Juvenile Anadromous Fish Passage at

Howard Hanson Project, Green River,

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Stephen J. Dilley

and

Robert C. Wunderlich

U.S. Fish and Wildlife Service
Western Washington Fishery Resource Office
Olympia, Washington

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ABSTRACT

We evaluated passage of juvenile anadromous fish at Howard Hanson Dam and Reservoir from April to November of 1991 over the course of the annual (spring-to-fall) reservoir refill and evacuation cycle. Anadromous salmonids originate from annual releases of Green River chinook, coho, and steelhead fry above Howard Hanson Dam. At full summer reservoir pool, the shallowest dam exit (bypass gate at elevation 1069 feet) is approximately 70 feet below the water surface. Deeper exits of the dam (two radial gates at elevation 1035 feet) are not normally used until final reservoir evacuation in the fall. A previous fish passage study conducted in 1984 at Howard Hanson Dam suggested that salmonid emigrants may be unable to find the bypass exit at increasing reservoir pool; however, only springtime passage of coho and steelhead was studied, and reservoir refill did not occur until after the peak of emigration. Our study objectives in 1991 were to 1) monitor baseline passage of juvenile chinook, coho, and steelhead through the project from spring refill through fall drawdown, and 2) examine juvenile anadromous fish passage through the project in relation to reservoir elevation and outflow. We fished fyke traps on principal reservoir tributaries to gauge fish movement into the reservoir, and operated hydroacoustic sensors in the dam's exits to estimate total fish movement through the dam. A scoop trap was periodically fished below the dam to identify species composition of emigrants. Overall fish movement past the project was characterized by 1) a large pulse of subyearling and yearling coho in the spring before project refill, 2) small pulses of subyearling chinook in the summer after refill, and 3) a large pulse of both chinook and coho subyearlings during final reservoir drawdown in the fall. Over the total monitoring period, we estimated passage at the dam to be approximately 760 yearling chinook, 21,500 subyearling chinook, 5,900 yearling coho, 31,600 subyearling coho, and 260 steelhead smolts. Spring refill of the reservoir reduced passage rates of yearling coho at the dam; reduced outflow and increased reservoir elevation were significantly related to this reduction. Over half of the observed subyearling chinook passage at the dam occurred after spring refill (late June to late November), with reservoir outflow accounting for up to half of the variation in chinook passage observed during this period. During the final reservoir drawdown in November, outflow accounted for approximately 30% of the variation in both subyearling chinook and coho passage. Fall emigrants from the project (subyearling coho and chinook) reached the size of yearling smolts, but exhibited relatively low ATPase (smolt readiness). Subyearling coho and chinook observed passing the dam through the summer and fall were likely trapped in the reservoir since the spring refill.

TABLE OF CONTENTS

	Page
Abstract	ii
Introduction	1
Methods	3
Overview	3
Hydroacoustic Monitoring	3
Hydroacoustic Equipment and Operation	3
Transducer Placement and Operation	4
Hydroacoustic Data Processing	4
Fish Trapping	5
Scoop Trap	5
Fyke Traps	7
Other Fish Collections	8
Spring Refill Test	8
Fish Passage Estimation	8
Fish Passage Evaluation	9
Results and Discussion	10
Overview	10
Chinook Yearlings	10
Chinook Subyearlings	10
Coho Yearlings	12
Coho Subyearlings	14
Steelhead	14
Other Salmonids	15
Summary	16

Table of Contents (continued)

	Page
Acknowledgements	18
References	19

LIST OF FIGURES

Figure		Page
1	Howard Hanson Reservoir showing trap sites and principal tributaries	21
2	Schematic of the lower section of Howard Hanson Dam intake tower showing approximate locations and beam patterns of transducers relative to radial gates and bypass	22
3	Side view of the scoop trap in fishing position	23
4	Mean water velocities measured at the mouth of the scoop trap	24
5	Outflow, reservoir elevation, and periods of gate operation at Howard Hanson Dam during the study period	25
6	Yearling chinook passage and reservoir elevation at Howard Hanson Dam during the study period	26
7	Weekly percentages of chinook yearlings moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates	27
8	Subyearling chinook passage and reservoir elevation at Howard Hanson Dam	28
9	Cumulative passage of subyearling coho and chinook	29
10	Weekly percentages of chinook subyearling moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates	30
11	Mean ATPase values for subyearling chinook collected in the Howard Hanson project area	31
12	Subyearling chinook passage and outflow at Howard Hanson Dam	32
13	Yearling coho passage and reservoir elevation at Howard Hanson Dam	33
14	Weekly percentages of coho yearlings moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates	34
15	Daily scoop trap catches of coho smolts and elevations of Howard Hanson Reservoir in 1984	35
16	Yearling coho passage and outflow at Howard Hanson Dam	36

LIST OF FIGURES (continued)

Figure		Page
17	Weekly percentages of coho subyearlings moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates	37
18	Subyearling coho passage and reservoir elevation at Howard Hanson Dam	38
19	Subyearling coho passage and outflow at Howard Hanson Dam .	39
20	Daily scoop trap catches of steelhead smolts and elevations of Howard Hanson Reservoir in 1984.	40
21	Daily outflow from Howard Hanson Dam in spring 1984 and 1991	41

LIST OF TABLES

Table		Page
1	Scoop trap efficiency tests by species and year class . . .	42
2	Estimates of fish passage through Howard Hanson by major periods of gate operation	43
3	Juvenile chinook and coho collected for age analysis . . .	44
4	Percentages of injuries and mortalities in scoop trap catches during major periods of gate operation and over the entire study period	45
5	Lengths and ATPase values from juvenile chinook and coho salmon collected at various locations in the Howard Hanson project area	47
6	Typical ATPase levels associated with juvenile chinook and coho salmon	48
7	Biweekly mean forklengths of subyearling and yearling coho and chinook caught in the scoop trap	49
8	Dye-mark recoveries at the mainstem fyke trap	50
9	Dye-mark recoveries at the scoop trap	51

APPENDICES

A	Recent subyearling anadromous salmonids planted above Howard Hanson Dam.	52
B	Daily scoop trap catches below Howard Hanson Dam	57
C	Daily mainstem Green River fyke trap catches	61
D	Daily North Fork Green River fyke trap catches	63
E	Estimated daily fish passage at Howard Hanson Dam during the 1991 study period	65

INTRODUCTION

The U.S. Army Corps of Engineers and the City of Tacoma have begun feasibility studies of the City's proposal to increase useable storage at Howard Hanson Dam from 25,375 to 62,359 acre-feet for purposes of municipal water supply and low-flow augmentation for fish. This added water storage would elevate reservoir pool levels in the spring and summer to a maximum of 1177 feet above mean sea level, as opposed to the existing maximum pool level of 1141 feet. The minimum flood-control pool elevation during winter would remain at approximately 1070 feet, maintaining a one-mile long impoundment.

During typical spring refill, outflow is shifted from the main outlets (two 12-foot-wide radial gates at elevation 1035 feet) to a 48-inch bypass outlet (at elevation 1069 feet) as the reservoir is raised to maximum pool elevation of 1141 feet (the reservoir may also be surcharged to elevation 1145 feet for one to two weeks after full pool is achieved for debris-removal purposes, as occurred in 1991). The pool is then gradually drafted through the summer and fall to augment downstream flows. Flow is diverted to the smaller bypass outlet during the refill and drawdown period because smaller flows can be passed more effectively through this exit than through the larger radial gates.

The Washington Departments of Fisheries and Wildlife, the Muckleshoot Indian Tribe, and Trout Unlimited have annually released steelhead, coho salmon, and chinook salmon in the watershed above Howard Hanson Dam. Releases of steelhead fry began in 1982, coho salmon fry in 1983, and chinook salmon fry in 1987, while adult steelhead releases began in 1992. Releases of all species continue to present (Appendix A). Of major concern in this endeavor is the potential impact of spring reservoir filling on the successful outmigration of anadromous salmonids. Fish passage studies conducted by the Washington Department of Fisheries in 1984 at Howard Hanson Dam (Seiler and Neuhauser 1985) suggested that, as depth over the bypass exit increased during the spring refill, outmigrating anadromous salmonids were less able to find and enter the bypass exit, and were delayed for an unknown period. If this were true, additional water storage could exacerbate downstream fish passage problems, as refill would occur earlier than presently occurs. Depth over the existing exits would also be greater under the increased storage proposal; however, the Corps and City of Tacoma propose to construct a fish passage facility in the dam.
As part of the feasibility studies for the Howard Hanson added storage proposal, information on anadromous fish passage in relation to reservoir elevations and outflow is needed to help define baseline passage conditions, and to document limitations and opportunities for achieving effective passage under the proposed storage regimen. Therefore, in 1991, we conducted further study of fish passage at Howard Hanson Dam and Reservoir. This study was accomplished with Corps of Engineers and project sponsor funding. Specific study objectives were:

1) Monitor juvenile anadromous fish timing and abundance as they emigrate through the project from the spring refill through fall drawdown.

2) Examine juvenile anadromous fish passage through the project in relation to reservoir elevation and outflow.

METHODS

Overview

Fish passage through the project was monitored with a combination of hydroacoustic detection at the dam exits and trapping both above and below the project. Fish passage through dam exits was monitored hydroacoustically from April 16 until November 22. A scoop trap was fished below the dam during this same period to assess species composition of the outmigrant population. That is, because the hydroacoustic estimates did not discriminate among species or year classes of outmigrating juvenile anadromous fish, scoop trap catches were used as a basis for apportioning acoustic counts at the dam. Apportioned hydroacoustic counts at dam exits were then compared to reservoir elevation and outflow data supplied by the Corps. Fish captured in the scoop trap were examined for condition and any previously applied marks. Fyke traps were operated in the two major reservoir tributaries: the North Fork and the mainstem of the Green River. Fyke trap catches were used to assess general movement trends into the reservoir for contrast with hydroacoustic estimates of passage past the dam, and to recover marked fish. Figure 1 shows general location of the project and locations of the several traps.

Hydroacoustic Monitoring

Hydroacoustic Equipment and Operation

A remote, computer-based hydroacoustic monitoring system was used at Howard Hanson Dam. This system consisted of three, 420-kHz transducers (two 15-degree and one 6-degree), three transducer rotators, an echo sounder/transceiver, a computer-based echo signal processor (ESP) and associated software programming, multiplexer/equalizer, dedicated phone line, remote control data acquisition system, and a thermal chart recorder.

When triggered by the echo sounder, the transducer emitted short sound pulses toward the area of interest. As these sound pulses encountered fish or other targets, echoes were reflected back to the transducer which then reconverted the sound energy to an electrical signal. These returning signals were amplified by the echo sounder and equalized. A target's range from the transducer was determined by the timing of its echo relative to the transmitted pulse (Raemhild, undated).

The echo sounder relayed the returning signals to the ESP and the thermal chart recorder. Returning signals passed to the ESP were recorded to hourly computer files. Returning signals passed to the thermal chart recorder produced an echogram which provided a permanent visual record of all targets detected. The echograms were initially used for setting fish tracking and processing parameters for the ESP. Once these parameters were established, the thermal chart recorder was used for periodically verifying the fish tracking and processing parameters and as a backup for the ESP in the event of a system problem.

The multiplexer/equalizer permitted the echo sounder to individually interrogate single or multiple transducers in an operator-specified sequence. This allowed transmitted pulses to be channeled from the echo sounder to the appropriate transducer and also equalized the returning signals to compensate for differing receiving channel sensitivities.

Transducer Placement and Calibration

The intake structure at Howard Hanson Dam has three possible fish exits. Two, 12-foot-wide, side-by-side radial gates at an elevation of 1035 feet and one 48-inch-wide bypass located at an elevation of 1069 feet (Figure 2). To achieve the best possible transducer position for fish passage monitoring at these intakes, two main criteria were considered: 1) maximize the available sample area, and 2) minimize hydroacoustic turbulence.

Three transducers were installed on the inside of the intake tower trash rack to monitor fish passage. Installation was accomplished by lowering personnel in a work basket suspended from a crane after the reservoir level was dropped below an elevation of 1069 feet. Because the transducers would be underwater and inaccessible for the entire study, it was important to have the ability to move the transducers remotely. For this reason, all three transducers were installed with rotators that were controllable from the gate house located at the top of the intake tower.

We used 15-degree transducers mounted on single-axis rotators at an elevation of approximately 1070 feet for both radial gates (Figure 2). Both of these transducers were located approximately on the center line of each gate. For the bypass, we used a 6-degree transducer mounted on a dual-axis rotator directly opposite the bypass (Figure 2). As a backup, an additional 15-degree transducer was mounted directly alongside the 6-degree transducer.

The hydroacoustic system was calibrated prior to data collection to assure that the system sensitivity for each receiving channel was properly equalized to each other. In addition, calibration information was used to set the equipment so that only targets greater than -50 dB would be recorded. This target strength was chosen so that even the smallest migrants would have a high probability of returning an echo with an amplitude large enough to be recorded. Debris, which has a substantially larger target strength than fish, was eliminated by a maximum threshold.

Hydroacoustic Data Processing

All individual echo information collected by the ESP system was stored to hourly computer files. These hourly files were compressed and remotely transferred by phone on a daily basis from the dam to our home-based computer.

Computer files were post-processed for potential valid fish targets based on a ping gap maximum of 10, tracking window of 1 meter, an average slope >= 0.0100 and <= 0.100, and a minimum target redundancy of 4 successive echoes. Valid fish targets used for estimates of fish passage were selected from these files based on a midpoint no closer to the transducer than 2 meters, a 75-echo maximum number of hits, and a linearity factor of no less than 0.9.

Since not all of the area in front of each radial gate was ensonified by the transducer beam, not all fish passing in front of those units were detected. To account for this undersampling, each detection was extrapolated across the width of the radial gate. Fish detection was weighted by the ratio of the width of the radial gate to the width of the acoustic beam at range. No expansion for time was used because sampling occurred 24 hours per day. No expansion was used for the bypass exit because the transducer beam covered the entire intake at range and sampling occurred 24 hours per day.

When the ESP system was not working, the thermal chart recorder echograms were used. Fish targets were acquired from these echograms by digitizing the information by hand and processing the files using the same criteria and expansions as mentioned above. When no information was available, the next-closest 24-hour data set on either side of the missing period was averaged to estimate fish passage. Periods of missing data constituted a negligible portion of all monitoring in 1991, and occurred only during portions of May 1st to 2nd, June 1st to 2nd and June 24th. Scoop trap catches were light during these times (Appendix B), suggesting that no spikes in fish passage were missed.

Fish Trapping

Scoop Trap

All recovery of outmigrants below the dam occurred at the scoop trap. The scoop trap was essentially an inclined-plane trap of Washington Department of Fisheries' (WDF) design. It consisted of two 38-foot-long pontoons spaced about 8 feet apart supporting an inclined screen section 6 feet wide by 6 feet deep at the mouth and 18 feet long (Figure 3). In operation, downstream migrants were swept up the inclined screen by the current and deposited in the live box. Flow into the trap was regulated by positioning the trap in the current (side to side and fore and aft) with the main winch cables anchored to shore on each bank, and by adjusting the level and angle of the inclined screen using its four winches (Figure 3).

The scoop trap was fished in the same manner and location below Howard Hanson Dam as by WDF in 1984 (Seiler and Neuhauser 1985), except trapping in this study extended beyond spring into late fall, and was not conducted continuously as was the WDF work. The scoop trap was installed about 100 yards below the dam outlet during the first week of April. Routine trap operation began April 11th. We trapped two days of the first week, every other day from April 18th until the end of June, twice per week in summer/fall (July to late November), and every day during the final week of the study (week of November 17th).

Trap position was checked every time the trap was fished to help ensure direct alignment into the main current and optimal velocity at the trap mouth. The scoop trap position was adjusted several times throughout the study to maximize efficiency under the wide range of flow conditions from April though November. Figure 4 indicates improvements in entrance velocity obtained by repositioning the trap in early June and early August. Water velocity was measured with a current meter (Swoffer model 2100) extended into the center of the trap mouth. The optimal water velocity at the trap mouth is approximately 6 to 8 feet per second for chinook, coho, and steelhead smolts (Dave Seiler, WDF, personal communication). This optimal velocity provides maximum trapping efficiency for smolts without excessive turbulence in the live box which, at high flows, can lead to fish injury as well as mechanical damage to the trap. Lower velocities may allow fish to evade the trap.

Daily scoop trap operation occurred over a 24-hour period beginning about 0900 each trap-day. During each 24-hour period of operation, trap checks occurred in late afternoon, midnight, and the following morning. At each trap check, the following data were collected (catch permitting):

1. Total catch by species/year class.

2. A random subsample of each species/year class was measured for fork length. In large catches, a minimum of 20 individuals per species/year class was measured. In small catches, all individuals were measured.

3. All chinook were examined for fluorescent dye marks applied by the Muckleshoot Tribe. A black light was used to identify green, orange, and red dye-marks applied to portions of chinook releases in the North Fork, upper mainstem, and an upper mainstem tributary (Snow Creek), respectively, to evaluate outplanting (Appendix A).

4. Scale samples were taken from juvenile chinook and coho salmon from July through November. Scale samples were taken biweekly (catches permitting) to help assess year classes, because larger-than-expected individuals began appearing in trap catches during July and visual assessment of age was less certain than earlier in the season. We pressed and aged the scales at the Western Washington Fishery Resource Office (WWFRO), and had them verified by WDF personnel.

5. ATPase samples were taken from juvenile chinook on a biweekly basis throughout the study (catches permitting) to help assess migratory readiness. For the same reason, one ATPase sample was also taken from subyearling coho in early November when these fish began passing the project at a highly atypical size and time-of-year. A target minimum of 10 individuals was taken in each field sampling and held on ice (but not frozen) for less than 24 hours in the field, then taken to the Service's Olympia Fish Health Center. At the Center, gill arches from each fish were excised, immersed in preservative solution, and stored in a super-cool freezer (-70° C) until shipment on dry ice to National Marine Fisheries Service at

Cook, Washington for ATPase measure (μmoles ATP hydrolyzed per mg protein per hour).

6. Injuries among captured fish were noted to infer exit-related injury and mortality. Major injury categories recorded were mortality (any reason), eye injury, bruising, and descaling. Descaling categories followed the Columbia River criteria of descaled (over 16% scale loss on either side of fish) or partially descaled (3% to 16% scale loss on either side of fish in either a patchy or scattered pattern). Descaling (> 16% scale loss) is considered probable mortality under the Columbia River criteria. Mortalities were noted in all catches, but only a random sample of fish (at least 20 of each species/year class) were examined for injuries in large scoop trap catches.

7. Fish caught in the trap were marked with a caudal-clip (catches permitting) and released above the trap to assess trap efficiency and ultimately species composition of the outmigrant population. The caudal clip consisted of squaring the tip of the fin, sufficient for short-term identification. Fish caught in the afternoon and at midnight were clipped, released above the trap at the dam outlet in the mainstream of the discharge, and recovered in the trap the following morning. Initially, a minimum of 50 individuals per species/year class were proposed for clipping and release, but low catches eventually resulted in our clipping and releasing all catches of all species of interest.

Fyke Traps

To gauge fish movement into the reservoir, fyke traps were fished approximately one-half river mile upstream of the full-pool reservoir at a railroad bridge in the mainstem, and approximately one river mile above full pool at a road bridge in the North Fork (Figure 1). Routine trapping began on April 22nd in the mainstem and concluded on November 21st. Trapping in the North Fork began on April 18th and concluded on August 8th due to insufficient flow. Both traps were operated on the same daily schedule as the scoop trap, that is, every other day in spring and twice weekly in summer/fall.

Each trap was of the same design and attached to a bridge. The traps were 6 feet wide and 4 feet high at the mouth, with a 15-foot taper to a 12-cubic-foot floating live box. Net mesh in each was 1/8-inch stretch measure. The mainstem fyke was operated on a "clothesline" anchored to the railroad bridge pylon on either river bank. This allowed us to move the trap into the channel center from a shore position during fishing periods. The North Fork trap was also anchored to bridge supports on either river bank, but was lowered into the channel center with a hand winch from the top of the bridge.

Daily fyke operation and data recording followed that described above for the scoop trap, with several exceptions: midnight trap checks were not feasible during the spring at the mainstem fyke because of hazardous flow conditions; injury recording and efficiency testing (points 6 and 7 under scoop trap operation above) were not conducted with fyke captures. Fyke trap catches were used to indicate trends in movement, rather than quantitative estimations of passage into the reservoir.

Other Fish Collections

Concurrent studies of the Howard Hanson Reservoir tributaries in 1991 involved electroshocking and snorkeling portions of the mainstem and North Fork affected by the proposed raise in pool level (Wunderlich and Toal 1992). Relevant information from tributary sampling was used to help assess anadromous fish movement into the reservoir and outmigration pattern of juvenile Green River chinook releases in this study.

Juvenile chinook were also collected in the forebay of Howard Hanson Reservoir and at the one-way bridge 3.5 river miles downstream of the scoop trap during late summer and early fall to augment ATPase sampling at the traps. These fish were collected biweekly on hook-and-line as available.

Spring Refill Test

We proposed a "test" refill of the reservoir during mid-May to evaluate, to the extent practical, the effect of reservoir change on fish passage through the dam. Previous work by Seiler and Neuhauser (1985) suggested that, as the spring refill occurred, coho smolt passage was curtailed. The curtailment they observed, however, occurred during the second week of June, when smolt passage was already substantially declining. Our rationale for a mid-May test was that coho (and steelhead) smolt passage could be expected to peak at this time, so an interruption in passage would be more detectable than at any other time.

Following interagency review and concurrence in the test, the Corps gradually raised the pool in early May and reached elevation 1110 feet on May 13th, then drafted the reservoir again prior to the actual spring refill which commenced in late May. During the "test" refill, as during the whole study period, we hydroacoustically monitored fish passage at all dam exits. Fish movement in relation to reservoir elevation and outflow were specifically examined to assess influences on fish passage.

Fish Passage Estimation

We estimated daily fish passage (by species and year class) through each exit of Howard Hanson Dam by apportioning the total daily hydroacoustic passage estimates according to the proportional representation of each species/year class in the scoop trap catches. We used length-frequency and/or scale analyses to determine year classes of chinook and coho salmon captured at the traps throughout the study period. We then computed the proportions of each species/year class (coho subyearling and yearling, chinook subyearling and yearling, and steelhead smolt) observed in each 24-hour scoop catch. These catch proportions were then applied to daily hydroacoustic estimates (midnight-to-midnight). The proportion of each species/year class was applied to the 24-hour hydroacoustic estimate for that same day and all succeeding 24-hour hydroacoustic estimates until the next scoop trapping period, and so on.

Our original intent was to test for species/year class-related differences in scoop trap efficiency and incorporate any such differences in our estimations of fish passage. However, we were unable to discern any differences from the 1991 efficiency data (Table 1), as they were too limited for this purpose. Additional efficiency measures in 1992 below Howard Hanson Dam (study in progress) may help evaluate differences in scoop trap efficiency for different species and year classes.

Fish Passage Evaluation

We examined passage of each species/year class in relation to outflow and depth of nearest exit. We specifically examined chinook and coho passage because chinook and coho were most numerous. We evaluated total daily chinook (subyearling) and coho (subyearling and yearling) passage against outflow and depth (instantaneous values at 0800 hours; Corps water management reporting time) using stepwise linear regression. For comparison, we also regressed coho yearling passage measured in 1984 (Seiler and Neuhauser 1985) in relation to outflow and depth of nearest exit at Howard Hanson Dam. Significance in all tests was established at $P < 0.05$.

For purposes of fish passage analysis, the data set was divided into five major periods based on fish availability and project operation (Figure 5):

1) The period before the test refill (April 16 to May 7) when reservoir elevation declined and then remained relatively stable following a flood event, and only radial-gate discharge occurred.

2) The test refill (May 8 to May 17, as described above) when only radial-gate discharge occurred.

3) The actual refill (May 20 to June 21) when reservoir elevation increased from winter low (1069 feet) to summer high with surcharge (1145 feet). Within this period, discharge shifted from the radial to bypass gates on May 29th.

4) High summer pool (June 22 to July 8) when reservoir elevation remained relatively stable, and discharge occurred through both radial and bypass gates.

5) The total drawdown (July 9 to November 22) when reservoir elevation fell from summer high to winter low. Within this period, discharge occurred totally in the bypass until November 5th, then discharge shifted totally to the radial gate during the final drawdown.

RESULTS AND DISCUSSION

Overview

Overall, movement of anadromous salmonids past Howard Hanson dam was characterized by 1) a large pulse of fish during the spring months comprised mainly of coho yearlings and subyearlings, 2) small pulses of chinook subyearlings during the summer months and, 3) another large pulse of both chinook and coho subyearlings in November. Increased pool levels (with associated reductions in outflows) both during the test and the actual refills were believed to inhibit successful fish passage, as indicated by reduced daily fish movement at the dam.

Appendices B, C, and D provide complete listings of catch and effort for the scoop and fyke traps. Appendix E lists estimated daily fish passage at the dam, by species and year class, throughout the study period.

Chinook Yearlings

An estimated 760 chinook yearlings (Table 2) egressed from the reservoir during the study, with the principal emigration period occurring in late April to early May (Figure 6). No yearling chinook occurred after late June, based on scale analysis of chinook captured at the scoop trap in late summer and fall (Table 3). The last yearling chinook at the scoop trap occurred on June 24th, several days after full reservoir pool (elevation 1145 feet) was achieved. Yearling chinook emigration in April and May is consistent with other Puget Sound and coastal Washington systems (Seiler et al. 1984; Wunderlich et al. 1989).

When the timing of these fish is compared to the mainstem fyke trap catches (Figure 7), it suggests that some entrapment or delay occurred in the reservoir. Cropp (undated) captured yearling chinook while gill netting in Howard Hanson Reservoir in summer of 1989, after refill of the reservoir.

Emigration of 760 chinook yearlings represents 0.045% of the 1990 chinook fry released into the upper watershed (Appendix A). This may be a conservative estimate of yearling passage, however, as emigration may have occurred prior to the start of our monitoring in mid-April.

Chinook yearlings were not observed during periods when only the bypass gate was used (Table 2). Yearling chinook were not detected in passage during the test refill, actual refill, or drawdown (Figure 6), so a direct measure of their response to these conditions is not available.

Scoop trap catches (Table 4) suggested that these fish passed through the reservoir and dam without injuries, although few individuals were available for examination.

Chinook Subyearlings

An estimated 21,513 chinook subyearlings (Table 2) egressed from the reservoir during the study. Emigration occurred sporadically throughout the study period with the major pulse of fish exiting during early November fall drawdown (Figure 8). Notably, only subyearling chinook passage occurred through much of the summer (Figure 9), and this passage occurred with up to 70 feet of water over the bypass exit (Figures 5 and 8). Mainstem fyke trap catches indicate that migration into the reservoir began at least by early April and ended by mid-June (Figure 10). Wunderlich and Toal (1992) also observed similar timing for chinook subyearlings based on electroshocking in the North Fork of the Green River. This suggested that chinook subyearlings were entrapped or delayed in the reservoir through summer and into fall.

The results of ATPase sampling (Figure 11, Table 5) strongly suggested the same conclusion. ATPase, an indicator of smolt readiness (Table 6), steadily increased beginning in May to mid-July when levels of high readiness were measured. ATPase then dropped significantly by mid-September to levels of marginal readiness and continued to drop as the season progressed. While the largest pulse of fish egressed during November (Table 2), low ATPase values suggested that this may not have been a "natural" emigration.

Daily passage of subyearling chinook was significantly related only to reservoir outflow. This relation held during high summer pool (June 21 to July 8; $r^2 = 0.53$), the total drawdown (July 9 to November 22; $r^2 = 0.34$), and the final drawdown (November 6 to November 22; $r^2 = 0.19$). Virtually no chinook passage was detected during either the test or the actual refills. Chinook passage in relation to elevation and outflow over the entire season is shown in Figures 8 and 12, respectively. During the study period, the bulk of chinook movement occurred during periods of high flows, when radial gate operation occurred (Figures 5 and 12).

Late-fall chinook emigrants displayed substantial growth, probably due to reservoir rearing. Mean lengths of subyearling chinook captured in the scoop trap ranged from approximately 60 mm in April to 200 mm by late November (Table 7). This compares to a mean size of 190 mm for yearling chinook reared in the upper Elwha River reservoir (Wunderlich et al. 1989), and far exceeds that of stream-reared yearling chinook emigrants in the Skykomish basin (≈110 mm, Seiler et al. 1984). Yearling chinook captured in the scoop trap during spring 1991 (Table 7) were similar in size to Skykomish yearlings. We surmise that the latter Green River yearling migrants reared in the watershed above Howard Hanson Reservoir after their release in February 1990, and thus did not attain the size of the 1991 subyearling chinook releases, which likely entered the reservoir by early-to-mid summer and reared there until fall drawdown.

Although the fate of the late-fall chinook emigrants is uncertain, Thorpe (1987) suggested that high growth rates may lead to early maturity, and possible residualism in anadromous salmonids. Low migratory disposition (as suggested by low ATPase levels), high growth rates, and potential residualism may be interrelated in these late-fall Green River chinook emigrants.

Passage of 21,513 chinook subyearlings represents approximately 1.1% of the 1991 release group. As monitoring did not cover the total passage period, this estimate of subyearling survival to the dam is probably conservative.

Dye-mark recoveries at the mainstem fyke trap are summarized in Table 8. These data suggest similar survival to the fyke trap for upper mainstem releases (Appendix A). Both groups were recovered over the same time period (late May to late June/early July) at similar sizes. Median recovery of the uppermost release (Snow Creek) was about 10 days later than the mainstem release. The later recovery of the Snow Creek fish may be related to the fact that the Snow Creek release site is about 8.5 miles further upstream than the mainstem release site.

Dye-mark recoveries at the scoop trap are summarized in Table 9. Recovery at the scoop trap encompassed a much longer period (early April to mid-November) than at the mainstem fyke trap. North Fork recoveries appear comparable to mainstem recoveries at the scoop trap, but Snow Creek recoveries are relatively low. The November recoveries of both mainstem (orange) and North Fork (green) chinook (Table 9) clearly indicated that young-of-the-year chinook reached substantial size by the time of fall drawdown, as scale analysis also indicated (Table 3).

The dominant injuries recorded for subyearling chinook recovered at the scoop trap during radial gate, bypass-and-radial gate, and bypass operations were partial descaling and eye damage (Table 4). These two injuries were consistently observed during the study. Subyearlings had higher multiple injuries and mortalities than other species/year classes over the entire evaluation. No clear differences in injury rates were apparent during different periods of gate operation (radial versus bypass).

Coho Yearlings

An estimated 5,901 coho yearlings egressed from the reservoir during the study (Table 2). Emigration from the reservoir was observed at the start of trapping on April 11th and continued through June with peak movement occurring in late April and early May (Figure 13). Mainstem fyke catches indicate movement into the reservoir during the same period (Figure 14), although a larger proportion of observed catches occurred in late May and early June. It is possible there is some entrapment of coho in the reservoir (Figure 14). However, fyke trap efficiency was unknown and the relative percentages shown may be a function of greater fyke trap efficiency at lower river flow during late May and early June. Coho smolts were not observed entering the reservoir after movement out of the reservoir had ceased (Figure 14). The observed emigration pattern from the reservoir was generally consistent with coho smolt emigration observed in 1984 (Figure 15).

No late-summer or fall emigration of coho yearlings from the reservoir was detected in this study, although previous gillnet sampling in Howard Hanson Reservoir indicated that yearling coho were entrapped in the summer of 1984 (Seiler and Neuhauser 1985) and in the summer of 1989 (Cropp undated). Reasons for this apparent difference in yearling coho presence in late summer are unclear at this time. Additional study of coho emigration at Howard Hanson Dam in 1992 (study in progress) may shed light on this apparent difference.

Reductions in coho yearling passage occurred during both the test and the actual refills in this evaluation. These daily reductions in yearling passage were significantly related to outflow during the test refill (r^2= 0.95), and to both outflow and depth during the period of bypass operation in the actual refill (r^2= 0.97). Coho passage in relation to reservoir elevation and outflow over the entire season is shown in Figures 13 and 16, respectively.

Scoop trap catches of coho below Howard Hanson Dam in spring of 1984 (Figure 15) and corresponding elevations and outflows (U.S. Army Corps of Engineers reservoir data) also showed a reduction in yearling passage significantly related to reduced daily outflow (r^2= 0.39).

Coho yearlings recovered at the scoop trap averaged approximately 110 mm forklength (Table 7), which was consistent with those captured in the spring 1984 WDF scoop trap sampling below Howard Hanson Dam (Seiler and Neuhauser 1985).

Passage of 5,901 coho yearlings represents approximately 0.44% of the 1990 coho fry released above Howard Hanson Dam (Appendix A). Monitoring in this study should have covered most of the potential emigration of coho smolts from the upper watershed. This survival value appears low compared to the 1.1% fry-to-smolt survival reported by Seiler and Neuhauser (1985) in their 1984 evaluation of Green River coho fry planting in the upper watershed, and coho fry-to-smolt values reported by Johnson and Cooper (1991) and Smith et al. (1985). Survival of hatchery fish after stocking is variable, however, being a function of a number of factors including stream productivity, habitat quality, the physical condition of hatchery fish and their ability to acclimatize to stream conditions, the size and stocking density of hatchery relative to wild fish, depredation and disease, genetics (origin of stock), and stocking practices and techniques (Steward and Bjornn 1990; Smith et al. 1985). Superimposed on these survival factors for anadromous fish in the upper Green River is the uncertain effect of the Howard Hanson project.

The dominant injury observed for coho yearlings at the scoop trap was partial descaling (Table 4). Partial descaling was about 16% higher when the radial gate was in operation compared to the bypass, although few fish (15 individuals) were available for comparison during bypass operation. In general, however, serious coho yearling injury and mortality were low during radial gate operation in spring of 1991. During bypass discharge, bruising, eye injuries, and multiple injuries were observed more frequently than during radial gate operation. In comparison, Seiler and Neuhauser (1985) observed no injury or mortality during radial gate operation, but reported about 3% mortality or severe injury (no details on injuries) among coho smolts during bypass discharge in 1984.

Coho Subyearlings

An estimated 31,635 subyearling coho egressed from the reservoir during the study (Table 2). Virtually all emigration occurred during spring and fall. Observations in mainstem fyke trap catches indicated fish moving downriver starting in April and continuing until mid-June (Figure 17). Since coho subyearlings normally do not migrate until the following spring, it is reasonable to assume that these fish were moving downriver due to displacement after release which occurred in mid April (Appendix A). Corresponding movement at the dam occurred in early spring prior to actual refill, but little further movement occurred until final drawdown in November (Figure 17), unlike chinook subyearlings (Figure 9). This suggested that coho subyearlings were entrapped or delayed in the reservoir until fall drawdown.

As with subyearling chinook, we surmise that young-of-the-year coho delayed by the project attain large size due to reservoir rearing, in contrast with coho subyearlings which rear in the upper watershed above the reservoir for one year prior to typical spring emigration. However, ATPase values for reservoir-delayed coho (Table 5) indicated a very low readiness to emigrate (Table 6), even though mean size of these fish was similar to yearling coho passing the project in the spring (Table 7).

No statistically significant relationships were found between daily coho subyearling passage and reservoir elevation or outflow until the final fall drawdown beginning November 6th (Figures 18 and 19). Of interest was the large pulse of subyearling coho observed passing the dam beginning that date, when the radial gate opened (Table 2). From that date forward, 8,397 subyearling coho (over one-third of the total coho observed) were estimated to pass the dam. During this period (November 6 to 22), coho passage was significantly related to increased outflows at the dam ($r^2 = 0.27$).

Passage of 31,635 coho subyearlings during the study period conservatively represents approximately 3.1% of the fry planted in 1991 above the dam. Further subyearling emigration probably also occurred after the end of monitoring in late November.

Relatively few injuries were observed among subyearling coho throughout the study period (Table 4). Some partial descaling and eye injury were observed during radial gate operation in spring and fall, but virtually no observations were available for comparison during summer operation of the bypass.

Steelhead

An estimated 259 steelhead smolts egressed from the reservoir during the study (Table 2). Given the low number of steelhead captured in the scoop trap (5 total smolts; Appendix B), the apportioned hydroacoustic estimate (259) may not adequately represent total steelhead abundance or emigration timing as implied in Table 2.

Low scoop trap steelhead captures may be explained by several factors. First, in a previous evaluation of steelhead passage at Howard Hanson Dam (Seiler and Neuhauser 1985), a total of 181 naturally reared smolts were captured during spring of 1984, with a late-April to mid-May peak in abundance (Figure 20). The 1984 recoveries were based on continuous operation of the trap from April 1 to June 15. In 1991, scoop trap operation did not begin until April 11, and then at a frequency of only twice per week until April 18, after which the trap was fished only every other day for the rest of the potential steelhead smolt recovery period (mid- to late-June). Thus, sampling during the potential steelhead smolt recovery period in 1991 was less than half that of 1984 .

A second factor in low steelhead captures at the scoop trap was that streamflows were lower during portions of the 1991 emigration compared to the 1984 season (Figure 21). Lower streamflows in 1991 translate into lower potential velocities at the scoop trap compared to 1984. As steelhead smolts require the highest velocity of all anadromous salmonids to maximize trapping efficiency in a scoop trap (7 to 8 feet per second, optimally), a lower recovery rate may be expected at the Howard Hanson trap site in 1991 compared to 1984. Figure 4 shows velocities encountered at the scoop trap over the season in 1991.

A third factor in low steelhead captures was that fewer steelhead fingerlings were released in 1989 compared to 1982, which would reduce expected smolt production, all other factors being equal. The 1989 release was only 51% of the size of the 1982 release (46,530 versus 91,772 fingerlings).

Other Salmonids

Scoop trap catches of other salmonids were minimal and scattered throughout the study. A total of 31 resident rainbow trout and 14 cutthroat trout were recorded. These fish were not used in the apportioning of the hydroacoustic counts because their numbers were negligible and they were assumed to be from a resident population below the dam.

SUMMARY

We evaluated passage of juvenile anadromous salmonids through the spring-to-fall refill and drawdown cycle of the Howard Hanson Project in 1991. Anadromous salmonids originated from annual chinook, coho, and steelhead fry releases in the upper watershed beginning in 1989. We fished fyke traps on the principal reservoir tributaries to gauge fish movement into the reservoir, and operated hydroacoustic gear in the dam's exits to estimate fish movement through the dam. A scoop trap was periodically fished downstream of the dam to apportion hydroacoustic estimates of total daily fish passage into species and year classes of emigrating salmonids. Fish passage through the project was examined in relation to seasonal changes in reservoir elevation and outflow, including a "test" refill in mid-May (partial raise and drop of the reservoir before the actual full-pool summer raise of the reservoir in late May).

Our principal findings were:

1) Overall fish movement past the project was characterized by a) large pulses of coho subyearlings and yearlings in the spring before refill, b) small pulses of chinook subyearlings in the summer after refill, and c) large pulses of both chinook and coho subyearlings in late fall at final reservoir drawdown. During monitoring of the dam's exits from mid-April until late November of 1991, we estimate passage of approximately 760 yearling chinook, 21,500 subyearling chinook, 5,900 yearling coho, 31,600 subyearling coho, and 260 steelhead smolts. Some passage of both subyearling chinook and coho was believed to occur both before and after our monitoring period, so these estimates may be somewhat conservative.

2) Yearling chinook passage occurred primarily in the spring before project refill. Based on their size and emigration timing, they likely reared in stream habitat since their release in the upper Green River watershed in 1990.

3) Subyearling chinook passage occurred throughout the monitoring period, with a substantial proportion (42%) exiting the project during fall drawdown (approximately the final two weeks of monitoring in November). However, fyke net catches and ATPase values suggested that fall emigrants were probably trapped in the reservoir since refill, as volitional movement from tributaries occurred by late spring/early summer. These trapped fall subyearling migrants were large (nearly 200 mm forklength), but exhibited relatively low ATPase levels (smolt readiness). Over the monitoring period, reservoir outflow accounted for an important part of the variation in subyearling chinook passage through the dam. Subyearling chinook passage was poorly related to reservoir elevation. Therefore, we conclude that greater flow enhances subyearling chinook emigration and reduced flow may hinder emigration.

4) Yearling coho emigration occurred, as expected, in April through June. The size (≈110 mm forklength) and emigration timing of yearling coho suggested that they had reared in the upper watershed above the reservoir since their release in 1990. Yearling emigration at the dam decreased

during both the test and actual reservoir refills. Reservoir outflow accounted for 95% of the reduction during the test fill, and outflow/elevation combined accounted for 97% of the reduction during radial gate operation in the actual refill.

5) Virtually all subyearling coho passed the dam either before summer refill (73%), or at fall drawdown (27%). Spring emigrants were probably displaced from upriver release sites, and appeared to pass the project without major delay prior to summer refill. Later emigrants were trapped in the reservoir through the summer until the final fall drawdown (November 6 to November 22), when substantial emigration occurred. Unlike subyearling chinook, virtually no subyearling coho were detected passing the dam between summer refill and the final fall drawdown. The size of subyearling coho at fall drawdown (≈120 mm forklength) was similar to that of yearling coho smolts, but the subyearlings exhibited very low ATPase levels. Over the monitoring period, only reservoir outflow at final fall drawdown was significantly related to subyearling coho passage at the dam, accounting for 27% of the variation in passage observed during this period.

6) Low numbers of steelhead smolts in scoop trap catches adversely affected our hydroacoustic-based estimate of steelhead abundance. Low steelhead catches were probably related to trapping effort, trapping efficiency, and release group size.

7) No clear differences in fish injuries were observed during different periods of gate operation (radial versus bypass), although only subyearling chinook were consistently available for observation throughout the study period. Subyearling chinook exhibited partial descaling and eye damage during all periods of gate operation. After passage through the radial gate, the dominant injury for yearling coho was partial descaling, but subyearling coho exhibited relatively few injuries after radial gate passage.

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Rob Fritz and Greg Bodine of the Western Washington Fishery Resource Office operated the scoop and fyke traps.

Wally Zaugg of National Marine Fisheries Service conducted laboratory analyses of ATPase.

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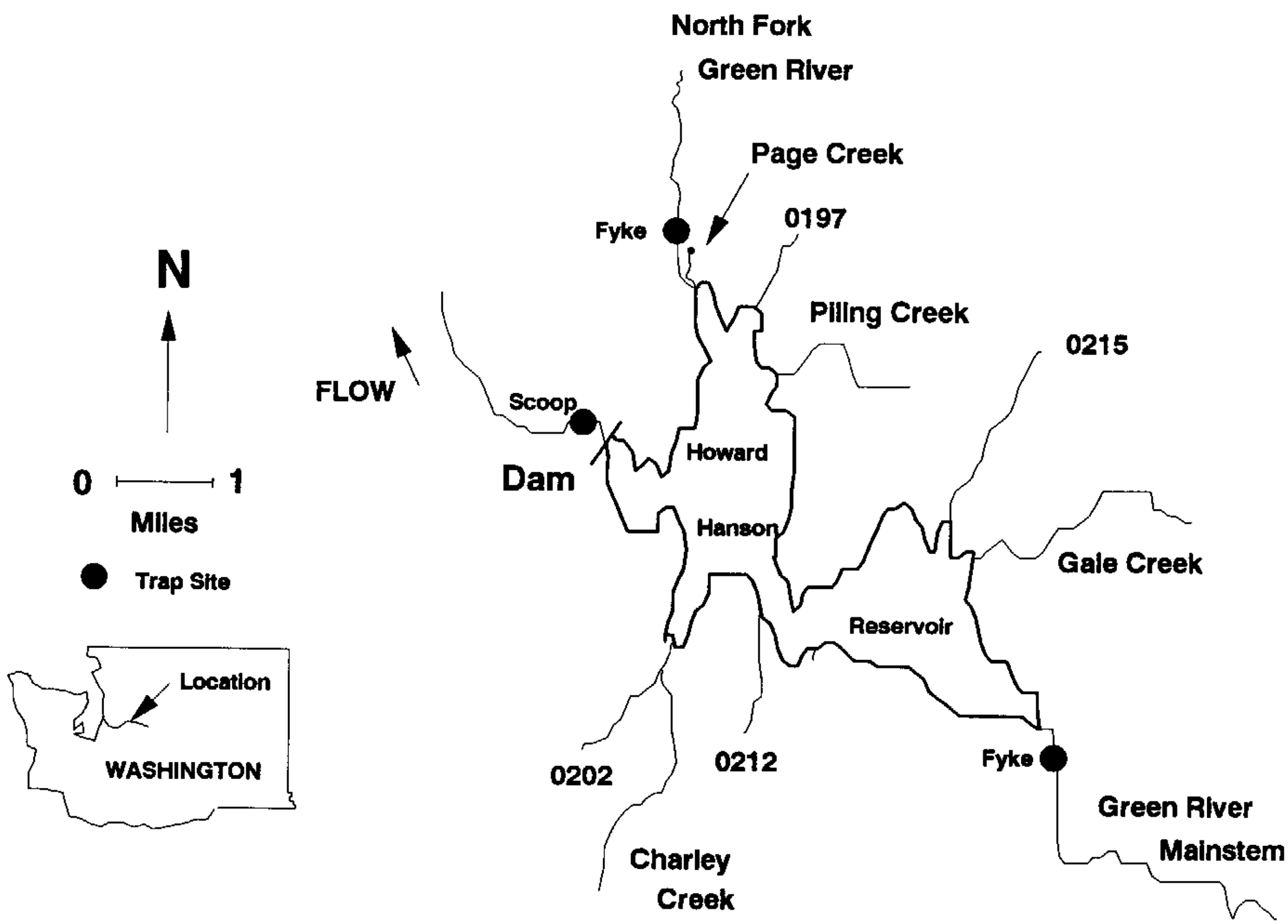

Figure 1. Howard Hanson Reservoir showing trap sites and principal tributaries. Map scale is approximate.

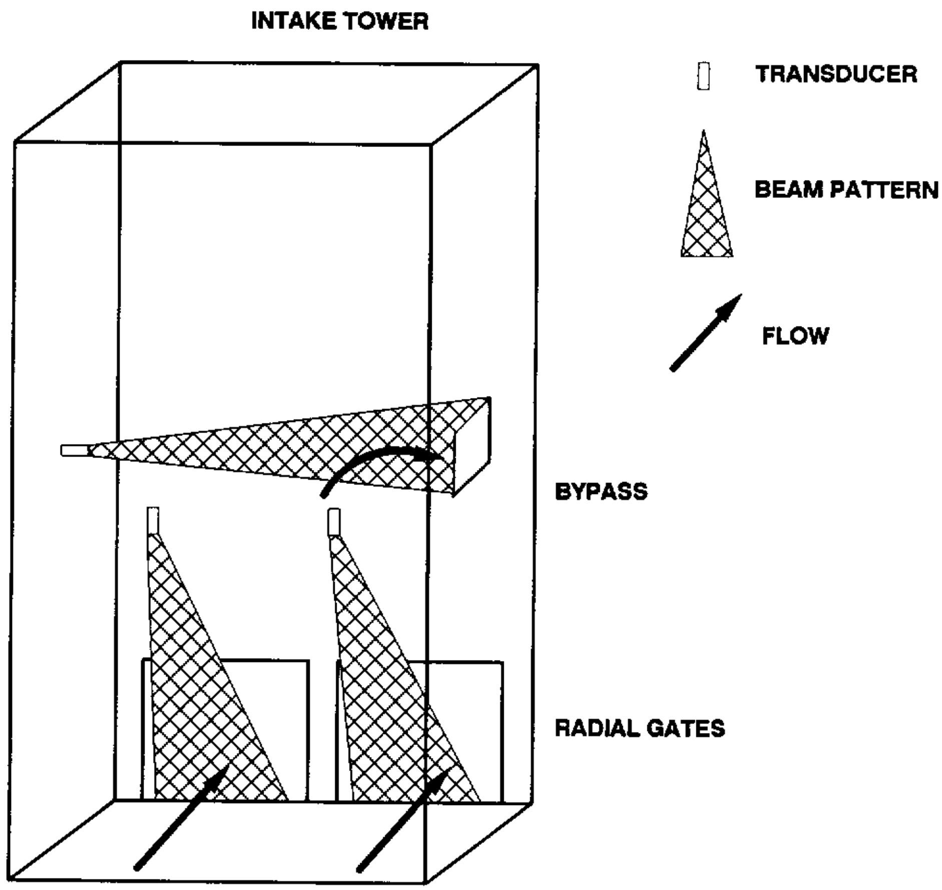

Figure 2. Schematic of the lower section of Howard Hanson Dam intake tower showing approximate locations and beam patterns of transducers relative to radial gates and bypass. Drawing is not to scale.

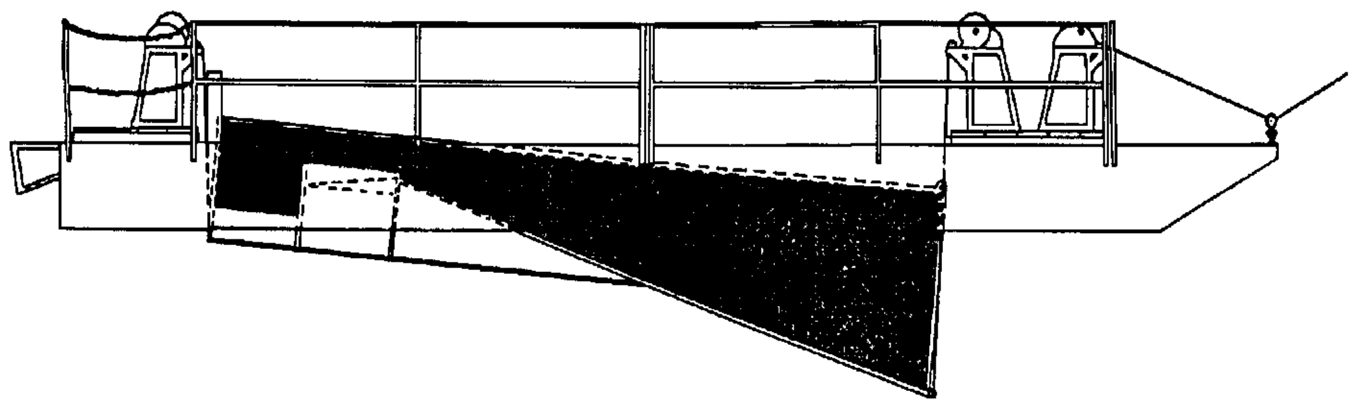

Figure 3. Side view of the scoop trap in fishing position (Source: Seiler et al. 1984.).

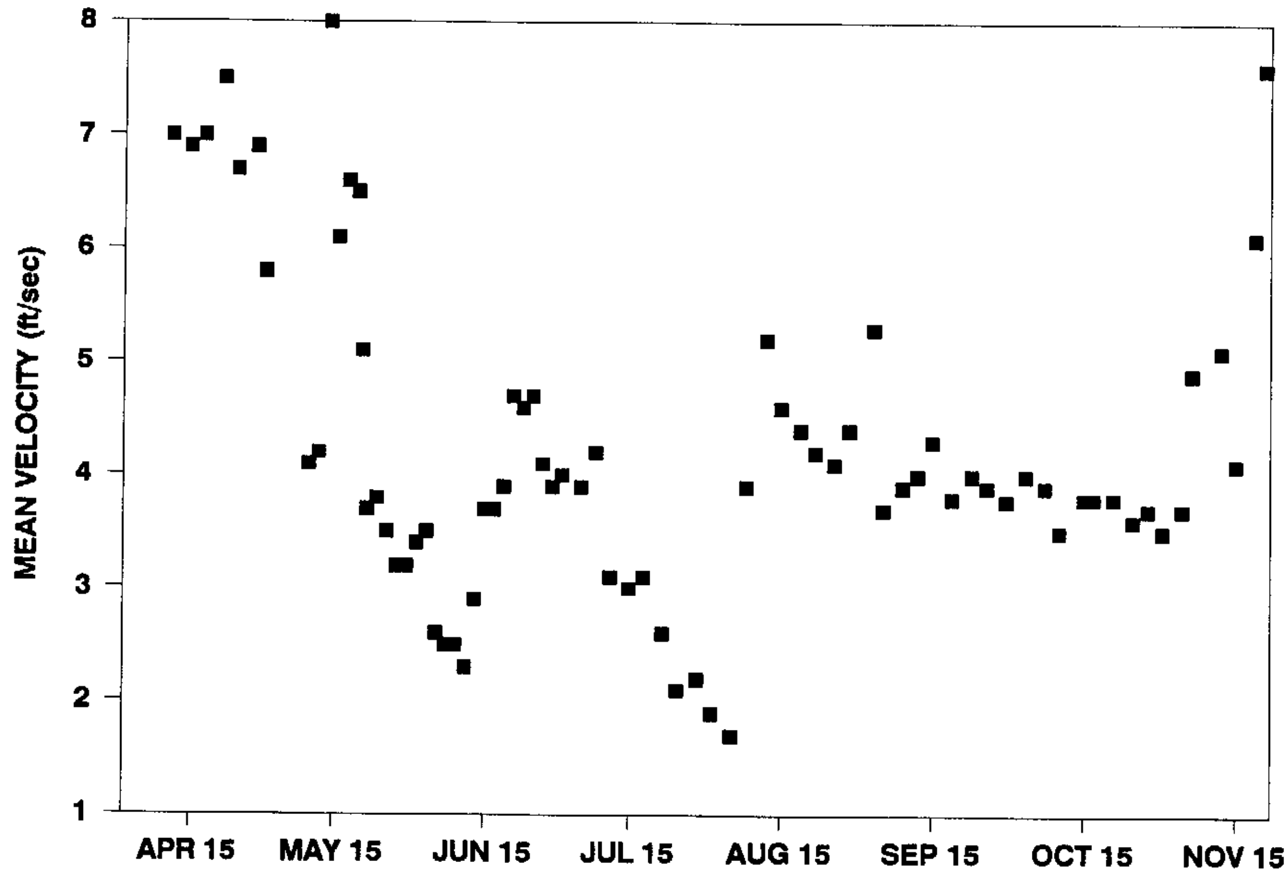

Figure 4. Mean water velocities measured at the mouth of the scoop trap.

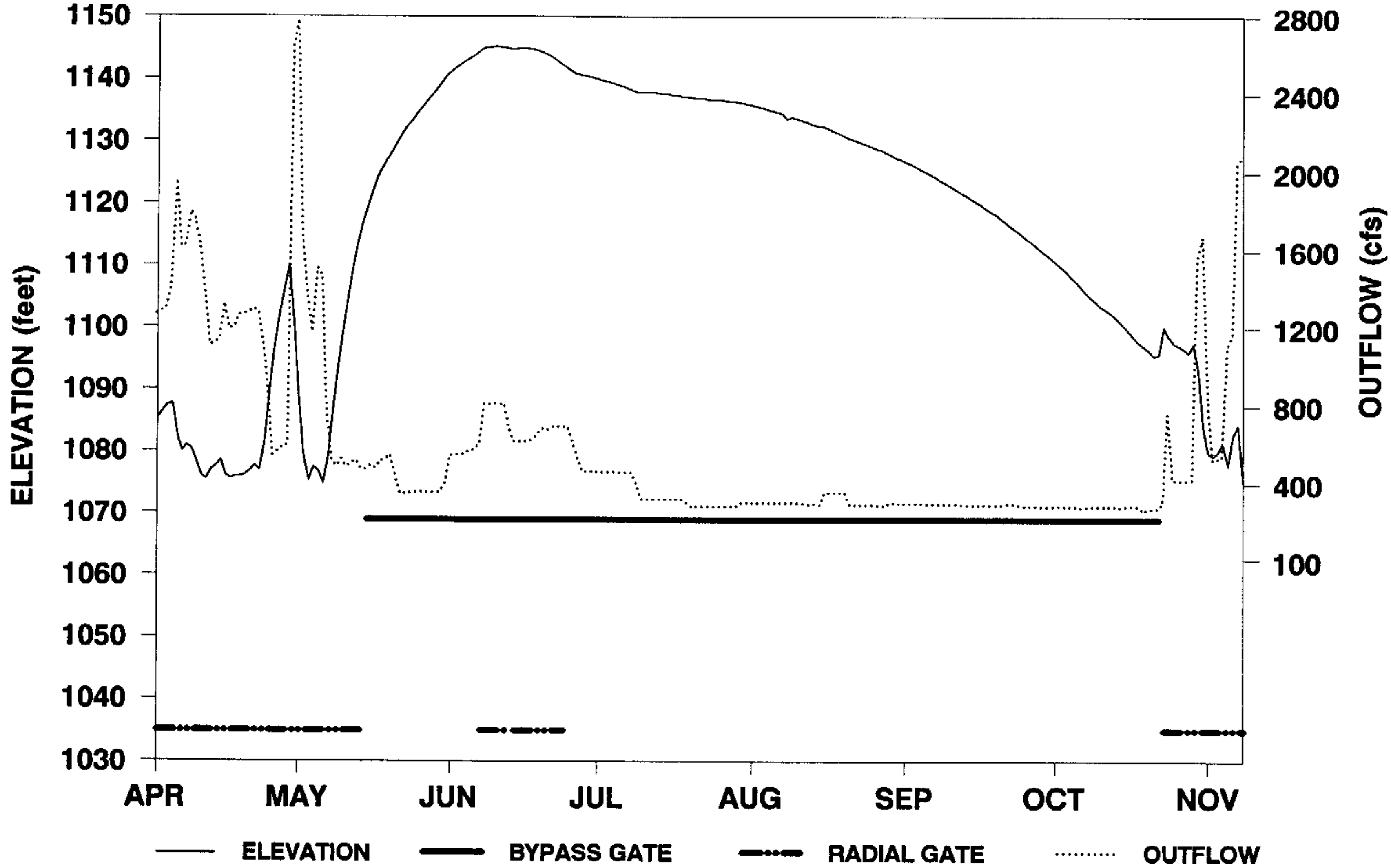

Figure 5. Outflow, reservoir elevation, and periods of gate operation at Howard Hanson Dam during the study period. Mid-months are shown.

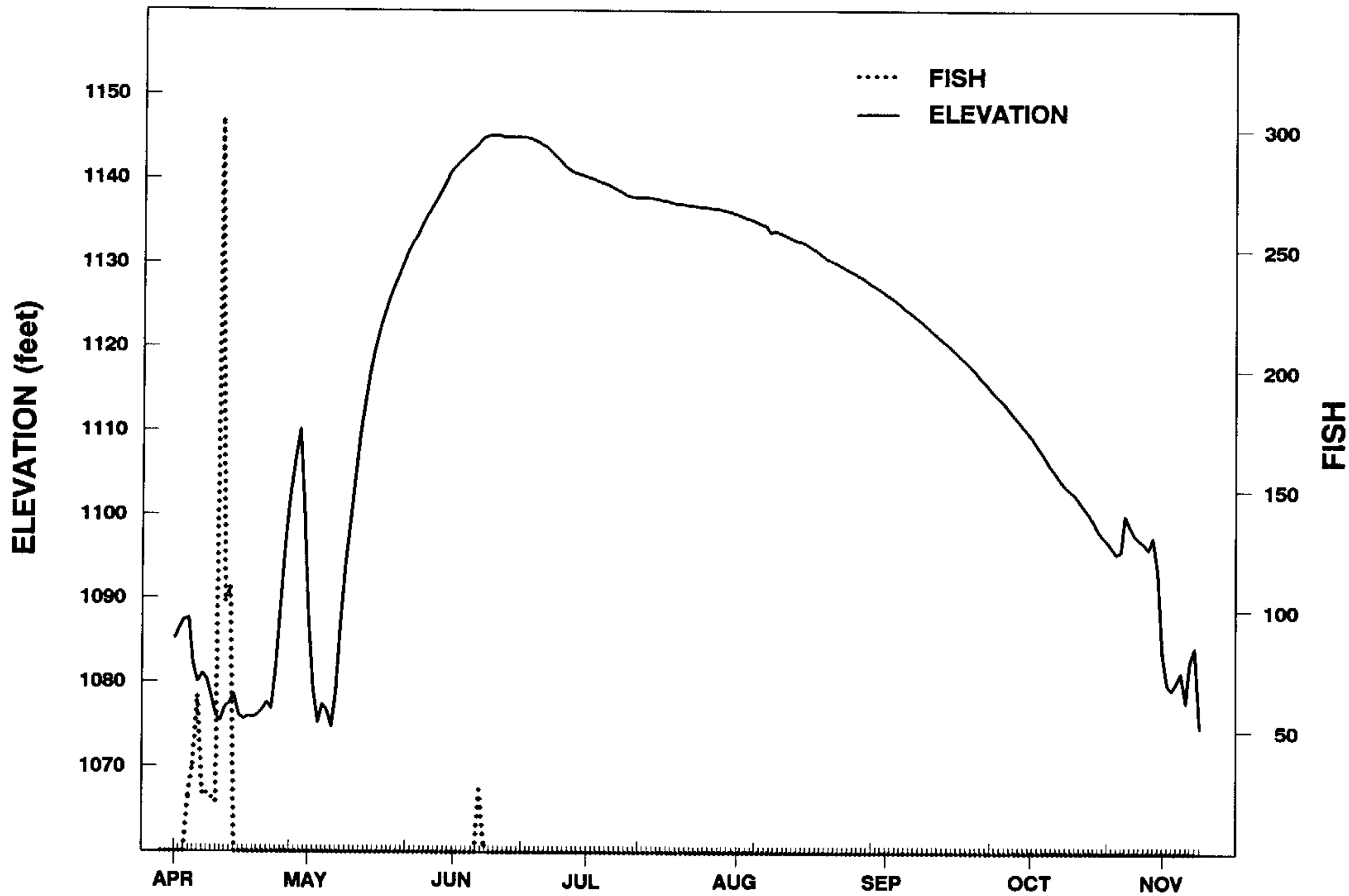

Figure 6. Yearling chinook passage and reservoir elevation at Howard Hanson Dam. Mid-months are shown.

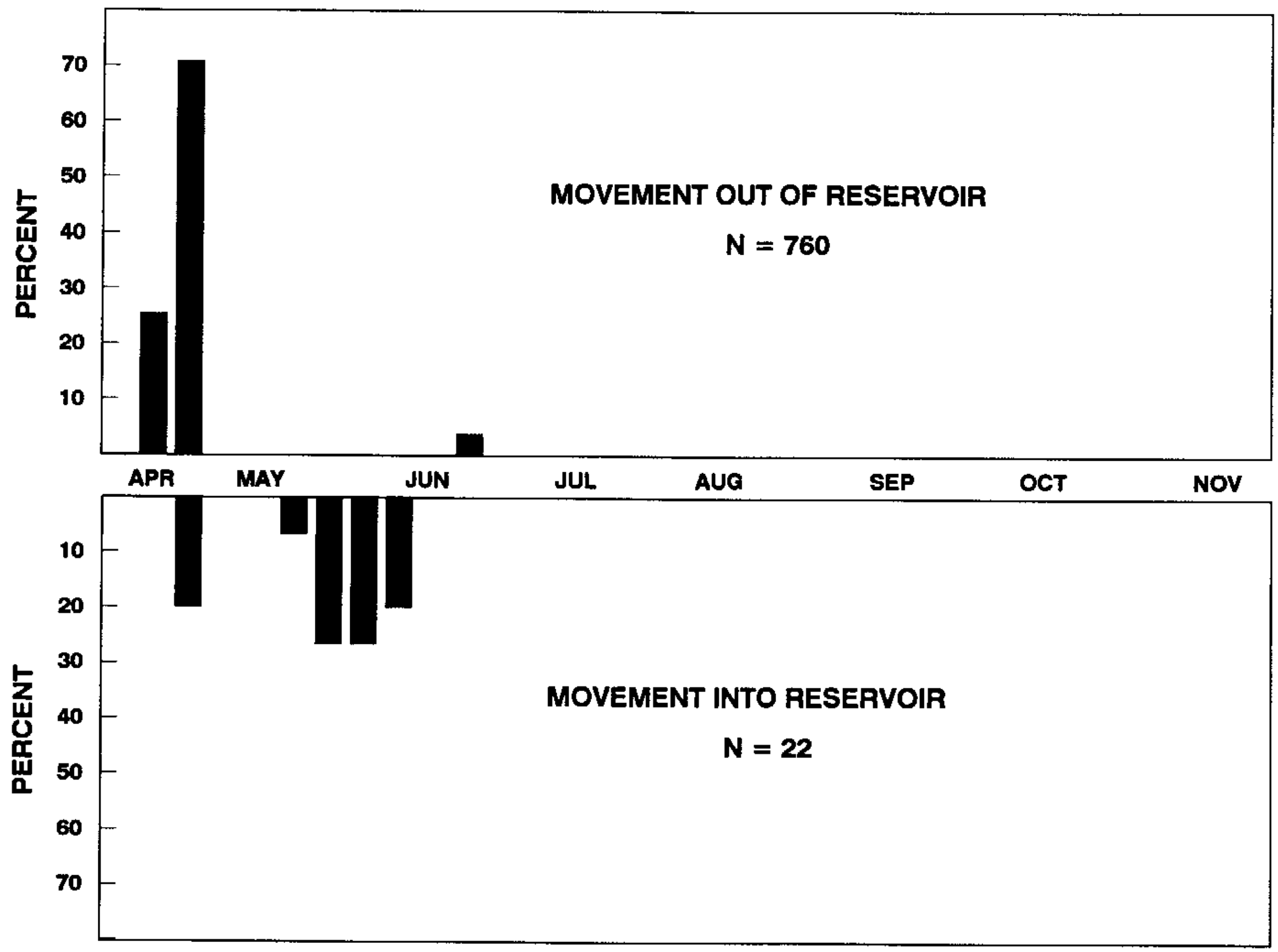

Figure 7. Weekly percentages of chinook yearlings moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates. Mid-months are shown.

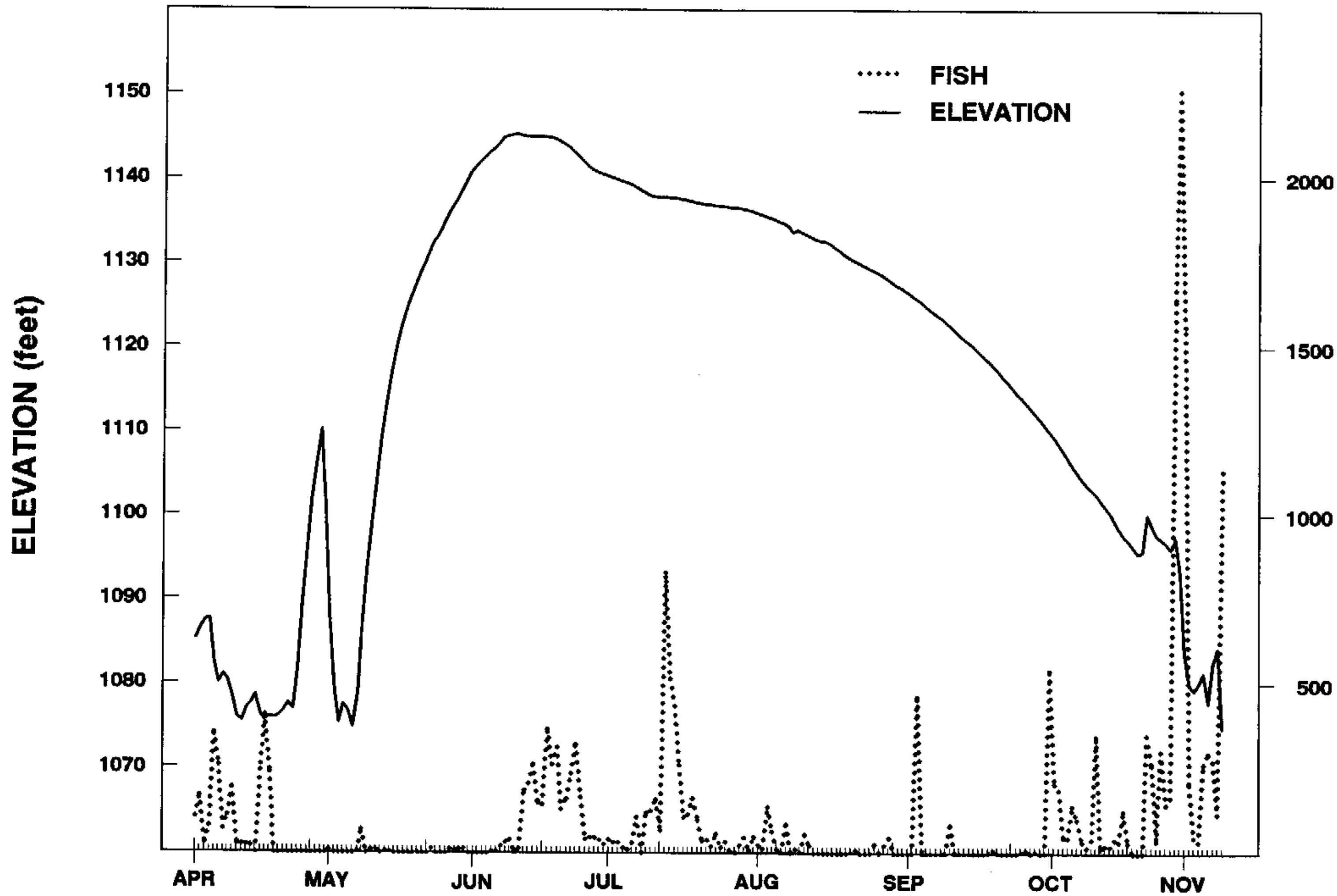

Figure 8. Subyearling chinook passage and reservoir elevation at Howard Hanson Dam. Mid-months are shown.

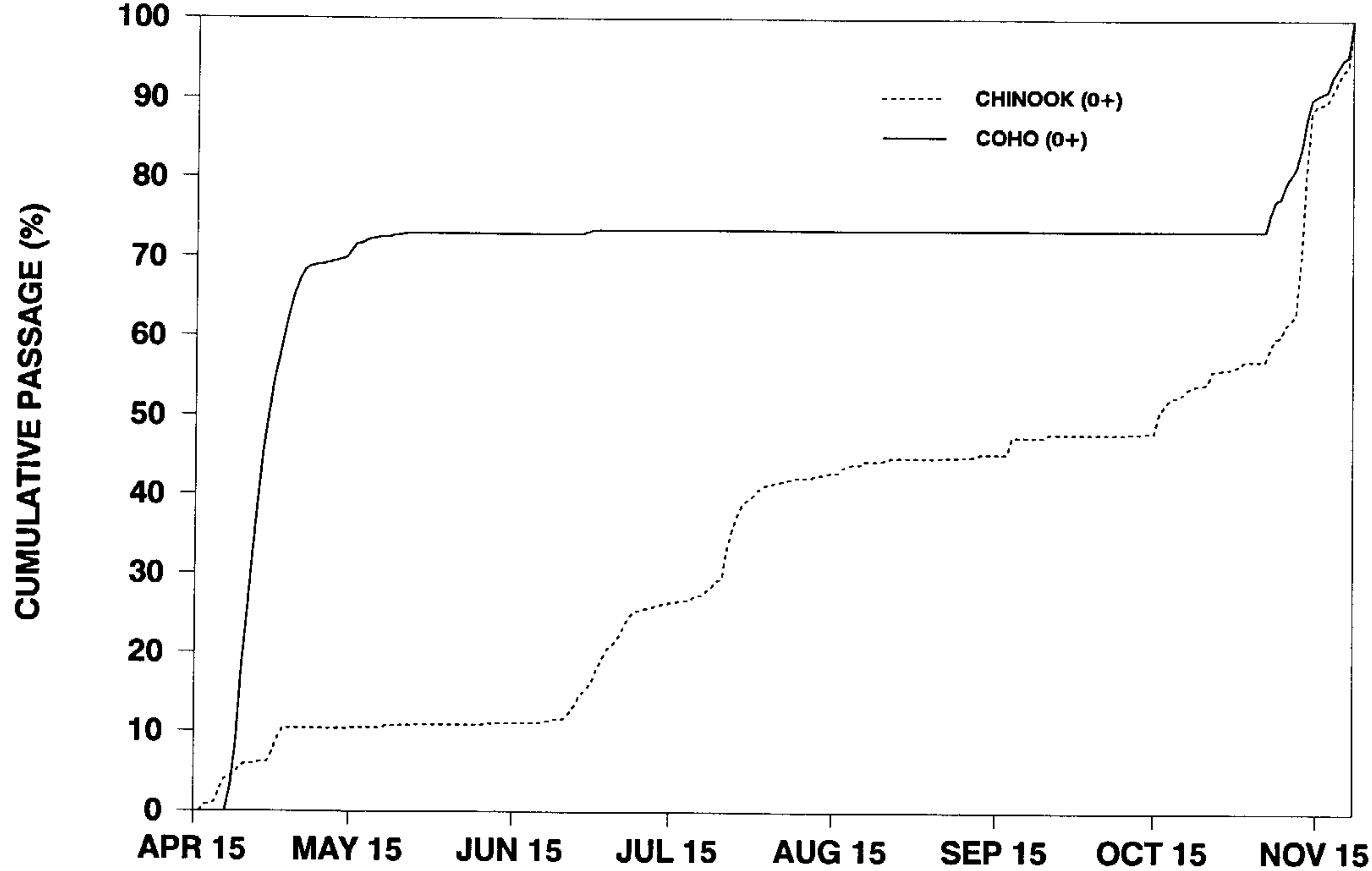

Figure 9. Cumulative passage of subyearling coho and chinook.

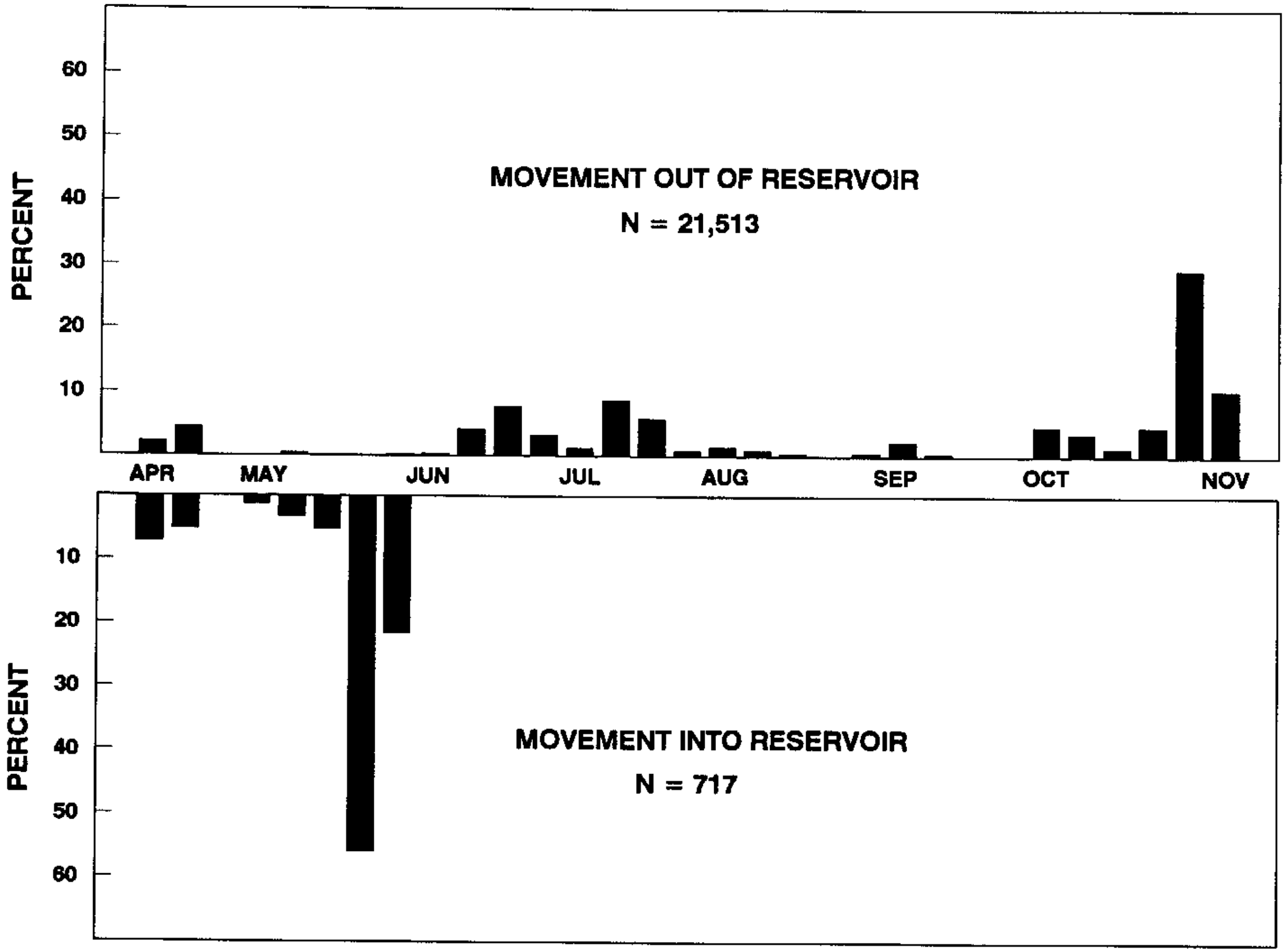

Figure 10. Weekly percentages of chinook subyearling moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates. Mid-months are shown.

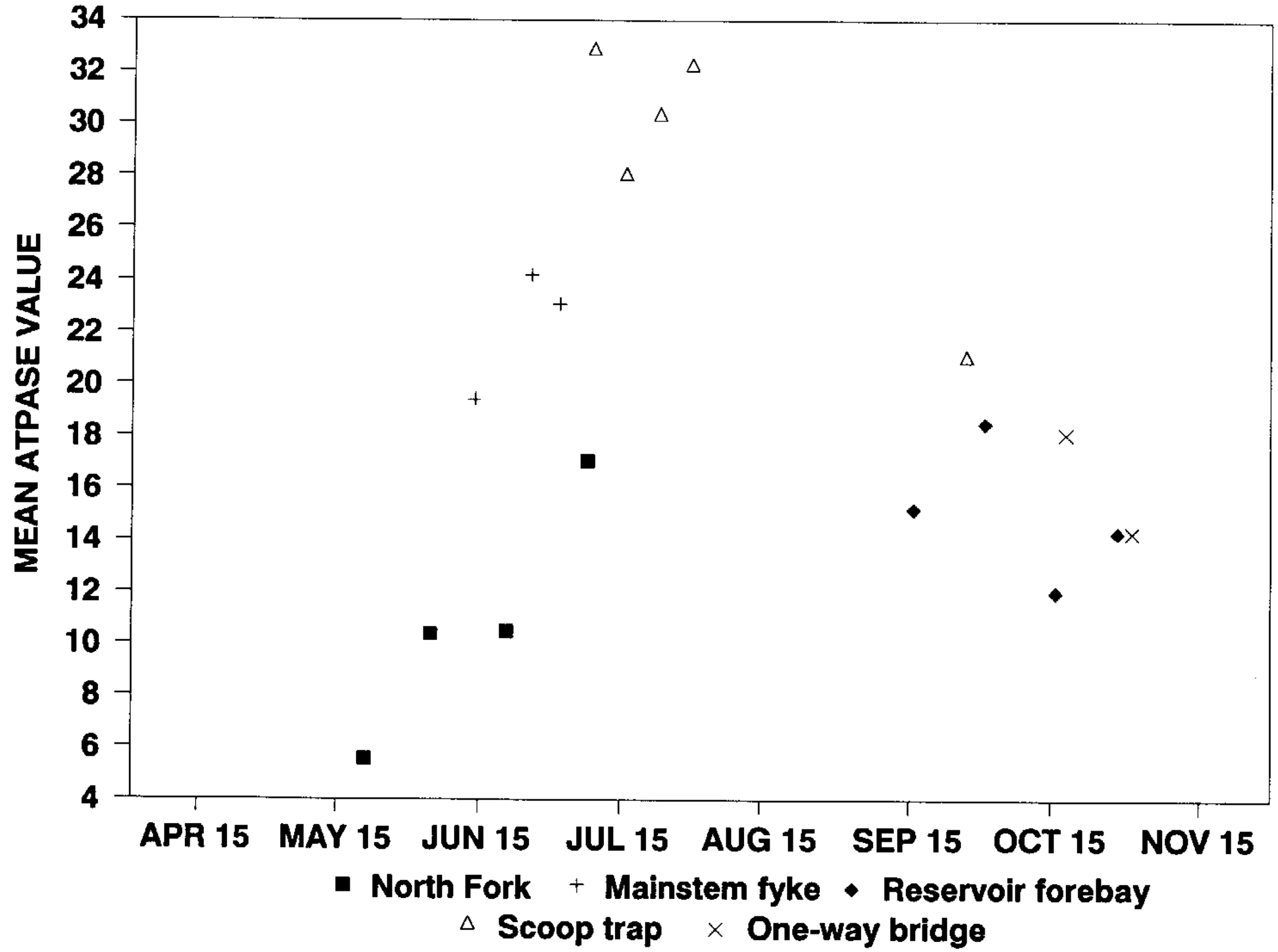

Figure 11. Mean ATPase values for subyearling chinook collected in the Howard Hanson project area. One-way bridge is located 3.5 river miles below the scoop trap.

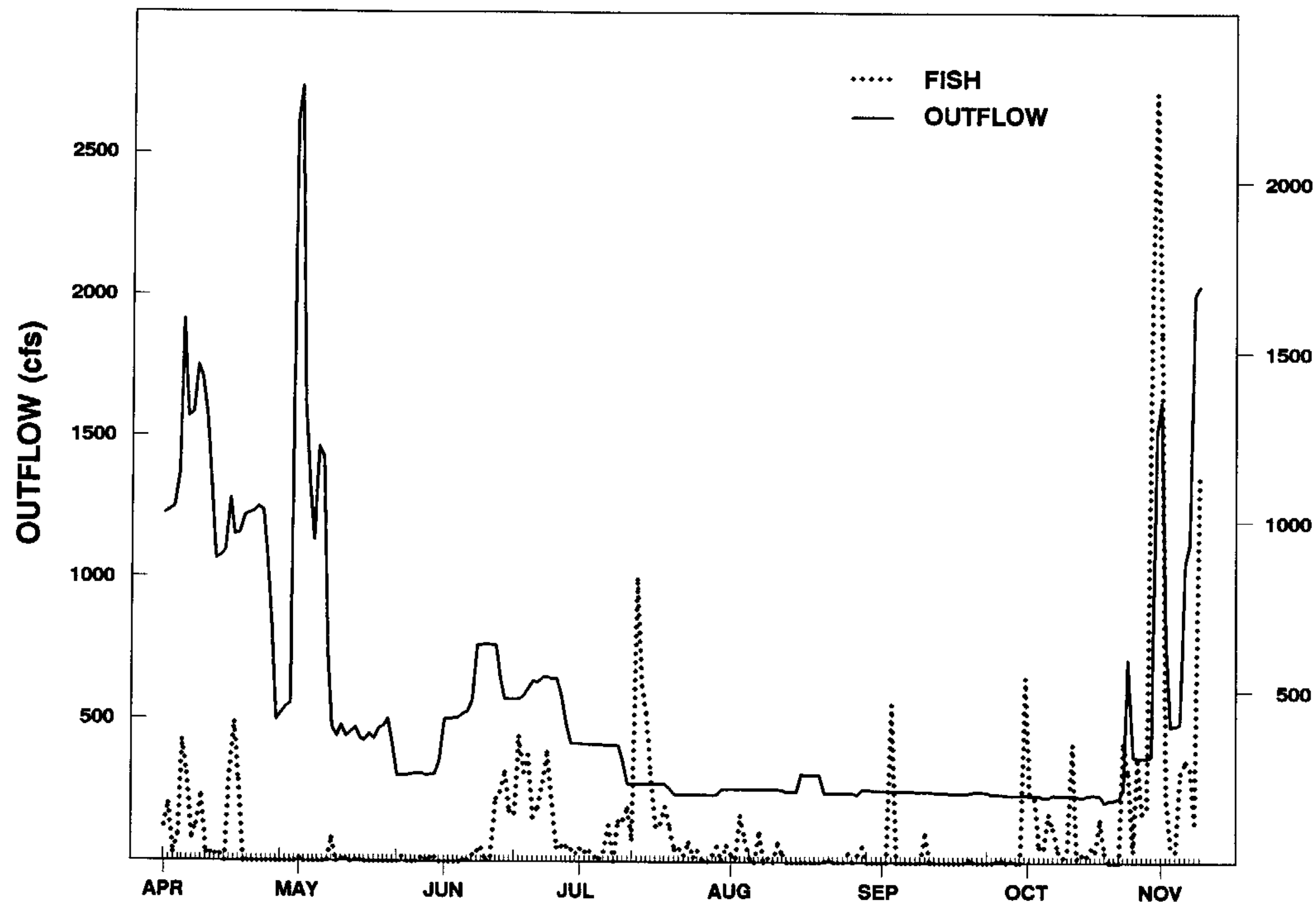

Figure 12. Subyearling chinook passage and outflow at Howard Hanson Dam. Mid-months are shown.

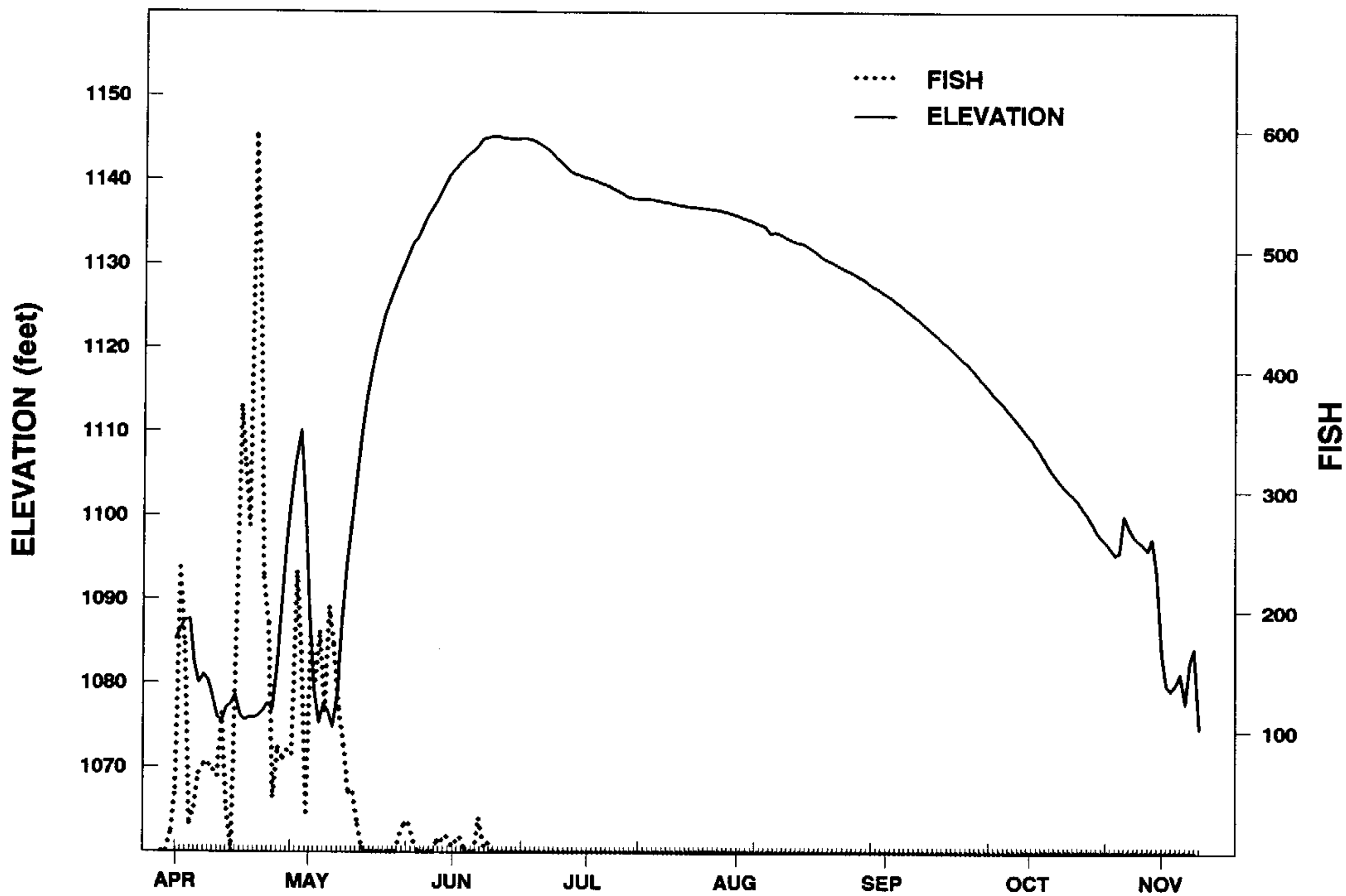

Figure 13. Yearling coho passage and reservoir elevation at Howard Hanson Dam. Mid-months are shown.

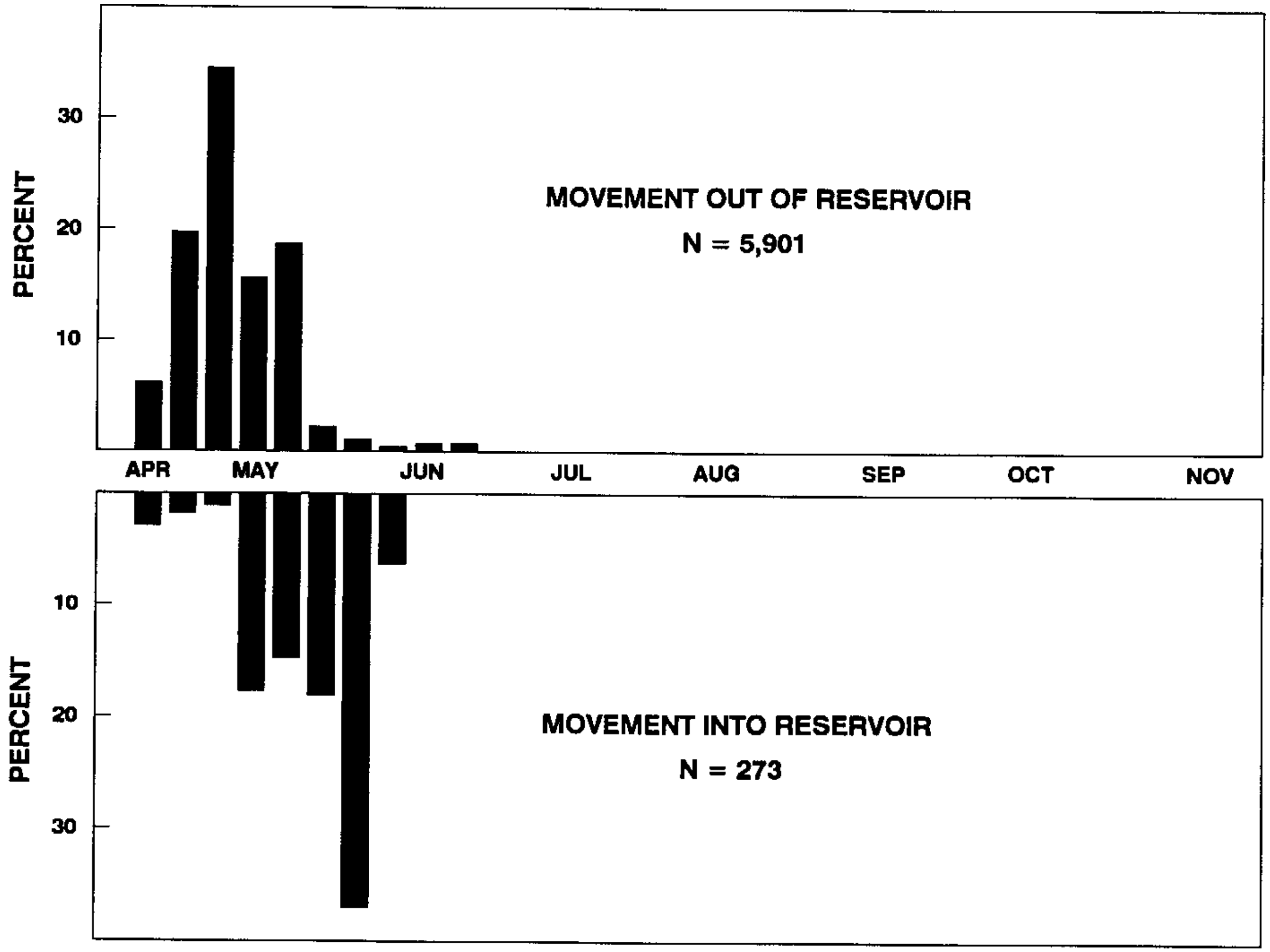

Figure 14. Weekly percentages of coho yearlings moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates. Mid-months are shown.

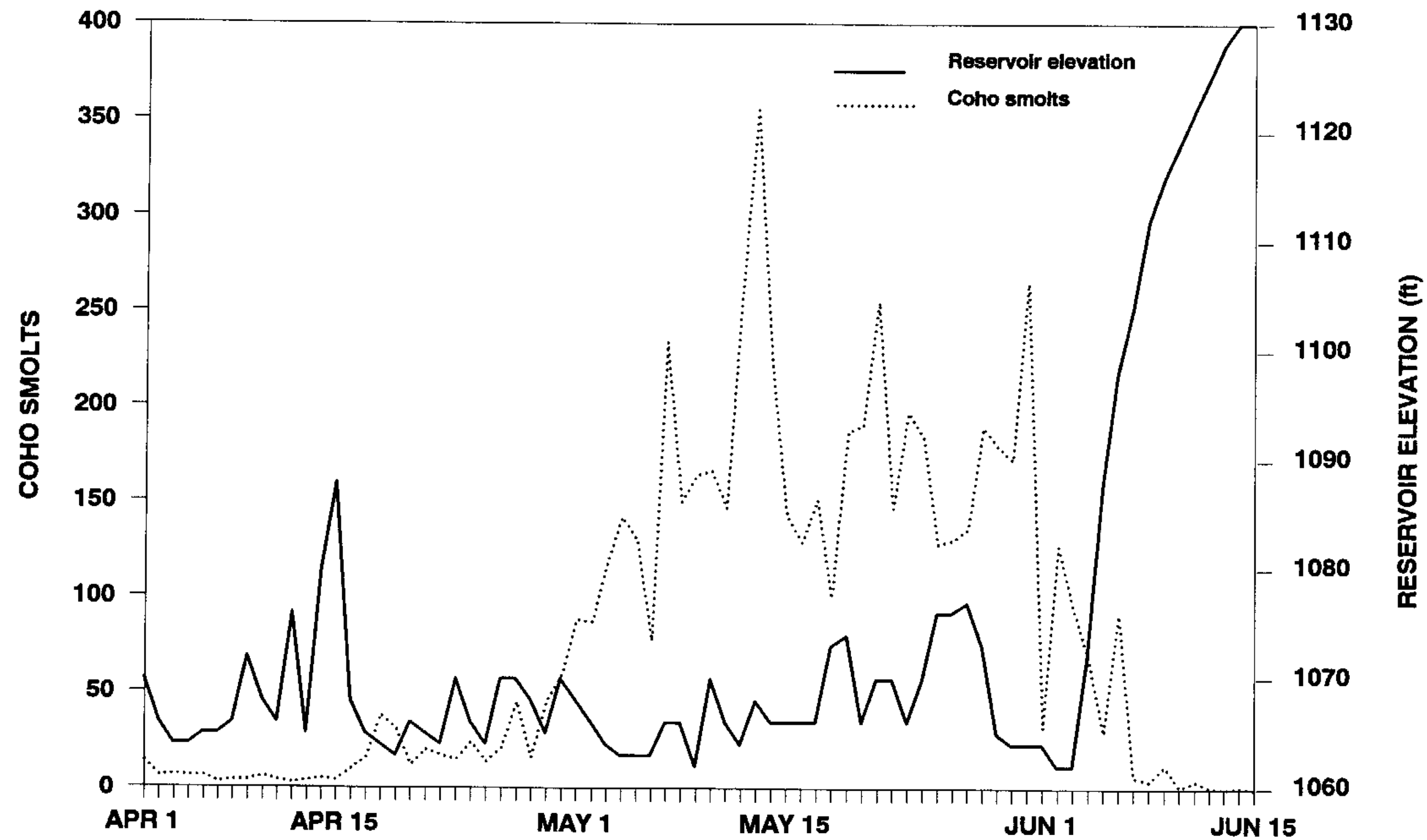

Figure 15. Daily scoop trap catches of coho smolts and elevations of Howard Hanson Reservoir in 1984. Source: Seiler and Neuhauser (1985) and U.S. Army Corps of Engineers.

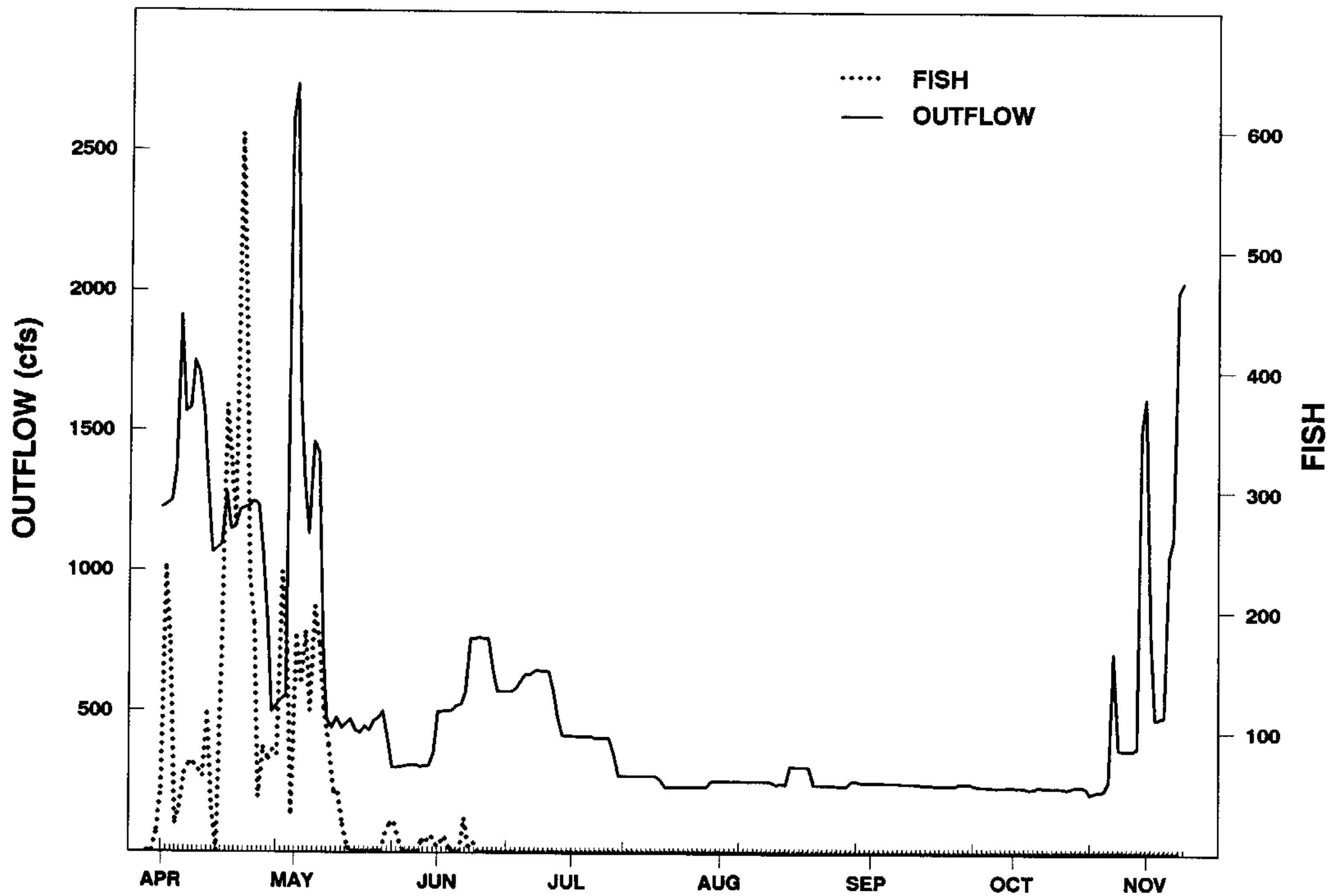

Figure 16. Yearling coho passage and outflow at Howard Hanson Dam. Mid-months are shown.

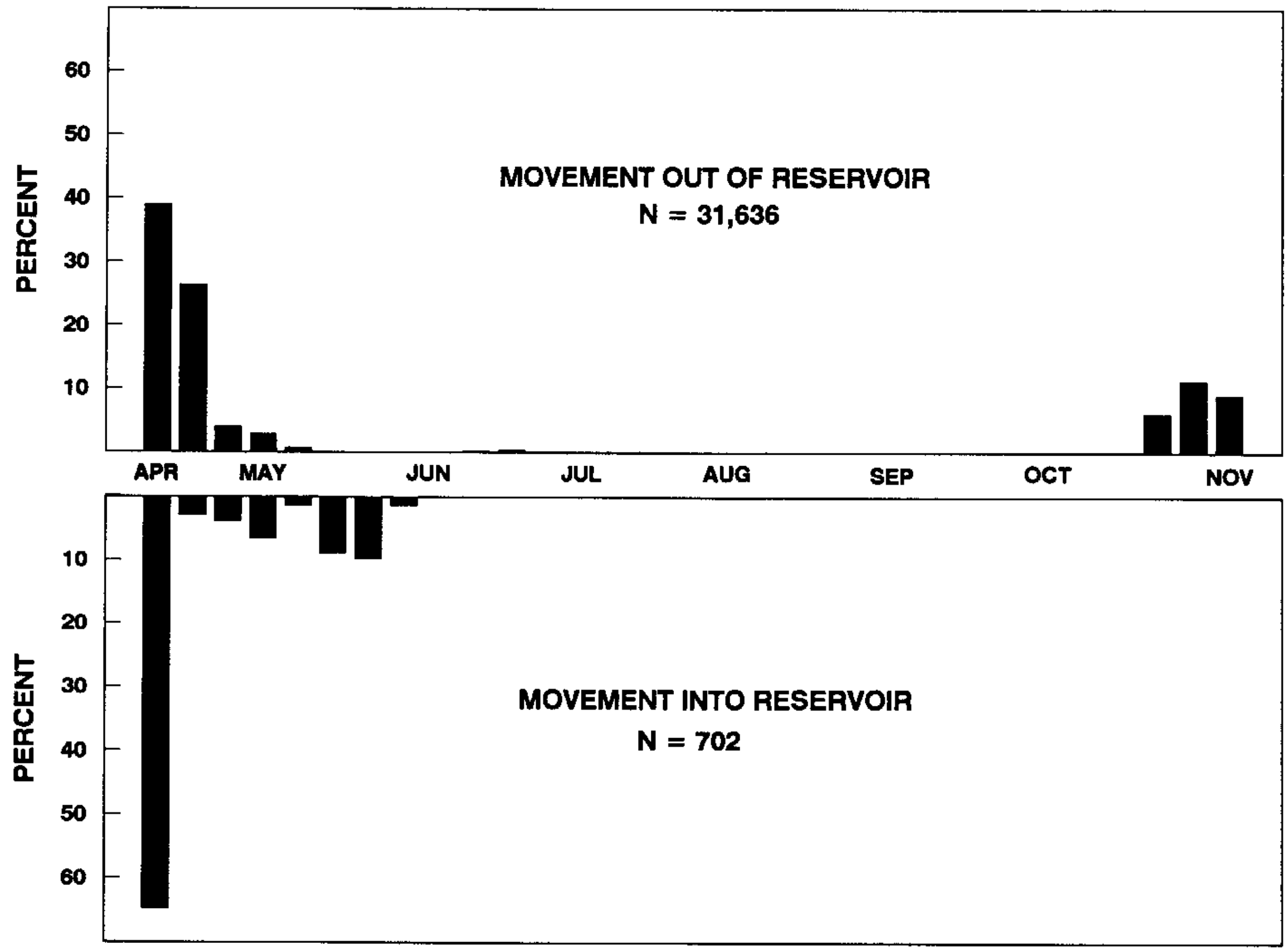

Figure 17. Weekly percentages of coho subyearlings moving into and out of Howard Hanson Reservoir based on mainstem fyke catches and hydroacoustic/scoop trap estimates. Mid-months are shown.

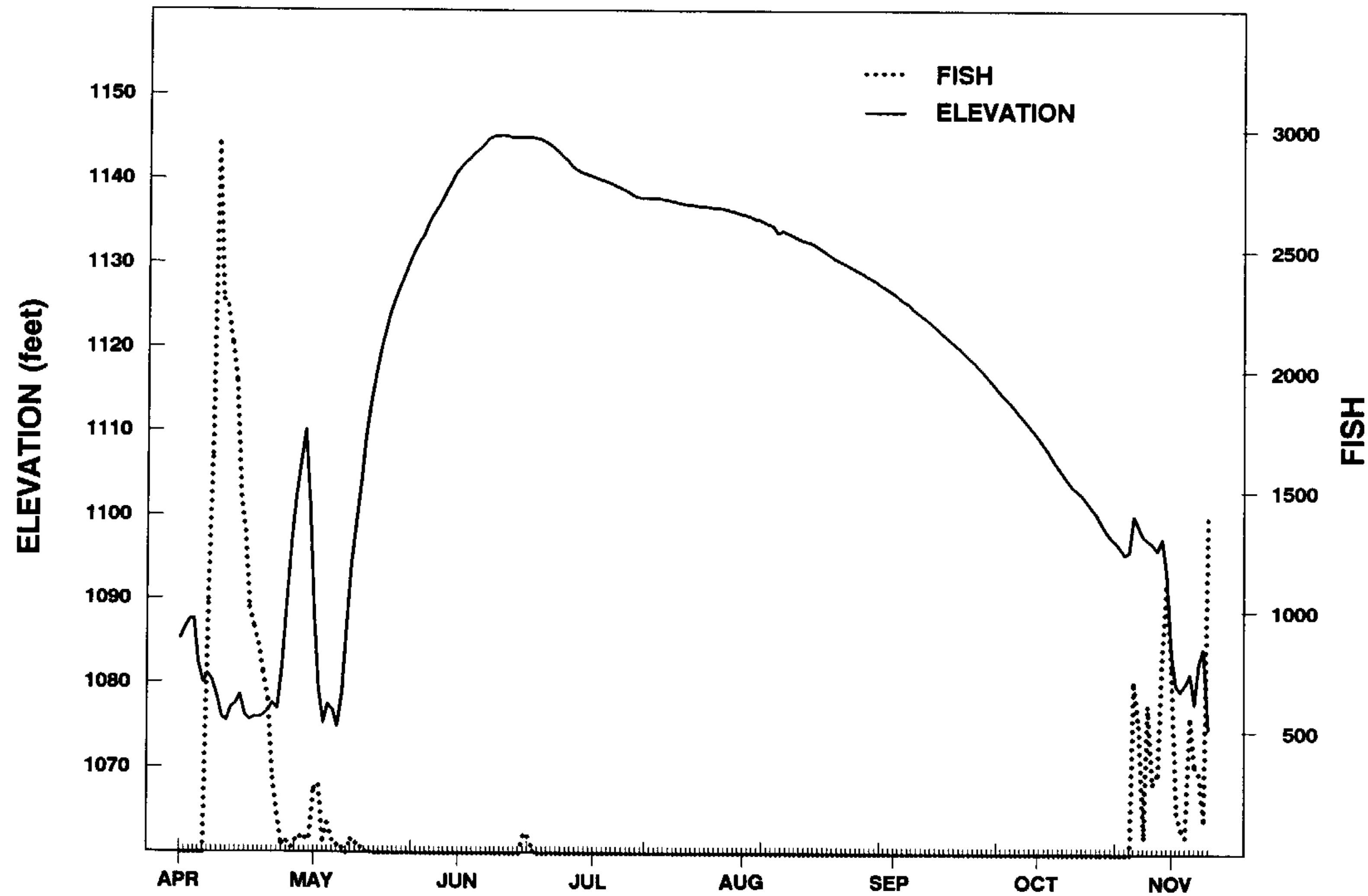

Figure 18. Subyearling coho passage and reservoir elevation at Howard Hanson Dam. Mid-months are shown.

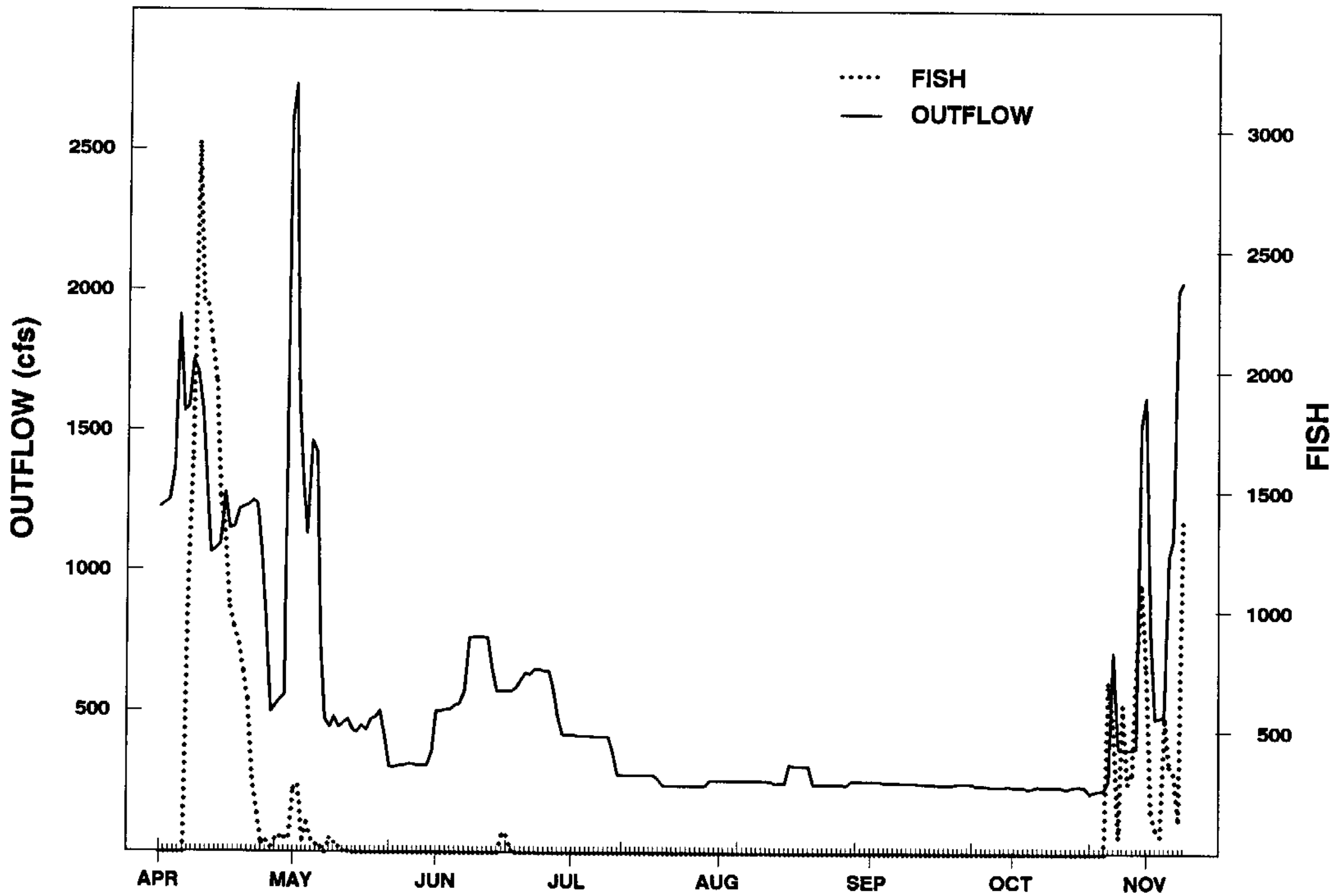

Figure 19. Subyearling coho passage and outflow at Howard Hanson Dam. Mid-months are shown.

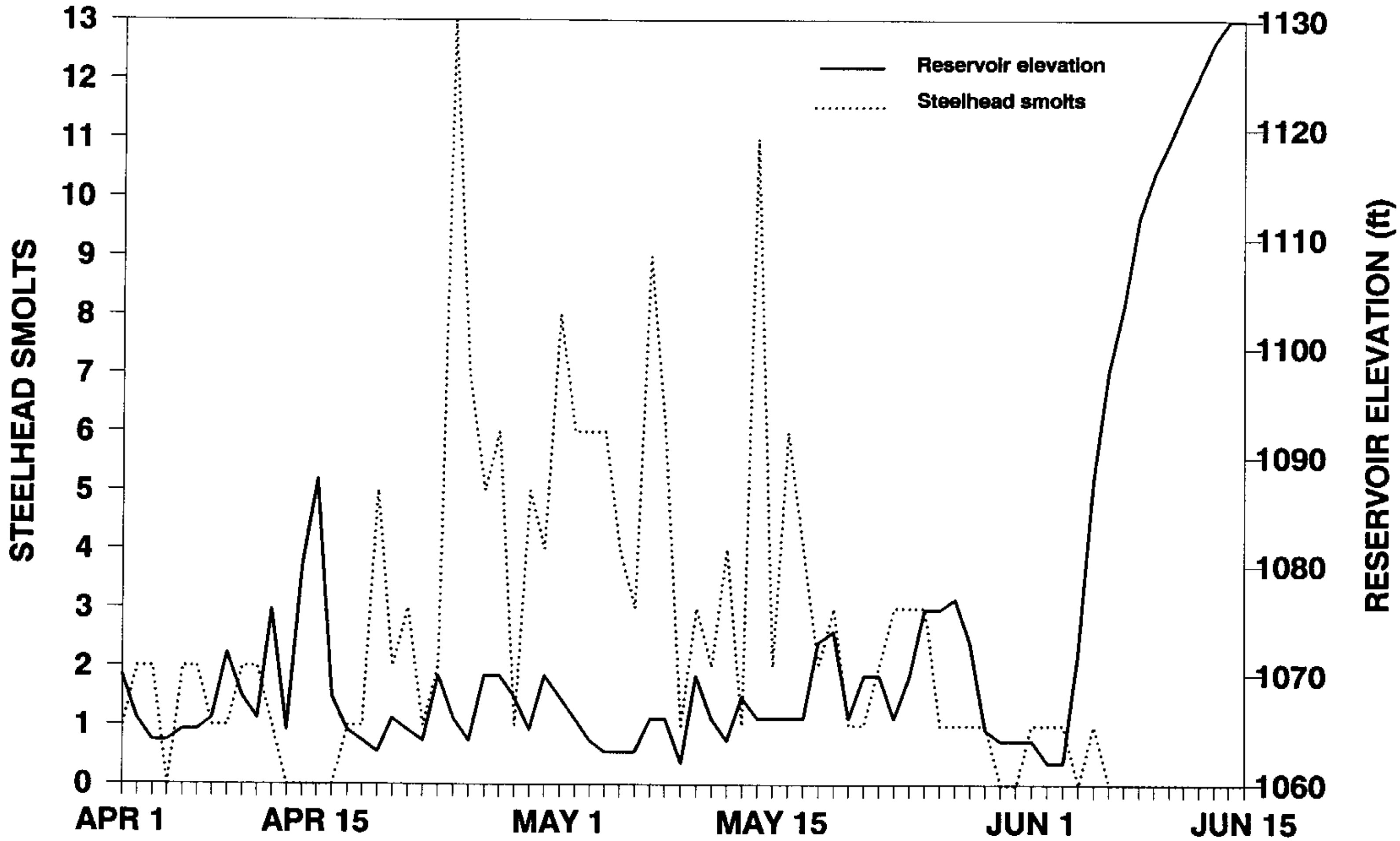

Figure 20. Daily scoop trap catches of steelhead smolts and elevation of Howard Hanson Reservoir in 1984. Source: Seiler and Neuhauser (1985) and U.S. Army Corps of Engineers.

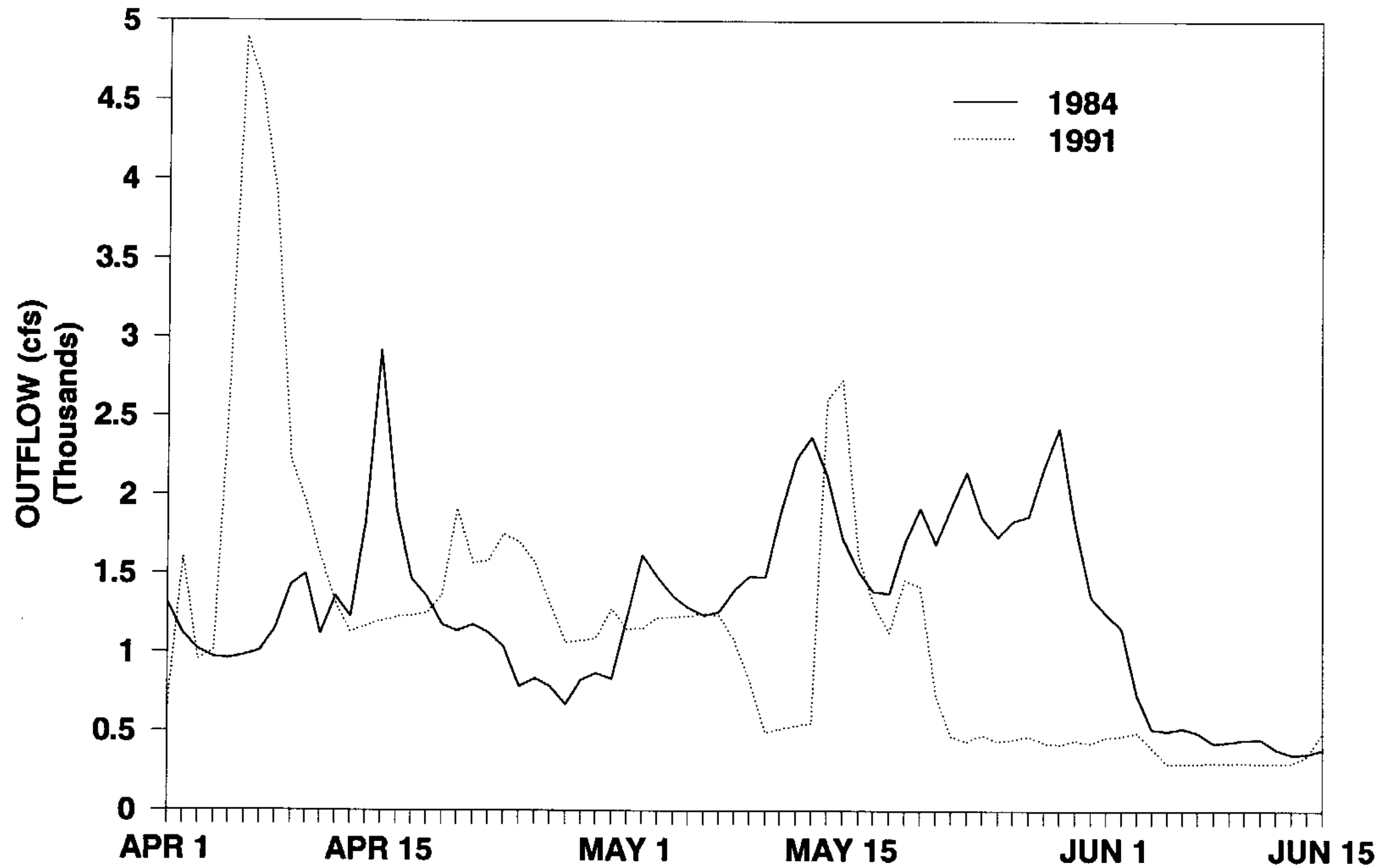

Figure 21. Daily outflow from Howard Hanson Dam in spring 1984 and 1991. Source: U.S. Army Corps of Engineers.

Table 1. Scoop trap efficiency tests by species and year class. Recoveries occurred on the day after release.

Rel. Date	Flow[A]	Trap vel.[B]	Coho (0+) Rel.	Coho (0+) Rec.	Coho (0+) (%)	Coho (1+) Rel.	Coho (1+) Rec.	Coho (1+) (%)	Chinook (0+) Rel.	Chinook (0+) Rec.	Chinook (0+) (%)
May 14	2737	8.0				20	2	(10)			
May 16	1318	6.9	26	2	(8)	28	1	(4)			
May 18	1463	6.6				33	4	(12)			
May 20	735	5.1	6	0	(0)	25	5	(20)			
May 24	442	3.8				4	1	(25)			
May 26	473	3.5	1	0	(0)	7	1	(14)			
May 29	449	3.2				5	0	(0)			
Jun 5	302	2.6				1	0	(0)			
Jun 19	523	3.9				1	0	(0)	1	0	(0)
Jun 21	762	4.7							1	1	(100)
Jun 25	762	4.7							1	0	(0)
Jun 27	572	4.1							4	0	(0)
Jul 5	649	3.9							25	5	(20)
Jul 8	645	4.2							70	10	(14)
Jul 11	416	3.1							30	2	(7)
Jul 18	409	3.1							31	4	(13)
Jul 25	273	2.1							1	0	(0)
Aug 1	258	1.9							4	0	(0)
Aug 8	236	3.9							6	0	(0)
Aug 22	255	4.1							5	0	(0)
Sep 5	243	3.7							1	0	(0)
Sep 9	241	3.9							1	1	(100)
Sep 15	253	4.3							2	0	(0)
Sep 19	250	3.8							15	0	(0)
Sep 30	243	3.7							3	0	(0)
Oct 3	241	4.0							8	1	(13)
Oct 7	246	3.9							2	1	(50)
Oct 21	238	3.8							2	0	(0)
Nov 4	224	3.7	3	0	(0)				5	0	(0)
Nov 6	714	4.9	53	0	(0)				31	4	(13)
Nov 12	1516	5.1	62	7	(11)				117	8	(7)
Nov 15	479	4.1	38	1	(3)				25	6	(24)
Nov 19	1122	6.1	40	6	(15)				32	9	(28)
Nov 21	2037	7.6	25	2	(8)				18	1	(6)

[A] Howard Hanson Dam discharge (cfs) measured at 0800 hours on the day following release.

[B] Mean velocity (fps) at the mouth of the scoop trap over the recovery period.

Table 2. Estimates of fish passage through Howard Hanson Dam by major periods of gate operation.

Period	Estimated fish passage					Total	(%)
	Chin (1+)	Chin (0+)	Coho (1+)	Coho (0+)	Sthd (2+)		
Apr 16-May 28 (radial only)	731	2,455	5,735	23,082	103	32,106	(53)
May 29-Jun 20 (bypass only)	0	67	128	0	0	195	(<1)
Jun 21-Jul 9 (bypass and radial gates)	29	3,041	38	156	156	3,420	(6)
Jul 10-Nov 5 (bypass only)	0	6,848	0	0	0	6,848	(11)
Nov 6-Nov 22 (radial only)	0	9,103	0	8,397	0	17,500	(29)
Total:	760	21,513	5,901	31,635	259	60,069	(100)

Table 3. Juvenile chinook and coho salmon collected for age analysis. Scale analysis indicated all fish were subyearlings (age 0+).

Collection date	Collection location	Mean length (mm)	s.d.	n
		Chinook salmon		
Jul 16	Scoop trap	137	14.3	10
Jul 23	Scoop trap	141	13.3	10
Jul 30	Scoop trap	133	11.8	11
Aug 23	Scoop trap	177	19.0	3
Sep 13	Scoop trap	177	7.4	4
Sep 16	Forebay	181	10.2	14
Sep 27	Scoop trap	171	5.9	8
Sep 30	Charlie Creek	207		1
Oct 1	Forebay	186	12.7	12
Oct 16	Forebay	196	20.2	8
Oct 18	One-way bridge[A]	185	9.1	16
Oct 29	Forebay	187	10.1	16
Nov 1	One-way bridge	185	16.6	11
Nov 13	Scoop trap	189		1
			Total:	127
		Coho salmon		
Jul 24	Gale Creek	91	2.9	3
Nov 7	Scoop trap	116	16.0	13
Nov 13	Scoop trap	117	12.5	7
Nov 18	Scoop trap	115	17.6	9
			Total:	32

[A] Approximately 3.5 river miles downstream of the scoop trap.

Table 4. Percentages of injuries and mortalities in scoop trap catches during major periods of gate operation and over the entire study period.

Species/ year class	Sample size[A]	Percentage of sample					
		Mortality	Partially descaled[B]	Descaled[C]	Bruising	Eye injury	Multiple injuries[D]
Radial gate only (Apr 11 to May 28)							
Chinook (1+)	10	0	< 2	0	0	10	0
Chinook (0+)	67	40	1	9	0	36	40
Coho (1+)	344	< 1	43	3	1	3	3
Coho (0+)	343	3	8	3	3	6	3
Bypass gate only (May 29 to Jun 20)							
Chinook (1+)	0	-	-	-	-	-	-
Chinook (0+)	4	25	25	25	0	25	50
Coho (1+)	15	0	27	0	7	7	13
Coho (0+)	0	-	-	-	-	-	-
Bypass and radial gates (Jun 21 to Jul 9)							
Chinook (1+)	2	0	50	0	0	0	0
Chinook (0+)	146	5	19	0	< 1	11	8
Coho (1+)	3	0	33	0	0	0	0
Coho (0+)	1	0	0	0	0	0	0
Bypass gate only (Jul 11 to Nov 5)							
Chinook (1+)	0	-	-	-	-	-	-
Chinook (0+)	282	9	35	< 1	< 1	8	17
Coho (1+)	0	-	-	-	-	-	-
Coho (0+)	7	43	14	0	0	57	14

Table 4. Continued.

Species/ year class	Sample size[A]	Percentage of sample: Mortality	Partially descaled[B]	Descaled[C]	Bruising	Eye injury	Multiple injuries[D]
		Radial gate only (Nov 6 to Nov 21)					
Chinook (1+)	0	-	-	-	-	-	-
Chinook (0+)	230	0	42	< 1	0	2	3
Coho (1+)	0	-	-	-	-	-	-
Coho (0+)	282	0	3	0	0	3	< 1
		Entire study period (Apr 11 to Nov 21)					
Chinook (1+)	12	0	8	0	0	8	0
Chinook (0+)	729	7	31	3	< 1	9	13
Coho (1+)	362	< 1	42	2	< 1	3	3
Coho (0+)	633	2	6	2	1	6	3

[A] Fish examined for any injury during the time period shown. In large scoop trap catches, a random sample of fish (at least 20 individuals of each species/year class) was examined for injuries.

[B] From 3% to 16% scale loss on either side of fish in either a patchy or a scattered pattern.

[C] Over 16% scale loss on either side of fish.

[D] Two or more of any injury categories, including mortality.

Table 5. Lengths and ATPase values from juvenile chinook and coho salmon collected at various locations in the Howard Hanson project area.

Location	Date	ATPase		Length		Sample size
		Mean	S.D.	Mean	S.D.	
		Chinook salmon				
North Fork	May 21	5.6	2.6	57	4.3	16
North Fork	Jun 5	10.4	2.6	57	3.5	11
North Fork	Jun 21	10.5	2.6	59	8.6	14
North Fork	Jul 8	17.1	5.2	65	7.8	12
Mainstem fyke	Jun 14	19.4	3.8	76	6.2	15
Mainstem fyke	Jun 26	24.2	6.1	84	5.4	20
Mainstem fyke	Jul 2	23.1	3.7	86	6.4	19
Forebay	Sep 16	15.2	6.6	181	10.2	14
Forebay	Oct 1	18.5	6.3	186	12.7	12
Forebay	Oct 16	12.0	6.0	196	20.2	8
Forebay	Oct 29	14.3	6.3	187	10.1	16
Scoop trap	Jul 9	32.9	7.4	112	9.5	10
Scoop trap	Jul 16	28.1	10.1	130	17.2	15
Scoop trap	Jul 23	30.4	7.9	134	13.0	20
Scoop trap	Jul 30	32.3	9.7	133	11.8	11
Scoop trap	Sep 27	21.1	6.8	171	5.9	8
One-way bridge[A]	Oct 18	18.1	9.6	185	9.1	16
One-way bridge[A]	Nov 1	14.3	7.8	185	16.6	11
		Coho salmon				
Scoop trap	Nov 7	6.5	1.8	116	16.0	13

[A] Approximately 3.5 river-miles downstream of the scoop trap.

Table 6. Typical ATPase levels associated with juvenile fall chinook and coho salmon. Levels shown are general guidelines and not strict criteria. ATPase levels are expressed in μmoles ATP hydrolyzed per mg protein per hr.

ATPase level		
Chinook[A]	Coho[B]	Degree of smoltification
< 8	5-10	Baseline
9-11	12-30	Onset of smoltification
12-24	15-35	Smoltification progressing
> 24	30-50	Outmigrating smolts

[A] Sources: Hosey and Associates 1990; Wunderlich and Dilley 1990.
[B] Source: Schroder and Fresh 1992.

Table 7. Biweekly mean forklengths of subyearling and yearling coho and chinook caught in the scoop trap.

Beginning date	Species/year class							
	Coho (0+)		Coho (1+)		Chinook (0+)		Chinook (1+)	
	Mean length (mm)	Sample size	Mean length (mm)	Sample size	Mean length (mm)	Sample size	Mean length (mm)	Sample size
Apr 7	--	--	100	17	56	23	--	--
Apr 21	49	169	96	18	57	39	105	10
May 5	59	138	107	58	51	2	--	--
May 19	56	35	108	136	75	4	103	2
Jun 2	--	--	124	6	107	2	--	--
Jun 16	--	--	119	8	117	21	--	--
Jun 30	--	--	--	--	113	155	--	--
Jul 14	--	--	--	--	129	98	--	--
Jul 28	--	--	--	--	137	25	--	--
Aug 11	--	--	--	--	170	21	--	--
Aug 25	--	--	--	--	176	4	--	--
Sep 8	--	--	--	--	180	49	--	--
Sep 22	--	--	--	--	180	25	--	--
Oct 6	--	--	--	--	181	13	--	--
Oct 20	--	--	--	--	184	11	--	--
Nov 3	121	154	--	--	194	140	--	--
Nov 17	121	134	--	--	191	101	--	--

Table 8. Dye-mark recoveries at the mainstem fyke trap.

Date	Length	Mark		
		Orange	Red	Green
May 31	72	O		
May 31	31		R	
Jun 4	70	O		
Jun 4	79	O		
Jun 6	72		R	
Jun 6	78			G
Jun 6	73		R	
Jun 6	84		R	
Jun 6	79	O		
Jun 6	85	O		
Jun 6	69		R	
Jun 8	68	O		
Jun 12	93	O		
Jun 12	98		R	
Jun 11	79	O		
Jun 11	79	O		
Jun 11	74	O		
Jun 11	80	O		
Jun 14	76	O		
Jun 14	74	O		
Jun 14	75	O		
Jun 14	73		R	
Jun 20	81		R	
Jun 20	86		R	
Jun 20	92	O		
Jun 20	80		R	
Jun 22	82		R	
Jun 22	76		R	
Jun 22	75		R	
Jun 22	82		R	
Jun 22	75		R	
Jun 22	82		R	
Jun 22	87		R	
Jun 25	85		R	
Jun 26	80		R	
Jun 30	83	O		
Jun 30	73	O		
Jul 2	81		R	
Jul 6	98		R	
Jul 9	88		R	
	Totals:	17	22	1

Table 9. Dye-mark recoveries at the scoop trap.

Date	Length	Mark		
		Orange	Red	Green
Apr 12	46	O		
Apr 16	58			G
Apr 16	57	O		
Apr 16	55			G
May 1	60			G
May 22	68		R	
Jun 1	80			G
Jun 27	116	O		
Jul 1	112		R	
Jul 9	108			G
Jul 11	113			G
Jul 18	128	O		
Jul 22	132	O		
Jul 22	129	O		
Jul 29	135			G
Nov 6	195	O		
Nov 12	189			G
	Totals:	7	2	8

Appendix A. Subyearling anadromous salmonids planted above Howard Hanson Dam. Sources of data: Washington Departments of Fisheries and Wildlife, and Muckleshoot Indian Tribe.

Release location	Release date	Size (number/ pound)	Number released
	Chinook salmon (1991)		
Upper mainstem:			
RM 76.5	Feb 21	449	274,326[A]
RM 85	Feb 25	449	150,000
RM 68.5	Feb 25	449	30,000
RM 74.8	Mar 6	515	202,653
RM 68	Mar 7	515	101,198
RM 87.2	Mar 7	515	103,773
Upper mainstem tributaries:			
Snow Cr. (RM 0.1)	Feb 22	449	275,120[B]
Friday Cr. (RM 0.1)	Feb 25	449	100,000
McCain Cr (RM 0.1)	Feb 25	449	50,000
Smay Cr. (RM 1.6)	Feb 25	449	50,000
Canton Cr. (RM 0.3)	Mar 7	515	100,940
Reservoir tributaries:			
Gale Cr. (RM 1.0)	Feb 25	449	50,000
Gale Cr. (RM 2.0)	Mar 6	515	100,554
North Fork:			
RM 1.0	Feb 21	515	199,382[C]
RM 3.0	Feb 25	515	50,000
RM 1.0	Mar 6	515	101,584
		Total:	1,939,530
	Chinook salmon (1990)		
Upper mainstem:			
RM 75-81	Feb 14	472	154,580
RM 68	Mar 1-6	406	363,776

Appendix A. Continued.

Release location	Release date	Size (number/ pound)	Number released
<u>Upper mainstem tributaries</u>:			
Sunday Cr.	Feb 14	472	56,404
May Cr.	Feb 28	406	20,300
Smay Cr.	Feb 28	406	60,900
Elder Cr.	Mar 1	406	70,542
Unnamed Cr.	Feb 28	406	60,900
Canton Cr.	Mar 6	406	126,672
McCain Cr.	Mar 7	406	142,201
<u>Reservoir tributaries</u>:			
Gale Cr. via Boundary Cr.	Feb 28	400	40,600
Gale Cr. (RM 1.5)	Feb 28	400	40,600
Charley Cr. (RM 0.3)	Mar 1-2	406	72,208
Piling Cr. (RM 0.5)	Feb 28	400	20,604
Stream 0212 (RM 0.2)	Mar 2	406	40,600
Stream 0213 (RM 0.2)	Mar 2	406	20,300
<u>North Fork</u>:			
RM 1.3	Feb 14-15	472	411,702
		Total:	1,702,889
	Coho salmon (1991)		
<u>Upper mainstem</u>:			
RM 75	Apr 17	533	91,143
RM 76	Apr 17	533	108,732
RM 79.5	Apr 17	533	82,082
<u>Upper mainstem tributaries</u>:			
Smay Cr.	Apr 17	533	108,199
Green Canyon Cr.	Apr 17	533	9,594
Friday Cr.	Apr 17	533	15,990
McCain Cr.	Apr 17	533	15,990
Tacoma Cr.	Apr 18	533	227,591

Appendix A. Continued.

Release location	Release date	Size (number/ pound)	Number released
Sunday Cr.	Apr 19	533	143,910
Snow Cr.	Apr 19	533	13,325
<u>Reservoir tributaries</u>:			
Gale Cr. via Boundary Cr.	Apr 18	533	128,986
<u>North Fork</u>:			
Eagle Lake	Apr 18	533	31,980
Eagle Cr.	Apr 18	533	15,990
Upper No. Fk.	Apr 18	533	34,645
		Total:	1,028,157
	Coho salmon (1990)		
<u>Upper mainstem</u>:	May 7	387	30,960
	May 8	366	306,342
	May 9	379	97,782
	May 10	380	87,400
<u>Upper mainstem tributaries</u>:			
Smay Cr.	Mar 12	670	126,630
Stream 0230	Apr 3	499	21,457
Canton Cr.	Apr 3	499	14,970
Tacoma Cr.	May 7	387	64,629
Twin Camp Cr.	May 7	387	62,307
Smay Cr. trib.	May 9	379	19,329
Friday Cr.	May 9	379	20,087
Sunday Cr.	May 9	379	133,408
<u>Reservoir tributaries</u>:			
Charley Cr.	Apr 3	499	31,437
Gale Cr.	Mar 12	670	122,610

Appendix A. Continued.

Release location	Release date	Size (number/ pound)	Number released
North Fork:			
Eagle Lake	Apr 9	448	25,088
Eagle Cr.	Apr 9	448	13,440
Upper No. Fk.	Apr 9		157,066
			Total: 1,334,942
	Steelhead (1991)		
Upper mainstem:			
RM 73-87	Aug 8	362	39,820
Upper mainstem tributary:			
Smay Cr.	Aug 8	362	1,086
			Total: 40,906
	Steelhead (1990)		
Upper mainstem:			
RM 73-87	Aug 30	162	30,618
Upper mainstem tributaries:			
McCain Cr.	Aug 30	162	324
Smay Cr.	Aug 30	162	1,620
			Total: 32,562
	Steelhead (1989)		
Upper mainstem:			
RM 65-87	Aug 24	330	41,910

Appendix A. Continued.

Release location	Release date	Size (number/ pound)	Number released
<u>Upper mainstem tributaries:</u>			
McCain Cr.	Aug 24	330	330
Smay Cr.	Aug 24	330	1,650
Sunday Cr.	Aug 24	330	2,640
			Total: 46,530

[A] Includes 137,163 orange-dyed chinook.
[B] Includes 137,560 red-dyed chinook.
[C] Includes 99,691 green-dyed chinook.

Appendix B. Daily scoop trap catches below Howard Hanson Dam.

Date	Coho (1+)	Coho (0+)	Chinook (1+)	Chinook (0+)	Steelhead
Apr 11	7	0	0	1	0
Apr 12	8	0	0	11	0
Apr 15	0	0	0	4	0
Apr 16	0	0	0	4	0
Apr 18	2	0	0	0	0
Apr 19	0	0	0	3	0
Apr 22	1	25	0	23	0
Apr 23	3	336	0	2	0
Apr 25	2	61	0	1	0
Apr 26	2	75	1	1	0
Apr 29	1	13	6	0	0
Apr 30	1	16	0	0	0
May 1	0	24	3	8	0
May 2	0	6	0	4	1
May 3	3	10	0	0	0
May 4	5	9	0	0	0
May 6	14	3	0	0	0
May 7	7	8	0	0	0
May 8	19	1	0	0	0
May 9	19	5	0	0	0
May 10	5	1	0	0	0
May 11	8	5	0	0	0
May 12	5	3	0	0	0
May 13	10	11	0	0	0
May 14	19	10	0	0	0
May 15	23	25	0	0	0
May 16	20	23	0	2	2
May 17	28	58	0	0	1
May 18	20	15	0	0	0
May 19	22	14	0	0	0
May 20	39	7	0	0	0
May 21	41	8	0	0	0
May 22	1	0	0	1	0
May 23	2	0	0	0	0
May 24	4	2	0	0	0
May 25	5	2	0	1	0
May 26	6	1	0	0	0
May 27	10	1	0	0	0
May 28	2	0	0	1	0
May 29	5	0	0	0	0
May 30	1	0	0	0	0
May 31	1	0	0	0	0
Jun 1	2	0	0	1	0
Jun 2	0	0	0	0	0

Appendix B. Continued.

Date	Coho		Chinook		Steelhead
	(1+)	(0+)	(1+)	(0+)	
Jun 3	0	0	0	0	0
Jun 4	0	0	0	0	0
Jun 5	2	0	0	0	0
Jun 6	1	0	0	1	0
Jun 7	0	0	0	0	0
Jun 8	1	0	0	0	0
Jun 9	1	0	0	0	0
Jun 10	0	0	0	0	0
Jun 11	0	0	0	1	0
Jun 12	0	0	0	0	0
Jun 13	0	0	0	0	0
Jun 15	1	0	0	0	0
Jun 16	1	0	0	0	0
Jun 17	0	0	0	0	0
Jun 18	2	0	0	0	0
Jun 19	1	0	0	1	0
Jun 20	1	0	0	0	0
Jun 21	0	0	0	2	0
Jun 22	0	0	0	5	0
Jun 23	0	0	0	2	0
Jun 24	2	0	2	1	0
Jun 25	1	0	0	1	0
Jun 26	0	0	0	1	0
Jun 27	0	0	0	5	0
Jun 28	0	0	0	3	0
Jun 29	0	0	0	1	0
Jun 30	0	1	0	1	1
Jul 1	0	0	0	29	0
Jul 5	0	0	0	1	0
Jul 6	0	0	0	30	0
Jul 8	0	0	0	39	0
Jul 9	0	0	0	27	0
Jul 11	0	0	0	14	0
Jul 12	0	0	0	16	0
Jul 15	0	0	0	10	0
Jul 16	0	0	0	6	0
Jul 18	0	0	0	28	0
Jul 19	0	0	0	24	0
Jul 22	0	0	0	12	0
Jul 23	0	0	0	20	0
Jul 25	0	0	0	0	0
Jul 26	0	0	0	2	0
Jul 29	0	0	0	11	0
Jul 30	0	0	0	0	0

Appendix B. Continued.

Date	Coho (1+)	Coho (0+)	Chinook (1+)	Chinook (0+)	Steelhead
Aug 1	0	0	0	4	0
Aug 2	0	0	0	4	0
Aug 5	0	0	0	0	0
Aug 6	0	0	0	0	0
Aug 8	0	0	0	2	0
Aug 9	0	0	0	4	0
Aug 12	0	0	0	1	0
Aug 13	0	0	0	0	0
Aug 15	0	0	0	0	0
Aug 16	0	0	0	3	0
Aug 19	0	0	0	1	0
Aug 20	0	0	0	3	0
Aug 22	0	0	0	7	0
Aug 23	0	0	0	6	0
Aug 26	0	0	0	2	0
Aug 27	0	0	0	0	0
Aug 29	0	0	0	0	0
Aug 30	0	0	0	2	0
Sep 3	0	0	0	0	0
Sep 4	0	0	0	0	0
Sep 5	0	0	0	1	0
Sep 6	0	0	0	0	0
Sep 9	0	0	0	5	0
Sep 10	0	0	0	3	0
Sep 12	0	0	0	4	0
Sep 13	0	0	0	7	0
Sep 15	0	0	0	2	0
Sep 16	0	0	0	3	0
Sep 19	0	0	0	17	0
Sep 20	0	0	0	9	0
Sep 23	0	0	0	0	0
Sep 24	0	0	0	0	0
Sep 26	0	0	0	8	0
Sep 27	0	0	0	0	0
Sep 30	0	0	0	4	0
Oct 1	0	0	0	0	0
Oct 3	0	0	0	11	0
Oct 4	0	0	0	3	0
Oct 7	0	0	0	2	0
Oct 8	0	0	0	0	0
Oct 10	0	0	0	0	0
Oct 11	0	0	0	0	0
Oct 15	0	0	0	0	0
Oct 16	0	0	0	1	0

Appendix B. Continued.

Date	Coho		Chinook		Steelhead
	(1+)	(0+)	(1+)	(0+)	
Oct 17	0	0	0	1	0
Oct 18	0	0	0	9	0
Oct 21	0	0	0	2	0
Oct 22	0	0	0	2	0
Oct 25	0	0	0	1	0
Oct 26	0	0	0	3	0
Oct 28	0	0	0	0	0
Oct 29	0	0	0	0	0
Oct 31	0	0	0	1	0
Nov 1	0	4	0	2	0
Nov 4	0	1	0	2	0
Nov 25	0	2	0	3	0
Nov 6	0	44	0	22	0
Nov 7	0	20	0	9	0
Nov 12	0	67	0	112	0
Nov 13	0	24	0	74	0
Nov 15	0	8	0	12	0
Nov 16	0	8	0	7	0
Nov 17	0	22	0	7	0
Nov 19	0	36	0	34	0
Nov 20	0	130	0	101	0
Nov 21	0	52	0	41	0

Appendix C. Daily Mainstem Green River fyke trap catches.

Date	Coho		Chinook		Steelhead
	Yearling	Subyearling	Yearling	Subyearling	
Apr 22	5	174	0	12	0
Apr 25	3	40	0	0	0
Apr 29	4	9	0	6	0
May 1	1	0	3	2	0
May 3	0	1	0	0	0
May 6	3	3	0	0	0
May 8	0	2	0	0	0
May 10	2	6	0	0	0
May 12	3	1	0	2	0
May 14	27	11	0	0	0
May 16	3	3	0	0	0
May 18	14	8	0	0	0
May 20	7	2	0	3	0
May 22	33	3	1	2	0
May 24	0	0	0	0	0
May 26	29	3	1	3	0
May 28	1	4	0	0	0
May 30	13	19	0	7	0
Jun 1	4	4	0	1	0
Jun 2	3	3	0	0	0
Jun 3	6	10	0	3	0
Jun 4	14	11	0	6	0
Jun 5	0	1	0	1	0
Jun 6	30	18	0	36	0
Jun 7	5	16	2	21	0
Jun 8	12	4	1	19	0
Jun 9	16	2	3	8	0
Jun 11	5	6	0	75	0
Jun 12	4	4	0	31	0
Jun 13	6	14	0	31	0
Jun 14	8	7	0	22	0
Jun 15	0	0	0	16	0
Jun 16	2	10	11	48	0
Jun 17	1	7	0	2	0
Jun 18	0	7	0	4	0
Jun 19	2	62	0	83	0
Jun 20	4	18	0	53	0
Jun 21	1	21	0	6	0
Jun 22	1	26	0	59	1

Species/Year class

Appendix C. Continued.

Date	Species/Year class				
	Coho		Chinook		Steelhead
	Yearling	Subyearling	Yearling	Subyearling	
Jun 23	0	3	0	0	0
Jun 24	1	9	0	12	0
Jun 25	0	1	0	12	0
Jun 26	0	7	0	44	0
Jun 27	0	0	0	0	0
Jun 28	0	1	0	5	0
Jun 29	0	58	0	7	0
Jun 30	0	19	0	22	0
Jul 1	0	3	0	19	0
Jul 2	0	5	0	8	0
Jul 5	0	14	0	6	0
Jul 6	0	21	0	18	0
Jul 8	0	0	0	1	0
Jul 9	0	4	0	0	0
Jul 11	0	1	0	0	0
Jul 12[A]	0	7	0	1	0

[A] Trapping continued on the same schedule as the scoop trap (Appendix B), but no catches occurred for the remainder of the study period.

Appendix D. Daily North Fork Green River fyke trap catches.

Date	Species/Year class				
	Coho		Chinook		Steelhead
	Yearling	Subyearling	Yearling	Subyearling	
Apr 18	0	0	0	2	0
Apr 22	0	0	0	0	0
Apr 25	1	0	0	0	0
Apr 29	0	0	0	0	0
May 02	1	0	0	0	0
May 03	0	0	0	0	0
May 06	0	0	0	0	0
May 08	3	0	0	0	0
May 10	0	0	0	0	0
May 12	0	0	0	0	0
May 14	0	0	0	0	0
May 16	0	0	0	0	0
May 18	4	0	0	0	0
May 20	0	0	0	0	0
May 22	0	0	0	0	0
May 24	0	0	0	0	0
May 26	3	0	0	0	0
May 28	0	1	0	0	0
May 30	1	0	0	0	0
May 01	0	0	0	0	0
Jun 03	1	0	0	0	0
Jun 05	0	0	0	0	0
Jun 07	1	0	0	0	0
Jun 09	0	0	0	0	0
Jun 11	0	0	0	0	0
Jun 13	1	0	0	0	0
Jun 15	0	0	0	0	0
Jun 17	0	0	0	0	0
Jun 19	0	0	0	0	0
Jun 21	0	0	0	0	0
Jun 23	0	0	0	0	0
Jun 25	0	0	0	1	0
Jun 26	1	0	0	1	0
Jun 27	0	0	0	0	0
Jun 29	0	0	0	2	0
Jun 30	0	0	0	1	0
Jul 01	0	0	0	0	0
Jul 05	0	0	0	0	0
Jul 08	0	0	0	0	0

Appendix D. Continued.

Date	Species/Year class				
	Coho		Chinook		Steelhead
	Yearling	Subyearling	Yearling	Subyearling	
Jul 11	0	0	0	0	0
Jul 15	0	3	0	0	0
Jul 18[A]	0	1	0	0	0

[A] Trapping continued on the same schedule as the scoop trap until August 8th (when lack of flow prevented further sampling), but no further catches occurred.

Appendix E. Estimated daily fish passage at Howard Hanson Dam during the 1991 study period.

Date		Coho		Chinook		Sthd	Total
		(1+)	(0+)	(1+)	(0+)		
Apr	16	0	0	0	103	0	103
Apr	17	0	0	0	168	0	168
Apr	18	17	0	0	25	0	42
Apr	19	51	0	0	77	0	128
Apr	20	236	0	0	354	0	590
Apr	21	172	0	0	258	0	430
Apr	22	23	1049	23	68	0	1163
Apr	23	36	1656	36	108	0	1836
Apr	24	64	2947	64	192	0	3267
Apr	25	73	2298	24	24	0	2419
Apr	26	72	2275	24	24	0	2395
Apr	27	67	2118	22	22	0	2229
Apr	28	62	1960	21	21	0	2063
Apr	29	114	1480	304	0	0	1898
Apr	30	35	1334	104	260	0	1732
May	1	0	1018	110	407	31	1566
May	2	168	938	0	238	56	1400
May	3	371	865	0	0	0	1235
May	4	321	748	0	0	0	1069
May	5	271	632	0	0	0	903
May	6	596	307	0	0	0	903
May	7	458	161	0	0	0	619
May	8	227	37	0	0	0	264
May	9	189	47	0	0	0	236
May	10	45	21	0	0	0	66
May	11	86	52	0	0	0	138
May	12	77	65	0	0	0	142
May	13	84	60	0	0	0	144
May	14	80	66	0	0	0	146
May	15	232	263	0	10	10	515
May	16	165	276	0	0	4	445
May	17	32	49	0	0	1	82
May	18	178	124	0	0	0	302
May	19	141	50	0	0	0	191
May	20	181	35	0	0	0	216
May	21	116	23	0	3	0	142
May	22	203	0	0	68	0	270
May	23	171	57	0	0	0	228
May	24	118	39	0	9	0	166
May	25	88	24	0	8	0	120
May	26	49	6	0	0	0	55
May	27	48	4	0	4	0	56

Appendix E. Continued.

Date		Coho (1+)	Coho (0+)	Chinook (1+)	Chinook (0+)	Sthd	Total
May	28	22	0	0	3	0	25
May	29	3	0	0	0	0	3
May	30	0	0	0	0	0	0
May	31	0	0	0	0	0	0
Jun	1	0	0	0	0	0	0
Jun	2	0	0	0	0	0	0
Jun	3	0	0	0	0	0	0
Jun	4	0	0	0	0	0	0
Jun	5	0	0	0	0	0	0
Jun	6	14	0	0	14	0	28
Jun	7	23	0	0	0	0	23
Jun	8	23	0	0	0	0	23
Jun	9	8	0	0	0	0	8
Jun	10	0	0	0	11	0	11
Jun	11	0	0	0	8	0	8
Jun	12	0	0	0	11	0	11
Jun	13	0	0	0	13	0	13
Jun	14	9	0	0	0	0	9
Jun	15	9	0	0	0	0	9
Jun	16	12	0	0	0	0	12
Jun	17	5	0	0	0	0	5
Jun	18	8	0	0	0	0	8
Jun	19	11	0	0	6	0	17
Jun	20	2	0	0	5	0	7
Jun	21	0	0	0	20	0	20
Jun	22	0	0	0	31	0	31
Jun	23	27	0	26	40	0	93
Jun	24	4	0	3	3	0	10
Jun	25	7	0	0	14	0	21
Jun	26	0	0	0	185	0	185
Jun	27	0	0	0	203	0	203
Jun	28	0	0	0	263	0	263
Jun	29	0	74	0	148	74	296
Jun	30	0	71	0	142	71	283
Jul	1	0	12	0	368	12	391
Jul	2	0	0	0	261	0	261
Jul	3	0	0	0	313	0	313
Jul	4	0	0	0	128	0	128
Jul	5	0	0	0	158	0	158
Jul	6	0	0	0	235	0	235
Jul	7	0	0	0	322	0	322
Jul	8	0	0	0	166	0	166
Jul	9	0	0	0	42	0	42

Appendix E. Continued.

Date		Coho		Chinook		Sthd	Total
		(1+)	(0+)	(1+)	(0+)		
Jul	10	0	0	0	46	0	46
Jul	11	0	0	0	45	0	45
Jul	12	0	0	0	37	0	37
Jul	13	0	0	0	27	0	27
Jul	14	0	0	0	38	0	38
Jul	15	0	0	0	30	0	30
Jul	16	0	0	0	31	0	31
Jul	17	0	0	0	16	0	16
Jul	18	0	0	0	9	0	9
Jul	19	0	0	0	29	0	29
Jul	20	0	0	0	107	0	107
Jul	21	0	0	0	2	0	2
Jul	22	0	0	0	118	0	118
Jul	23	0	0	0	124	0	124
Jul	24	0	0	0	158	0	158
Jul	25	0	0	0	67	0	67
Jul	26	0	0	0	831	0	831
Jul	27	0	0	0	517	0	517
Jul	28	0	0	0	435	0	435
Jul	29	0	0	0	261	0	261
Jul	30	0	0	0	105	0	105
Jul	31	0	0	0	113	0	113
Aug	1	0	0	0	162	0	162
Aug	2	0	0	0	99	0	99
Aug	3	0	0	0	36	0	36
Aug	4	0	0	0	38	0	38
Aug	5	0	0	0	20	0	20
Aug	6	0	0	0	59	0	59
Aug	7	0	0	0	16	0	16
Aug	8	0	0	0	35	0	35
Aug	9	0	0	0	4	0	4
Aug	10	0	0	0	2	0	2
Aug	11	0	0	0	22	0	22
Aug	12	0	0	0	47	0	47
Aug	13	0	0	0	8	0	8
Aug	14	0	0	0	49	0	49
Aug	15	0	0	0	22	0	22
Aug	16	0	0	0	12	0	12
Aug	17	0	0	0	137	0	137
Aug	18	0	0	0	64	0	64
Aug	19	0	0	0	11	0	11
Aug	20	0	0	0	1	0	1
Aug	21	0	0	0	87	0	87

Appendix E. Continued.

Date	Coho (1+)	Coho (0+)	Chinook (1+)	Chinook (0+)	Sthd	Total
Aug 22	0	0	0	0	0	0
Aug 23	0	0	0	12	0	12
Aug 24	0	0	0	1	0	1
Aug 25	0	0	0	57	0	57
Aug 26	0	0	0	24	0	24
Aug 27	0	0	0	0	0	0
Aug 28	0	0	0	0	0	0
Aug 29	0	0	0	0	0	0
Aug 30	0	0	0	0	0	0
Aug 31	0	0	0	0	0	0
Sep 1	0	0	0	0	0	0
Sep 2	0	0	0	0	0	0
Sep 3	0	0	0	0	0	0
Sep 4	0	0	0	3	0	3
Sep 5	0	0	0	9	0	9
Sep 6	0	0	0	0	0	0
Sep 7	0	0	0	0	0	0
Sep 8	0	0	0	0	0	0
Sep 9	0	0	0	28	0	28
Sep 10	0	0	0	0	0	0
Sep 11	0	0	0	22	0	22
Sep 12	0	0	0	47	0	47
Sep 13	0	0	0	0	0	0
Sep 14	0	0	0	0	0	0
Sep 15	0	0	0	0	0	0
Sep 16	0	0	0	0	0	0
Sep 17	0	0	0	0	0	0
Sep 18	0	0	0	463	0	463
Sep 19	0	0	0	0	0	0
Sep 20	0	0	0	0	0	0
Sep 21	0	0	0	0	0	0
Sep 22	0	0	0	0	0	0
Sep 23	0	0	0	0	0	0
Sep 24	0	0	0	0	0	0
Sep 25	0	0	0	84	0	84
Sep 26	0	0	0	0	0	0
Sep 27	0	0	0	0	0	0
Sep 28	0	0	0	0	0	0
Sep 29	0	0	0	0	0	0
Sep 30	0	0	0	0	0	0
Oct 1	0	0	0	0	0	0
Oct 2	0	0	0	0	0	0
Oct 3	0	0	0	1	0	1

Appendix E. Continued.

Date		Coho		Chinook		Sthd	Total
		(1+)	(0+)	(1+)	(0+)		
Oct	4	0	0	0	10	0	10
Oct	5	0	0	0	2	0	2
Oct	6	0	0	0	0	0	0
Oct	7	0	0	0	0	0	0
Oct	8	0	0	0	0	0	0
Oct	9	0	0	0	0	0	0
Oct	10	0	0	0	4	0	4
Oct	11	0	0	0	9	0	9
Oct	12	0	0	0	0	0	0
Oct	13	0	0	0	5	0	5
Oct	14	0	0	0	0	0	0
Oct	15	0	0	0	0	0	0
Oct	16	0	0	0	541	0	541
Oct	17	0	0	0	206	0	206
Oct	18	0	0	0	187	0	187
Oct	19	0	0	0	46	0	46
Oct	20	0	0	0	44	0	44
Oct	21	0	0	0	141	0	141
Oct	22	0	0	0	101	0	101
Oct	23	0	0	0	35	0	35
Oct	24	0	0	0	16	0	16
Oct	25	0	0	0	40	0	40
Oct	26	0	0	0	347	0	347
Oct	27	0	0	0	13	0	13
Oct	28	0	0	0	23	0	23
Oct	29	0	0	0	19	0	19
Oct	30	0	0	0	42	0	42
Oct	31	0	0	0	34	0	34
Nov	1	0	0	0	125	0	125
Nov	2	0	0	0	30	0	30
Nov	3	0	0	0	0	0	0
Nov	4	0	0	0	0	0	0
Nov	5	0	0	0	0	0	0
Nov	6	0	710	0	349	0	1059
Nov	7	0	533	0	263	0	796
Nov	8	0	72	0	36	0	108
Nov	9	0	614	0	302	0	916
Nov	10	0	293	0	144	0	437
Nov	11	0	333	0	164	0	497
Nov	12	0	810	0	1645	0	2455
Nov	13	0	1114	0	2263	0	3377
Nov	14	0	763	0	1550	0	2313
Nov	15	0	175	0	206	0	381

Appendix E. Continued.

Date	Coho		Chinook		Sthd	Total
	(1+)	(0+)	(1+)	(0+)		
Nov 16	0	103	0	49	0	152
Nov 17	0	73	0	35	0	108
Nov 18	0	561	0	264	0	825
Nov 19	0	365	0	299	0	664
Nov 20	0	336	0	275	0	611
Nov 21	0	143	0	117	0	260
Nov 22	0	1398	0	1143	0	2541