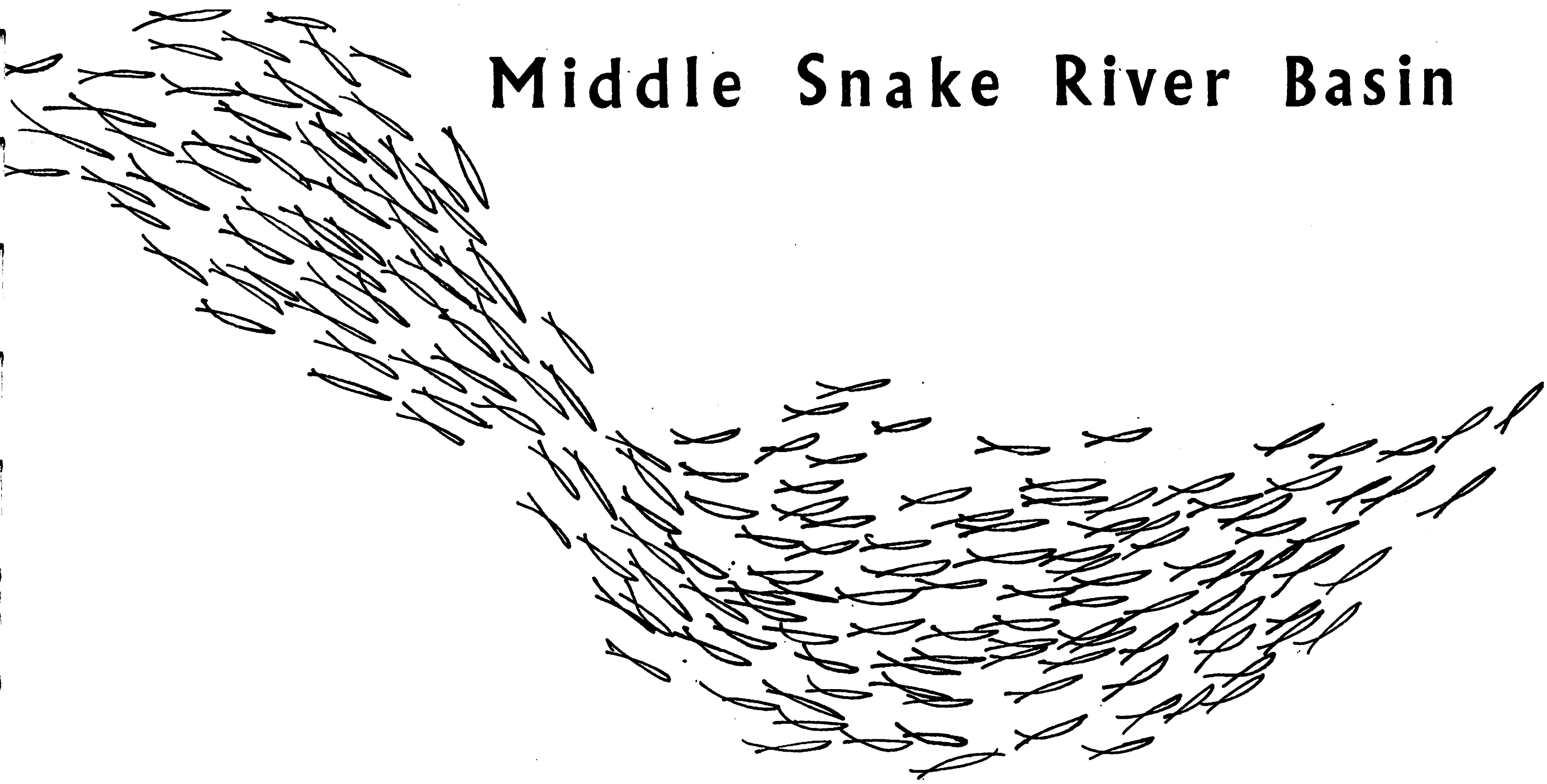
Comparison of Alternative Fish Hauling Costs

Middle Snake River Basin



Prepared for

Fish Passage Research Program
United States Department of the Interior
Fish and Wildlife Service
Bureau of Commercial Fisheries

Consulting Services Corporation

A COMPARISON OF ALTERNATIVE FISH HAULING COSTS

IN THE MIDDLE SNAKE RIVER BASIN

Prepared For

Fish Passage Research Program
United States Department of the Interior
Fish and Wildlife Service
Bureau of Commercial Fisheries

October 1964

Consulting Services Corporation
768 Dexter Horton Building
Seattle, Washington 98104

TABLE OF CONTENTS

	Page
INTRODUCTION	1
SUMMARY OF FINDINGS AND CONCLUSIONS	2
BASIC ASSUMPTIONS	4
THE CURRENT FISH POPULATION	6
THE COSTS OF ALTERNATIVE HAULING SYSTEMS	8
Light Truck with Portable Tank	
Medium Truck with Portable Tank	
Combination 3/4-Ton Truck and 3-5 Ton Stake Truck	
Air Freight Transportation	
ESTIMATING COST OF TRANSPORTING POTENTIAL POPULATIONS	17
RECOMMENDATIONS FOR FUTURE RESEARCH	19
APPENDIX: ILLUSTRATIVE ANALYSIS OF HAULING COSTS FOR POTENTIAL SALMON POPULATION ON THE SNAKE RIVER	21

A COMPARISON OF ALTERNATIVE FISH HAULING COSTS IN THE MIDDLE SNAKE RIVER BASIN

INTRODUCTION

The Oxbow and Brownlee Dams are located 270 and 287 miles, respectively, from the confluence of the Columbia and Snake Rivers. Located in the Middle Snake River Basin, they form a total barrier to the migration of salmon and steelhead fish on the Snake River. The upstream migrating adult salmon and steelhead are currently trapped and transported around this dam system by the Idaho Power Company. When Hell's Canyon Dam is completed (its construction has just begun), the barrier to salmon migration will be moved further downstream--and still further downstream upon completion of High Mountain Sheep Dam just below the mouth of the Salmon River. In each case, it is expected that a trapping and transport system for adult fish will be operated at each dam.

For the downstream migrating young salmon, the dams also constitute barriers. Only here it is not the dams themselves but rather their reservoirs which constitute the effective block to the migrants. Consequently, it has become necessary to catch the young fish in the streams above the reservoir and transport them for release below the dams. As the Hell's Canyon and High Mountain Sheep Dams are added to the Middle Snake River Basin complex, it will become necessary to transport the fingerling salmon and steelhead still further downstream. The purpose of this report is to estimate, by stages, alternative hauling costs for the transportation of fingerlings from their collection points to the furthest downstream dam currently anticipated.

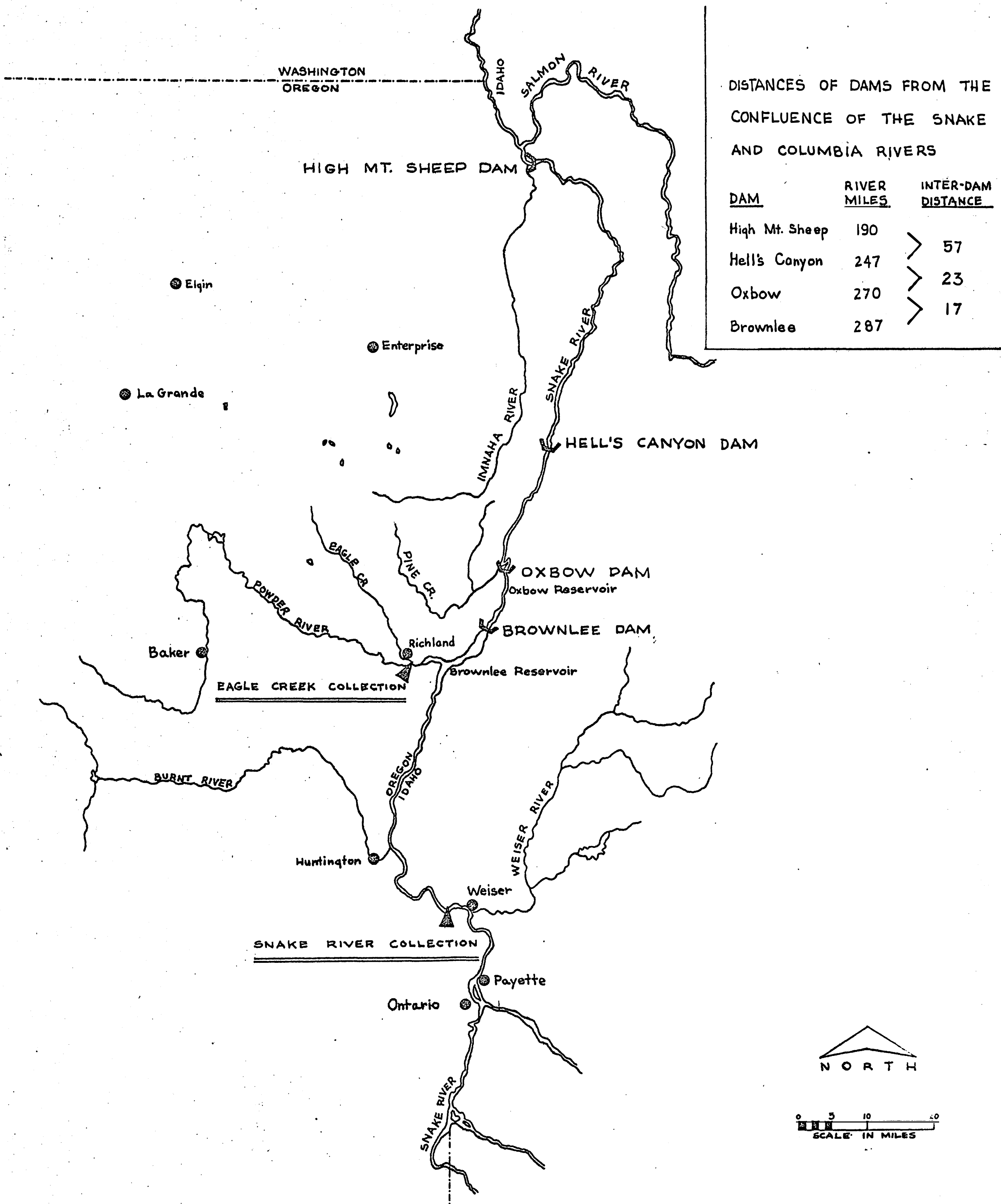


Figure 1
Dam Complex and Fish Collection Points
Middle Snake River Basin

SUMMARY OF FINDINGS AND CONCLUSIONS

Findings

The following findings are drawn from the data and analysis contained in subsequent sections of this report:

1. The current fish population has two peak run periods. The first occurs during October at the Eagle Creek station, and the second occurs during May primarily at the Snake River station.

2. Using a 3/4-ton pickup truck with a portable 150-gallon tank, the hauling cost per pound of fish is approximately 14.5¢ for the trip to Oxbow Dam, 17.5¢ to Hell's Canyon Dam, and 66.66¢ to High Mountain Sheep Dam.

3. Using a 3-5 ton stake truck with a portable 800-gallon tank, the hauling cost per pound of fish is approximately 8¢ for the trip to Oxbow Dam, 11¢ to Hell's Canyon Dam, and 40¢ to High Mountain Sheep Dam.

4. Using a 3-5 ton stake truck with a portable 800-gallon tank for peak-load hauling and a 3/4-ton pickup truck with a portable 150-gallon tank for hauling off-peak loads reduces hauling costs per pound of fish to approximately 7¢ for the trip to Oxbow Dam, 9¢ to Hell's Canyon Dam, and 35.5¢ to High Mountain Sheep Dam.

5. The cost per pound of fish for air freight hauling is approximately 19¢ for the trip to Oxbow Dam, 26¢ to Hell's Canyon Dam, and 33¢ to High Mountain Sheep Dam.

Conclusions

1. Given the existing fish population, the use of a 3-5 ton stake truck with a portable 800-gallon tank for peak-load hauling and a 3/4-ton pickup truck with a 150-gallon portable tank for off-peak hauling would be the minimum cost system for hauling fish to both Oxbow Dam and Hell's Canyon Dam.

2. For the trip to High Mountain Sheep Dam, air freight would be the minimum cost means of hauling.

3. For the estimated potential salmon population (fall chinook), air freight transportation is the minimum cost means of hauling when a 5% survival rate is assumed.

4. If a 15% survival rate is assumed for the potential salmon population, the minimum hauling cost means of transportation is a 3-5 ton stake truck with a portable 800-gallon tank.

BASIC ASSUMPTIONS

The complete transportation process actually involved three conceptually distinct activities: (1) The holding of the fish after their collection; (2) the handling of the fish in getting them first from the holding area to the hauling equipment and then back into the river; and (3) the actual hauling.

While there is reason to believe that wild fingerlings can be held for relatively long periods of time when sufficiently large holding areas, temperature control systems, and aeration systems are used, the exact costs associated with each of these holding problems could not be accurately estimated at the time of this study. It was our further understanding that several experimental collecting and holding methods were currently being tested. Until the most efficient of these methods is ascertained, precise cost estimates could contain such wide margins of potential error as to be virtually meaningless. Consequently, we have assumed throughout this report a maximum holding period of three and one-half days (i.e., a minimum of two hauling trips a week). Under this assumption, holding costs were considered identical for all methods of fish hauling and were not explicitly analyzed in the material presented in this report.

Much the same sort of assumption, and for generally the same reasons, was made with respect to the handling aspects of the transportation process. Two additional assumptions were made, however. First, the fish would not be fed during the period of time they were retained in the holding area and consequently the collection of fish excrement in the holding tanks would probably not be necessary. Second, it was assumed that the fingerlings would be anesthetized and/or tranquilized during movement, and no predation would occur in the hauling tanks. In general, it was assumed throughout the report that sufficient care would be taken in the handling of the fingerlings to either minimize or eliminate injuries and fatalities. Since the problems involved in handling the fish were considered to be roughly comparable for all of the hauling methods investigated in this report, they were not considered to account for the differential costs of fish transportation--and in consequence were not explicitly considered.

Our analysis of alternative hauling costs (which is discussed in the main body of this report) was predicated upon certain further assumptions. The first of these was that, regardless of the type of tank used, an average maximum of two pounds of fish per gallon of water could be hauled for trips of two hours or less. For trips over two hours, but under four hours, it was assumed that the average maximum capacity of the tank was one and a half pounds of fish per gallon of water. For trips in excess of four hours, but less than ten hours, the assumed average maximum capacity of a tank was one pound of fish per gallon of water.

It was further assumed, following discussions with Messrs. Tuttle, Kennedy, and Smith of the Bureau of Sports Fisheries and Wildlife, that neither the water conditions in the Snake River nor the length of trips to be made would require extensive use of refrigeration systems during the hauling operation. Occasional exceptions to this assumption might occur when the river temperature is too high to allow for optimum tank hauling conditions. Should this occur, however, it was assumed that the water temperature in the tanks would be lowered through the use of ice and that this operation would involve sufficiently small costs that they could be ignored in our analysis of the entire hauling process.

THE CURRENT FISH POPULATION

The current population of fingerlings to be hauled around existing and prospective dam sites consists of chinook salmon and steelhead. Numerically, there are more salmon than steelhead; however, the larger average size of the steelhead fingerlings gives them a larger poundage to be hauled. Salmon are estimated to vary between 61 mm. to 128 mm. (or from 110 fish per pound to 22 fish per pound), while the steelhead vary from 147 mm. to 285 mm. (or from 15 fish per pound to approximately one fish per pound).1/

The chinook run has two distinct phases. The first of these occurs at the Eagle Creek collection point and extends from the end of September through the latter part of June. The majority of chinooks recorded at the Eagle Creek station are collected during the first eight weeks of the run. During this period, the estimated average daily number of pounds of salmon per week varies from a low of approximately 13 pounds to a peak of approximately 212 pounds. Over the next thirty weeks, the salmon continue to migrate past the Eagle Creek station but in very small numbers--during only one of these thirty weeks does the average daily run of fish exceed five pounds per day.

During the last eight to ten weeks of activity at the Eagle Creek station, a second large run of salmon fingerlings occurs at the Snake River collection point (approximately five miles downstream from Weiser). This second run of salmon varies from a weekly average of about 15 to 20 pounds of fish per day during the first part of April to a high of over 240 pounds per day during mid and late May. It then drops off rapidly and remains quite small except for the second week of July when it reaches a second--but smaller--peak of approximately 70 pounds per day (see table 1 and figure 2).

Steelhead fingerlings are also collected at both the Eagle Creek and Snake River stations. In this case, however, the peak runs at both stations roughly coincide. Measured in average daily pounds of fish per week, the Eagle Creek station shows a Fall peak of approximately 35 pounds per day during the

1/ See note at end of section.

TABLE 1

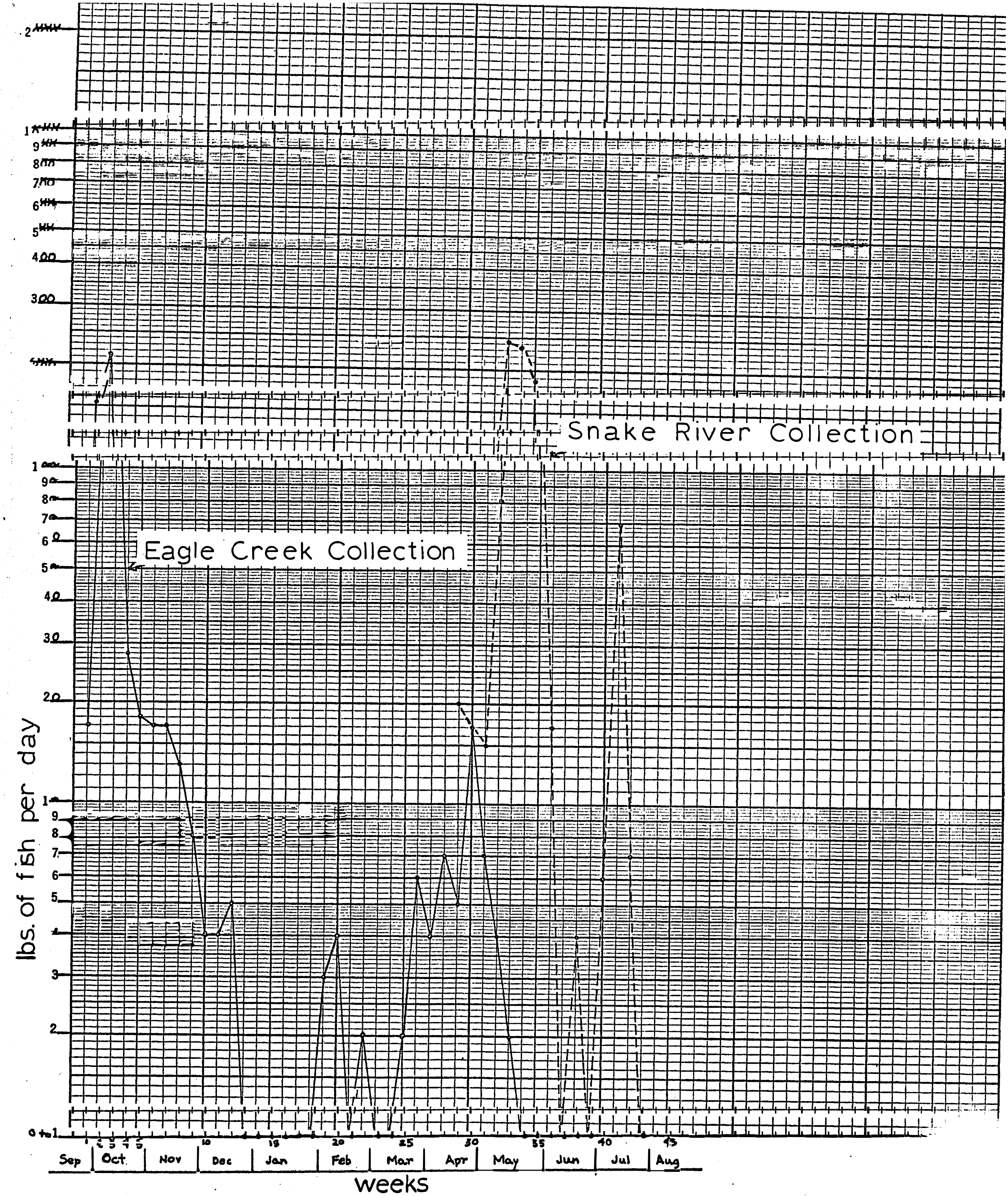
TOTAL FINGERLING SALMON RUN ON MIDDLE SNAKE RIVER: Sept. 1962-July 1963
(Eagle Creek and Snake River Stations)

Week of Run	Week No.	Estimated Total Number of Fingerling Salmon*	Estimated Total Pounds of Fingerling Salmon	Est. Average No. of Pounds of Fingerling Salmon Per Day Per Week
9/30-10/6	1	3,966	120	17
10/7 -10/13	2	37,721	1,143	163
10/14-10/20	3	48,859	1,481	212
10/21-10/27	4	6,517	197	28
10/28-11/3	5	4,060	123	18
11/4 -11/10	6	3,849	117	17
11/11-11/17	7	4,001	121	17
11/18-11/24	8	2,995	91	13
11/25-12/1	9	1,895	57	8
12/2 -12/8	10	842	26	4
12/9 -12/15	11	1,018	31	4
12/16-12/22	12	1,193	33	5
12/23-12/29	13	82	3	0.4
1/1 - 1/5	14	240	5	0.7
1/6 - 1/12	15	68	1	0.1
1/13- 1/19	16	0	0	0
1/20- 1/26	17	0	0	0
1/27- 2/2	18	0	0	0
2/3 - 2/9	19	1,043	20	3
2/10- 2/16	20	1,330	25	4
2/17- 2/23	21	505	10	1
2/24- 3/2	22	562	11	2
3/3 - 3/9	23	240	5	0.7
3/10- 3/16	24	458	9	1
3/17- 3/23	25	700	13	2
3/24- 3/30	26	2,063	39	6
3/31- 4/6	27	1,466	28	4
4/7 - 4/13	28	2,568	48	7
4/14- 4/20	29	5,092	175	25
4/21- 4/27	30	3,560	133	34
4/28- 5/4	31	5,203	154	22
5/5 - 5/11	32	38,170	597	85
5/12- 5/17	33	123,662	1,720	246
5/18- 5/24	34	122,092	1,657	236
5/25- 6/1	35	92,357	1,311	187
6/2 - 6/8	36	7,843	128	18
6/9 - 6/15	37	1,795	35	5
6/16- 6/27	38	480	7	2
6/28- 7/4	39	400	5	1
7/5 - 7/11	40	1,000	39	6
7/12- 7/18	41	10,700	480	69
7/19- 7/25	42	1,100	46	7
7/26- 8/1	43	200	9	1

(*) Salmon varied from 61 mm. (110 fish/lb.) to 128 mm. (22 fish/lb.).

Figure 2

Fingerling Salmon Run - Middle Snake River Basin 1962-1963



middle of October. After this, it rapidly diminishes and does not go above ten pounds per day until early May of the following year. During this latter period, a four-week peak period is reached where the average daily number of pounds of fish per week continuously exceeds ten pounds per day, reaching a peak of almost 110 pounds per day. At roughly the same period of time, the peak run at the Snake River station is occurring. During the week of April 14, 1963, an average of over 1,100 pounds of fish per day migrated past this point; and during the succeeding six-week period, the average daily run only once dropped below 200 pounds per day. The run falls off very sharply thereafter, and by the second week in June is less than 15 pounds per day, which is reduced to zero by the beginning of July (see table 2 and figure 3).

Note

1/ Current collections include many hatchery plants that are presumably catchable rainbow trout, not sea-going trout (i.e., steelhead). Therefore, the average weights for steelhead listed in the text may well be somewhat higher than those for wild, migrant steelhead. For purposes of this report, however, all fish other than salmon were classified as "steelhead" and considered transportable.

TABLE 2

TOTAL FINGERLING STEELHEAD RUN ON MIDDLE SNAKE RIVER: Sept. 1962-July 1963
(Eagle Creek and Snake River Stations)

Week of Run	Week No.	Estimated Total Number of Fingerling Steelhead*	Estimated Total Pounds of Fingerling Steelhead	Est. Average No. of Pounds of Fingerling Steelhead Per Day Per Week
9/30-10/6	1	1,180	118	17
10/7 -10/13	2	2,160	216	31
10/14-10/20	3	2,440	244	35
10/21-10/27	4	160	16	2
10/28-11/3	5	60	6	1
11/4 -11/10	6	140	14	2
11/11-11/17	7	0	0	0
11/18-11/24	8	260	26	4
11/25-12/1	9	60	6	1
12/2 -12/8	10	0	0	0
12/9 -12/15	11	0	0	0
12/16-12/22	12	40	4	1
12/23-12/29	13	0	0	0
12/30- 1/5	14	80	5	1
1/6 - 1/12	15	20	1	0
1/13- 1/19	16	0	0	0
1/20- 1/26	17	0	0	0
1/27- 2/2	18	0	0	0
2/3 - 2/9	19	280	19	3
2/10- 2/16	20	500	33	5
2/17- 2/23	21	100	7	1
2/24- 3/2	22	80	5	1
3/3 - 3/9	23	40	3	0
3/10- 3/16	24	20	1	0
3/17- 3/23	25	20	1	0
3/24- 3/30	26	20	1	0
3/31- 4/6	27	360	24	3
4/7 - 4/13	28	730	49	7
4/14- 4/20	29	8,220	8,015	1,142
4/21- 4/27	30	4,080	4,005	571
4/28- 5/4	31	3,150	2,077	297
5/5 - 5/11	32	5,800	2,253	322
5/12- 5/17	33	12,190	1,746	250
5/18- 5/24	34	2,830	1,589	227
5/25- 6/1	35	2,400	1,840	263
6/2 - 6/8	36	1,570	851	121
6/9 - 6/15	37	580	132	19
6/16- 6/27	38	240	109	15
6/28- 7/4	39	100	100	14
7/5 - 7/11	40	0	0	0
7/12- 7/18	41	0	0	0
7/19- 7/25	42	0	0	0
7/26- 8/1	43	0	0	0

(*) Steelhead varied from 147 mm. (15 fish/lb.) to 285 mm. (1 fish/lb.).

Figure 3

Fingerling Steelhead Run - Middle Snake River Basin 1962-1963

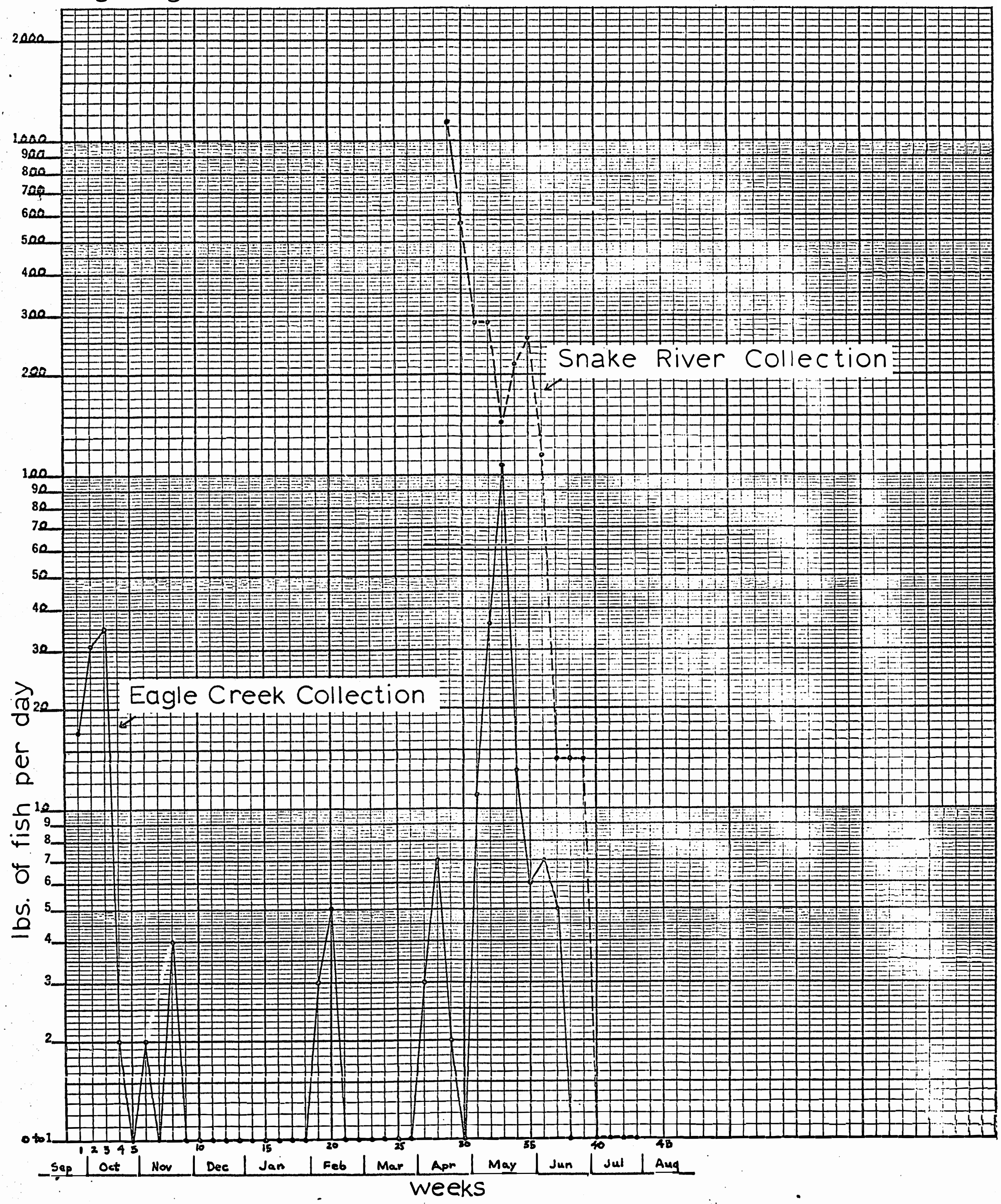
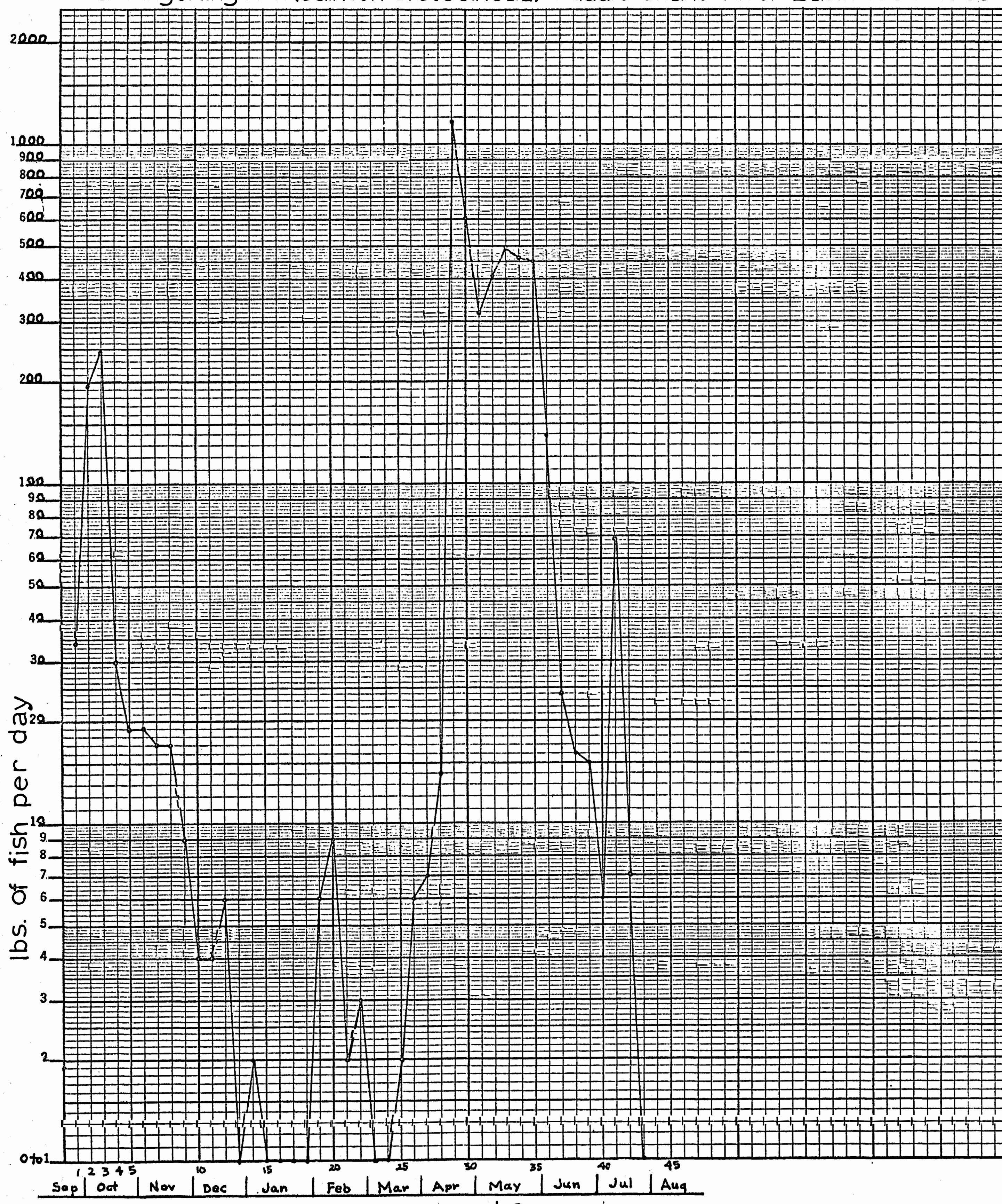


Figure 4

Total Fingerling Run (Salmon & Steelhead) - Middle Snake River Basin 1962-1963



THE COSTS OF ALTERNATIVE HAULING SYSTEMS

1. Light Truck with Portable Tank

The first method of fish hauling investigated was a small tank and light truck. The costs incurred by this method of hauling were estimated in the following manner.

The costs of acquiring and operating a 3/4-ton, 4 x 2 pickup truck were estimated from the General Service Administration's "Motor Vehicle Service Rates for Interagency Motor Pools, Region X." These rates include fuel, lubrication, maintenance, tires and, if required, storage for the vehicle. The rate for such a truck varies between 8.5¢ per mile for the first 1,000 miles driven per month to 8¢ per mile thereafter. In our report, we used an average figure of 8.25¢ per mile for cost of truck operation.

The costs of a 150-gallon tank, including all auxiliary equipment, were obtained from the article, "Fish Planting Tank for 3/4-Ton Pickup Truck" in the October 1950 Progressive Fish Culturalist. The costs were updated to current value 1963 dollars by use of the "Implicit Price Deflators for Producers Durable Equipment" as reported by the U. S. Department of Commerce. On the basis of an assumed ten-year life expectancy and the average number of miles which the tank would be covering each year, we estimated the average cost of the 150-gallon tank to be 0.45¢ per mile.

The final cost considered was that of the vehicle's driver. On the basis of the most recent joint United States Army-Air Force wage survey of the Spokane Metropolitan Area, we estimated a prevailing wage of $2.70 per hour for light truck driver. While this wage is slightly below that existing in the Puget Sound Region (Seattle Metropolitan Area), it is probably reasonable for the wage which would have to be paid for a driver operating along the Snake River (if anything, it is on the high side). Preliminary findings of the U. S. Bureau of Labor Statistics study, as reported in the Weekly Federal Employees News Digest, indicate that government fringe benefits average about 23% of the hourly wage. Consequently, the total hourly labor cost for a driver including his hourly wage and non-wage compensation was estimated to be $3.32 per hour. It was assumed that an average of ten minutes per hour of driving time was spent by the driver in waiting for the loading and unloading of his tank. Allowing for this waiting time brings the total labor costs to $3.70 per hour for every hour of actual driving time. Assuming an average truck speed of 42 miles an hour over an entire trip, average total driver costs per hour were estimated to be 8.98¢ per mile.

Summing these three costs, the total cost per mile for a 3/4-ton pickup truck carrying a 150-gallon tank was estimated to be 17.68¢.

The total number of miles which will be traveled in hauling the fingerlings during each stage of the Middle Snake River Basin's dam complex was estimated in the following manner. The average number of pounds of fish per day (both steelhead and salmon) was estimated by week for both the Eagle Creek and Snake River collection stations. These figures were summed to get the total number of pounds of fingerlings per day, by week, to be hauled (see table 3, end of text). Under an assumed average speed of 42 miles an hour, the maximum load which could be carried in a 150-gallon tank was: 300 pounds of fish for trips of 82 miles or less; 225 pounds of fish for trips of 83 to 168 miles; and 150 pounds of fish for trips in excess of 169 miles.

On the basis of this assumption, the number of trips required by a 150-gallon tank, 3/4-ton pickup truck going from Eagle Creek to Oxbow Dam, Hell's Canyon Dam, and High Mountain Sheep Dam were estimated. During the period of overlapping runs at the Eagle Creek and Snake River stations, the estimated number of miles traveled were based on a trip originating at the Snake River station, proceeding to Eagle Creek for a second collection, and then proceeding to the final destination. When collections were made only at the Snake River station, the estimated number of trips required was based upon the most direct route from Weiser to the point of final destination (see table 4, end of text).

The road distances for each of these types of trips were estimated by Consulting Services Corporation from measured inches taken from a road map and converted, according to scale, to miles traveled. The round trip distance required per trip was then multiplied by the number of trips required for each of the three possible routes discussed above to give the total number of miles per year covered by the truck. This figure was multiplied by the average total cost per mile of operating the truck (discussed above) to give a total annual operating cost for hauling the fish. The total number of pounds of fish hauled per year (from the existing population) was then divided into this estimated annual total cost to derive a cost per pound of hauling fish. In the case of the 3/4-ton pickup truck equipped with the 150-gallon tank, these costs varied from approximately 14.45¢ per pound for the trip to the Oxbow Dam; to 17.59¢ per pound for the trip to Hell's Canyon Dam; and 66.68¢ per pound for the trip to the High Mountain Sheep Dam.

3/4-Ton Truck Equipped with 150-Gallon Tank

	Total Miles Per Year	Total Costs Per Year	Total Pounds Per Year	Cost Per Pound
Eagle Creek & Snake River to Oxbow Dam	27,680	$ 4,893.82	33,859	$.1445
Eagle Creek & Snake River to Hell's Canyon Dam	33,680	$ 5,954.62	33,859	$.1759
Eagle Creek & Snake River to High Mountain Sheep Dam	127,700	$22,577.36	33,859	$.6668

2. Medium Truck with Portable Tank

The second hauling system to be investigated was a 3-5 ton stake truck equipped with an 800-gallon portable tank. Using the same sources of data as before, the estimated cost of the truck was taken as 20.50¢ per mile. The price of an 800-gallon tank, fully equipped, was estimated for Consulting Services Corporation by the Bureau of Sports Fisheries and Wildlife office in Portland. Dividing an assumed 15-year tank life by the estimated number of miles which the tank would cover over its lifetime gave us a figure of about one-tenth of a cent (0.13¢) per mile as the tank cost. From the same sources discussed above, the average hourly wage of a truck driver for a 3-5 ton truck was taken as $2.78 per hour; and the total labor cost (including waiting time) of the driver was estimated to be $3.42 per hour. Dividing by an estimated speed of 42 miles an hour over the entire length of the trip gave an estimated total labor cost of 9.45¢ per mile. Thus, the total operating and capital cost for a 3-5 ton stake truck and 800-gallon, fully equipped, tank was estimated to be 30.08¢ per mile.

Through the Portland office of the Bureau of Sports Fisheries and Wildlife, data were obtained for eight stations which used 800-gallon tank trucks for hauling from hatcheries to final distribution points. These data were available for both 1963 and 1964. Four of the stations engaged in trips involving distances that were either so small (e.g., four miles per round trip in one case) or so large (e.g., 379 miles per trip) that direct comparisons were not useful. For the remaining four stations, the average operating and capital costs per mile were estimated for 1963 and 1964. The years were appropriately weighted and averaged to arrive at an average figure for similar equipment over the two-year period. The data thus derived varied from the estimated cost per mile used in this report by less than 1.25%.

The same procedures used to determine the number of miles per year driven when hauling with a 3/4-ton pickup (as discussed earlier) were also used here to determine the total number of miles per year which would be covered by a 3-5 ton stake truck equipped with an 800-gallon tank (the pounds of fish varying by the length of the trip, however, from a maximum of 1,600 pounds to a midpoint of 1,200 pounds and a low of 800 pounds). Once the total miles per year were estimated, the total cost was derived by multiplying these miles by the average cost per mile of operating the equipment. Dividing this total cost through by the total pounds of fish hauled during the year produced an estimated cost per pound of fish hauled.

The estimated cost of hauling fingerlings by this type of equipment varied from a low of 8.88¢ per pound for the trip to Oxbow Dam, to a midpoint of 11.19¢ per pound for the trip to Hell's Canyon Dam, and a high of 40.02¢ per pound for the trip to High Mountain Sheep Dam.

3-5 Ton Stake Truck Equipped with 800-Gallon Tank

	Total Miles Per Year	Total Costs Per Year	Total Pounds Per Year	Cost Per Pound
Eagle Creek & Snake River to Oxbow Dam	9,990	$ 3,004.99	33,859	$.0888
Eagle Creek & Snake River to Hell's Canyon Dam	12,600	$ 3,790.08	33,859	$.1119
Eagle Creek & Snake River to High Mountain Sheep Dam	45,050	$13,551.04	33,859	$.4002

3. Combination 3/4-Ton Truck and 3-5 Ton Stake Truck

Because of substantial differences in pounds of fish per day (and consequently average maximum loads per week) which exist over the fingerling run, it was next assumed that a 3/4-ton truck carrying a 150-gallon tank would be used during the non-peak periods; and that a 3-5 ton stake truck with an 800-gallon tank would be used during the peak periods.

To avoid the costs of continually installing and taking off the various tanks from the different trucks, the system was designed to have the 3/4-ton pickup truck handle all hauls for approximately the first 28 and last four weeks of the run. The intervening two and a half months' period (the peak period) was assumed to be handled by the 3-5 ton stake truck. In effect, then, all of the hauls departing from either the Eagle Creek or the Snake River collection points and proceeding directly to their destination were handled by the 3/4-ton truck. Alternately, those trips originating at the Snake River station and proceeding to Eagle Creek prior to their final destination were serviced by the larger equipment.

The total costs per mile of operating the two types of equipment were the same as those derived in the earlier sections. Likewise, the same procedures discussed earlier were again used to derive the total number of miles and total number of trips required for each type of equipment. Using these data, the average cost per pound of hauling fish was estimated for a system utilizing different equipment for peak and non-peak periods. These costs varied from a low of 7.33¢ per pound for the trip to Oxbow Dam, to a midpoint of 9.20¢ per pound for the trip to Hell's Canyon Dam, and a high of 35.31¢ per pound for the trip to High Mountain Sheep Dam.

Combination 3/4-Ton Truck with 150-Gallon Tank and 3-5 Ton Stake Truck with 800-Gallon Tank

	Total Miles Per Year	Total Costs Per Year	Total Pounds Per Year	Cost Per Pound
Eagle Creek & Snake River to Oxbow Dam	10,340	$ 2,481.59	33,859	$.0733
Eagle Creek & Snake River to Hell's Canyon Dam	13,280	$ 3,116.70	33,859	$.0920
Eagle Creek & Snake River to High Mountain Sheep Dam	52,200	$11,956.96	33,859	$.3531

4. Air Freight Transportation

To estimate the air freight costs of hauling fingerling fish, Consulting Services Corporation requested two air service companies from the Lewiston, Idaho, area to submit cost estimates for transporting fish from the two collection points to the destination points for each stage of the dam system. Both of the air service companies contacted promptly replied, and from the data contained in their replies combined with Consulting Services Corporation's knowledge of the air transportation and air freight industry, we derived the following estimates of air hauling costs.

When shipping by air, the largest costs are associated with short hauls, where take-off and landing approaches are sufficiently close to prevent the maintenance of cruising speeds for any substantial periods of time. Consequently, based upon our own knowledge and the two estimates referred to above, we estimated that the average cost per 100 gallons of water of air freight would be 60¢ per air mile flown for trips of 80 miles or less and 45¢ per air mile flown for trips of 80 miles or more. The air miles to be flown were calculated between the Eagle Creek and the Snake River collection points and the final points of destination, under the assumption that either single engine (maximum capacity, 100-gallon tanks) or double engine (maximum capacity, 400-gallon tanks) light planes would be used for the air hauling and that these planes would be able to land in the immediate proximity of the collection points. The average number of air miles per trip was then multiplied by the number of trips required from each collection point to derive the total air miles flown to each destination.

Based upon the number of miles covered in each trip (or each leg of each trip), the appropriate costs per air mile were multiplied by the total miles flown to derive the total costs of air transportation. These total costs were then divided by the total pounds of fish hauled per year to arrive at an estimated average cost per pound of fish hauled. These costs vary from a low of 18.89¢ per pound to Oxbow Dam, to a middle cost of 26.16¢ per pound to Hell's Canyon Dam, and a high of 33.14¢ per pound to High Mountain Sheep Dam.

Hauling Costs by Air Freight

	Total Miles Per Year	Total Costs Per Year	Total Pounds Per Year	Cost Per Pound
Eagle Creek & Snake River to Oxbow Dam	10,659	$ 6,395.40	33,859	$.1889
Eagle Creek & Snake River to Hell's Canyon Dam	14,763	$ 8,857.80	33,859	$.2616
Eagle Creek & Snake River to High Mountain Sheep Dam	23,220	$11,220.75	33,859	$.3314

These hauling costs were estimated under the assumption that land based planes would be used and that the fish would be released by free fall dumping. If float planes were to be used, the hauling costs per pound would rise by approximately 10%.

Comparison of Alternative Hauling Costs

The major determinants of the various systems' hauling costs per pound were (a) the number of miles covered and (b) the size of the average load hauled. With respect to the first of these, as the distance between pickup and final destination points increases, the relative advantage of air freight increases. Conversely, where the distance between pickup and the destination is quite small, air transportation costs per pound are exceedingly high vis-a-vis other transportation systems. On the other hand, if the average size of the hauls is quite small, a 3/4-ton pickup truck with a 150-gallon tank provides the most inexpensive means of hauling. Conversely, where average load sizes are quite large, costs per pound of hauling with this type of equipment become very expensive.

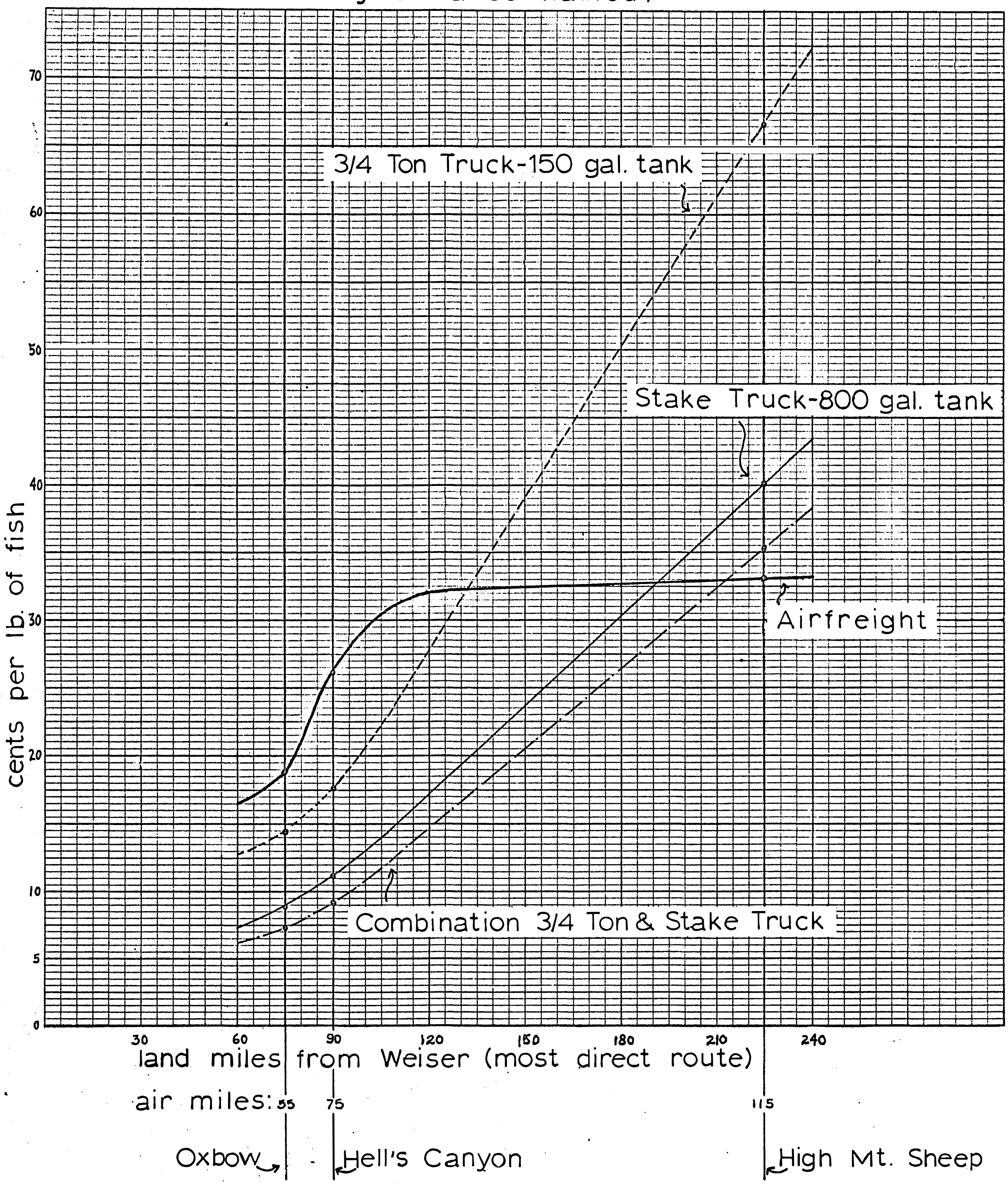
For the existing fingerling population, minimum transportation costs to both Oxbow and Hell's Canyon Dams would be achieved by using a combination 3/4-ton pickup and a 3-5 ton stake truck (as described in the previous text). On the other hand, as the full dam complex becomes developed and it is necessary to haul the fish beyond High Mountain Sheep Dam, air freight appears to be the cheapest method of hauling fish.

The advantages of air freight shipping for long distances, however, are predicated upon two assumptions. The first is that whatever air freight carrier contracts to do the work, he will have available to him equipment for hauling both 100 and 400 gallon tanks. The second assumption is that the amount of inclement weather capable of forcing cancellation of a flight following pickup of the fish but prior to their release will be negligible. The first of these assumptions is a very safe one to make, for if any particular air service firm does not have all of the equipment required, it is almost always easily available to him. The second assumption, however, requires an analysis of the weather conditions during the months of the run. Such a meteorological investigation, of course, lies beyond the scope of this present study.

One final comment on relative costs of hauling fish seems to be in order. During a relatively large number of the weeks covered by this study, the number of pounds of fish to be hauled is very small. If as a general rule, fingerling fish collected at a rate of less than ten pounds per day were released instead of being hauled, the reduction in the number of pounds of fish hauled over the year would be approximately 1.5% (i.e., 98.5% of the total run, measured in poundage, would be hauled). This reduction of approximately 1.5% in the number of fish hauled would produce a cost saving estimated to run between 12% and 14%.

Figure 5

Differential Hauling Costs for Fingerlings
(by distance hauled)



ESTIMATING COST OF TRANSPORTING POTENTIAL POPULATIONS

From data supplied to us by the Fish Passage Research Program of the U. S. Bureau of Commercial Fisheries, the costs of transporting chinook salmon and steelhead fingerlings in the future were estimated. This process primarily involved an estimation of the number of trips required by various types of fish transportation equipment, for the cost per mile of each type of equipment is expected to remain constant in terms of current value dollars (i.e., dollars having their current purchasing power).

The potential adult salmon population (25,000 fish), however, is estimated to be over four times the existing population (6,000 fish). If the potential fingerling population is distributed over the entire run period according to the distribution of the 1962-1963 run for which we have data, exceedingly high peak load hauls would occur. However, with only one year's data available, it was not possible to arrive at a reasonable distribution that would allow for both an increase in peak loads and a relative increase in average loads over the entire run. Consequently, the only cost estimates that could be derived were those predicated upon the assumption that future distributions of the run would be the same as the existing distribution.

A better guide for the future would be the realization that as the fish population increases simultaneously with the completion of the entire dam complex, both the average length of haul and the average number of pounds per haul will increase. We would thus expect future costs per pound to reach a maximum of those reported in the main body of this study for the trip to High Mountain Sheep Dam. As the average size of a haul gets larger and it becomes feasible to use larger equipment, it is expected that the economies of such large-scale equipment would come into play and a reduction in the cost per pound of hauling the fish would occur. It is, therefore, expected that the most econonical means of transporting the fish will be by either air freight or the use of a 3-5 ton stake truck carrying an 800 (or larger) gallon tank.

By the time the problem of hauling the potential population becomes a pressing one, however, it is assumed that additional years of data on the distribution of the fingerling runs will be available. From such future data, a more precise determination of costs per pound and total costs can be made.

However, in order to allow generalized comparisons to be made between current and future hauling costs, an illustrative set of data has been calculated for the existing and future costs of hauling fall chinook salmon. These data are presented in the appendix to the report.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. At such time as more precise data on the means of collecting, holding, and handling fish is available, the cost per pound of each of these stages in the transportation process can be determined with some degree of accuracy. We would fully expect that the cost of collection will probably be fairly uniform regardless of the size of the run or the length of time the fish are held. On the other hand, we would equally expect that the cost of holding and handling would rise fairly substantially as the length of time the fish are held increases. Particularly during off-peak periods, however, increased holding times allow for larger average load sizes and fewer trips; consequently, they also allow for greater economy of scale in the hauling phase of the transportation process.

   With these two costs (those of holding and handling and those of hauling) moving in opposite directions, it is possible to determine the optimum holding period and the optimum load size which would allow for a minimization of costs over the entire year. This can be done along lines already well developed in the field of linear programming. Consequently, we would recommend that upon the development of relatively precise data on the holding, handling, and collection costs associated with the transportation of the fish, a linear program be developed for the entire transportation process.

2. Assuming an average life expectancy of 100 years for the dams being constructed in the Middle Snake River system, it is our opinion that the construction of a fixed installation system which allows for the automatic transportation of fish would reduce the total transportation costs over the lifetime of the dams--even though the cost of erecting such a facility would be larger than any one year's hauling cost.

On the basis of a highly preliminary investigation of the subject, we are of the opinion that a suspended capsule system could be devised, utilizing existing high-voltage electric towers and incorporating an automatic loading and releasing system at each end, which would be feasible from an engineering point of view and which would result in substantial cost savings over the lifetime of the dam system. We consequently recommend that this, or some similar, type of automatic transportation system be investigated for its feasibility and its immediate adoption.

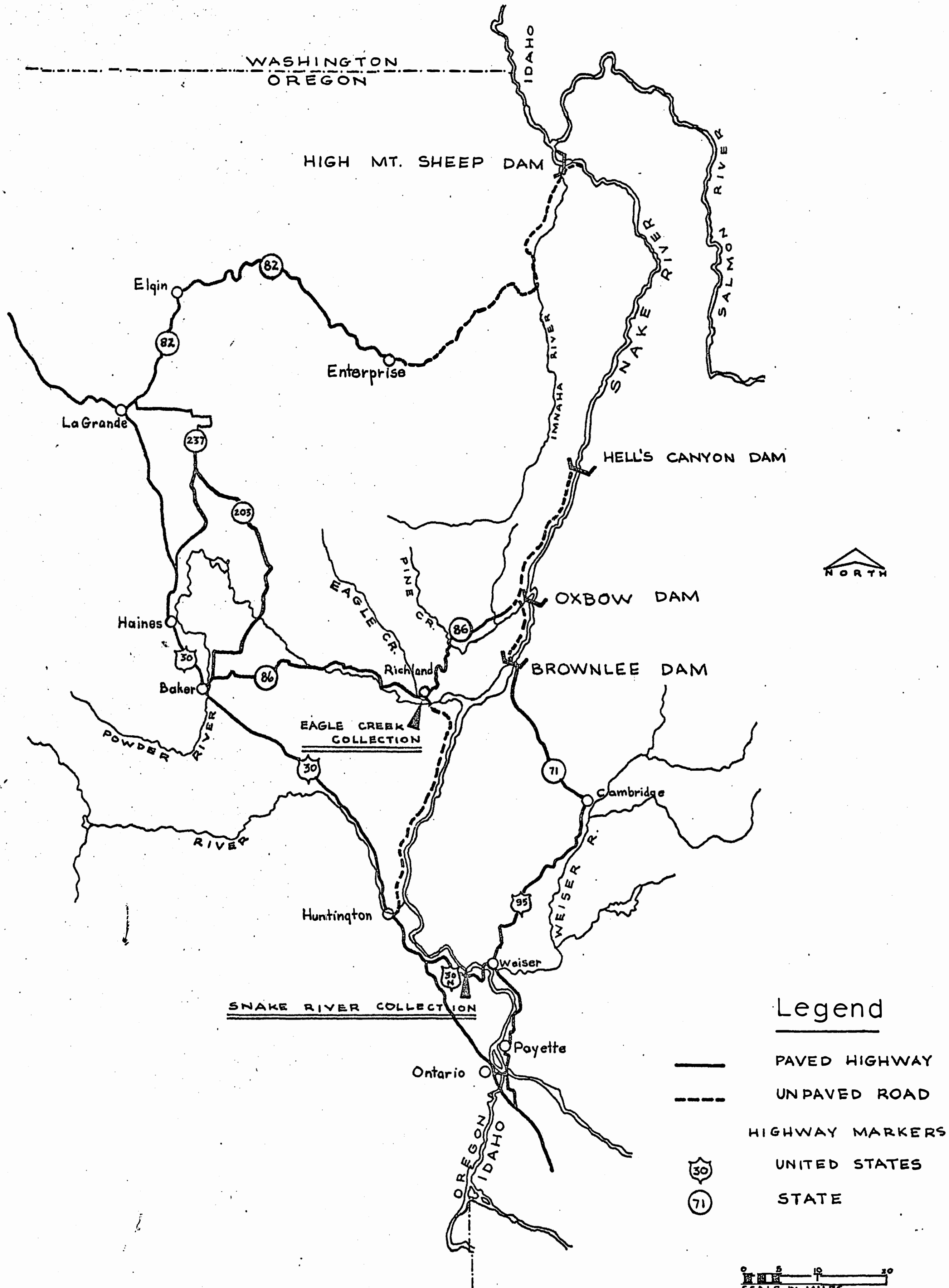


Figure 6
Road Transportation Network
Middle Snake River Basin

TABLE 3

TOTAL POUNDS OF FISH TO BE HAULED FROM MIDDLE SNAKE RIVER BASIN
(By Collection Station)

Week of Run	Eagle Creek Collection: Avg.Lbs. Salmon/Day	Eagle Creek Collection: Avg.Lbs. Steelhead per Day	Eagle Creek Collection: Average Total Lbs./Day	Snake River Collection: Avg.Lbs. Salmon/Day	Snake River Collection: Avg.Lbs. Steelhead per Day	Snake River Collection: Average Total Lbs./Day	Average Total Lbs. Fish/Day Both Stations (Col. 4 + 7)
9/30-10/6	17	17	34	-	-	-	34
10/7 -10/13	163	31	194	-	-	-	194
10/14-10/20	212	35	247	-	-	-	247
10/21-10/27	28	2	30	-	-	-	30
10/28-11/3	18	1	19	-	-	-	19
11/4 -11/10	17	2	19	-	-	-	19
11/11-11/17	17	0	17	-	-	-	17
11/18-11/24	13	4	17	-	-	-	17
11/25-12/1	8	1	9	-	-	-	9
12/2 -12/8	4	0	4	-	-	-	4
12/9 -12/15	4	0	4	-	-	-	4
12/16-12/22	5	1	6	-	-	-	6
12/23-12/29	0	0	0	-	-	-	0
12/30- 1/5	1	1	2	-	-	-	2
1/6 - 1/12	0	0	0	-	-	-	0
1/13- 1/19	0	0	0	-	-	-	0
1/20- 1/26	0	0	0	-	-	-	0
1/27- 2/2	0	0	0	-	-	-	0
2/3 - 2/9	3	3	6	-	-	-	6
2/10- 2/16	4	5	9	-	-	-	9
2/17- 2/23	1	1	2	-	-	-	2
2/24- 3/2	2	1	3	-	-	-	3
3/3 - 3/9	1	0	1	-	-	-	1
3/10- 3/16	1	0	1	-	-	-	1
3/17- 3/23	2	0	2	-	-	-	2

TABLE 3 (Continued)

TOTAL POUNDS OF FISH TO BE HAULED FROM MIDDLE SNAKE RIVER BASIN
(By Collection Station)

Week of Run	Eagle Creek Collection: Avg. Lbs. Salmon/Day	Eagle Creek Collection: Avg.Lbs. Steelhead per Day	Eagle Creek Collection: Average Total Lbs./Day	Snake River Collection: Avg.Lbs. Salmon/Day	Snake River Collection: Avg.Lbs. Steelhead per Day	Snake River Collection: Average Total Lbs./Day	Average Total Lbs. Fish/Day Both Stations (Col. 4 + 7)
3/24- 3/30	6	0	6	-	-	-	6
3/31- 4/6	4	3	7	-	-	-	7
4/7 - 4/13	7	7	14	-	-	-	14
4/14- 4/20	5	2	7	20	1,140	1,160	1,167
4/21- 4/27	17	1	18	17	570	587	605
4/28- 5/4	7	11	18	15	286	301	319
5/5 - 5/11	4	36	40	81	286	367	407
5/12- 5/17	2	107	109	244	143	387	496
5/18- 5/24	0	13	13	236	214	450	463
5/25- 6/1	0	6	6	187	257	444	450
6/2 - 6/8	1	7	8	17	114	131	139
6/9 - 6/15	1	5	6	4	14	18	24
6/16- 6/27	0	1	1	1	14	15	16
6/28- 7/4	0	0	0	1	14	15	15
7/5 - 7/11	0	0	0	6	0	6	6
7/12- 7/18	0	0	0	69	0	69	69
7/19- 7/25	0	0	0	7	0	7	7
7/26- 8/1	0	0	0	1	0	1	1
							4,837
					Annual Total Pounds of Fish (4,837 x 7)		33,859

Note: Collection at the Snake River station began the week of April 14th.

TABLE 4

TYPES OF TRIPS AND NUMBERS OF TRIPS REQUIRED TO HAUL FISH DOWNSTREAM IN MIDDLE SNAKE RIVER BASIN -- ALTERNATIVE EQUIPMENT

(Per Week)

Week of Run	Average Total Lbs. Fish/Day To Be Hauled	Type of Trip Required*	Air Freight No. Trips	3/4 Ton Pickup with 150 Gal. Tank — Number Trips Assuming Fish/Gallon Water: 2 Lb.	1.5 Lb.	1 Lb.	3-5 Ton Stake Truck with 800 Gal. Tank — Number Trips Assuming Fish/Gallon Water: 2 Lb.	1.5 Lb.	1 Lb.
9/30-10/6	34	E	2	2	2	2	2	2	2
10/7 -10/13	194	E	7	5	7	10	2	2	2
10/14-10/20	247	E	9	6	8	12	2	2	3
10/21-10/27	30	E	2	2	2	2	2	2	2
10/28-11/3	19	E	2	2	2	2	2	2	2
11/4 -11/10	19	E	2	2	2	2	2	2	2
11/11-11/17	17	E	2	2	2	2	2	2	2
11/18-11/24	17	E	2	2	2	2	2	2	2
11/25-12/1	9	E	2	2	2	2	2	2	2
12/2 -12/8	4	E	2	2	2	2	2	2	2
12/9 -12/15	4	E	2	2	2	2	2	2	2
12/16-12/22	6	E	2	2	2	2	2	2	2
12/23-12/29	0	E	0	0	0	0	0	0	0
12/30- 1/5	2	E	2	2	2	2	2	2	2
1/6 - 1/12	0	E	0	0	0	0	0	0	0
1/13- 1/19	0	E	0	0	0	0	0	0	0
1/20- 1/26	0	E	0	0	0	0	0	0	0
1/27- 2/2	0	E	0	0	0	0	0	0	0
2/3 - 2/9	6	E	2	2	2	2	2	2	2
2/10- 2/16	9	E	2	2	2	2	2	2	2
2/17- 2/23	2	E	2	2	2	2	2	2	2
2/24- 3/2	3	E	2	2	2	2	2	2	2
3/3 - 3/9	1	E	2	2	2	2	2	2	2
3/10- 3/16	1	E	2	2	2	2	2	2	2
3/17- 3/23	2	E	2	2	2	2	2	2	2

TABLE 4 (Continued)

TYPES OF TRIPS AND NUMBERS OF TRIPS REQUIRED TO HAUL FISH DOWNSTREAM IN MIDDLE SNAKE RIVER BASIN -- ALTERNATIVE EQUIPMENT
(Per Week)

Week of Run	Average Total Lbs. Fish/Day To Be Hauled	Type of Trip Required*	Air Freight No. Trips	3/4 Ton Pickup with 150 Gal. Tank, Number Trips Assuming Fish/Gallon Water: 2 Lb.	1.5 Lb.	1 Lb.	3-5 Ton Stake Truck with 800 Gal. Tank, Number Trips Assuming Fish/Gallon Water: 2 Lb.	1.5 Lb.	1 Lb.
3/24- 3/30	6	E	2	2	2	2	2	2	2
3/31- 4/6	7	E	2	2	2	2	2	2	2
4/7 - 4/13	14	E	2	2	2	2	2	2	2
4/14- 4/20	1,167	E & S	42	28	37	55	6	7	11
4/21- 4/27	605	E & S	21	15	19	28	3	4	6
4/28- 5/4	319	E & S	11	7	10	15	2	2	3
5/5 - 5/11	407	E & S	14	10	13	19	2	3	4
5/12- 5/17	496	E & S	17	12	16	24	3	3	5
5/18- 5/24	463	E & S	16	11	15	22	3	3	5
5/25- 6/1	450	E & S	16	11	14	21	2	3	4
6/2 - 6/8	139	E & S	6	4	5	7	2	2	2
6/9 - 6/15	24	E & S	2	2	2	2	2	2	2
6/16- 6/27	16	E & S	2	2	2	2	2	2	2
6/28- 7/4	15	S	2	2	2	2	2	2	2
7/5 - 7/11	6	S	2	2	2	2	2	2	2
7/12- 7/18	69	S	3	2	3	4	2	2	2
7/19- 7/25	7	S	2	2	2	2	2	2	2
7/26- 8/1	1	S	2	2	2	2	2	2	2

(*) E = Trip directly from Eagle Creek station to destination.
S = Trip directly from Snake River station to destination.
E & S = Trip originating at Snake River station and stopping at Eagle Creek station to take on additional loads before going to destination.

APPENDIX

ILLUSTRATIVE ANALYSIS OF HAULING COSTS FOR POTENTIAL SALMON POPULATION ON THE SNAKE RIVER

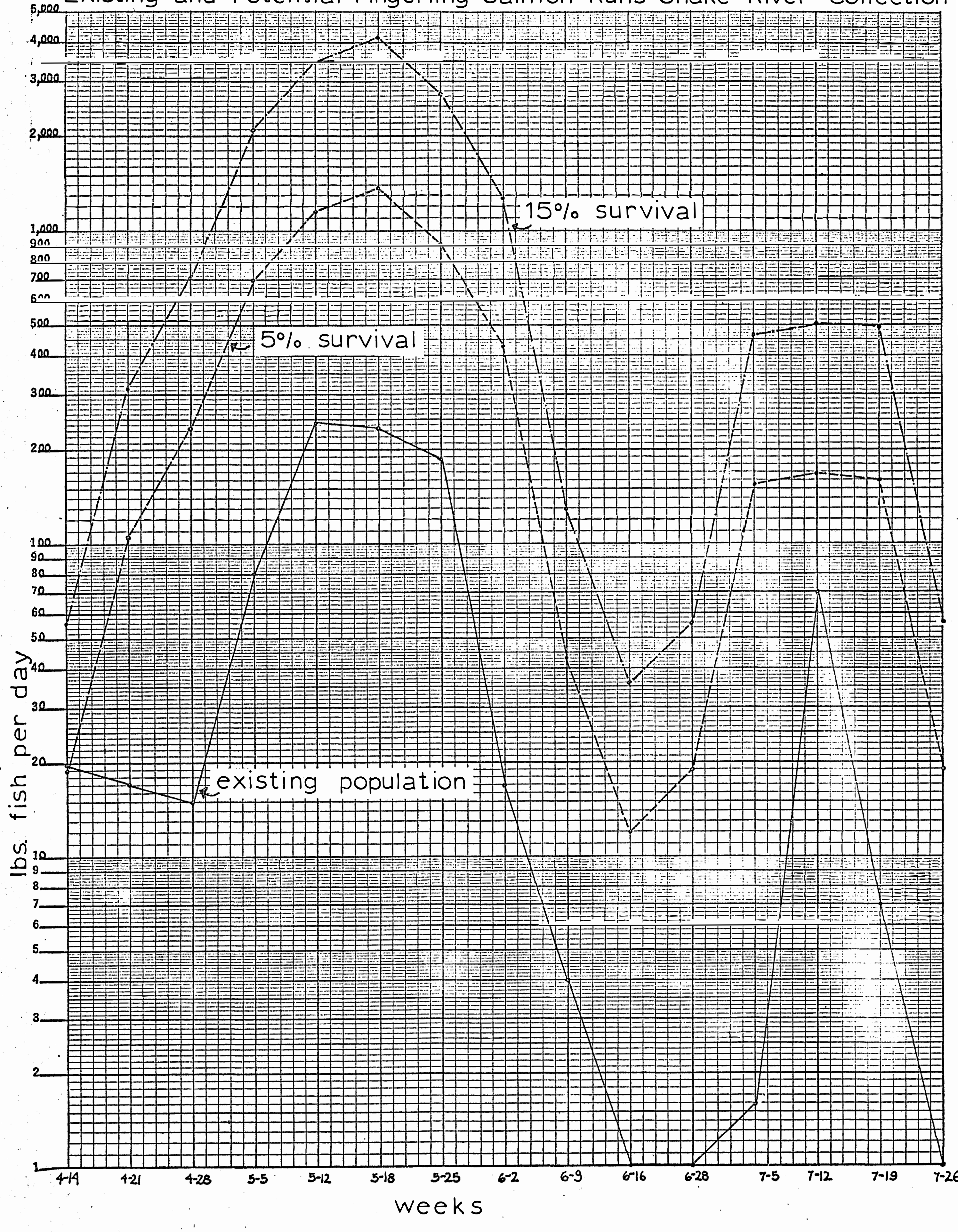
In order to provide an indication of the problems and costs associated with hauling the potential fingerling population in the Middle Snake River Basin, an illustrative analysis was conducted for the run of fall chinook salmon collected at the Snake River station. From data provided to us by the Fish Passage Research Program of the U. S. Bureau of Commercial Fisheries, the potential adult population was estimated at 12,500 females. Each female was assumed, on the average, to spawn 4,000 eggs--giving a total of 60,000,000 eggs. Two survival rates were assumed for the fingerlings: one of 5% and the other of 15%. Under the 5% survival rate, an estimated 3,000,000 fingerling salmon would constitute the potential population to be hauled from the Snake River station. Under the 15% survival rate, the fingerling population would be 9,000,000. Finally, the mean length of the fingerlings was assumed to be the same for the potential and the existing populations. Consequently, a mean length of 72 mm. was used, which would mean approximately 78 fingerlings per pound.

In order to distribute the two potential populations over the length of the run, the following procedure was used.

A three week moving average was taken of the weekly distribution (by pounds) of fingerling fall chinook salmon reported for 1963 at the Snake River station. Once this average was derived, the percentage distribution, by week, for the smoothed out fingerling run was computed. This percentage distribution was then applied to the estimated potential populations to distribute them over the length of the run. A comparison of the actual 1963 fall chinook run (as reported at the Snake River station) and the two estimated potential populations is presented in figure 7.

Figure 7

Existing and Potential Fingerling Salmon Runs-Snake River Collection



Once both the potential fingerling populations and their distributions over the length of the run were estimated, it was next possible to derive the cost of the hauling operation. These costs were computed for air freight (assuming the use of a twin engine light plane with a 400-gallon tank), a 3-5 ton stake truck with a portable 800-gallon tank, and a 1,000-gallon tanker-truck. The costs of using each type of hauling equipment were derived in a manner identical to that discussed in the main body of the text. The results of these cost calculations are presented in table 5. To allow for a comparison of the current and future hauling costs for fall chinook fingerlings, these same calculations also were made for the existing run and are also presented in table 5.

In general, total hauling costs rise very substantially as the size of the fingerling population increases. On the other hand, cost per pound of hauling diminishes sharply. For example, the existing population (approximately 6,340 pounds of fingerling salmon) would cost roughly $3,300 to haul, giving an average cost per pound of about 52¢. The potential population, assuming a 5% survival rate (roughly 38,500 pounds) would cost just over $6,600 to haul--although the cost per pound would fall to roughly 17¢. With a 15% survival rate, the fingerling population would be approximately 115,400 pounds, and the total cost of hauling would rise to approximately $14,600--although the cost per pound will have declined to approximately 13¢.

In making the cost estimates for hauling the potential fall chinook runs, the same type of equipment as discussed in the main body of the report was assumed to be used for the air freight and 800-gallon portable tank hauling. The 1,000-gallon tanker-truck hauling costs were estimated for the first time for this appendix. The method of estimating these costs was similar to the method used to develop costs for the other transportation equipment. Our conclusion is that for a 5% survival rate air freight hauling would show a slight advantage over any other form of transportation. This conclusion rests on the assumption that the size of the tank used in the air freight hauling would remain constant at 400 gallons. This assumption was maintained to allow full comparability between cost estimates in this appendix and the main part of the text. For the 15% survival rate, on the other hand, a truck with a portable 800-gallon tank would have the advantage.

However, should an adequate landing facility be available at Weiser for larger sized planes, and it becomes possible to use 600 to 800 gallon tanks, it is expected that air freight costs would again become less than any alternative form of hauling.

Figure 8

Total and Unit Cost of Hauling Fingerling Salmon
Existing and Estimated Potential Populations
(Weiser to High Mt. Sheep Dam)

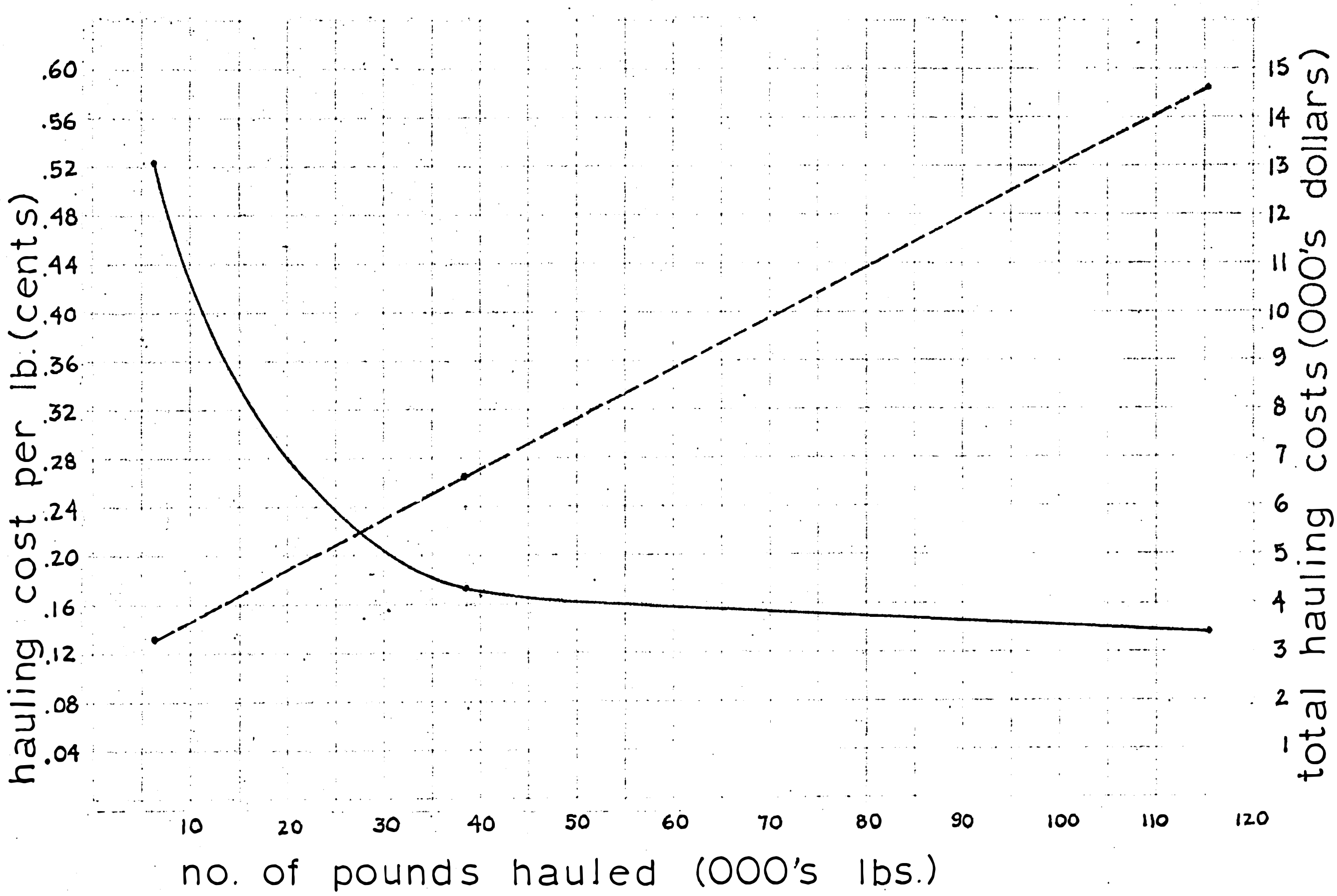


TABLE 5

COST OF HAULING EXISTING AND POTENTIAL FINGERLING SALMON POPULATION
SNAKE RIVER STATION TO HIGH MOUNTAIN SHEEP DAM

Total Miles Traveled*			Total Costs*			Pounds Fish Hauled*			Cost per Pound*		
Current#	5%	15%	Current#	5%	15%	Current#	5%	15%	Current#	5%	15%
Air Freight											
7,360	14,720	35,880	$3,312	$6,624	$16,146	6,342	38,458	115,374	$.5222	$.1722	$.1399
Stake Truck with 800-Gallon Tank											
- -	22,050	48,600	- -	$6,633	$14,619	- -	38,458	115,374	- -	$.1725	$.1267
Tanker-Truck with 1,000-Gallon Tank											
- -	19,800	40,950	- -	$9,563	$19,779	- -	38,458	115,374	- -	$.2487	$.1714

(*) 5% and 15% refer to assumed survival rates.
(#) Current costs calculated for air freight only to allow for direct comparisons between total cost data in text (where air freight was determined to be minimum cost hauling technique between Weiser and High Mountain Sheep Dam).

TABLE 6

POTENTIAL RUN OF FALL CHINOOK FINGERLINGS*
SNAKE RIVER STATION

Week of Run	Number of Chinook Fingerlings# 5%	Number of Chinook Fingerlings# 15%	Pounds of Chinook Fingerlings# 5%	Pounds of Chinook Fingerlings# 15%	Pounds/Day Chinook Fingerlings# 5%	Pounds/Day Chinook Fingerlings# 15%
4/14-4/20	10,200	30,600	131	392	19	56
4/21-4/27	57,300	171,900	735	2,204	105	315
4/28-5/4	128,100	384,300	1,642	4,927	235	704
5/5 -5/11	381,300	1,143,900	4,888	14,665	698	2,095
5/12-5/17	630,900	1,892,700	8,088	24,265	1,155	3,466
5/18-5/24	749,100	2,247,300	9,604	28,812	1,372	4,116
5/25-6/1	496,200	1,488,600	6,362	19,085	909	2,726
6/2 -6/8	232,800	698,400	2,985	8,954	426	1,279
6/9 -6/15	23,700	71,100	304	912	43	130
6/16-6/27	6,600	19,800	85	254	12	36
6/28-7/4	10,200	30,600	131	392	19	56
7/5 -7/11	84,300	252,900	1,091	3,242	154	463
7/12-7/18	91,500	274,500	1,173	3,519	168	503
7/19-7/25	87,600	262,800	1,123	3,369	160	481
7/26-8/1	10,200	30,600	131	392	19	56
	3,000,000	9,000,000	38,463	115,384	5,494	16,482

(*) For distribution and size of current run see table 3.
(#) 5% and 15% refer to the assumed survival rates.