Chinook and Coho Emigration
in the Elwha River, Washington

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ABSTRACT

We examined emigration patterns of chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon during fish passage evaluations at two hydroelectric projects in the Elwha River, Washington over the past seven years. Glines Canyon Dam and Elwha Dam currently block all anadromous fish from extensive habitat in the upper Elwha River basin within Olympic National Park. Our objectives were to determine emigration pattern and exit selection of chinook and coho over a range of spill and flow conditions at the dams, as part of a program to restore anadromous fish to the upper Elwha River basin. We released Elwha-stock chinook and coho salmon in the upper river basin via truck and helicopter, and intensively monitored fish passage via trapping and hydroacoustic sensing. Fish were released separately in space and time to allow species-specific passage monitoring. Coho emigration extended from April to June, peaking in mid-May. Emigration was strongly influenced by availability of near-surface exits at Glines Canyon Dam, and was positively related to surface flows. Coho emigration occurred predominately at night. In contrast, chinook emigration extended over a fifteen-month period, with peak movement in late summer as subyearlings. Chinook emigration was strongly influenced by availability of near-surface exits at Glines, but was not strongly related to surface flows. Nighttime passage preference was not as pronounced as for coho. Peak subyearling chinook passage in late summer occurred as fish reached 11 cm and ATPase level reached 25. Chinook length and ATPase level were significantly related.

The Elwha River is located in the northwest corner of Washington on the Olympic Peninsula (Figure 1). The Elwha is the largest river on the northern Peninsula with a drainage area of about 300 square miles and a mean annual discharge of about 1,500 cfs. Historically, the Elwha River was the biggest producer of anadromous fish in the region (Schoeneman and Junge 1954). It produced an extremely large chinook of 100-pound size prior to hydroelectric development, which occurred just after the turn of the century. Two hydroelectric dams were built without fish passage facilities, and over 90% of the watershed has been barred to anadromous fish (except for experimental releases in the course of this work) since

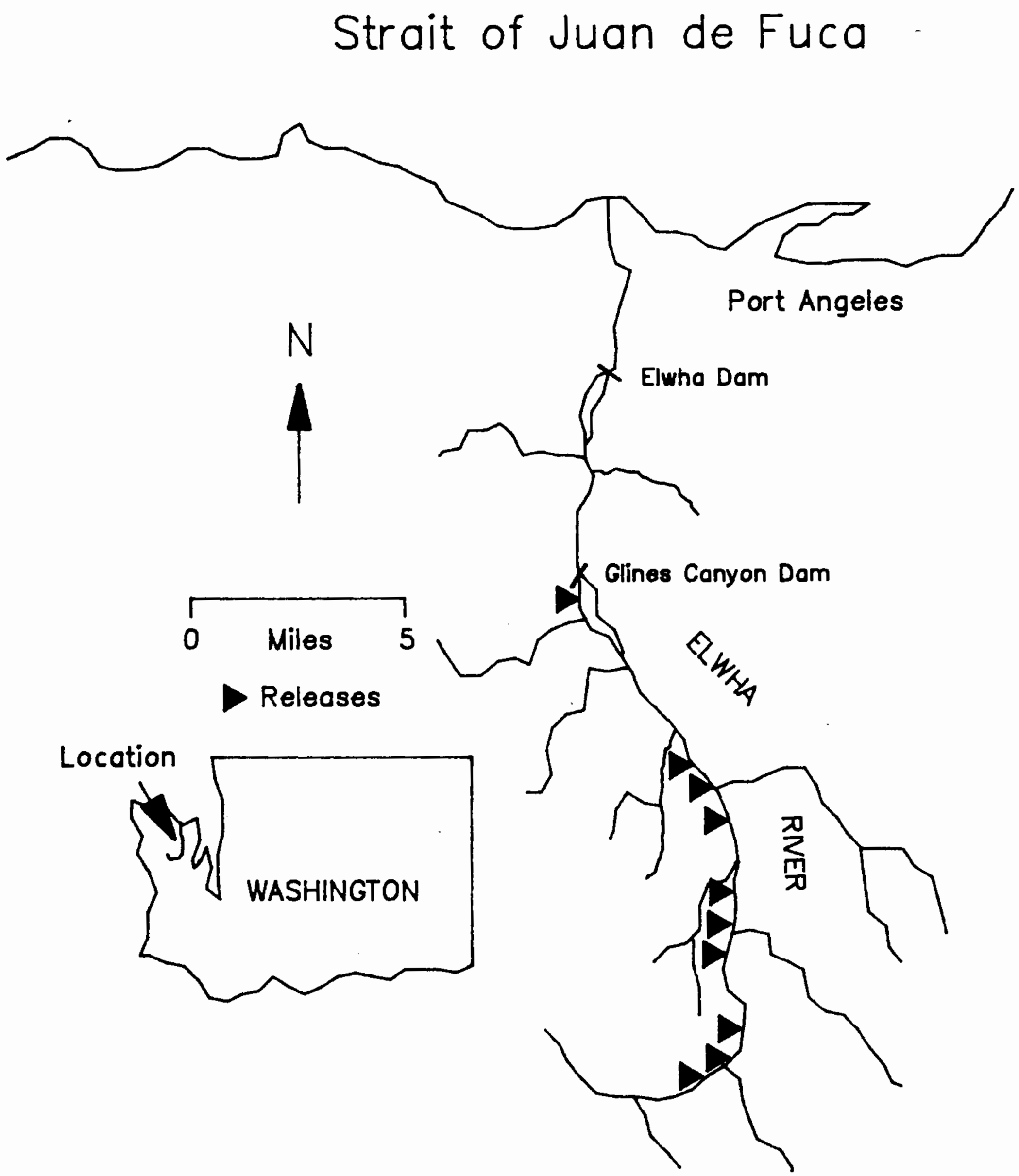

Figure 1. The Elwha River watershed and sites of anadromous salmonid releases.

the dams were constructed. The upper Elwha River is mostly within Olympic National Park, and upriver habitat is pristine.

Efforts are now underway to restore anadromous fish to the upper Elwha River within Olympic National Park. Studies for Federal licensing of the dams are now occurring. Two of our study objectives related to restoration were to determine emigration pattern, and to determine exit selection of coho and chinook over a range of spill and flow conditions at the Elwha River dams (Figure 1) from 1984 through 1990.

Both Elwha River dams are run-of-the-river, but differ in exit configuration. The lower dam, Elwha Dam, is a 100-foot high earth-fill structure located at river mile 5. Elwha Dam forms a 2-mile long reservoir. The dam's turbine and spillway exits are both located near the surface of the reservoir. Glines Canyon Dam (Glines), located at river mile 14, is a 200-foot high concrete-arch dam which forms a 2-mile long reservoir within Olympic National Park. The 20-foot wide by 40-foot high turbine intake is located in the reservoir's forebay between 60- and 100-foot depth. The turbine's capacity (1,100 cfs) exceeds natural river flow during low-flow periods. Most of our emigration work has centered on Glines because screening fish from its turbine intake is not considered feasible.

METHODS

To simulate natural production and to determine emigration patterns and exit selection, we released Elwha-stock chinook and coho salmon in the upper reservoir and in three areas of the upper watershed (Figure 1). Both chinook and coho are propagated at hatcheries in the lower river. Chinook salmon enter the river in summer/fall and coho in fall/winter.

Fish were released by tank truck and helicopter. Chinook and coho were released separately in space and time to permit species-specific passage monitoring. Initial releases of both species were made by truck in the reservoir's forebay because the upper watershed within the Park is roadless (Wunderlich and Dilley 1985, 1988). Yearling coho were released at smolt-size (approximately 13 cm forklength) during the expected emigration period from mid-April to the end of May. Chinook fry (approximately 7 to 8 cm forklength) were released in May and June at the expected onset of emigration. Because of questions about the effects of reservoir release on emigration timing, subsequent releases of both species were made via helicopter in the upper river. Coho fry were trucked from the hatchery to a staging site in the Park, and then air-lifted in fish boxes to upriver release sites and hand-distributed (Wunderlich and Hager 1988). Chinook fry were released by means of a fire bucket (also called a Bambi Bucket) with an oxygen system (Dilley and Wunderlich 1990). At upriver release points, the pilot lowered the bucket to the water surface, and tripped the bottom to gently release the chinook. This method proved efficient for scatter planting large numbers of juvenile chinook in remote areas of the upper Elwha mainstem.

We monitored fish passage throughout the expected emigration periods of both species. Coho were monitored April through June, and chinook from

April through June of the following year (15 months). For monitoring, we used a scoop trap below the dams in 1984, but used hydroacoustic sensors in subsequent years. Both spillway and turbine exits at Glines were continuously monitored with a single-beam system. Except for 1984, we requested periodic spills of at least 100 cfs at Glines. Spill was normally restricted to one spillgate nearest the center of the dam to reduce any effects that spilling at different gates might have on fish passage. We fished a fyke trap in the Glines turbine tailrace to help validate hydroacoustic estimates of turbine passage. We also fished scoop traps below both dams to help validate hydroacoustic estimates.

Portions of the chinook groups released in the reservoir forebay were held in the hatchery for several months and sampled for ATPase level (Na^+ $-K^+$ ATPase activity expressed as μmoles ATP hydrolyzed per mg protein per hr) (Wunderlich and Dilley 1988). Chinook released in the upper river were collected by stick seining or electroshocking at the head of Glines reservoir and sampled for ATPase level (Hosey and Associates 1990).

RESULTS AND DISCUSSION

Coho Emigration

We observed unexpected delays in coho salmon emigration as indicated by recoveries in 1984 at the scoop trap (Figure 2), and a very strong preference for a surface exit from the upper reservoir (Wunderlich and Dilley 1985). Review of spill records suggested that recoveries did not occur in the trap until spilling began in late May at Glines, even though the dam's deep-water turbine exit passed most of the river flow the entire passage period.

In 1988, we measured a mid-May peak in emigration of coho with the hydroacoustic sensors at Glines (Wunderlich et al. 1989). This peak was consistent with regional emigration patterns of coho smolts (Figure 3). The fish originated from upriver fry releases, and averaged 12 cm in fork length at passage. Hydroacoustic monitoring confirmed the strong preference by coho for a surface exit, which was continuously available (Figure 4). Over 90% of smolts used the spillway exit over the season. We observed a significant, positive relation between volume of water spilled and number of smolts passing the spillway (Figure 5). This relation was stronger at night (r^2 = 0.63) than day (r^2 = 0.31). Mean passage rate was also significantly greater at night than day through the spill exit, but not through the turbine exit.

Chinook Emigration

In contrast to coho, chinook movements were much more complex. Ou initial monitoring in 1987 showed very protracted chinook movement throug late summer (Figure 6), with no strong relation to flow or spil Intermittent monitoring through December of 1987 showed continued passag Our subsequent evaluation of chinook emigration in 1989-1990 showed a ve protracted movement pattern, with most fish also moving in late summer subyearlings. Comparison of 1987 passage data with 1989 showed that t

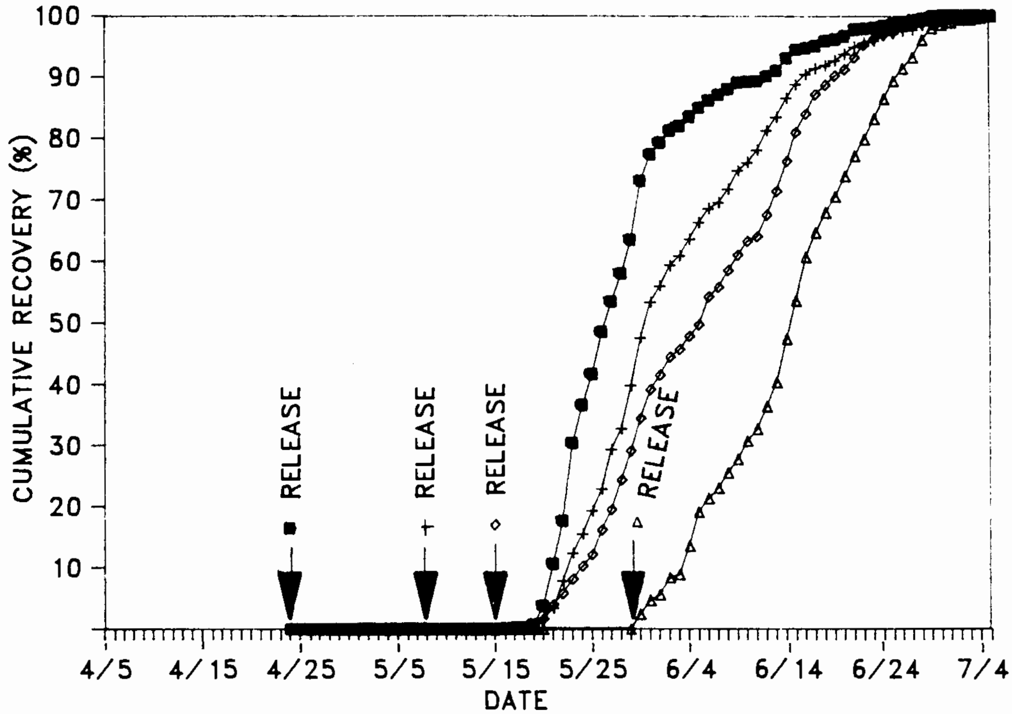

Figure 2. Cumulative scoop trap recoveries of four marked groups of coho smolts in the lower Elwha River in 1984. Smolt releases occurred in the forebay of Glines Canyon Dam.

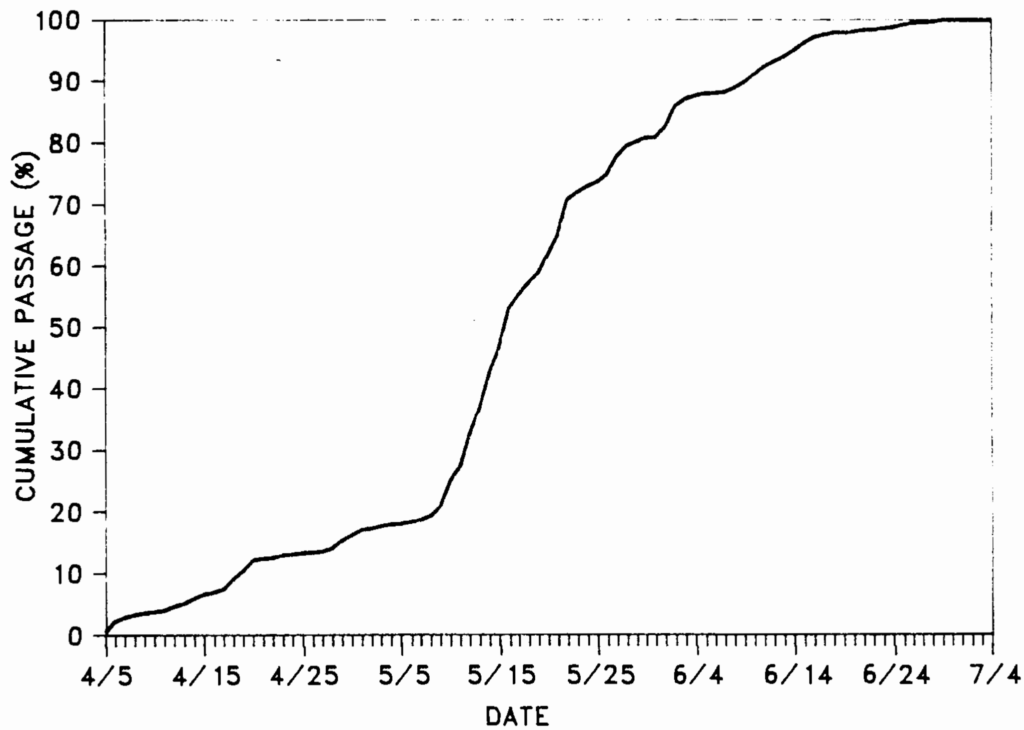

Figure 3. Hydroacoustic estimates of coho smolt passage at Glines Canyon Dam in 1988. Smolts originated from upriver fry plants.

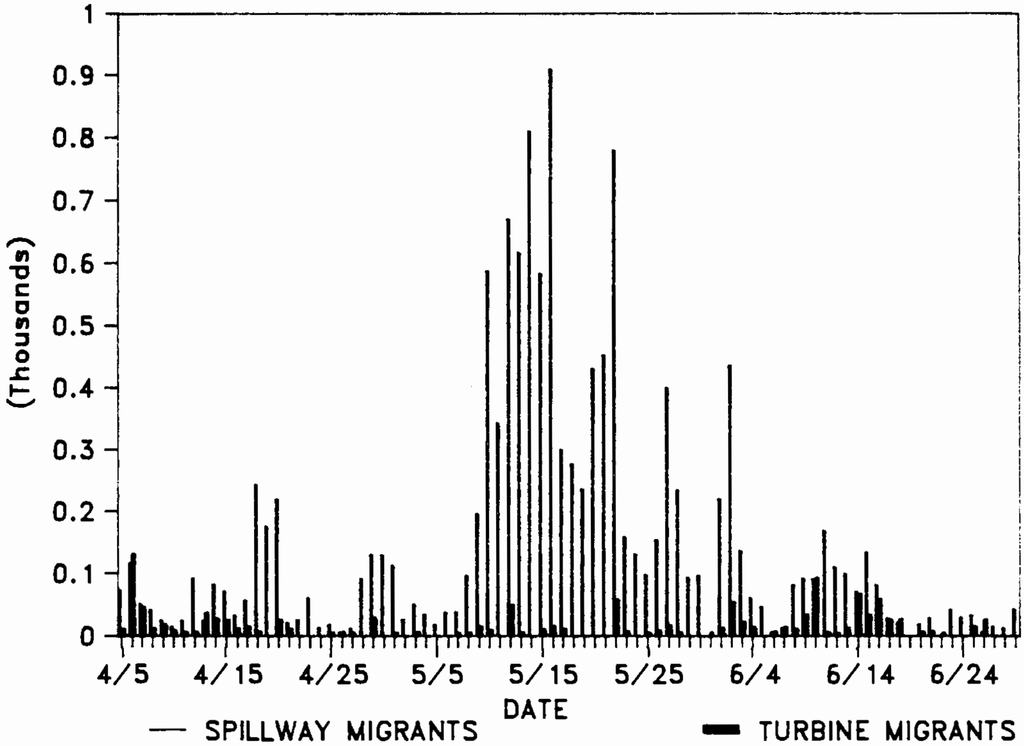

Figure 4. Hydroacoustically estimated coho smolt passage through Glines Canyon Dam in 1988.

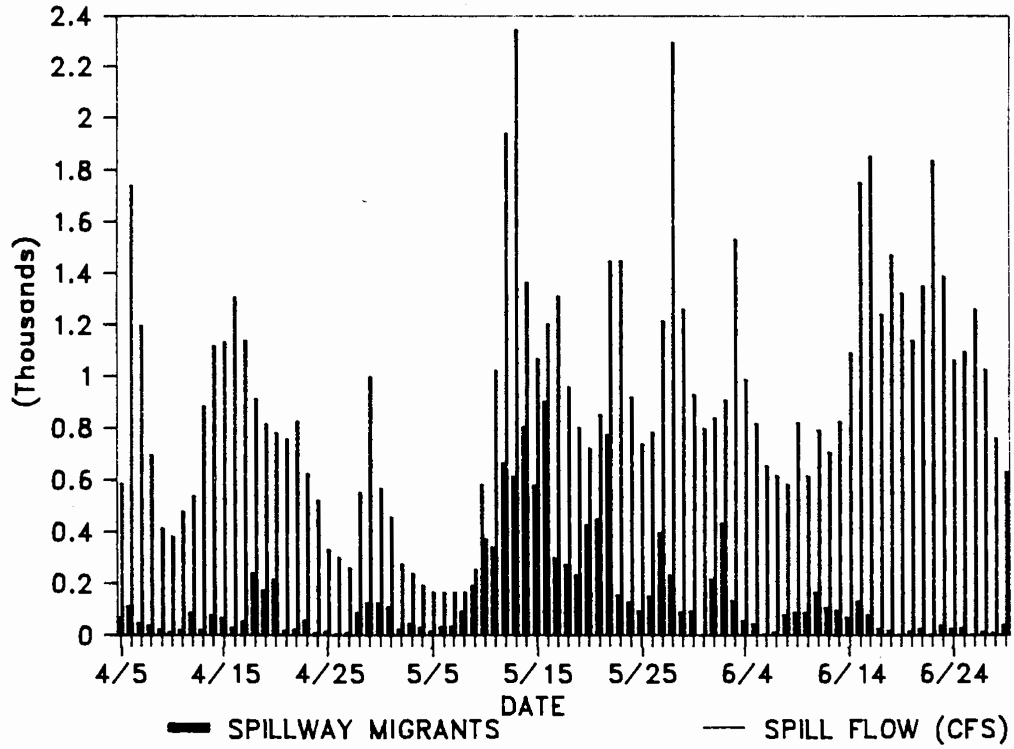

Figure 5. Coho smolt passage through the Glines Canyon Dam spillway in 1988.

1989 peak occurred about four weeks later than the 1987 peak (Figure 7). There were no major differences in streamflow and spill at Glines in 1987 and 1989 that might account for the later peak observed in 1989.

In spring and early summer of 1989, with a minimum spill of about 170 cfs, over 90% of subyearling chinook used the surface exit. Unlike coho salmon, chinook movement was not strongly related to volume of water spilled. In late summer, when only night spill occurred, virtually half the population emigrated, and 99% used the spill exit. However, chinook passage was again not strongly related to amount of water spilled, which ranged between 20% and 50% of the total river flow. When spill was completely stopped in early fall (due to reasons unrelated to this study), virtually all movement through the dam stopped until spilling resumed (Figures 8 and 9). The balance of chinook movement occurred in the late fall and early winter of 1989. Yearling chinook passage in 1990 was negligible (<3%).

Chinook salmon passed through both spill and turbine exits predominately at night, but not to the degree shown by coho. Over the 15-month monitoring period (1989-1990), 63% of chinook passed Glines at night, when a day or night passage choice was available (late summer spill was restricted to night only). In comparison, 72% of coho passed Glines at night during continuous spilling in the spring of 1988.

Qualitative snorkel surveys in the Elwha River immediately above the reservoir in 1989 also suggested that downstream movement of chinook peaked in late summer, as hydroacoustic monitoring at the dam indicated. As well, biweekly hydroacoustic surveys of the reservoir's fish population through the summer of 1989 did not reveal any substantial increase in the reservoir population that could be related to juvenile chinook delaying in the reservoir (Hosey and Associates 1990). A late-summer peak in chinook emigration has been noted in other coastal rivers. This pattern was suspected in the Quinault River in western Washington (Quinault Fisheries Division 1977), and a number of coastal Oregon rivers (Nicholas and Hankin 1988).

ATPase was about 10 units higher in 1987 than in 1989 at a given length (Figure 10). Thus, earlier peak passage in 1987 may have been related to higher ATPase levels in that year. There was a highly significant, positive relation between chinook lengths and ATPase levels collected in 1989 ($r^2 = 0.77$, $P < 0.01$) (Figure 11). This relation suggested that peak emigration occurred as length reached approximately 11 cm and ATPase level reached approximately 25 (Hosey and Associates 1990). Subyearling movement prior to the summertime peak may have reflected only redistribution of chinook from the upriver releases. The demarcations in ATPase levels shown in Figure 11 are only generalizations, however, and not strict criteria.

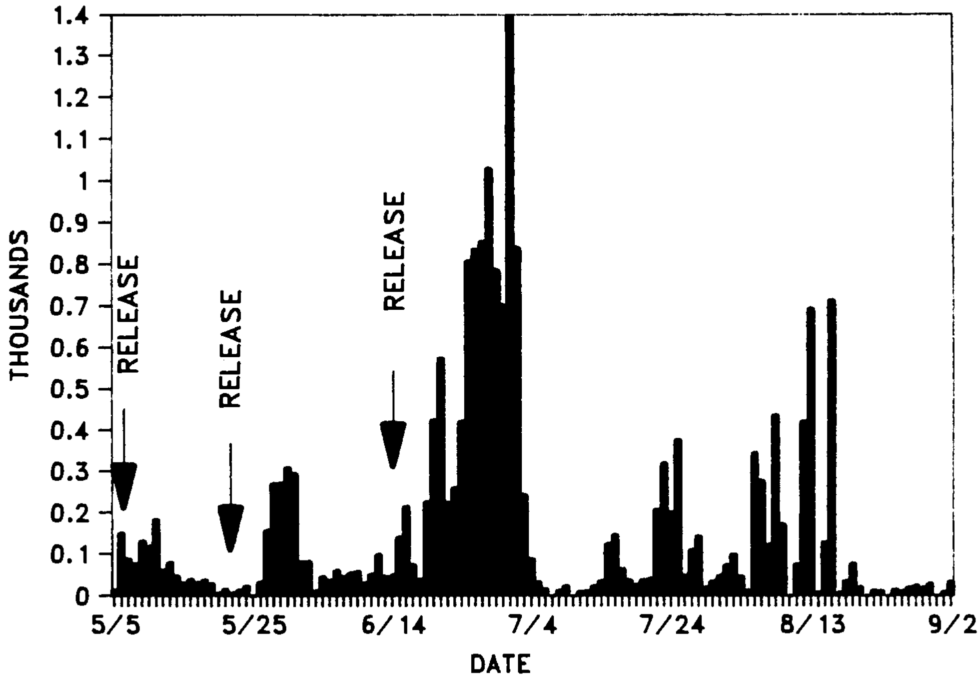

Figure 6. Daily hydroacoustic estimates of subyearling chinook passage through Glines Canyon Dam in 1987. Releses were made in the dam's forebay.

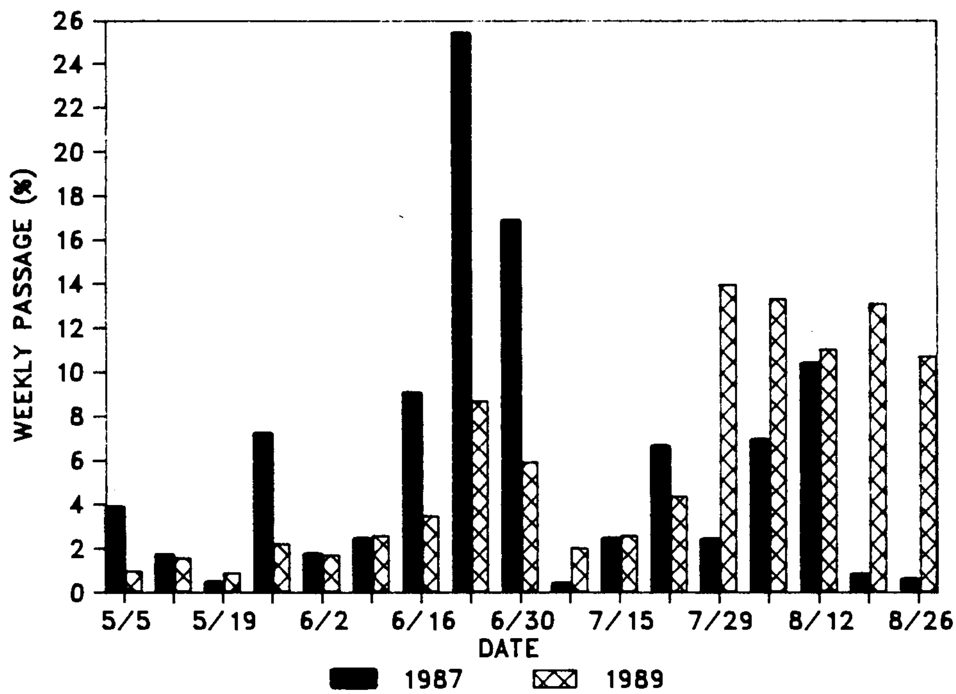

Figure 7. Weekly subyearling chinook passage through Glines Canyon Dam in 1987 and 1989. Starting dates of each week are indicated. Releases in 1987 were made in the dam's forebay, and releases in 1989 were made in the upper river.

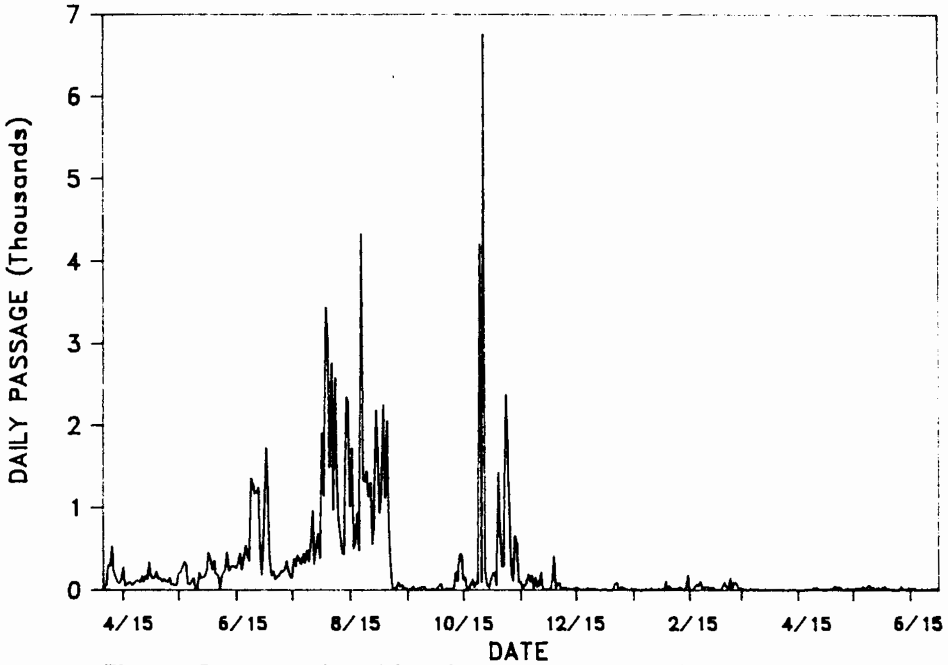

Figure 8. Juvenile chinook passage through Glines Canyon Dam from April 1989 through June 1990. Chinook migrants originated from upriver fry plants made in early April of 1989.

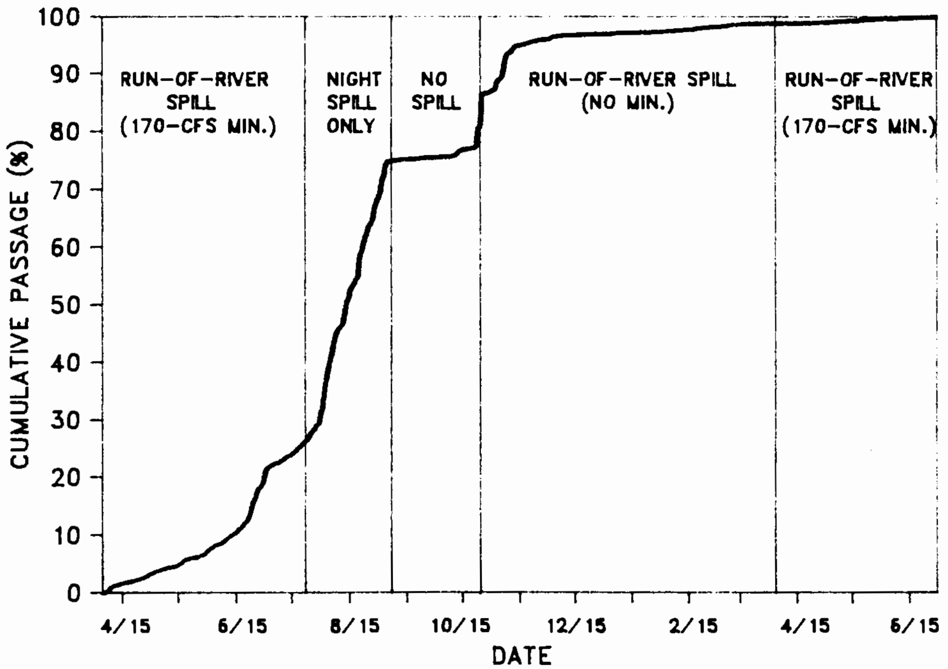

Figure 9. Cumulative juvenile chinook passage through Glines Canyon Dam from April 1989 through June 1990. Major spill periods are shown.

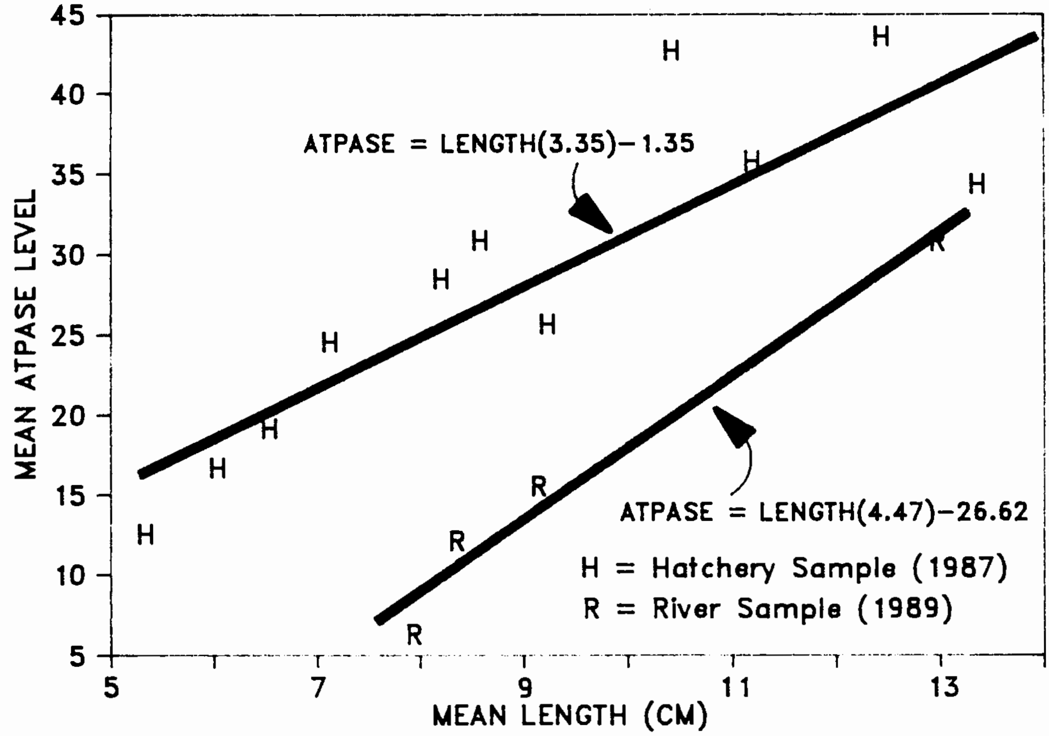

Figure 10. Mean ATPase level versus mean length of subyearling chinook in 1987 and 1989.

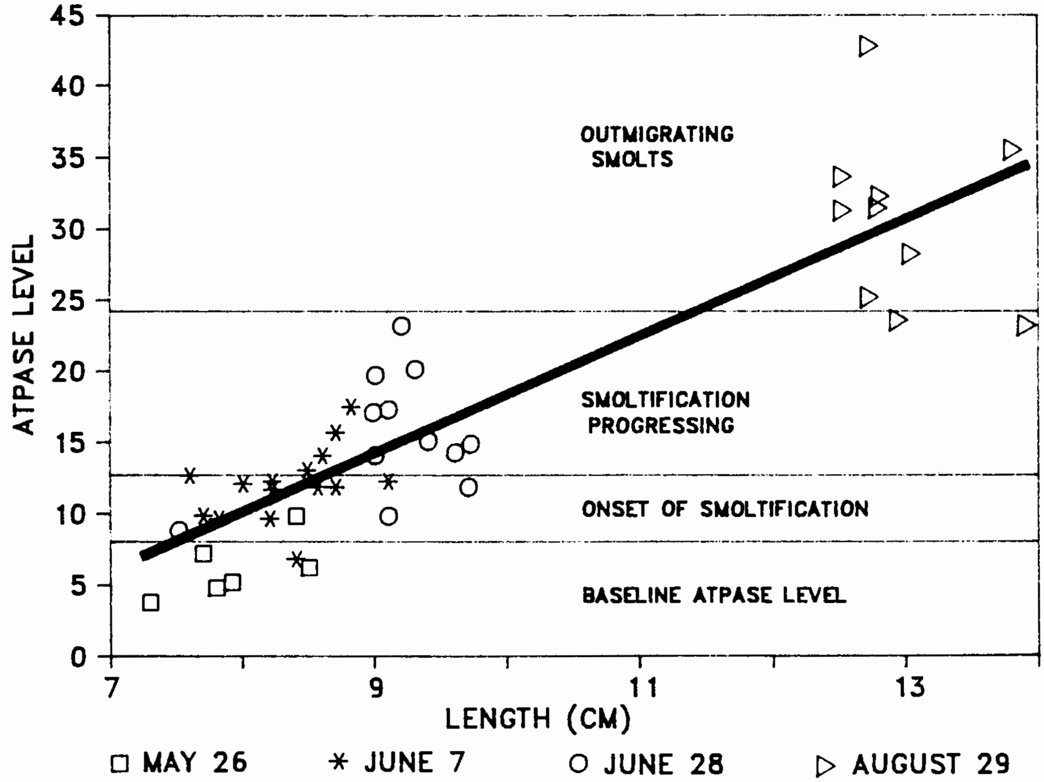

Figure 11. ATPase levels and lengths of subyearling chinook in the Elwha River above Lake Mills in 1989. Collection dates are indicated. Source: Hosey and Associates (1990).

CONCLUSIONS

Our general conclusions from the coho and chinook work were:

1) Coho and chinook smolts readily sought a surface exit from the reservoir, and generally avoided the deep-water turbine exit, even when the majority of streamflow passed via the deep-water exit.

2) Coho smolts displayed a stronger response to volume of surface flow than did subyearling chinook, and also exhibited a more pronounced nighttime movement preference than did subyearling chinook.

3) Elwha coho smolt emigration was consistent with other regional coho stocks. It extended from April through June, peaking in mid-May.

4) Elwha chinook emigration was very protracted and extended over a 15-month period, with a substantial peak in subyearling movement in late summer. This emigration pattern was consistent with certain other coastal stocks in Washington and Oregon. Peak subyearling chinook passage occurred as length reached 11 cm and ATPase level approached 25. Some annual variability in peak chinook emigration may occur from year-to-year, however, based on comparison of the 1987 and 1989 emigrations.

ACKNOWLEDGEMENTS

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