TRANSPORTATION OF CHINOOK SALMON AND STEELHEAD SMOLTS 1968-80 AND ITS IMPACT ON ADULT RETURNS TO THE SNAKE RIVER

Submitted by

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INTRODUCTION

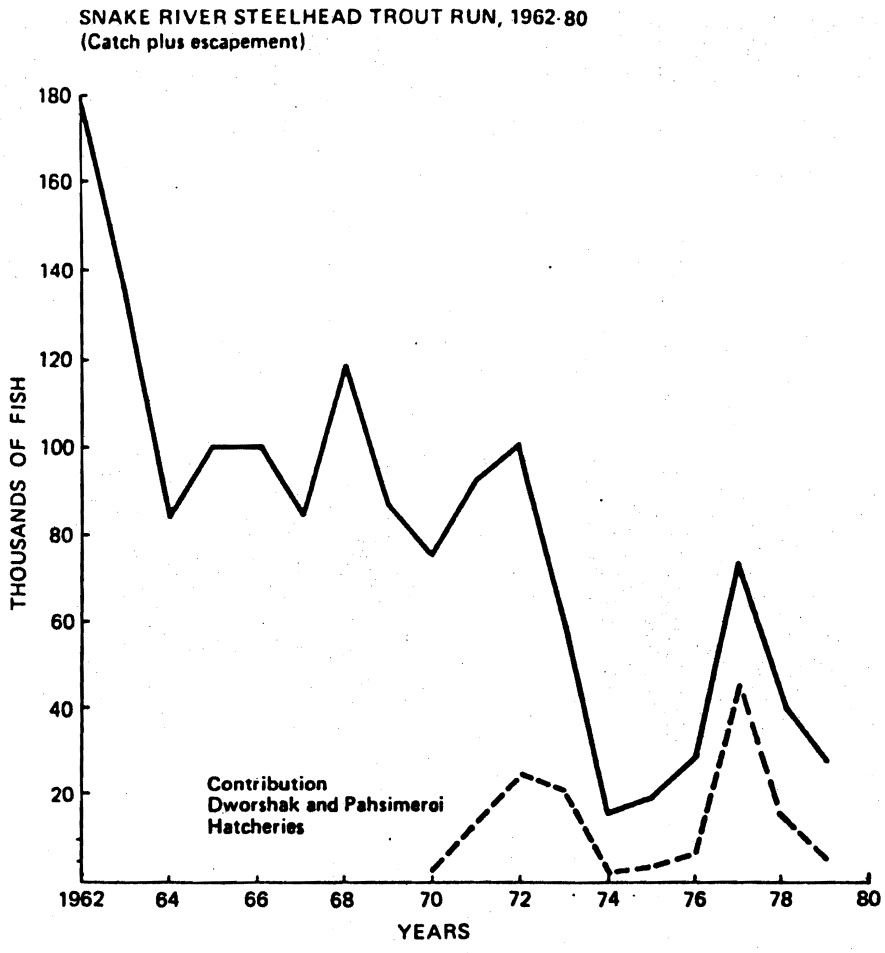
Chinook salmon and steelhead runs in the Snake River have been in a serious downward trend since the late 1960's (Figure 1). The major factor contributing to low fish runs was the completion of four new dams (John Day 1968, Lower Monumental 1969, Little Goose 1970, and Lower Granite 1975) on the Columbia and Snake Rivers. The new dams greatly increased mortality to seaward migrating fingerlings in a variety of ways: passage through turbines, gas bubble disease (caused by river water entrained with atmospheric gases passing over spillways), predation in reservoirs, and delays in migration.

In 1965, National Marine Fisheries Service (NMFS) scientists began preliminary work on a plan to collect seaward bound smolts at upper dams and transport the juveniles to safe release sites below Bonneville Dam, thereby bypassing as many as eight dams and their associated problem areas. The concept was first studied on the Snake River at Ice Harbor Dam in 1968-70, then at Little Goose Dam 1971-73 and 1976-78, and Lower Granite Dam in 1975-78. It was expanded to include McNary Dam on the Columbia River in 1978.

COLLECTION AND TRANSPORTATION OF SMOLTS

Snake River

The need for a collection and transportation system can be readily seen when one realizes the consequences of more dams and the associated increase in generation capacities brought about by ever increasing power demands. The number of dams in the lower Snake River increased from one



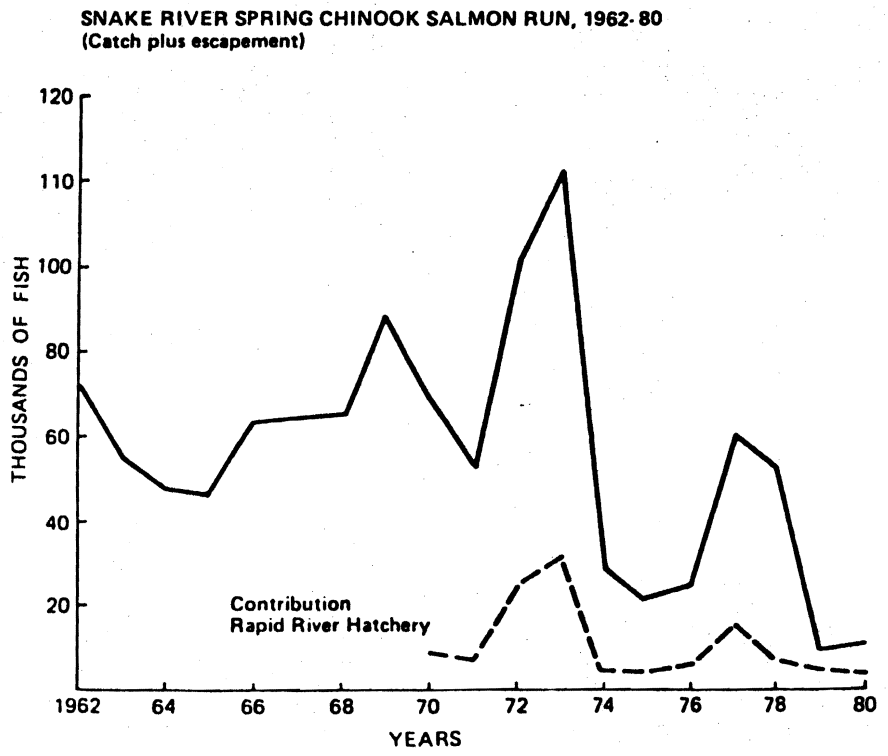


Figure 1.--Snake River spring chinook salmon and steelhead runs, 1962-80. (Includes Ice Harbor Dam count plus estimated lower river harvest).

to four during the period 1968-75, and by 1979 the number of turbines on-line increased from 3 to 24 (Table 1). It is clear that regardless of whether collection of fish for transportation is the goal, protection of fish by diversion from dangerous turbine intakes is essential.

Concurrently with the initial studies on transportation, a system of traveling screens for diverting fingerlings from turbine intakes into turbine gatewells and ultimately into bypass channels for collection and transportation purposes was developed (Figure 2). The traveling screen devices are now an integral part of the transport-collection system used at Lower Granite and Little Goose Dams.

Transportation from 1968 to 1976 was accomplished by hauling fingerlings in trucks from the collector dams to release sites below Bonneville Dam. Since 1977, a combination of trucks and barges have been used. To be able to establish benefit ratios or success of transport, juveniles were marked with a combination of a freeze brand, an adipose fin clip, and a coded wire tag. Depending on the requirements of the test, the marked fish were released into trucks or barges to be transported to the Columbia River below Bonneville Dam or they were released as a control group upstream from the collector dam. Test and control groups consisted of about 40,000 fish in each lot. Upon their return from the ocean, tagged fish were intercepted by a special detector in the fish ladder at the upriver dam and diverted automatically to a holding area for examination and determination of its proper test/control group. For all practical purposes, evaluation of adult returns took place at Ice Harbor Dam for experiments originating there, at Little Goose for those experiments, etc. Throughout the experiments,

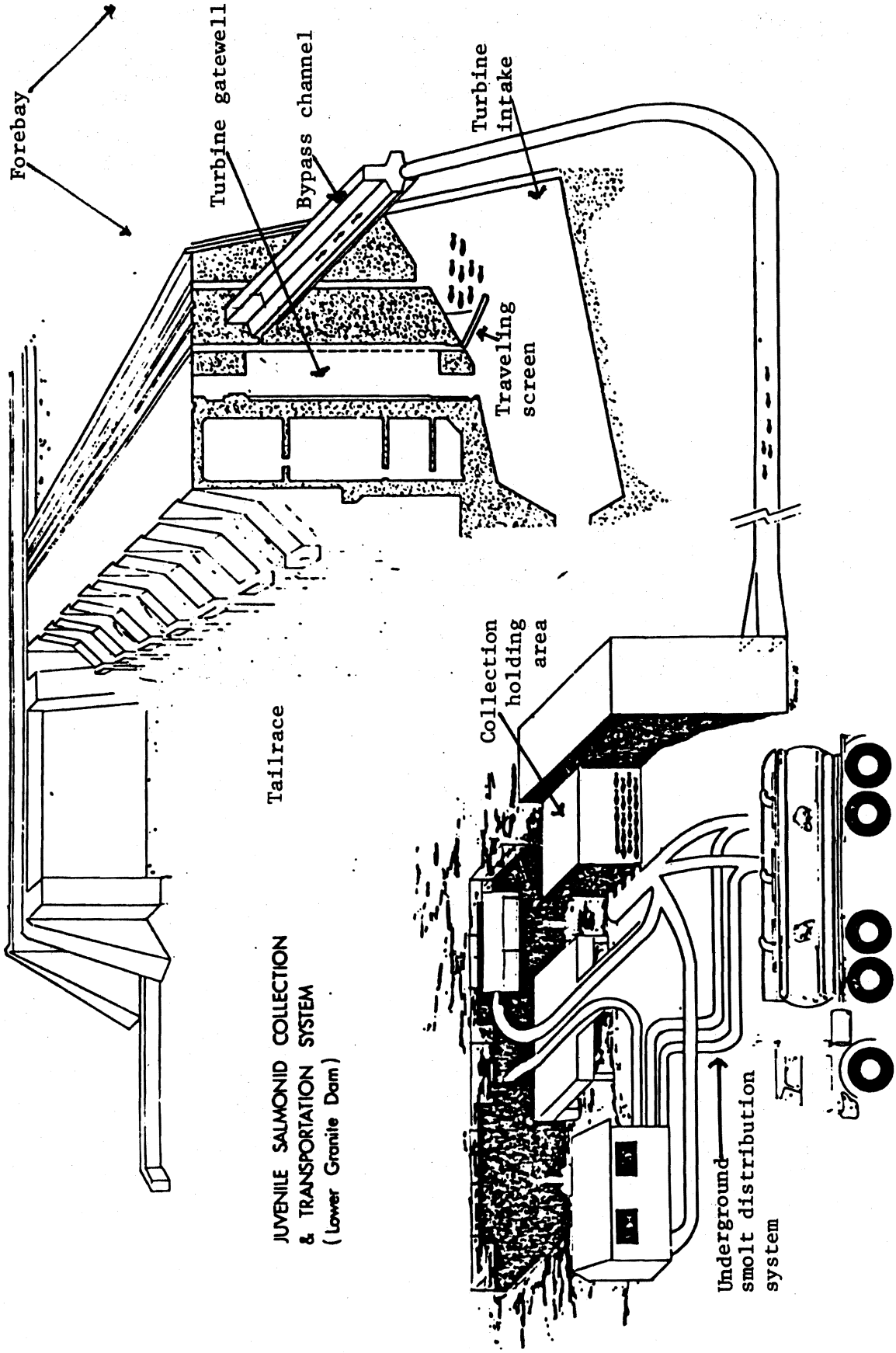


Figure 2.--A cross section of a powerhouse at a major collector dam showing the typical collection and transport system including traveling screen placement, bypass channel and pipe to tailrace, holding ponds, and distribution system to trucks or barges.

Table 1.--Number of turbine units at hydroelectric dams on the Snake River, 1968 to 79.[a/]

River/dam	Cumulative number of turbine units in place											
	1968	69	70	71	72	73	74	75	76	77	78	79
Snake River												
Lower Granite	0	0	0	0	0	0	0	3	3	3	6	6
Little Goose	0	0	0	3	3	3	3	3	3	3	6	6
Lower Monumental	0	0	3	3	3	3	3	3	3	3	3	6
Ice Harbor	3	3	3	3	3	3	3	6	6	6	6	6
Total	3	3	6	9	9	9	9	15	15	15	21	24

a/ Data source: Bell et al. (1976).

tagged fish were recovered from a variety of other sources; however, discussion in this brief summary is limited to returns to the collector dam.

From 1968 to 1973, transportation of smolts from the Snake River was limited, with minor exceptions, to those fish tagged to evaluate the program. By 1975, however, enough positive data supporting the transport concept were accumulated to warrant hauling all fish that could be collected. This practice was begun in 1975 at Little Goose Dam and expanded to include Lower Granite Dam in 1976. Table 2 reflects increases in numbers of smolts hauled each year as more traveling screens were used and subsequently higher percentages of smolt collections were attained.

Columbia River

In 1978, transportation and traveling screen tests were begun at McNary Dam on the mainstem Columbia River. In the first year, traveling screen tests were completed and marked smolts were transported by truck. In 1979-80, transport tests involved both trucks and barges. The marking procedures, transport systems, release sites, and adult evaluation were essentially the same as those discussed for the Snake River. The only significant change was that in addition to testing spring chinook salmon and steelhead, stocks of coho, sockeye, and summer/fall chinook salmon were readily available at McNary Dam and were added to our experimental design.

To date, no more than six screening devices were used to enhance the collection of smolts. Even with this limited collection capability, the number of smolts collected were substantial. The number of smolts transported to Bonneville Dam in 1978-80 is summarized in Table 3.

Table 2.--Number of chinook salmon and steelhead smolts and percent of total Snake River outmigration transported below Bonneville Dam 1971-1979 (includes experimental fish marked for transport evaluation).

Year	No. of turbine units screened	Chinook smolts			Steelhead smolts		
		No. at upper dam (1,000)	No. hauled (1,000)	% hauled	No. at upper dam (1,000)	No. hauled (1,000)	% hauled
Transport from Little Goose Dam							
1971	3	4,000	109	3	5,500	154	3
1972	3	5,000	360	7	2,500	227	9
1973	9[a/]	5,000	247	5	5,500	176	3
1974	0	3,500	0	0	5,000	0	0
Transport from Lower Granite and Little Goose Dams combined							
1975	9	4,000	414	10	3,200	549	17
1976	10	5,000	751	15	3,200	435	14
1977	15	2,000	1,365	68	1,400	895	64
1978	30	3,180	1,623	51	2,120	1,355	64
1979	33	4,270	2,109	49	2,550	1,712	67
1980	36	5,400	3,254	60	3,600	2,860	79

a/ Nine screens were used only until 11 May 1973 - thereafter, three were used for duration of the outmigration.

Table 3.--Number of smolts transported from McNary Dam to Bonneville Dam, 1978-80. Numbers include experimental fish marked for transport evaluation.

Year	No. of units screened	Spring chinook (No.)	Summer/fall chinook (No.)	Coho (No.)	Sockeye (No.)	Steelhead (No.)
1978	1	32,000	40,000	22,000	7,000	24,000
1979	2	405,000	581,000	87,000	211,000	185,000
1980	2	380,000	1,060,000	33,000	50,000	210,000

ADULT RETURNS

Snake River

A useful technique for expressing the success of transporting smolts is to use a benefit ratio for returning adults transported vs nontransported fish. Other factors such as percent of adult return from smolts transported (by truck or barge) and total adult returns to the river (especially in recent years where high percentages of the total outmigration were transported) weigh heavily in totally evaluating the transport concept. These data are summarized in Tables 4 and 5.

During the 1970's, sufficient positive data were accumulated for transported chinook salmon and steelhead to lead NMFS scientists to believe that runs of Snake River salmonids could be maintained or perhaps even increased to former predam levels by fully utilizing the transport concept. By the late 1970's, collection systems (traveling screens) and transport equipment were sufficiently developed to permit transportation of enough smolts to work toward our goal of restoring fish runs to former healthy populations in the Snake River.

Chinook Salmon

A summary of the percent of chinook salmon smolts transported and subsequently returning as adults to the Snake River along with transport benefit ratios for 1968 to 1978 are shown in Table 4. Examination of the data clearly reveals early success with the program. However, it is equally clear that since the outmigration year of 1975, chinook salmon runs have declined, even though the number of smolts transported has greatly increased.

Table 4.--Percent adult return from transported chinook salmon smolts with benefit ratios (transported vs. control) and total adult return to the Snake River, 1969-79.

Year	Population at upper dam (million)	Percent return of transported smolts	Transport benefit ratio	Total adults returning from smolt outmigration[a/] (No.)
1968	2.5	9.00	3:1	104,000
1969	2.5	1.60	1.3:1	87,000
1970	5.4	0.90	1.5:1	162,000
1971	4.0	0.77	1.6:1	90,000
1972	5.0	0.11	1.1:1	41,000
1973	5.0	0.52	15.4:1	18,000
1974	3.5	No Transport Tests		43,000
1975	4.0	2.11	2.1:1	104,000
1976	5.0	0.14	1:1	25,000
1977	2.0	<0.10	∞:1[b/]	7,000
1978	3.2	0.11	5.2 to 7.7:1	19,000[c/]
1979	4.3	[d/]	[d/]	[d/]

a/ Ice Harbor escapement plus Columbia River harvest.

b/ No controls returned; therefore, a useful benefit ratio could not be established.

c/ Estimate based on 1- and 2- ocean returns to date.

d/ Only jacks have returned to date.

Table 5.--Percent adult return from transported steelhead smolts with benefit ratios (transported vs. control) and total adult return to the Snake River, 1971-79.

Year	Population at upper dam (million)	Percent adult return from transported smolts	Transport benefit ratio	Total adults returning from smolt outmigration (No.)
1971	5.0	1.4	1.7:1	74,000
1972	2.5	1.8	3.25:1	26,000
1973	3.8	2.7	13.4:1	12,000
1974	5.5	No Transport tests		23,000
1975	3.2	2.5	3.26:1	68,000
1976	3.2	2.1	1.5 to 5:1	60,000
1977	1.4	0.9	7.4 to 16.6:1	12,000
1978	2.1	2.2	3.8 to 4.1:1	43,000
1979	2.6	a/	3.5:1	a/

a/ Data insufficient at this time to estimate percent return or total adult return.

The most consistent benefit ratios and highest percentage returns from transported smolts occurred in all years from 1968 to 1975 except 1972. Impact on total adults returning to the Snake River was slight because transport was generally limited to experimental fish marked to evaluate the program (Table 2). These consistent returns, however, led to an expanded transport effort in 1976 and each succeeding year.

In 1972, we experienced the first major decrease in the percent return of smolts transported; this was accompanied by a low benefit ratio (1.1:1). Although benefit ratios improved, similar low percentage returns were recorded from 1976 through 1978.

To determine the cause for this downturn of events, NMFS scientists began examining the relationship between traveling screens, which were used in increasing numbers in the mid 1970's, and the percentage return of transported chinook for various years. In 1972, when one of the lowest returns were recorded, only 3 screens were in use, and only a fraction of the smolts marked and transported were exposed to screens. Conversely in 1973 and 1975, years when high percentage returns were recorded, virtually all the transported smolts were diverted from the turbine intakes by screens. Thus the increased use of traveling screens in later years does not appear to be the main factor causing the decreased percentage return of adults. Research is currently being conducted to isolate the cause, but there are no conclusive results at this time.

The good years, e.g., 1975, indicate that chinook salmon smolts can be collected by traveling screens, transported, and ultimately yield a high rate of adult returns each year if healthy fish are available. However, there exists the possibility that in certain years, there are

greater problems facing the seaward migrating chinook salmon after they are released below Bonneville Dam than those described earlier which occur in the river above Bonneville Dam.

There is evidence that the problem may be related to heavy estuary and or early ocean mortality. Raymond and Sims (1980) calculated survival rates for seaward migrants from the upper Snake River Dam to the lower Columbia River annually since 1966 (Figure 3). High survival is generally indicative of a healthy population, although dam operation, flow, and flow regulation are important factors influencing survival. In 1974, 76, 78, and 79, survival to the lower river was, relatively speaking, fair to good, but dissappointing runs returned. The collection and transportation activities could not have been major influencing factors on these runs until 1976 when large numbers began to be collected and transported.

A comparison of percentage return of adults to the mid-Columbia River where collection and transportation has not been a factor with percentage return of adults to the Snake River (Figure 4) where transportation has been a major factor since 1977 reveals that the trends are nearly identical. These data suggest that the same mortality causing forces are influencing both stocks, and the implication is that they are acting downstream from the sites used to measure survival of juvenile migrants (John Day, The Dalles, and Bonneville Dams). The problem appears to be severe enough that releases of large numbers of transported fish have little effect on adult runs when this mortality is great. Conversely, when estuary/ocean survival is high, e.g., 1968 and 1975, large numbers of transported smolts could provide a dramatic increase in the numbers of adults returning to the Snake River.

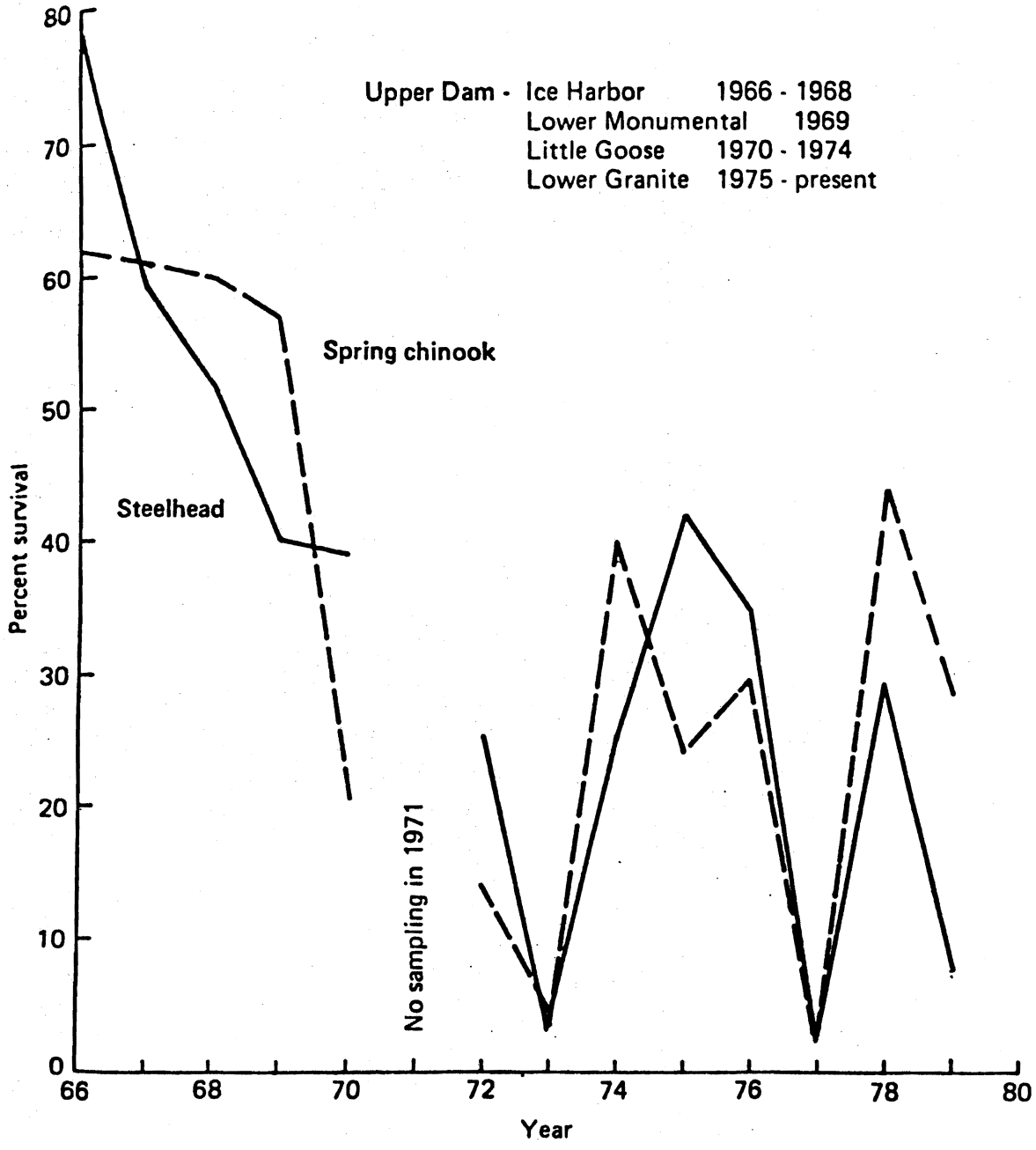


Figure 3.--Survival of juvenile chinook salmon and steelhead from the upper Snake River Dam to the Dalles - John Day Dams, 1966-1979.

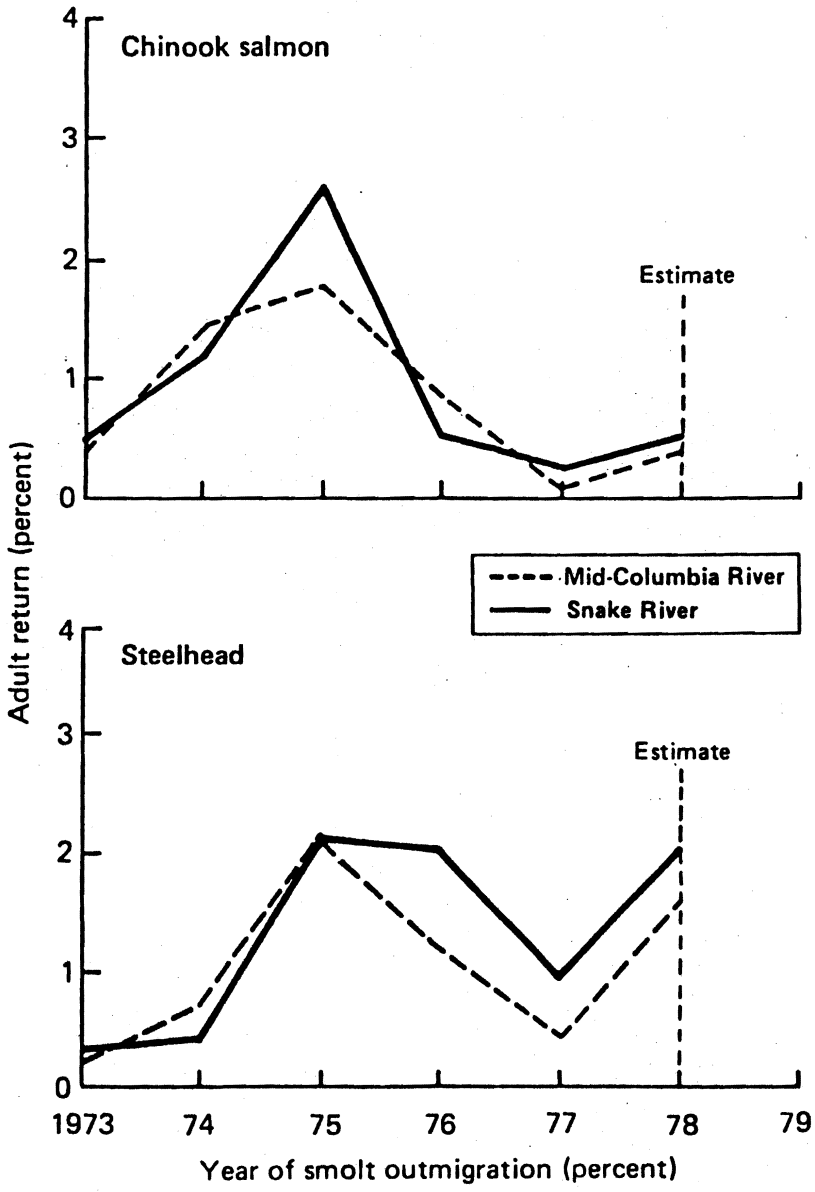


Figure 4.--Percent return of adult mid-Columbia and Snake River stocks of spring chinook salmon and steelhead from smolt outmigrating, 1973-78.

Steelhead

Table 5 presents a summary of the percentage of steelhead smolts transported and subsequently returning as adults to the Snake River along with transport benefit ratios for 1971 through 1979. It is significant that the percent return of smolts transported and benefit ratios have been relatively consistent from year to year except in 1973 and 1977 when drought conditions severely affected survival of smolts. As expected, when river conditions were worst (i.e., the low flow years of 1973 and 77), the benefit from transport was greatest. The consistency of returns from transported steelhead (percent of smolt release) is indicative that steelhead are not subjected to the same mortality after their release below Bonneville Dam as was previously discussed for chinook salmon.

Figure 5 portrays the contribution of transported and nontransported fish from each outmigration of smolts since 1971. In 1973, only about 3.5% of the steelhead smolts were transported, but adult returns indicated that 40% were from this small number of smolts hauled. River/dam mortality during this low-flow year was severe for nontransported smolts; thus, the large contribution from the small portion transported. In 1975 when river conditions were favorable, transport of 17% of the smolts produced a contribution of 25% of the adults in returning runs. These data suggest that transportation can increase survival of steelhead smolts and produce more returning adults regardless of river conditions in any given year.

The run returning to the Snake River this fall is a good one--32,000 to date (30,000 Ice Harbor Dam count plus 2,500 harvest in the Indian net

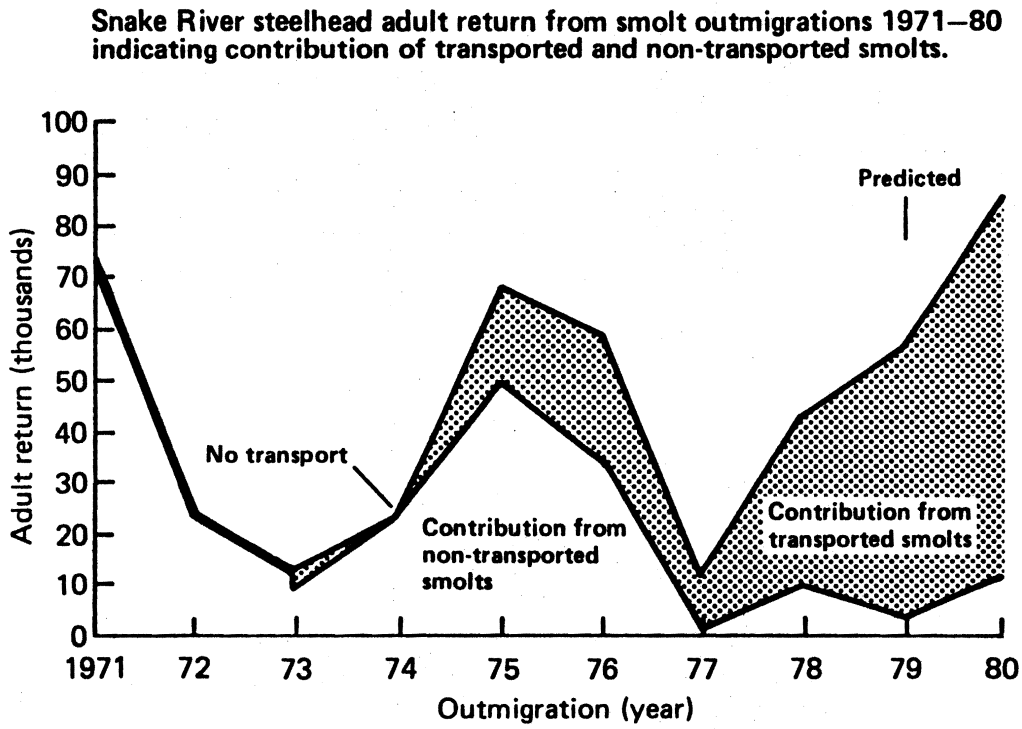


Figure 5.--Snake River steelhead adult return from smolt outmigrations 1971-80 indicating contribution of transported and nontransported smolts.

fishery). At final count, the run is estimated to be 45,000. This is not a record, but it is well above the 1971-79 average and provides cause for optimism for future steelhead runs.

In 1978-79, 64 and 67% of the available Snake River smolts were transported. The total adult return from this transport effort is projected to be 80,000 to 95,000 adults. The contribution of adults from nontransported smolts would, of course, add to the total projections.

Based on the three consecutive good years (1978, 79, and 80) for steelhead smolts transported (Table 2), we feel it is possible to have record runs over Ice Harbor Dam by 1982. There is little chance this would occur without transportation.

Columbia River

The first adults from groups of smolts transported from McNary Dam in 1978 were recovered there in 1979. Monitoring of returns from the 1978-79 operations is still in progress; so complete data are lacking. However, transport benefit ratios based on preliminary data are: 10:1 for fall chinook salmon, 2.3:1 for coho salmon, and a range of 1.9:1 to 4:1 for steelhead (recoveries are made at Lower Granite and Bonneville Dams in addition to McNary Dam).

PLANS FOR THE FUTURE

There appears to be no viable alternative to transportation for protection of Snake River chinook salmon and steelhead. Therefore, we expect continued use of full screening at Lower Granite and Little Goose Dams (18 screens each dam) for diversion and collection of smolts accompanied by their transport, by truck or barge, to release sites below Bonneville Dam.

At McNary Dam, although we have only preliminary data for transported fish, the U.S. Army Corps of Engineers, supported by concerned fisheries agencies, is making plans to provide traveling screens in all turbine units (14) at the dam. Complete screening is expected by mid-summer 1981. The additional screening is estimated to boost collection capability at McNary Dam from about 1.5 million to 4.0 million smolts annually. The decision whether or not to transport these smolts will be made by the fisheries agencies in the fall of 1980.

In anticipation of greater collection at McNary Dam, a new fish transport barge is now planned for the spring of 1981. In 1981, the total transport fleet will consist of five truck-trailer units of 3,500 gal capacity each and three barges of approximately 110,000 gal capacity each. The fleet should be capable of transporting up to 10,000,000 smolts annually from McNary, Little Goose, and Lower Granite Dams.

The future of the runs of chinook salmon and steelhead in the Snake River appear promising. A system of turbine intake traveling screens and bypasses have been developed that permit a large percentage of the downstream migrating chinook salmon and steelhead to be collected at selected upstream dams. To complement the collection system, a transport system utilizing trucks and barges is fully developed. If the problem of reduced survival of spring chinook salmon can be solved, it appears that runs of both chinook salmon and steelhead can be restored to their former level with the combined collection and transportation system.

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