C. TRAVEL TIME

1. Methods.

Travel time estimates were computed for hatchery and in-river marked freeze brand (FB) and PIT tag (PIT) groups of yearling and subyearling chinook and steelhead in several index reaches. These index reaches are shown in the following shaded box:

Snake River (above Lower Granite Dam)
- Hatchery release site or Idaho trap to Lower Granite Dam (FB, PIT)
- Lower Granite Dam to McNary Dam (FB, PIT)

Snake River (below Lower Granite Dam)
- Hatchery release site to McNary Dam (FB)

Mid-Columbia River
- Hatchery release site to McNary Dam (FB)
- Rock Island Dam to McNary Dam (PIT)

Lower Columbia River
- McNary Dam to John Day Dam (FB)
- McNary Dam to Bonneville Dam (FB)

For PIT groups, travel time was estimated for each individual fish recovered, and a travel time distribution was formed for each daily release or multi-day block of releases. Before computing estimates of median travel time, the recovery number for each daily PIT group release was checked at downstream monitoring sites. Multi-day blocking of adjacent release days was used to increase recovery samples size to close to 30 fish when possible, in order to increase precision around the median travel time estimate. The median travel time for this distribution was estimated as the value of the median observation in the distribution when recovery sample sizes were odd, and the average of the two middle observations when recovery sample sizes were even. No adjustment for passage through spill was made to the resulting 1990 PIT tag recovery distributions at McNary Dam in order to facilitate computation of 95% confidence interval for the median travel time estimate using the normal approximation to the binomial confidence interval around rank ordered observations (Dudewics 1976). For the Lower Granite Dam to McNary Dam index reach, additional blocking of releases was necessary to achieve an adequate recovery size at McNary Dam. New travel time distributions and medians were computed for these two recovery sites. A total of 28 PIT tagged fish were excluded from the McNary Dam recovery distributions because they had obviously escaped from one transportation barge on four occasions in May (a problem confirmed by the on-site COE biologist). The index reach median travel time was computed as the difference between the median travel time estimates at McNary and Lower Granite dams. Although a 95% confidence interval cannot be directly computed for this index reach median estimate, an indirect error bound was computed. The lower limit error bound was computed as the difference between the upper 95% confidence limit at Lower Granite Dam and the lower limit at McNary Dam. The upper limit error bound was computed as the difference between the lower 95% confidence limit at Lower Granite and the upper limit at McNary Dam.

For FB hatchery groups, travel time was estimated from release to first recovery site by taking the difference between the release date (or median date of release from multi-day releases) and the date nearest the median recovery. In the Lower Granite Dam to McNary Dam index reach, the difference between the dates nearest median passage at each site provided an estimate of median travel time. This is the same method used in previous annual reports. Using the replicate groups released from each hatchery, 95% confidence intervals were computed.

In-river migrating smolts were collected, freeze branded with an unique code on a daily basis, and released 5 to 6 days per week at McNary Dam for estimating travel time in the McNary Dam to John Day Dam index reach. Brand recovery data was expanded by the proportion of flow through the sampled unit at John Day Dam, to adjust for daily changes in operation of Unit 5 and spill. With this expanded recovery data, a frequency distribution of travel times was obtained for the weekly release blocks, and median travel time was interpolated to the nearest tenth of a day. A 95% confidence interval for this median was estimated from the travel time distribution of non-expanded recovery data, as was done for PIT tag groups. This was possible because there was little change in the proportion of flow through the sampled unit, and there was not any spill until sampling on these marked groups was terminated.

Regression analyses were conducted on the PIT groups released from the Idaho traps and from Rock Island Dam. The median travel time and average flow data were both transformed to natural log scale prior to the linear regression analysis. The methods of computing average flow (unchanged from previous years) is specified in the Appendix G travel time tables for each index reach. Differences in median travel time between the Clearwater and Snake River traps, and between hatchery and wild steelhead, were conducted using an analysis of covariance. Because the Snake River trap operated later into the season than the Clearwater River trap, homogeneity of slopes and analysis of covariance were tested for releases covering the same time interval at both sites. Significance was determined at the $\alpha=0.05$ level. Non-significantly different groups were pooled.

Data from the entire release period were used in final regression analyses.

2. Results and Discussion.

The emphasis of this section is to present travel time results for marked groups released in 1990. It covers in-season trends observed in the data, and only limited comparisons with prior years. Although an extensive multi-year data analysis is outside the scope and schedule of this report, the Fish Passage Center staff will continue to analyze the 1990 travel time data along with data from prior years in the context of evaluating factors influencing smolt travel time. This basic information is useful when in-season Water Budget decisions are needed. Detailed travel time tables in a format similar to that of prior years are presented in Appendix G.

a. Idaho Traps to Lower Granite Dam.

A total of 15,165 chinook and steelhead were PIT tagged and released by IDFG from the Snake and Clearwater River traps between March 30 and June 14 (see Buettner and Nelson [in press] for a complete report of this work). Day-to-day recovery proportions of these PIT tagged fish showed random fluctuations, but no trends over the spring migration season (Appendix Tables G-1 to G-6).

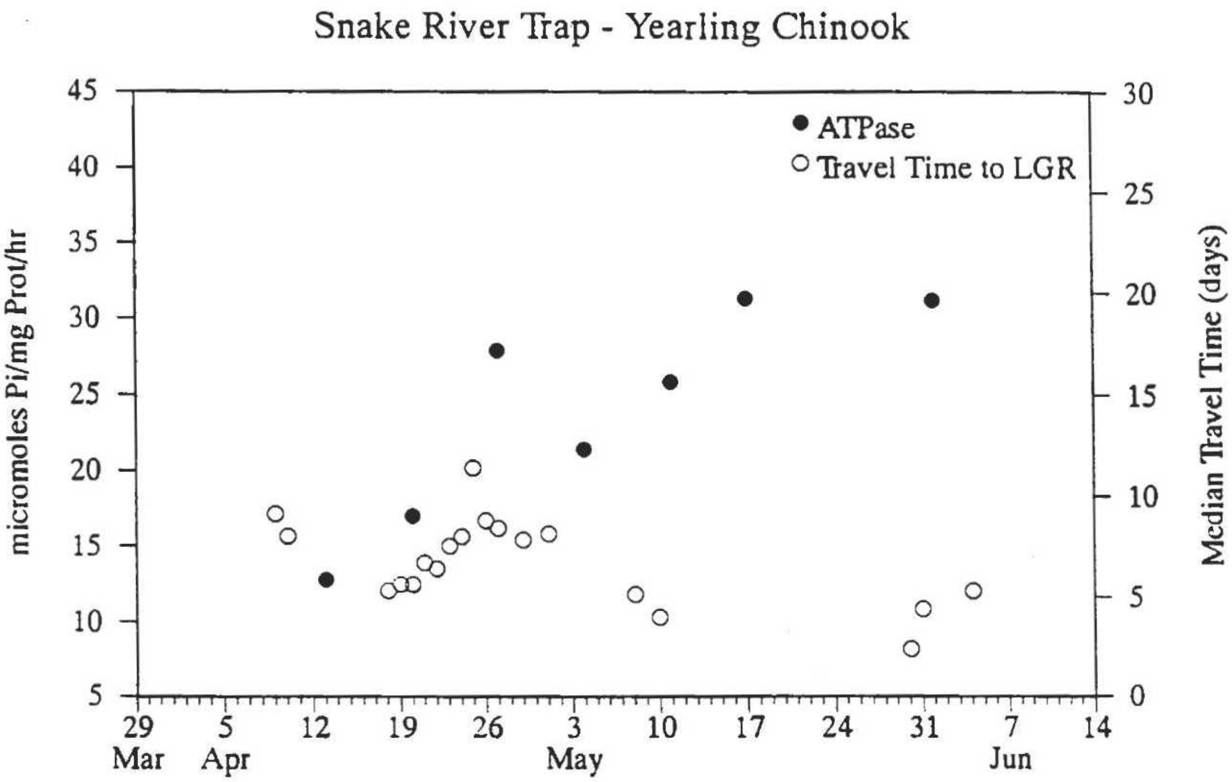
Travel time from the Idaho traps to Lower Granite Dam generally decreased as flow increased, as shown by travel time data averaged into 20 kcfs flow intervals (Table 13). The travel time data was averaged from daily and multi-day estimates of median travel time for chinook, wild steelhead, and hatchery steelhead in Lower Granite reservoir for 1990 given in Appendix Tables G-1 to G-6. Eighty-five percent of the median travel time estimates occurred for flow conditions between 40 and 80 kcfs. At these low flow levels, smolt travel time was more than double what was observed with flows over 100 kcfs.

Table 13. Average travel time from Snake River and Clearwater River traps to Lower Granite Dam, 1990, stratified by 20-kcfs flow intervals.

	— YEARLING CHINOOK —				— WILD STEELHEAD —				— HATCHERY STEELHEAD —			
FLOW RANGE	SNK TRAP		CLW TRAP		SNK TRAP		CLW TRAP		SNK TRAP		CLW TRAP	
(kcfs)	Days	N	Days	N	Days	N	Days	N	Days	N	Days	N
40-59.9	8.6	(2)	14.1	(19)	5.1	(5)	6.2	(9)	7.8	(10)	6.7	(6)
60-79.9	7.5	(12)	11.6	(13)	3.8	(23)	4.6	(8)	5.0	(25)	5.6	(14)
80-99.9	4.8	(3)	7.7	(2)	3.3	(1)	3.6	(1)	3.6	(10)	6.2	(1)
>100	3.4	(2)	NA	(0)	2.1	(2)	NA	(0)	2.0	(5)	NA	(0)

The average recovery rate over the entire season at Lower Granite Dam was 32% for Clearwater River chinook, 43% for Snake River chinook, 57% for wild Snake River steelhead, 66% for wild Snake River steelhead, 71% for hatchery Clearwater River steelhead, and 73% for hatchery Snake River steelhead. In all cases, Clearwater River smolts were recovered at a lower rate than Snake River smolts (although some differences were very slight), and wild steelhead were recovered at a lower rate than hatchery steelhead. Whether these different recovery rates at Lower Granite Dam were due to differences in survival through Lower Granite reservoir or differences in guidance efficiency of the turbine deflector screens for these PIT tagged fish, is not known from this data. It was known that smoltification development, as measured by ATPase level, averaged higher for yearling chinook from the Snake River trap than those from the Clearwater River trap, and higher for wild steelhead than hatchery steelhead at both the Snake River trap and Lower Granite Dam over most of the season (Figure 10 and Appendix Figure H-6). Although the Snake River chinook and wild steelhead groups had the highest ATPase levels, they both did not have the highest recovery rates. Past fish guidance studies of the turbine deflector screens at Lower Granite Dam indicated an exponential relation between guidance efficiency and smoltification for chinook (Muir *et al.* 1990). The chinook from the trap which had the highest ATPase levels were recovered at Lower Granite Dam at the higher rate; however, the increase in ATPase level over the season at either trap did not result in any increasing trend in recovery rate at Lower Granite Dam. In an earlier paper, Muir *et al.* (1988) cited several researchers working with Atlantic salmon and brown trout, who found that hatchery fish were more buoyant than wild fish, due to dietary differences. If this occurred for the steelhead races marked at the Snake River trap, then wild steelhead with higher ATPase levels, but lower buoyancy levels than hatchery steelhead, could tend to migrate lower in the water column and get diverted by the screens at Lower Granite Dam at a lower rate. These arguments must be viewed cautiously, as they are very speculative.

Differences were apparent in smoltification development and migration rate of chinook released from the Snake and Clearwater River traps. Using chinook travel time data from the one month period (April 9 - May 8) of comparable PIT tagging effort at both traps, an analysis of covariance with trap as a factor and flow as the covariate (following confirmation of homogeneous slopes) showed (Figure 10) that Snake River chinook migrated about 40% faster than Clearwater chinook through Lower Granite reservoir over the same range of flows observed (50-85 kcfs). Before April 9, only the Clearwater River trap was collecting enough chinook for marking, which was typical of previous years. These fish, predominantly of Dworshak Hatchery origin, had very low ATPase levels, experienced very low flows in the reservoir, and had median travel time estimates ranging from 16 to 25 days (Figure 10). From May 9 - 16, the Clearwater River trap was out of service due to high flows. When sampling resumed, the shortest travel times were observed under some of the lowest flows for the season. Although significant regressions between travel time and flow could be obtained for portions of the season, the regression using data from the entire season of marking at the Clearwater River trap was not significant (R^2=0.057; n=34). Changes in median travel time for Clearwater River trap chinook correlated better with simple serial date (R^2=0.842; n=34), apparently due to the influences in smoltification and lack of data during the period of high flow. Unlike the Clearwater River trap, the Snake River trap has better collection efficiency during periods of



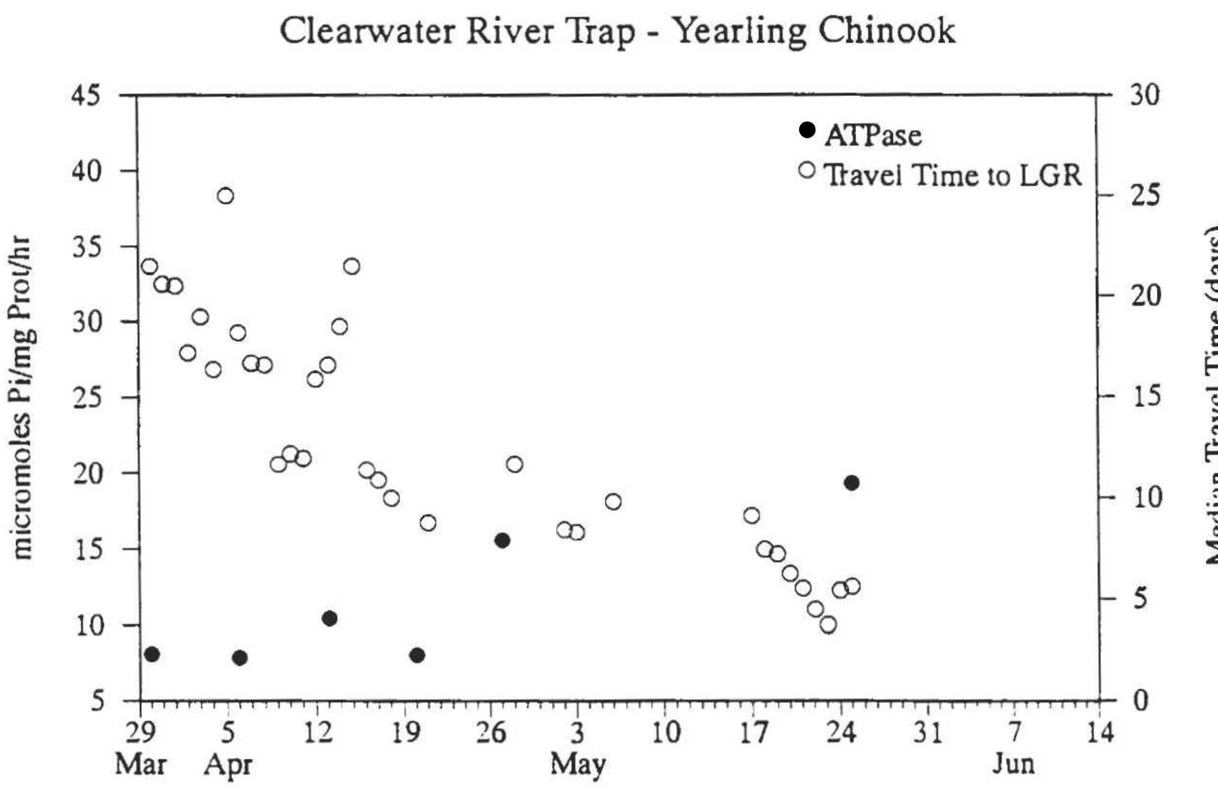


Figure 10. Comparison of average ATPase level of yearling chinook arriving at Snake River and Clearwater River traps, and estimated median travel time from there to Lower Granite Dam, 1990.

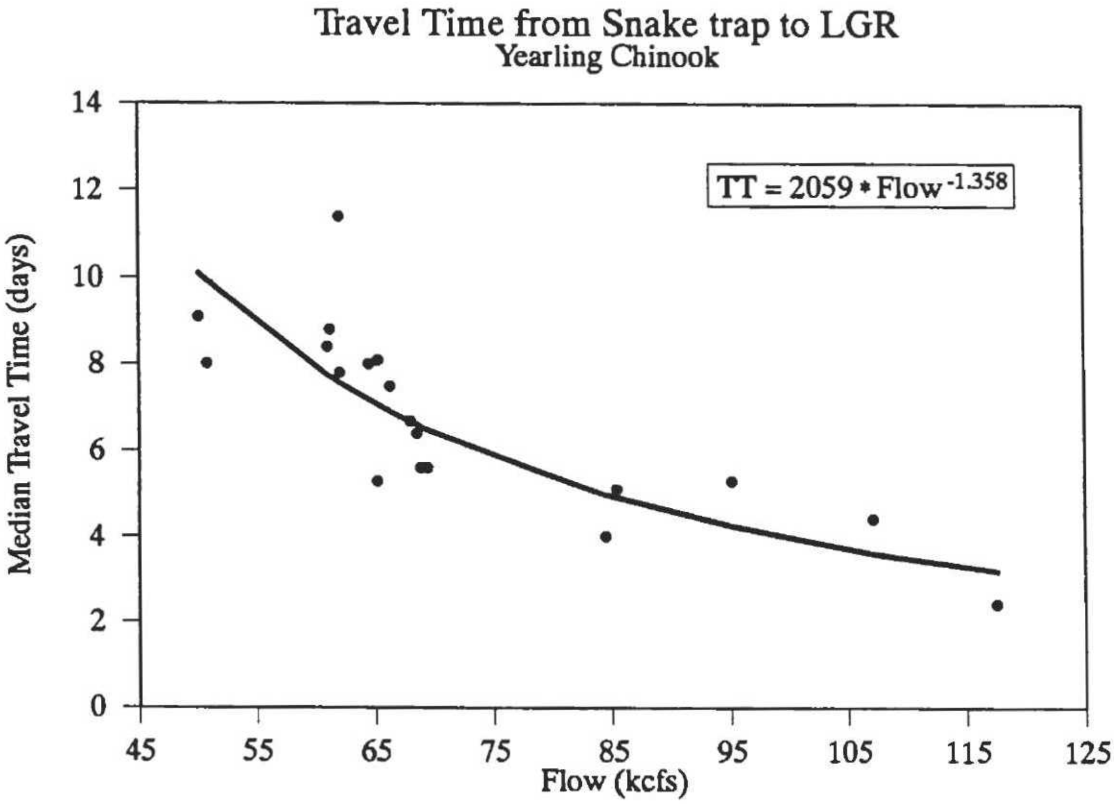
moderate to high flow than during periods of low flow. A significant travel time and flow relation (R^2=0.727; n=19) was observed for the Snake River trap chinook for the season (April 9 - June 8). The travel time and flow relation for chinook released from the Snake River trap (transformed back to the original scale from the natural log scale) is presented in Figure 11.

There was a difference between the migration rates of wild and hatchery steelhead released from the Snake and Clearwater River traps. An analysis of covariance with trap and race as factors, and flow as the covariate (following confirmation of homogeneous slopes), was conducted on steelhead travel time in Lower Granite reservoir for releases through May 25, a period when comparable marking effort occurred at both sites (Figure 12). No significant difference between traps, and no significant interaction between the trap and race variables, were obtained, but a significant difference between races was shown. Wild steelhead migrated about 25% faster than hatchery steelhead over the same flows observed (44-86 kcfs). The Snake River trap continued to operate through June 14 into a period of higher flows. Encompassing flows up to 117.6 kcfs, a final steelhead travel time/flow regression model (R^2=0.659; n=127) was run with race (0=wild, 1=hatchery) and flow as variables. The model produced the two curves shown in Figure 11.

b. Hatchery Release Sites to Lower Granite Dam.

Estimates of median travel time for individual freeze-branded hatchery groups to Lower Granite Dam is presented in Appendix Table G-1 for ease of comparison with past years. To summarize these data, the average of the median travel time estimates from replicate groups are presented here. The estimated average travel times to Lower Granite Dam for hatchery yearling chinook were: 17 days from Lookingglass Hatchery; 24 days from the Imnaha River; 25 days from Dworshak Hatchery; 29 days from Rapid River Hatchery; 36 days from Sawtooth Hatchery; and 61 days from the McCall Hatchery release in the South Fork Salmon River. For hatchery steelhead groups, estimates were: 7 days from Asotin Creek; 8 days from Dworshak Hatchery; 11 days from Wildcat Creek; 16 days from Wallowa Acclimation Pond; 18 days from Little Sheep Creek; 43 days from the Magic Valley Hatchery release in the East Fork Salmon River; and 44 days from the Magic Valley Hatchery release at Sawtooth Hatchery. Details of the migration timing past Lower Granite Dam for these marked groups was presented earlier in Section IV.B.2 of this report, and is graphically shown in Appendix F.

The PIT tagged steelhead released from Dworshak Hatchery provided travel time and recovery data for fish reared in raceways from each of the different water systems available there. Approximately 1000 steelhead were PIT tagged in each of three raceways that also contained a freeze-branded production fish (LA-Z-1). The main differences between the three systems was source of water (flow through versus recirculated), temperature (ambient versus heated), and rearing



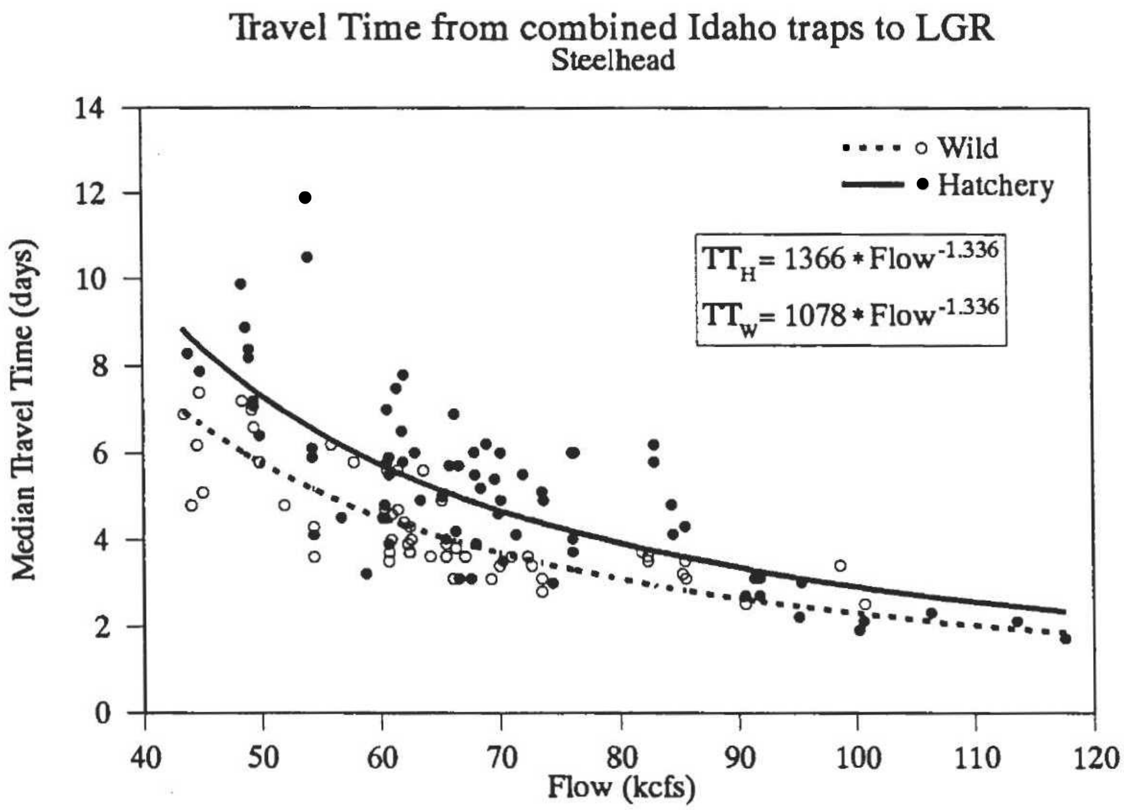
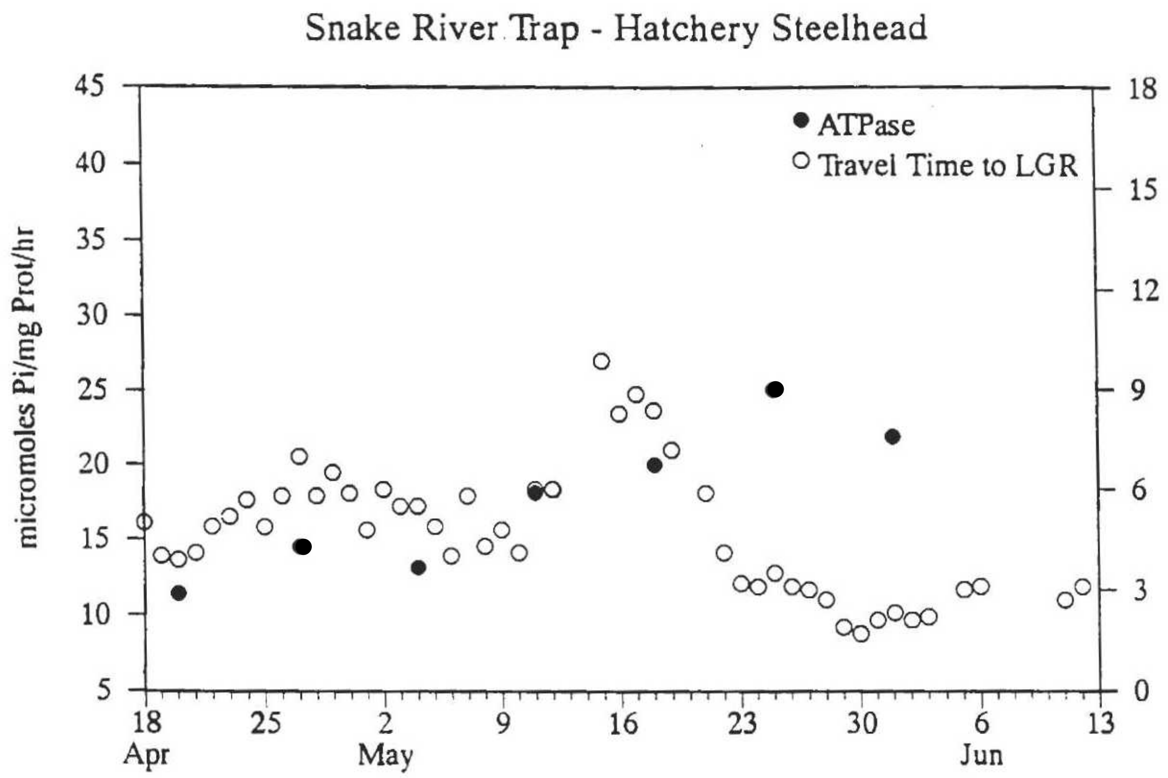


Figure 11. Median travel time to flow relations for yearling chinook and steelhead (marked at Idaho traps) in the Lower Granite Reservoir index reach, 1990.



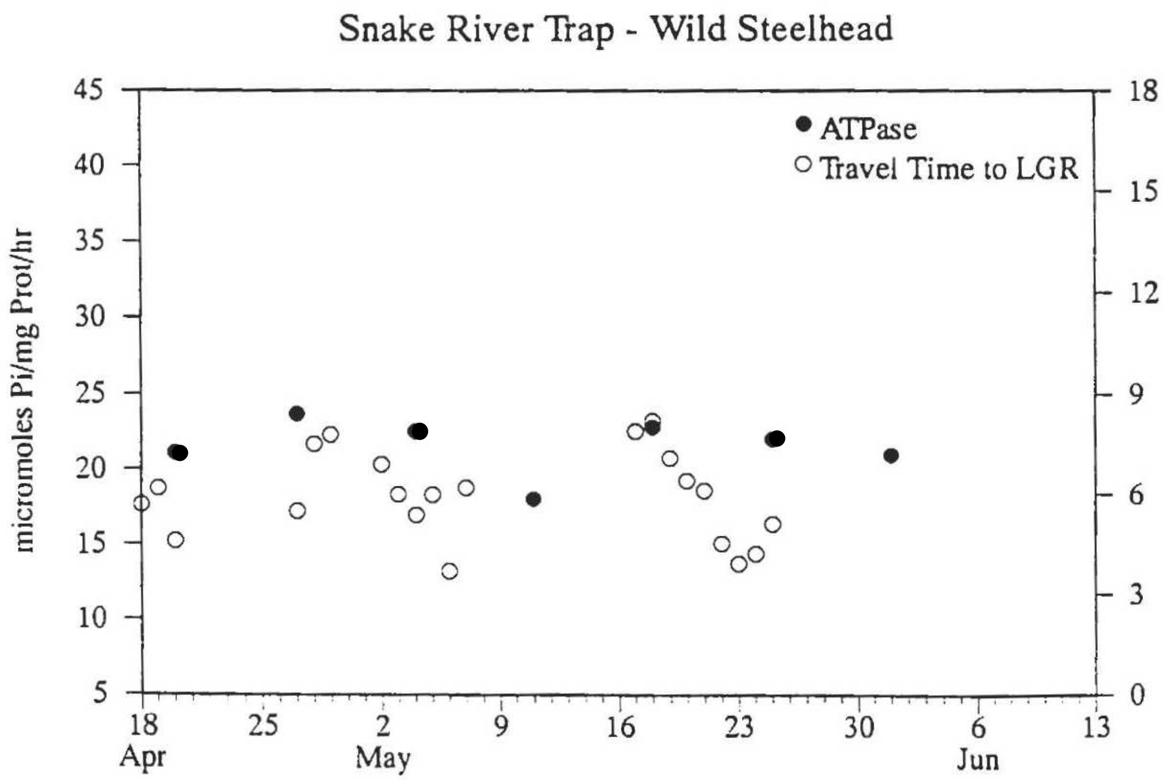


Figure 12. Comparison of average ATPase level of steelhead arriving at the Snake River trap, and estimated median travel time from there to Lower Granite Dam, 1990.

time in a particular system. System 1 had flow-through, ambient-temperature water, while Systems 2 and 3 had separate systems of recirculated, heated water. System 1 raceways were stocked with steelhead earlier than the other systems because longer rearing time is required at ambient water temperature for these fish to reach a size comparable to the fish reared in the other, heated, systems. At time of PIT tagging and release, the largest steelhead were in System 1, and the smallest steelhead were in System 2 (Figure 13). The System 1 PIT tagged steelhead had the lowest median travel time (6.3 days) and highest recovery rate (78.7%) of the three groups at Lower Granite Dam. Median travel times (and recovery percentages) were 7.5 days (67.0%) for System 3 fish and 8.8 days (50.8%) for System 2 fish. Of the size range of fish marked, there was a tendency for a greater proportion of the larger fish (>170mm) to be recovered at Lower Granite Dam (Figure 13). These findings show that rearing environment can greatly influence the size of smolts being released from the hatchery and their subsequent migration and recovery rates to at least the first dam.

c. Lower Granite Dam to McNary Dam Index Reach.

Estimated median travel time (averaged over the replicates) ranged from 11.3 to 16.5 days in the index reach for FB groups of hatchery spring chinook and 10.3 days for the McCall Hatchery summer chinook (Table 14). The spring chinook mark groups migrated through the index reach between mid-April and mid-May, which is typical of past years; the associated average flows for these groups was around 65 kcfs. The summer chinook marked group migrated through the index reach later than in prior years of the SMP (late May instead of the first half of May); the associated average flow for this group was 90 kcfs. Flows dropped nearly in half after May 16 for an 8-day period, which appears to have delayed the bulk of the McCall Hatchery summer chinook passage through the index reach.

Estimated median travel time in the Lower Granite Dam to McNary Dam index reach for multi-day blocks of PIT releases (spanning March 30 - April 26, and May 17-25) from the Idaho traps ranged from 6.7 to 19.3 days. Median travel times over similar dates of release were not significantly different between the two traps, so data from both traps were pooled. A significant relation between travel time and flow (R^2=0.85; n=15) was obtained (Figure 14). The slope of this relation (b=-1.476) was similar to that obtained for the Lower Granite reservoir index reach (b=-1.358), indicating a consistancy in the influence of flow on travel time between the two index reaches. The prediction with these regression models was that increasing flows from 60 to 100 kcfs would approximately cut in half the travel time through each of these respective index reaches. Across this range of flows, the median travel time between Lower Granite and McNary dams (140 miles) was predicted to be about 2¼ times longer than that in Lower Granite pool (31 miles). In terms of migration speed, the yearling chinook were migrating at twice the speed between Lower Granite and McNary dams than through Lower Granite reservoir under similar flows, apparently due to increases in smoltification

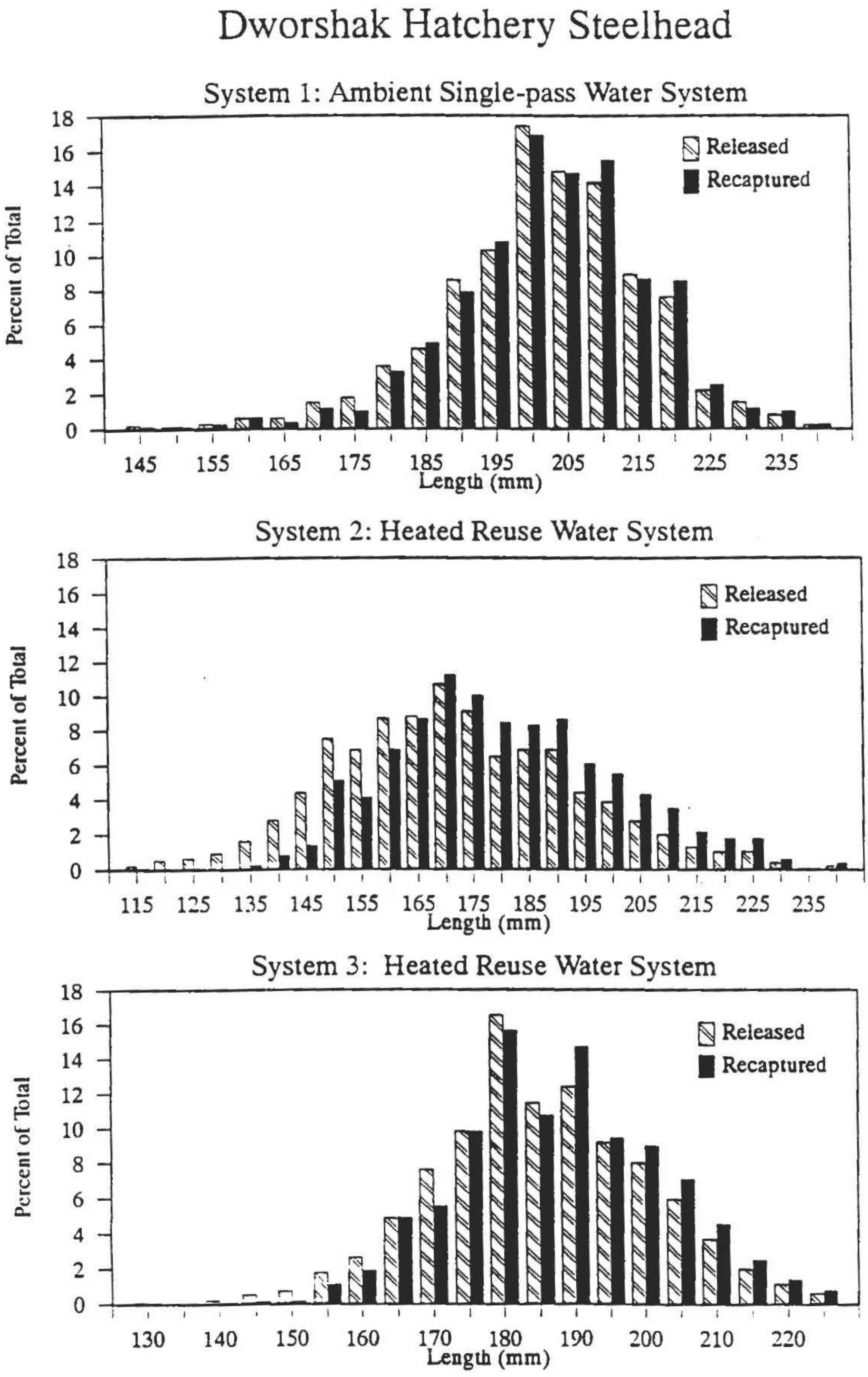


Figure 13. Comparison of the "at time of marking" fork lengths between released Dworshak Hatchery steelhead and those individuals recovered at Lower Granite Dam for the hatchery's three water systems, 1990.

Table 14. Travel time of marked fish in key index reaches, 1990.

			TRAVEL TIME ESTIMATES					
SPECIES	RELEASE SITE (ORIGIN)	RLSE #	AVERAGE MEDIAN	STD ERROR	95% CONF. INT. L.LIMIT	U.LIMIT	AVG INDEX FLOW	SPEED (MI/DAY)
	SNAKE RIVER INDEX REACH: LOWER GRANITE TO MCNARY DAM							
Yrlg Chinook	Sawtooth Hatchery	3	11.3	0.33	9.9	12.7	62.8	12.4
	SF Salmon (McCall H)	3	10.3	1.76	2.7	17.9	90.1	13.6
	Rapid River Hatchery	3	13.7	1.20	8.5	18.9	61.7	10.2
	Dworshak Hatchery	3	15.3	1.20	10.1	20.5	74.5	9.2
	Lookingglass Hatchery	4	15.8	0.85	13.1	18.5	62.0	8.9
	Imnaha R. Accl. Pond	2	16.5	0.50	n/a	n/a	65.4	8.5
Steelhead	Grande Ronde R.	1	14.0	n/a	n/a	n/a	67.4	10.0
	MID-COLUMBIA RIVER INDEX REACH: RELEASE TO MCNARY DAM							
Yrlg Chinook	Winthrop Hatchery	3	30.7	0.33	29.3	32.1	169.9	9.2
	Entiat Hatchery	2	20.0	0.00	n/a	n/a	151.9	10.1
	Leavenworth H on 4/18	3	26.3	0.33	24.9	27.7	152.1	7.8
	Leavenworth H on 5/4	4	17.5	0.29	16.6	18.4	132.0	11.7
	Ringold Hatchery	2	7.5	0.50	n/a	n/a	151.3	7.5
Steelhead	Similkameen R (Wells H)	2	22.0	0.00	n/a	n/a	144.7	14.3
	Methow R (Wells H)	2	16.0	0.00	n/a	n/a	168.9	15.1
	LOWER COLUMBIA RIVER INDEX REACH: MCNARY TO JOHN DAY DAM							
Yrlg Chinook	Below McNary 4/30-5/18	3	5.3	0.03	5.2	5.4	220.6	14.3
Steelhead	Below McNary 4/30-5/18	3	4.4	0.19	3.6	5.2	219.2	17.3

- This table summarizes data in Appendix G Tables G-12, G-14, and G-15.
- Average flow reported is the mean of the average flows for replicate release groups (Appendix G). Flow is indexed at Ice Harbor Dam for the Snake River index reach, Priest Rapids Dam for the mid-Columbia River index reach, and John Day Dam for the lower Columbia River index reach.
- Distance traveled in the Snake River index reach is 140 miles, the mid-Columbia index is release site specific, and the lower Columbia River index reach is 76 miles. Distances for the mid-Columbia groups are: Winthrop H, 282 miles; Entiat H, 202.3 miles; Leavenworth H, 204.6 miles; Ringold H, 56 miles; Similkameen R, 315.6 miles; and Methow R, 241.9 miles.
- Grande Ronde River release incorporates eight separate brand groups pooled together.

development by the time chinook smolts are migrating through the lower index reach (Appendix Figures H-1 and H-2).

Limited travel time data is available for 1990 on steelhead in the Lower Granite Dam to McNary Dam index reach. Given the high efficiency of the collection system for steelhead at Lower Granite and Little Goose dams, and subsequent transportation via barge of all collected steelhead, few steelhead arriving at these projects continue their migration in-river. For this reason, too few of the PIT tagged Dworshak Hatchery steelhead and freeze branded Wildcat Creek (Irrigon Hatchery plant) steelhead were collected at McNary Dam to allow estimation of median travel time. Because all marked groups of hatchery steelhead released in the Grande Ronde River drainage migrated by Lower Granite Dam over the same time period with very close median dates of passage, the eight ODFW brand groups released at Wallowa Hatchery (Spring Creek Channel), Wallowa River, and

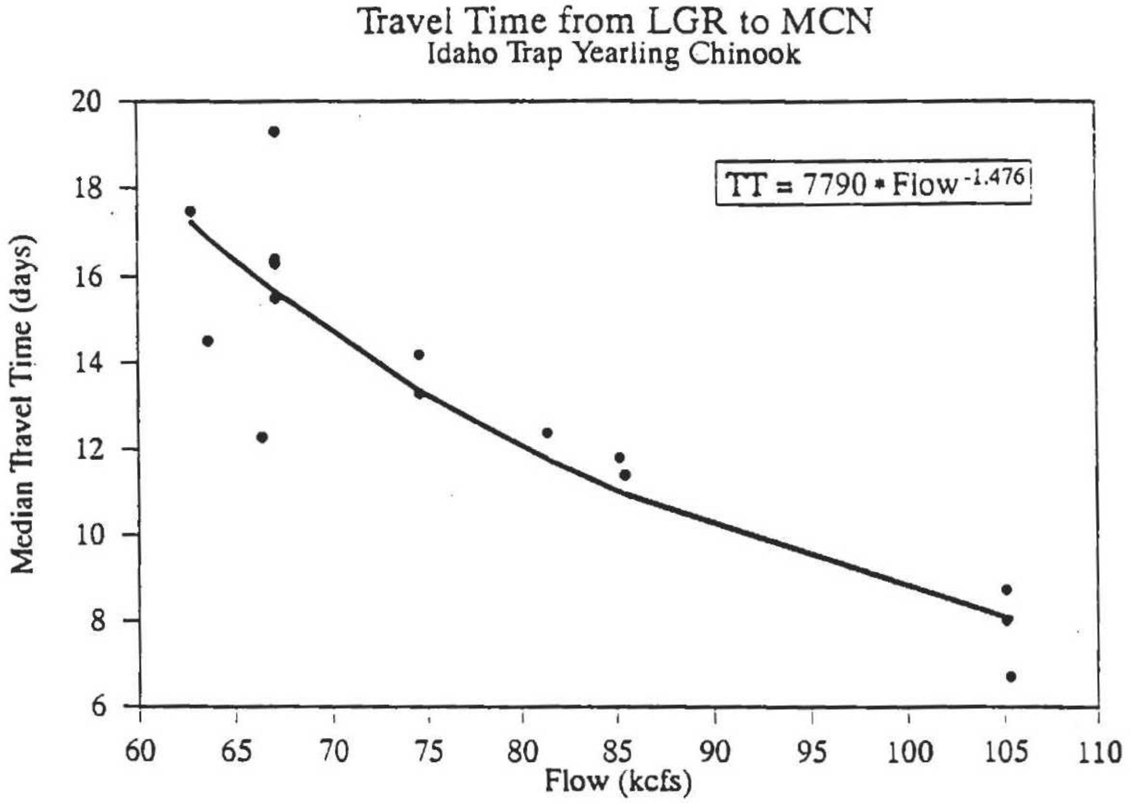


Figure 14. Median travel time to flow relation for yearling chinook (marked at Idaho traps) in the Lower Granite Dam to McNary Dam index reach, 1990.

Wildcat Creek were pooled together to provide an estimate of 14 days median travel time between Lower Granite and McNary dams (Table 14). Large numbers of wild steelhead were PIT tagged at the Snake River trap during the latter part of April. These wild steelhead releases were blocked into two multi-day release groups, and provided median travel time estimates of 10.4 and 10.5 days between Lower Granite and McNary dams.

d. Hatchery Release Sites Below Little Goose Dam to McNary Dam.

Marked Lyons Ferry Hatchery steelhead, released at the hatchery and at Marengo on the Tucannon River, migrated their respective distances of 91 and 111.5 miles to McNary Dam with very consistent migration speeds ranging from 6 to 7 miles/day (Appendix Table G-13). Subyearling chinook released from Lyons Ferry Hatchery on June 6 had travel time estimates ranging from 23 to 24 days, resulting in a migration speed of nearly 4 miles/day (Appendix Table G-13).

e. Mid-Columbia Hatchery Release Sites to McNary Dam.

For hatchery marked groups, the mid-Columbia River index reach spans from a given hatchery's release site to McNary Dam. Because of the variable distances involved, the preferred measure for characterizing index reach travel time is smolt migration speeds. Estimated median travel time (averaged over the replicates) for spring chinook ranged from 7.5 to 30.7 days (Table 14), with Ringold Hatchery and the April 18 release from Leavenworth Hatchery being the slowest migrating fish (around 8 miles/day), followed by Winthrop and Entiat hatcheries (9-10 miles/day), and the release on May 4 from Leavenworth Hatchery being the fastest migrating chinook group (nearly 12 miles/day). Marked steelhead from the Wells Hatchery releases in the Methow and Similkameen rivers migrated faster (14-15 miles/day) than the yearling chinook groups under similar levels of flow.

The estimated median travel time for subyearling summer chinook from Wells Hatchery (released May 22-25) to McNary Dam was 39 to 40 days, and those of Priest Rapids Hatchery fall chinook for five releases made at 3-day intervals beginning June 7 were 13, 11, 11, 10, and 9 days, respectively (Appendix Table G-14). Average flows of 200 kcfs or better occurred during most of the time these subyearling chinook were migrating through the mid-Columbia River.

f. Rock Island to McNary Dam Index Reach.

A total of 5,808 yearling chinook and steelhead were PIT tagged by Chelan County PUD at Rock Island Dam between April 21 and May 25. The average recovery rate over the entire season at McNary Dam was 25% for chinook, 23% for hatchery steelhead, and 30% for wild steelhead (Appendix Tables G-8 to G-10). Recovery rates did not remain as stable at McNary Dam as had been observed at Lower Granite Dam for the PIT groups from the Idaho traps. Beginning with the May 9 release of yearling chinook, recoveries dropped in half from the levels observed earlier (from averages of 30% to 14%); hatchery steelhead recoveries dropped over half beginning with the May 13 release from the earlier levels (from averages of 27% to 12%); and wild steelhead had a single 4-day block (May 20-23 releases) drop to 14% recovered. These reductions in recovery proportions at McNary Dam may be influenced by lower survival during periods of low flow in mid-to-late May through McNary reservoir, and by lower collection efficiency during periods of high flow and spill after May 30 at McNary Dam. Due to the proximity of the spillway to the Washington shore, large numbers of mid-Columbia fish may be passing in spill.

Estimates of median travel time in the Rock Island Dam to McNary Dam index reach showed a general decreasing trend over time for yearling chinook, but were relatively stable over time for wild and hatchery steelhead. Yearling chinook median travel time estimates dropped from 21.7 days to 8.1 days over the migration season, with the April releases averaging 15.0 days and May releases averaging 9.8 days. No significant relation between travel time and flow was observed for yearling chinook, wild steelhead, or hatchery steelhead within the low range of flows observed in 1990. Mid-Columbia River flows, indexed as 7-day averages at Priest Rapids Dam during the time these PIT tagged groups were estimated to be passing this project, varied only 40 kcfs in 1990, between approximately 130 and 170 kcfs. A significant regression between median travel time and Julian date (R^2=0.705; n=23) was observed for yearling chinook. Julian date was used as a surrogate for smoltification development. Weekly ATPase levels increased over the period that PIT tagged

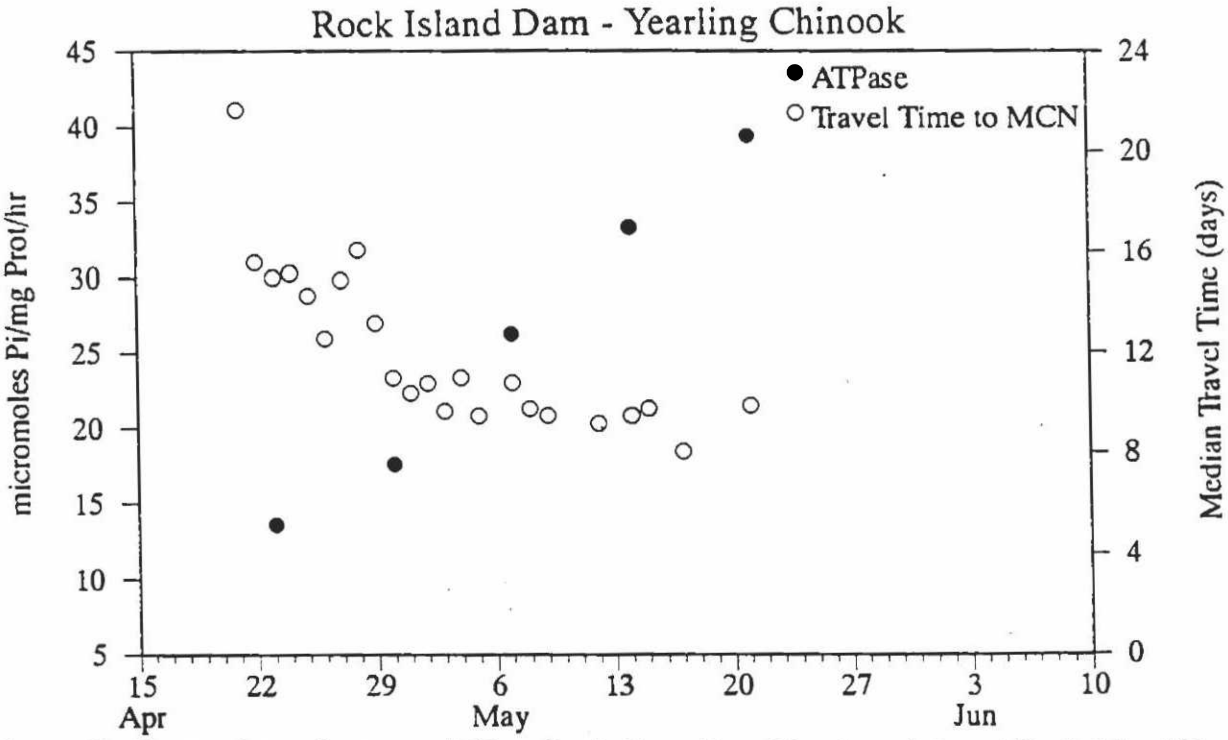


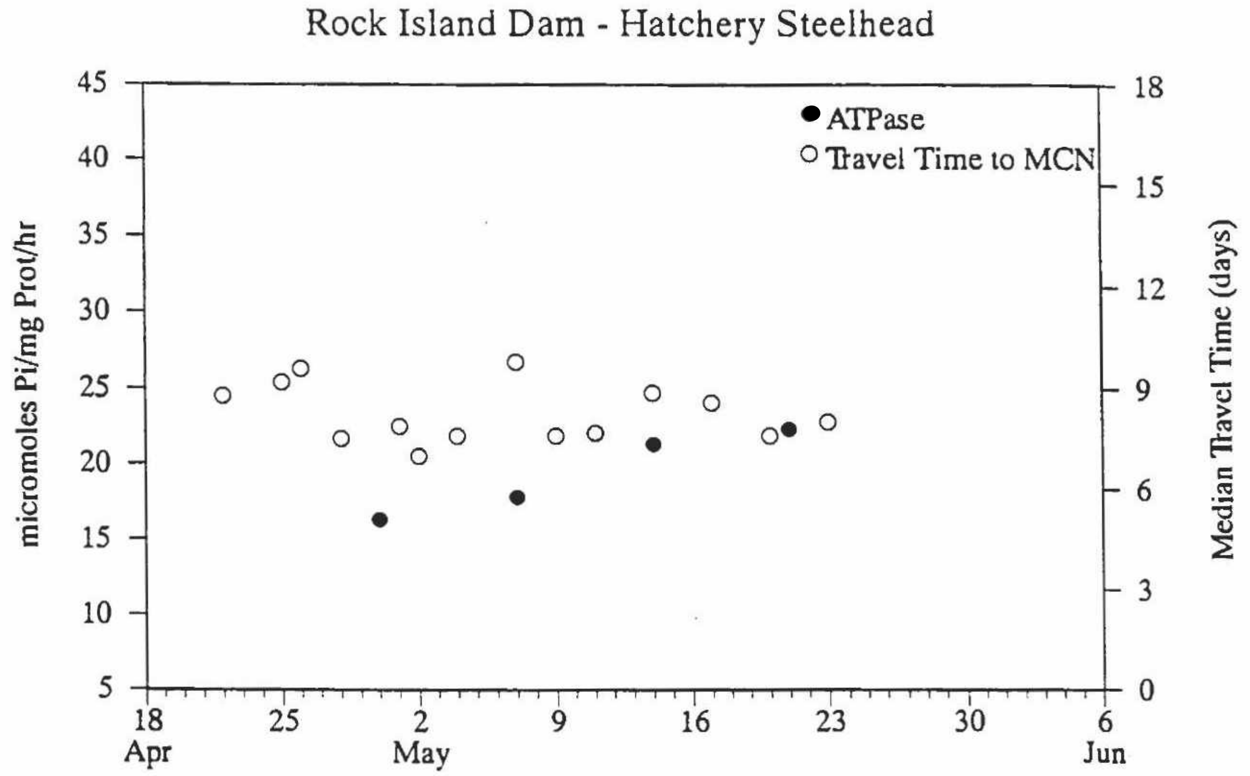
Figure 15. Comparison of average ATPase level of yearling chinook arriving at Rock Island Dam, and estimated median travel time from there to McNary Dam, 1990.

chinook were released from Rock Island Dam (Figure 15).

Although ATPase levels also increased for steelhead over the migration season, no significant relation between median travel time and Julian date (Figure 16) was observed for steelhead, as had been demonstrated for chinook. Median travel time estimates for the multi-day releases of steelhead were relatively stable over the season, varying by less than three days for hatchery steelhead and less than four days for wild steelhead. The average median travel time for the season was 8.3 days for hatchery steelhead and 8.0 days for wild steelhead. These averages are not significantly different.

g. McNary to John Day Dam.

A total of 25,744 yearling chinook and 20,195 steelhead were marked and released at McNary Dam during 5 weeks in 1990. Yearling chinook were released during the week of April 9 to 13 and the four weeks between April 30 and May 25; steelhead were released during the five weeks between April 30 and June 1. Only data from three of these weekly releases were usable for determining median travel time of chinook and steelhead, because of curtailment of monitoring due to outages of Unit 5 at John Day Dam. A 3-day outage between April 16 and 19, and an 11-day outage from May 30 to June 9, resulted in too few recoveries during the first and last weeks for chinook and the fourth and fifth weeks for steelhead. During the three weeks between April 30 and May 18, relatively stable estimates of median travel time (Appendix Table G-15) were observed for yearling chinook and steelhead, averaging 5.3 and 4.4 days, respectively (Table 14). Index reach flow averaged around 220 kcfs during this period. The average recovery proportion over these three weeks for yearling chinook (6.8%) was about half of that observed for steelhead (12.4%).



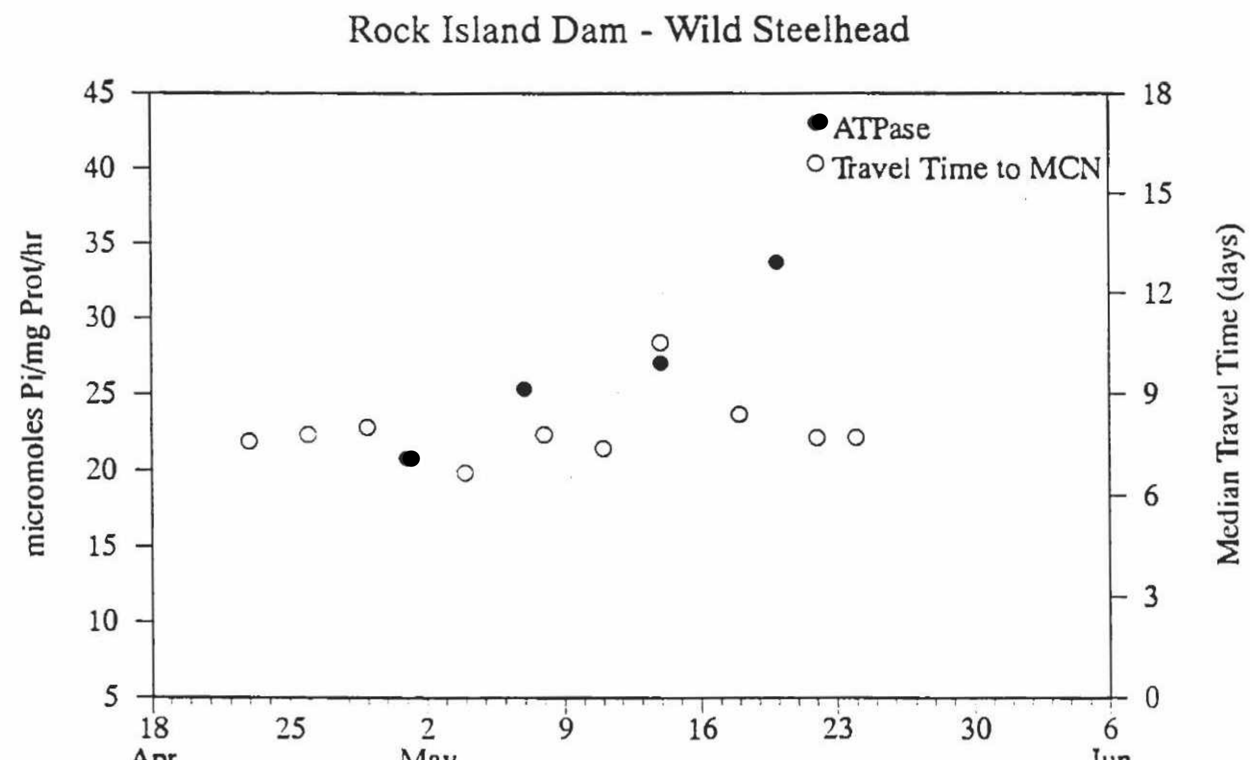


Figure 16. Comparison of average ATPase level of steelhead arriving at Rock Island Dam, and estimated median travel time from there to McNary Dam, 1990.

Unfortunately, no recoveries of steelhead from the last week of marking were possible at John Day Dam when flows in excess of 300 kcfs occurred in the lower Columbia River.

No reliable estimates of median travel time are available for subyearling chinook for John Day reservoir in 1990, because of either too few recoveries of marked fish in Unit 5 or outages in Unit 5 near the middle of marked groups' passage distributions. Either of the incidents would have impacted the determination of a reasonable median. In addition, the high flow and spill levels at McNary Dam may have passed more marked subyearling chinook, particularly those of mid-Columbia River origin approaching the project along the Washington shore, through spill than was accounted for in the passage index. Even with these problems in attempting to estimate median travel time through John Day reservoir, it was apparent from the passage timing of those marked fish recovered at John Day Dam that the higher flows of 1990 in the lower Columbia River during June and early July moved subyearling chinook more quickly through John Day reservoir than the typical estimates above ten days observed in previous years. General information on migration timing, based on approximate 10 and 90% passage dates at John Day Dam, is presented in Appendix F for the marked subyearling chinook from Lyons Ferry, Priest Rapids, and Irrigon hatcheries.

h. McNary Dam to Bonneville Dam.

Limited data on travel time to Bonneville Dam is available for spring migrants in 1990, because of the low numbers of branded yearling chinook and steelhead recovered. The largest recovery at the powerhouse 1 trap was 34 branded steelhead from the first release period (April 30 - May 5) at McNary Dam. This group of steelhead had an estimated median travel time of six days under flows averaging approximately 250 kcfs. (Incidently, from the last weekly release made at McNary Dam, three steelhead were recovered at Bonneville Dam in only 4, 4, and 5 days, respectively, at flows above 300 kcfs.)

Subyearling chinook appeared to migrate faster through the lower Columbia River under the higher flow levels observed in 1990. The five marked fall chinook groups from Priest Rapids Hatchery provided median travel time estimates that ranged from 4 to 6 days between McNary and Bonneville dams, under flows averaging near 265 kcfs. While the recovered numbers were low at Bonneville Dam (*i.e.*, 5-25 fish), the travel time estimates were much shorter than seen in previous years. At the same time, flow was much higher than in the past years. The subyearling chinook released in the Umatilla River from Irrigon Hatchery had a median travel time of 32 days to Bonneville Dam in 1990. The 7-day flow average at the time of median passage at Bonneville Dam was 269 kcfs for this marked group. Subyearling chinook releases in the Umatilla River in 1988 and 1989 took a median of 46 and 32 days, respectively, just to migrate as far as John Day Dam under lower flow levels.

3. Conclusions.

Flow and smoltification development together influenced smolt migration rates in 1990. Smolts migrating in the Snake River drainage experienced flows between 40 and 80 kcfs during most of the spring of 1990. However, when flows increased to over 100 kcfs, travel times were reduced by one-half. In addition to increased flow, smoltification development influenced how quickly smolts were moved through Lower Granite reservoir and the Lower Granite Dam to McNary Dam index reach. With a similarily sloped travel time/flow relation and same range of flows (60 to 100 kcfs), PIT tagged groups of yearling chinook consistently migrated twice as fast between Lower Granite and McNary dams than they did through Lower Granite reservoir, apparently as a result of greater smoltification development by the time the fish were migrating through the lower index reach. The relative range of flows observed in the mid-Columbia River was smaller and at a level above the fishery minimum (140 kcfs) during most of the season. At these high flows, the yearling chinook travel time between Rock Island and McNary dams appeared highly influenced by smoltification development, whereas both wild and hatchery steelhead appeared to migrate at a fairly constant rate regardless of increasing smoltification development over time. In the lower Columbia River, higher flows (over 300 kcfs) beginning at the end of May, and continuing (above 200 kcfs) through mid-July, appeared to have a profound effect on the smolt migration rates. Subyearling chinook migrated between McNary and Bonneville dams much faster in 1990 than in recent years.