Distribution of Seaward-Migrating Chinook Salmon and Steelhead Trout in the Snake River above Lower Monumental Dam

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ABSTRACT—Distribution of seaward-migrating juvenile salmonids was determined from gillnet catches in impounded waters upstream from Lower Monumental Dam on the Snake River in eastern Washington. Fifty-eight percent of the chinook salmon, Oncorhynchus tshawytscha, *and thirty-six percent of the steelhead trout,* Salmo gairdneri, *were taken in the upper 12 feet of the water mass. Significance of the vertical distribution of these species is discussed in relation to supersaturation of dissolved atmospheric gases and survival of the migrants.*

Additional data are presented on horizontal and diel (day-night) distribution of the migrants, their direction of travel (downstream or upstream) when caught and proportions caught by mesh size of the gillnets. Effects of river discharge, temperature, and turbidity on fish distribution are considered in the analysis.

INTRODUCTION

Knowledge of the distribution of migrating juvenile salmonids in rivers and impoundments can be important to our understanding of their survival during passage to the sea. High concentration of dissolved gas is recognized as a potentially serious problem to valuable stocks of salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri,* in the Columbia and Snake Rivers, where direct and indirect mortalities have been attributed to supersaturated concentrations during seaward migration of juvenile fish. Concentrations as high as 140 percent saturation have occurred and are highly lethal to salmonids migrating in surface waters.

These concentrations, however, tend to become progressively less damaging as a fish dives to deeper waters. Each foot of hydrostatic pressure enables a fish to compensate for about 3 percent excess saturation (over 100 percent). Hence, the depth at which a fish travels becomes an important factor in determining overall effects of supersaturated waters on its survival. The primary objective of this study, therefore, was to obtain information on the depth traveled by juvenile salmon and trout during their seaward migration in the Snake River.

This study was part of a cooperative research effort funded by the U.S. Army Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation. It enabled us to gain further understanding of the effects of supersaturated gases on migrating juvenile salmonids.

GENERAL EXPERIMENTAL PROCEDURE AND DESIGN

Fishing of varied mesh gillnets at selected depths and locations in the reservoir was the basic method selected for this study. This procedure was similar to that used by Smith, Pugh, and Monan (1968), which was patterned after that used by Rees (1957).

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The sampling site was toward the north shore of the Snake River between one-half to three-fourths of a mile upstream from Lower Monumental Dam. The reservoir at this location is about 2,200 ft wide and has a maximum depth of about 115 ft. Two sampling stations were established; one station (nearest shore) was sampled to a depth of 48 ft, the other to 96 ft.

Both stations were in the same cross-section of the reservoir to enable a comparison of fish movement and occurrence in shallow and deep areas. Sample fishing at these stations was done on a 4-day test cycle from 23 April to 25 May 1973. At the deeper station, two nets were fished each day at different depths; vertical distance between the nets was 12 ft at all times. A single net was fished at the shallow station at one of four 12-ft levels each day. Weather permitting, nets were lifted and reset at dawn and dusk to obtain a comparison between night and day catches; otherwise the nets were checked once daily. A random selection for fishing positions was as follows:

Shallow Station
Day 1 — Position 4 (36'-48')
Day 2 — Position 1 (0-12')
Day 3 — Position 2 (12'-24')
Day 4 — Position 3 (24'-36')

Deep Station
Day 1 — Positions 5 (48'-60') and 7 (72'-84')
Day 2 — Positions 1 (0 -12') and 3 (24'-36')
Day 3 — Positions 2 (12'-24') and 4 (36'-48')
Day 4 — Positions 6 (60'-72') and 8 (84'-96')

Records of fish caught in gillnets included details on: (1) direction of travel (upstream or downstream) when caught; (2) species; (3) length; and (4) vertical location in net (upper, middle, or lower third). In addition, the location of fish caught in the surface nets (upper 12 ft) was recorded by 1-ft intervals of depth.

Turbidity was measured with a Secchi disc; a Whitney[1] thermometer was used for water temperature measurements. A solar illuminance meter, model LMA-8A manufactured by Montedoro Whitney, was used to measure light penetration.

[1] Mention of trade names in this publication does not necessarily imply endorsement by the National Marine Fisheries Service, NOAA.

SAMPLING NETS AND SUSPENSION SYSTEM

Sampling nets were constructed with monofilament nylon. Each net consisted of three panels, each 20 ft long by 12 ft deep. Respective mesh sizes (stretched measure) were ⅞ inch, 1⅛ inch, and 1⅜ inch; strand diameters were 0.015 cm, 0.015 cm, and 0.02 cm. These panels were arranged horizontally by order of mesh size to form a net 60 ft long by 12 ft deep. Each net was equipped with a leadline and floats; they were suspended by pulleys from two rafts anchored 60 ft apart at each station (Fig. 1). The pulleys were attached to concrete anchors positioned directly below each raft. Multistrand polypropylene rope ran from the surface down through the pulley blocks and back to the surface, forming an endless loop. One-half of the loop was marked at 12-ft intervals to enable accurate positioning of the nets at the desired depth.

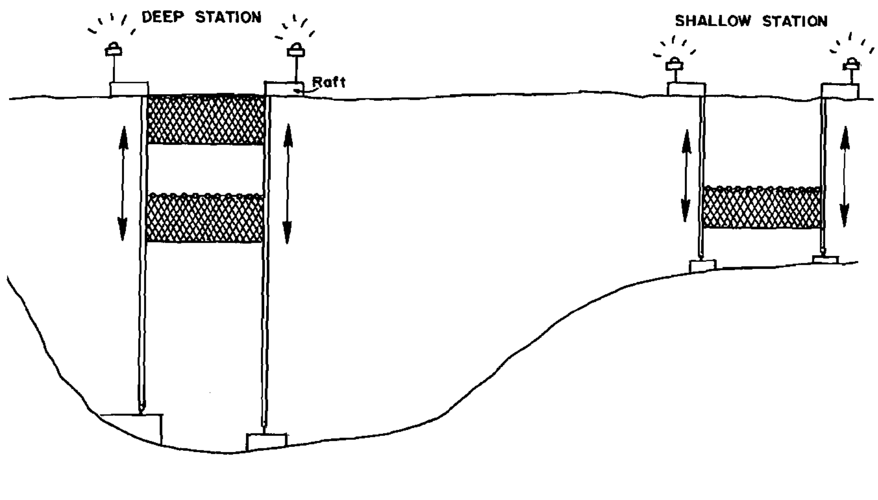

Figure 1.—Diagramatic sketch of net suspension system for sampling of vertical distribution of juvenile salmonids in Lower Monumental pool, 1973.

RESULTS

Fish captured in the gillnets were principally wild and hatchery stocks of juvenile chinook salmon, *O. tshawytscha,* and steelhead trout of the Snake River system. Northern squawfish, *Ptychocheilus oregonensis,* channel catfish, *Ictalurus punctatus,* and redside shiner, *Richardsonius balteatus,* also appeared in the catches. Fifty-three percent of the steelhead trout caught were of hatchery origin. These were easily identified by their eroded dorsal fins. It was impossible to accurately distinguish between hatchery and wild stocks of chinook salmon.

Combined catches (Table 1) at the deep and shallow stations show that 58 percent of the chinook salmon and 36 percent of the steelhead trout were traveling in the upper 12 ft of the reservoir. A breakdown of catches in the upper 12 ft of the reservoir at 1-foot intervals (Fig. 2) provides further insight of fish distribution in what is probably the most critical area of the water mass. Depth distribution of fish in this area is important in computing possible losses that could occur from exposure to supersaturated atmospheric gases because hydrostatic pressure compensates for about 3 percent excess gas saturation for each foot of depth. For example, 130 percent saturation at the surface would result in about 112 percent saturation for a fish traveling 6 ft beneath the surface and approximately 100 percent for fish at 10- to 12-ft depths.

Of fish caught in the upper 12 ft of the reservoir, 80 percent of the chinook salmon and steelhead trout were in the upper 6 ft of the nets. Thus, when applied to the total catch, we find that about 46 percent (0.80 × 58) of the chinook salmon and 29 percent (0.80 × 36) of the steelhead trout were migrating between the surface and 6 ft of depth. The significance of this observation is that more chinook salmon (because of their tendency to migrate nearer the surface) than steelhead trout would be subject to losses from supersaturation of dissolved gases.

Comparisons also were made of the horizontal distribution by species, catches by mesh size, direction of migration, and the proportion of catches made during day and night. Diel occurrence of the chinook salmon and steelhead trout catches appears in Table 2. Approximately 92 percent of the chinook and 76 percent of the steelhead were taken at night (between dusk and dawn). Owing to the method of capture, the predominance of nighttime catches may not necessarily be indicative of actual migratory behavior. Gillnets characteristically are more effective during periods of reduced visibility. Hence, one might expect greater catches at night or when the water is highly turbid. Examination of catches from 24 ft and below (depths at which very little or no light prevailed) suggests, however, that most of the migration did, indeed, occur at night.

Table 1.—Vertical distribution of juvenile chinook salmon and steelhead trout caught at shallow and deep stations in the forebay of Lower Monumental Dam, 1973.

Depth (feet)	Chinook Number of fish	Chinook %	Steelhead Number of fish	Steelhead %
Shallow station				
0-12	50	69	260	51
12-24	20	28	135	26
24-36	1	1.5	70	14
36-48	1	1.5	46	9
Totals	72	100	511	100
Deep station				
0-12	93	53	181	25
12-24	43	24	156	22
24-36	18	11	119	16
36-48	3	2	60	9
48-60	3	2	61	9
60-72	6	4	62	9
72-84	2	1	32	4
84-96	5	3	48	6
Totals	173	100	719	100
Shallow and deep stations combined				
0-12	143	58	441	36
12-24	63	26	291	24
24-36	19	8	189	15
36-48	4	2	106	8
48-60	3	1	61	5
60-72	6	2	62	6
72-84	2	1	32	2
84-96	5	2	48	4
Totals	245	100	1,230	100

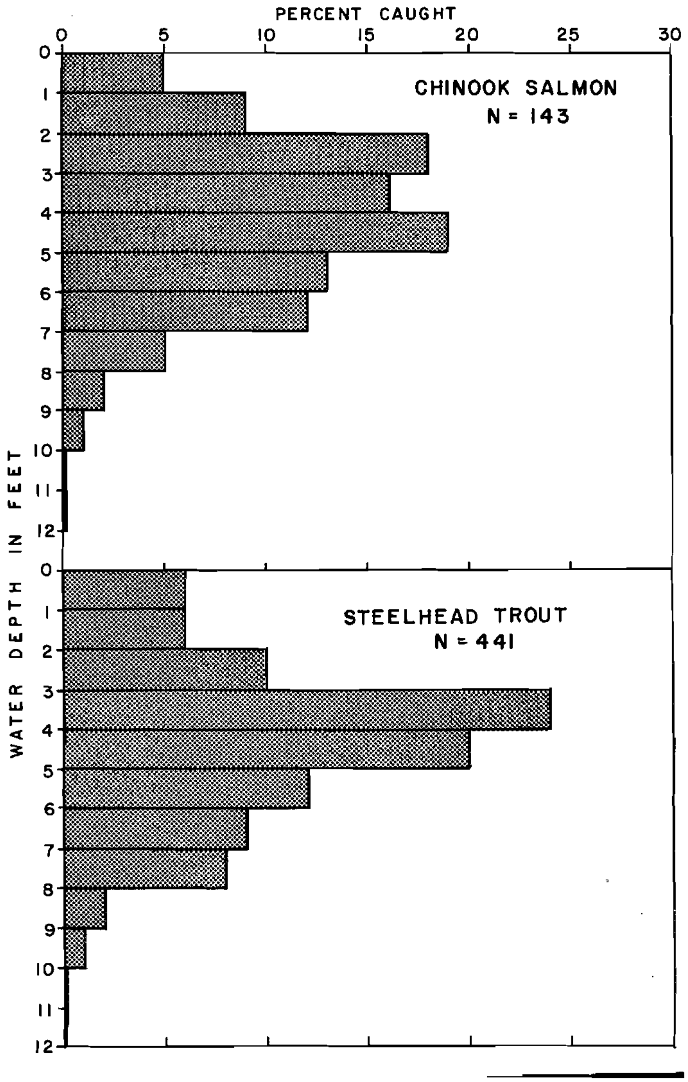

Figure 2.—Vertical distribution (in percent) of chinook salmon and steelhead trout caught in the upper 12 feet of Lower Monumental Forebay in 1973.

Among fish caught at these deeper levels, 76 percent (19 of 25) of the chinook and 88 percent (420 of 476) of the steelhead trout were taken at night.

Vertical distributions of the fish also were examined to determine whether demonstrable changes occurred between day and night periods. Data from catches in the upper 12 ft and from 12 to 24 ft (Table 2) were compared in this analysis. The proportion of chinook salmon catches in the surface nets (0-12 ft) increased at night whereas that of steelhead trout declined. No chinook were taken from 0 to 12 ft during the day, but at night 60 percent of the total catch in the upper 24 ft was taken in the surface nets. Steelhead catches in the surface nets declined from 74 percent during the day to 36 percent at night. If these catches reflect actual behavioral changes in the species, then chinook tend to be more surface-oriented at night whereas steelhead trout are the reverse—nearer the surface during the day.

Comparison of total catches in the upper 48 ft at the shallow and deep stations (Table 1) indicates that steelhead trout were uniformly distributed across the reservoir but that chinook clearly favored the more central portion of the reservoir. Twice as many chinook were taken at the deep or offshore station as at the shallow station (near shore). These horizontal distributions remained relatively the same from day to night (see Table 2, upper 48 ft only).

Table 2.—Day and night distribution of juvenile chinook salmon and steelhead trout caught at shallow and deep stations upstream from Lower Monumental Dam, spring 1973.

Depth (feet)	Daylight Chinook	Daylight Steelhead	Dark Chinook	Dark Steelhead
Shallow station				
		Number of fish		
0-12	0	99	27	94
12-24	3	20	17	115
24-36	0	8	2	61
36-48	0	5	1	41
Totals	3	132	47	311
Deep station				
		Number of fish		
0-12	0	48	38	49
12-24	2	29	27	138
24-36	1	6	1	88
36-48	2	10	1	51
48-60	0	9	3	51
60-72	1	3	5	60
72-84	0	4	2	27
84-96	2	11	4	41
Totals	8	120	81	505

Salmonid catches by mesh size of the gillnets were as follows: 1⅜-inch—48 percent, 1⅛-inch—45 percent, and ⅞-inch—7 percent. Eighty-six percent of the salmonids were headed downstream when captured.

RELATIONS BETWEEN PHYSICAL CONDITIONS OF THE RIVER AND DISTRIBUTION OF JUVENILE SALMONIDS

Effects of changes in the river temperature, flow, and turbidity and the solar illumination on the horizontal and vertical distribution of juvenile salmon and steelhead trout were examined, but no specific correlations were found. I believe this may possibly be due to the lack of substantial variations in the prevailing river conditions. Secchi disc readings ranged from 34 to 54 inches. Secchi disc readings in the Snake River during the spring freshet normally range as low as 6 inches but, owing to the prolonged low runoff in 1973, the river was consistently much clearer than the norm. Readings from the solar illuminance meter indicated that total darkness in the river ranged from 16 to 25 ft. Water temperatures at the surface of the reservoir ranged from 51 to 60.5°F and generally varied between 2 and 5 degrees cooler at 96 ft (maximum depth). Total river discharge at the dam ranged from 60 to 90,000 cfs which is far below the normal range of flow in the spring. The relatively narrow range of flow volume resulted in only minor changes in current velocity, and no correlation between velocity change and catches was noted.

The unusual clarity of the river in 1973 could have had some influence on the fish distributions in this study. For that reason, additional depth distribution studies would be in order in future years to determine whether significant changes in orientation and behavior of the fish occur with increasing turbidity.

LITERATURE CITED

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