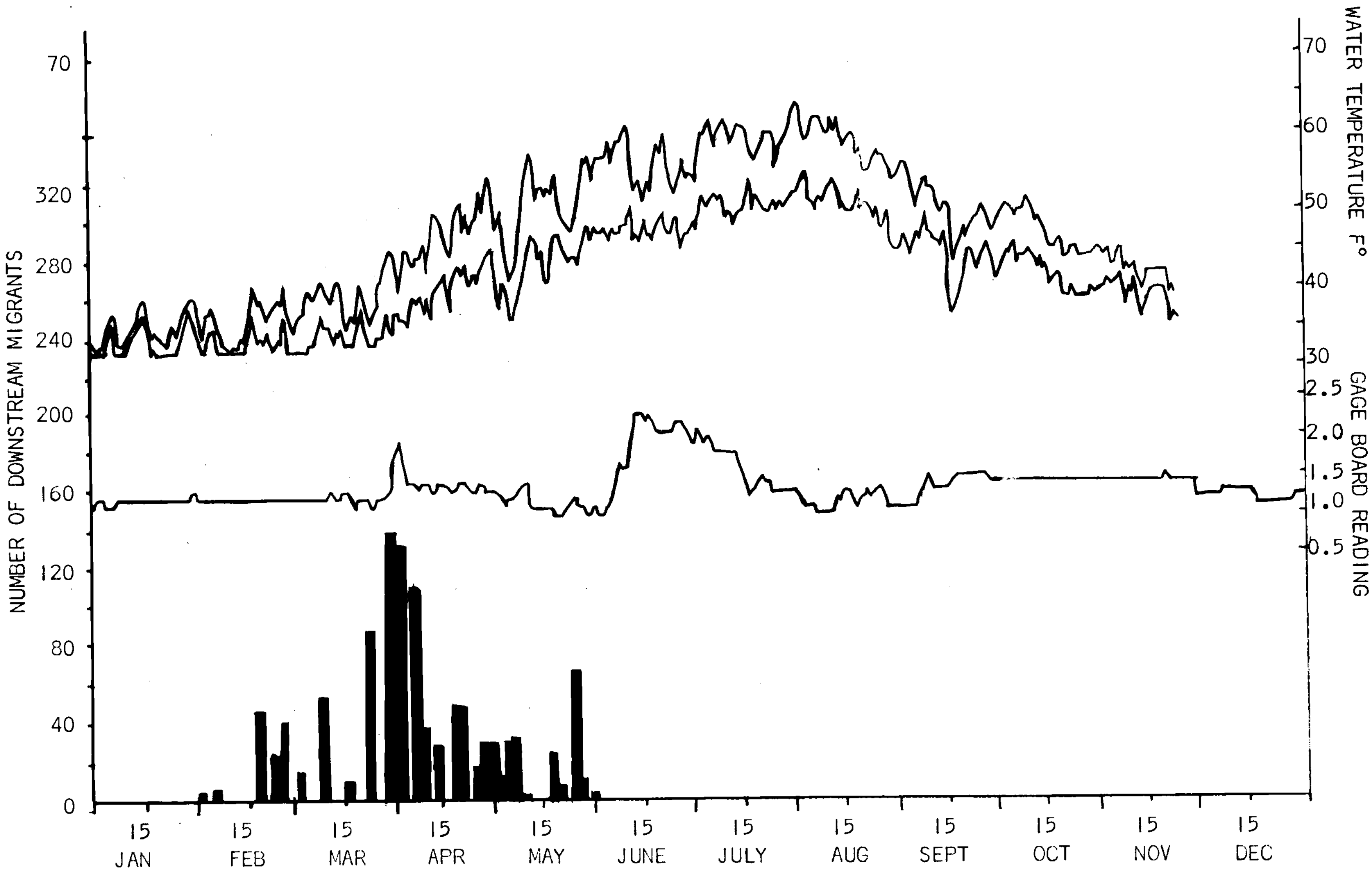

Figure 16. The daily catch of chinook fry, flow of the Lemhi River (gage board readings), and maximum-minimum temperature of the Lemhi River at the weir site during 1965.

Table 2. Catches in the louver trap with the fence installed and removed illustrating the degree of guidance along the weir for steelhead and chinook smolts.

Month	Fence installed			Fence removed		
	Catch	Days	Catch/day	Catch	Days	Catch/day
			Chinook			
November, 1964	360	12	30.0	354	9	39.3
December, 1964	53	4	13.3	69	7	9.9
April, 1965	54	4	13.5	78	4	19.5
May, 1965	54	2	27.0	161	7	23.0
August, 1965	197	8	24.6	286	15	19.1
September, 1965	166	5	33.2	241	7	34.4
TOTALS	883	35	25.2	1,189	49	24.3
			Steelhead			
November, 1964	21	12	1.8	12	9	1.3
December, 1964	4	4	1.0	5	7	0.7
April, 1965	29	4	7.3	61	4	15.3
May, 1965	22	2	11.0	201	7	28.7
August, 1965	25	8	3.1	129	15	8.6
September, 1965	30	5	6.0	112	7	16.0
TOTALS	131	35	3.7	520	49	10.6

on the deflection of chinook fry by the rack, but it is doubtful that the swimming ability of fry is sufficient to allow a reaction to the barrier pickets.

Steelhead smolts were observed easily maintaining positions upstream from the rack for extended periods of time. The steelhead smolts frequently moved laterally to the stream flow but did not exhibit a preference for moving in the direction of the louver at the downstream end of the rack. No steelhead smolts were observed being guided along the rack to the louver. Chinook smolts were observed maintaining positions upstream from the rack for short periods of time. The chinook smolts did not move laterally to the stream flow and subsequently passed between the weir pickets more readily than did the steelhead smolts.

Lateral Distribution of Migrants

The Kray-Meekin traps were effective in capturing chinook smolts and provided data from which an estimate of lateral distribution was derived (Table 3). From the data collected at the three sample stations, three points were plotted on a graph and the points were connected by straight lines (Figure 17). This graph represents the lateral distribution of chinook smolts upstream from the weir and illustrates the preference of smolts for the midstream area.

The Kray-Meekin trap did not effectively collect steelhead smolts or chinook fry. Steelhead smolts generally avoided the traps, and the openings in the screen on the traps were too large to retain the chinook fry.

Table 3. The catches, catch rates, and the estimated total monthly catches of chinook smolts in the Kray-Meekin traps at three stations across the Lemhi River during 1965. The estimated total was determined by proportion expansion.

		East bank station			Intermediate station			Midstream station		
Month	Hours	Catch	Catch/hr	Est. total	Catch	Catch/hr	Est. total	Catch	Catch/hr	Est. total
May	140	6	0.0428	31.8	16	0.114	84.8	72	0.514	382
June	37	1	0.0270	19.4	0	0	0	3	0.081	58.3
July					--No Samples--					
August	48	2	0.0417	31.0	3	0.062	46.1	6	0.104	77.4
September	4	2	0.500	360	1	0.250	180	5	1.25	900
October	22	7	0.318	237	58	2.64	1,960	86	3.91	2,910
November	31	32	1.03	742	101	3.26	2,347	173	5.58	4,020
TOTALS		50		1,420	179		4,620	345		8,380

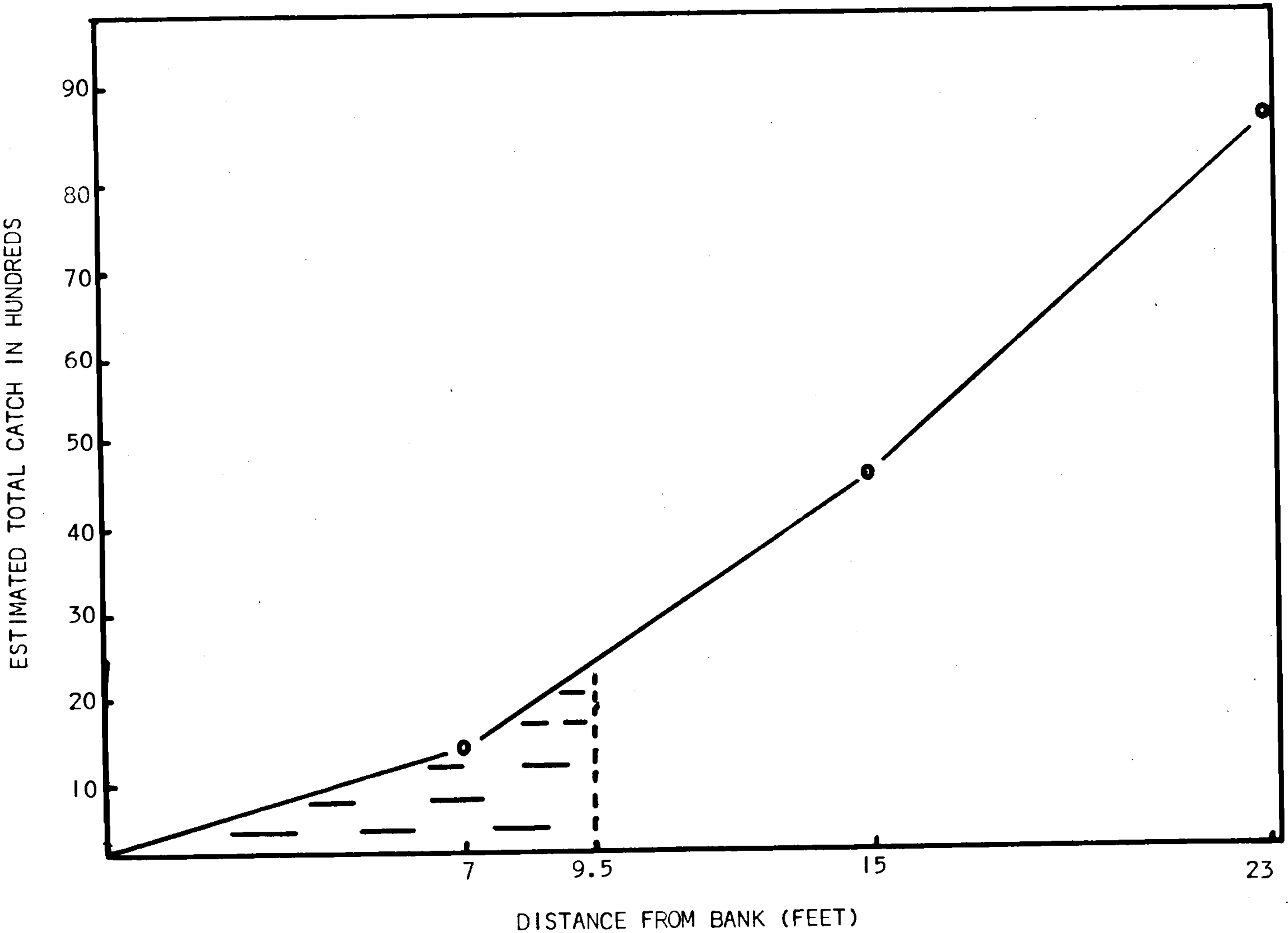

Figure 17. The lateral distribution of chinook smolts from bank to midstream in the Lemhi River based on the estimated total catch from the Kray-Meekin traps (Table 3). The shaded area represents the portion of the stream entering the louver.

Water velocity was slightly greater at the midstream station than in the remainder of the stream cross section. There appeared to be a direct correlation between water velocity and the numbers of migrating smolts. Water velocities at the center of the stream ranged from 2.1 fps to 3.8 fps; the velocities at a point 7 feet from the east bank fluctuated between 1.8 fps and 3.3 fps, depending on the water level. Water velocity measurements were also taken in the Kray-Meekin traps at each sample station. The velocities within the traps proved to be almost uniform in the three different locations despite the slight difference in approach velocities.

Proportion of Migrating Smolts Captured by the Louver Facility

The proportion of marked steelhead smolts captured was considerably larger than that of the chinook smolts. The marked steelhead smolts were captured at a rate of 21.0 percent in two migration seasons (Table 4). The marked chinook smolts were captured at a rate of 3.24 percent through two seasons (Table 5). The recapture rates for both species were relatively constant from season to season although, there was some variation in recapture rates from one lot of marked fish to another. Steelhead smolts released in groups of 50 or more were recaptured at rates ranging from 16.1 to 27.7 percent. Chinook smolts released in groups of 100 or more were recaptured at rates from 1.55 to 8.28 percent.

Distance from the release point to the louver recapture site did not appear to affect the recapture rates of either chinook or steelhead smolts. The steelhead and chinook smolts that were marked in

Table 4. The numbers of steelhead smolts marked with a thermal brand, released upstream from the louver trap, and subsequently recaptured in the louver trap.

Date of release	Number released	Number recaptured	Percent recaptured
Spring, 1965			
May 10-13	220	53	24.1
May 17	18	7	38.9
May 18	3	0	0.0
May 20	6	1	16.7
May 24	6	1	16.7
May 25	23	3	13.0
May 26	5	1	20.0
May 27	9	1	11.1
May 28	4	0	0.0
May 31	5	2	40.0
June 1	7	0	0.0
June 2	9	1	11.1
Subtotal	315	70	22.2
Fall, 1965			
September 1-10	29	2	6.9
September 11-20	265	49	18.5
September 21-30	155	43	27.7
October 1-10	30	8	26.7
October 11-20	50	8	16.0
October 21-31	18	4	22.2
November 1-10	4	0	0.0
November 11-20	17	0	0.0
November 21-30	18	4	22.2
December 1-15	8	3	37.5
Subtotal	594	121	20.4
Grand Totals	909	191	21.0

Table 5. The numbers of chinook smolts marked with a thermal brand, released upstream from the louver trap, and subsequently recaptured in the louver trap. Grand totals include 550 releases and 16 recoveries of thermal-marked fish from the fall of 1964.

Date of release	Number released	Number recaptured	Percent recaptured
Spring, 1965			
April 12-May 10	376	15	3.99
May 17	32	1	3.13
May 18-24	67	0	0.00
May 25	5	0	0.00
Subtotal	480	16	3.33
Fall, 1965			
September 1-14	838	13	1.55
September 16-22	1,159	22	1.90
September 24-Oct. 2	2,200	81	3.68
October 3-12	664	55	8.28
October 13-22	2,288	59	2.58
October 23-Nov. 1	1,603	33	2.06
November 3-12	844	25	2.96
November 15-21	2,316	72	3.11
November 23-Dec. 2	1,395	73	5.23
December 3-10	569	19	3.34
Subtotal	13,876	452	3.26
Grand Totals		483	3.24

the spring of 1965 were released in the Lemhi River approximately 15 stream miles upstream from the weir. Those smolts that were marked in the fall of 1965 were released approximately one stream mile above the weir. Recapture rates for the two groups of fish that were released in different locations were very similar (Tables 4 and 5). With rare exception, all recaptures were taken within two nights of the release date regardless of the distance between the release and recapture sites.

Estimates of Smolt Emigration

Having established the percentage of smolts that are captured by the louver trap, I was able to estimate the total number of migrants passing the weir each month by expanding the louver catch (Tables 6 and 7). An estimated 9,830 steelhead smolts and 325,020 chinook smolts migrated from the upper Lemhi River in 1965.

Estimates of emigrant numbers will continue to be made in the future, and trends in chinook fry emigration will be observed. The relationship between numbers of spawners and resultant smolt production will be established to determine the optimum spawning density for both species.

Table 6. Proportion-expansion estimates of the total number of steelhead trout emigrants passing the Lemhi weir during 1965.

Month	Days sampled	Steelhead smolts captured	Estimated trap catch for full month	Estimated total emigrants
January	19	0	0	0
February	15	0	0	0
March	11	24	68	320
April	20	170	255	1,210
May	21	405	599	2,850
June	22	73	99	470
July	31	23	23	110
August	31	172	172	820
September	30	658	658	3,130
October	30	111	114	540
November	30	37	37	180
December	12	16	41	200
				9,830

Table 7. Proportion-expansion estimates of the total number of chinook smolt emigrants passing the Lemhi weir during 1965.

Month	Days sampled	Chinook smolts captured	Estimated trap catch for full month	Estimated total emigrants
January	19	231	377	11,630
February	15	261	488	15,060
March	14	208	460	14,200
April	20	310	465	14,350
May	21	250	370	11,420
June	22	34	46	1,420
July	31	335	335	10,340
August	31	545	545	16,820
September	30	1,935	1,935	59,710
October	30	2,709	2,799	86,380
November	30	1,715	1,715	52,920
December	31	997	997	30,770
				325,020

DISCUSSION

There appeared to be no consistent differences in recapture rate with time or season for either chinook or steelhead smolts, so the average for all releases was considered the best estimate of the percent recaptured. Physical conditions in the spring varied considerably from those in the fall, but the recapture rates were not significantly different. The consistency of the recapture rates for marked smolts is evidence that the louver facility took a uniform proportion of the total number of steelhead and chinook smolts passing the weir. The proportion of smolts entering the louver trap can vary for several reasons, but the two most likely causes for variation are changes in the lateral distribution of the smolts and changes in the guiding efficiency of the louver facility.

The lateral distribution of chinook smolts remained relatively uniform during the study (Table 3). In an attempt to relate the lateral distribution of chinook smolts to the sample obtained by the louver, a planimeter was used to determine the proportion of fish that migrated in the louver approach waters (Figure 17). It was estimated that 4.7 percent of the chinook smolts migrating downstream were in that portion of the stream that passes through the louver. From the louver efficiency data, it was estimated that 16 percent of these smolts would not be guided to the trap. Subtracting this louver loss from the 4.7 percent, I estimated that 3.9 percent of the chinook smolts passing the weir should be captured in the louver trap. From the mark-and-recapture work, it was determined that 3.2 percent of the marked chinook smolts were recaptured in the louver trap. There is a relatively close agreement in these two figures derived from completely different data. Sufficient data were not collected to make the same comparison on the lateral distribution of steelhead smolts.

There were no evident changes in the guiding efficiencies for steelhead smolts, but the guiding efficiencies for chinook smolts were affected by turbidity and water temperature. Turbidity remained at a low level in the Lemhi River except during the high water period in early June, and smolt movement at this time was at a low level. Most of the smolt movement occurred during the spring and fall months when the water temperature was varying; however, the average temperatures during the spring and fall migration seasons were comparable. Neither chinook nor steelhead smolts migrate when water temperatures are at the upper or lower extremes. Despite the variation in efficiency with temperature, recapture rates for chinook smolts from different seasons were comparable.

The catches of chinook fry in the louver trap were not useful for estimating the total number of migrants. The majority of the fry entering the louver system were lost through the louver blades. Intensive mark-and-recapture studies will have to be conducted on these small migrants before estimates of total emigration can be made. The catches were useful for determining relative abundance of emigrant fry.

The efficiency of the louver system is greatest for large migrants and when water temperature is high. Other studies have shown that swimming ability is directly correlated with length or size of fish and with water temperature. Underyearling coho salmon (54 mm mean length) maintained a maximum swimming rate of 1.0 fps at a temperature approaching 0° C. Underyearling sockeye salmon (69 mm mean length) showed a maximum swimming rate of 1.1 fps at an optimum temperature of 16° C and a minimum of approximately 0.4 fps (Brett, Hollands, and Alderdice, 1958). A linear relation between swimming speed and length of fish for the same frequency of tail beat was reported by Gray (1957). Louver efficiency is probably directly correlated with swimming ability or ability of the migrant to react to the louvers.

The two-inch spacing between the louver blades was sufficient to pass most of the debris and small enough to guide the smolts efficiently. The chinook fry did not guide effectively along the louver line; if the spacing between the louver blades had been less than two inches, the fry might have guided more efficiently. Ruggles and Ryan (1964) found that as louver spacing was decreased, guiding of chinook fry improved. However, debris would have caused maintenance problems with a louver spacing less than two inches.

The loss rate for migrants through the louver blades was highest in that section of louver that was adjacent to the bypass (Section A). This differential loss was partly due to the fact that more fish entered this section of the louver than the other two sections. Those guided past Sections B and C also had to pass Section A. This loss may also indicate that the bypass was not entirely acceptable to the downstream migrants, especially chinook salmon. Previous workers have pointed out that bypass width and ratio of bypass velocity to approach velocity are the two most important criteria in bypass design. Where schooling, yearling salmon are involved, an 18-inch-wide bypass should be provided (Ruggles and Ryan, 1964). The bypass width in the Lemhi facility is six inches. Guidance efficiencies for chinook smolts and fry would probably have been better with a wider bypass. A bypass velocity of about 140 percent of the approach velocity is recommended (Ruggles and Ryan, 1964). Approximately this ratio was maintained in the louver facility at the Lemhi weir at all water levels.

The guidance of steelhead smolts by the upstream migrant barrier increased the size of the sample for these large migrants, although the Lemhi weir was not designed to guide them. If it were desirable to gather an even larger sample, the weir could be modified to guide a greater proportion of fish. If the angle between the weir and the direction of flow were made more acute, more migrants would be guided into the louver facility. The shape of the picket could be changed to guide additional migrants. A weir picket that would cause additional turbulence and change the direction of flow would cause migrants to be guided along the picket line in greater numbers.

Sampling with a louver in a portion of the stream is sometimes feasible when conventional screening of the entire flow is not practical. The louver principle has many advantages over conventional screening, and sampling techniques have advantages over screening of the entire flow. Louvers require less maintenance than screen traps do. Louvers will operate under unfavorable trash and ice conditions that would render conventional screen traps inoperable. Collecting downstream migrants from the entire flow of a stream is a costly operation unless the stream is very small. Many streams that produce anadromous salmonids are large and swift and vary greatly in flow. These conditions are not conducive to the use of conventional screening for the enumeration of downstream migrants. A louver sampler can operate well in rapidly changing flows and is effective over a wide range of approach velocities. Ruggles and Ryan (1964) report that guidance efficiencies are not significantly altered when approach velocity is varied between 1.3 fps and 3.8 fps. Louver traps can be designed to collect migrants effectively in streams with a wide range of water levels by incorporating an adjustable damper into the bypass. The damper allows the maintenance of acceleration of velocities in the bypass through a wide range of flows. In many streams, the downstream migrations of juvenile salmonids occur during the spring and fall when water levels are fluctuating. Many conventional downstream migrant traps do not operate well under these changing conditions, but the louver system can be effectively operated in rapidly changing conditions. The versatile louvers might also be a useful tool in the constantly changing conditions encountered in the trapping of juvenile salmonids in estuaries.

The louver principle could be applied to a portable sampling device and could provide a method of indexing smolt numbers in streams where permanent structures are not desirable. Portable louver samplers could be installed in a stream during key periods of migration and removed to be used in other streams or the same stream in other seasons. Information on trends in migrant abundance could be gathered in this manner with a minimum of effort.

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APPENDIX

APPENDIX A

CATCHES IN LOUVER TRAP AND LOUVER NET (1965)

Month	Net Position	Hours	Steelhead smolts Net	Steelhead smolts Trap	Chinook smolts Net	Chinook smolts Trap	Chinook fry Net	Chinook fry Trap
April	A	57	0	35	7	52	364	153
	B	44	0	11	1	42	136	116
	C	22	0	12	0	12	53	46
May	A	33	0	81	1	52	12	13
	B	53	0	45	0	41	43	65
	C	56	0	83	0	36	29	82
June	A	90	4	159	12	50		
	B	68	2	111	6	26		
	C	43	0	79	0	44		
July	A	167	0	12	3	50		
	B	97	0	21	2	55		
	C	162	0	28	3	51		
August	A	129	0	9	0	45		
	B	144	0	25	0	81		
	C	144	0	29	0	93		
September	A	198	0	100	78	479		
	B	168	0	173	5	313		
	C	118	0	61	0	170		
October	A	193	0	27	70	789		
	B	115	0	13	4	384		
	C	120	0	18	9	434		
November	A	240	0	14	122	689		
	B	264	0	11	27	629		
	C	192	0	12	13	420		
Totals for smolts	A	1,107	4	437	293	2,206		
	B	953	2	410	45	1,571		
	C	857	0	322	25	1,260		
Totals for fry	A	90					376	166
	B	97					179	181
	C	78					82	128