Lower Snake River Compensation Plan
Confederated Tribes of the Umatilla Indian Reservation
Evaluation Studies for 1 January to 31 December 1994

Section I
Evaluation of reestablishing natural production of spring chinook salmon in Lookingglass Creek, Oregon, using a non-endemic hatchery stock

Section II
Assistance provided to LSRCP cooperators

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SECTION I

Evaluation of reestablishing natural production of spring chinook salmon in Lookingglass Creek, Oregon, using a non-endemic hatchery stock

Abstract

This was the third year of a study to evaluate the reestablishment of natural production of spring chinook salmon in Lookingglass Creek using the non-endemic Rapid River Hatchery stock. Of the 221 adult spring chinook salmon returns to Lookingglass Hatchery in 1994, 112 were tagged and released above the hatchery weir. Thirty-nine out of the 112 chinook salmon released above the weir were unmarked, and presumed to be of natural origin. Four of the 112 salmon were later recovered or observed below the weir. We estimated that an additional 14 salmon escaped above the weir without being handled at the hatchery for a population estimate of 122 salmon above the weir available for spawning, 58 males and 64 females. Age composition of fish released above the weir was 21.4% age 5, 75.9% age 4, and 2.7% age 3.

During weekly spawning surveys, we observed a total of 40 redds above the weir and 8 below the weir. Observations in the index area above the weir from Summer Creek to the mouth of Little Lookingglass Creek were used to index spawning timing. The peak in the appearance of new redds and live fish both occurred on 29 August. The peak in the observations of dead fish was on 6 September. Above the weir, the area farthest from the hatchery contained 10.0% of the total redd count, which was much lower than the other three areas which contained 27.5, 30.0, and 32.5%. Redd densities in the three areas farthest from the hatchery ranged from 0.6 to 2.7 redds per kilometer while redd density in the area immediately above the weir was 5.4 redds per kilometer.

We found a positive relationship between fork length and fecundity ($p < 0.05$), ($r^2=0.60$). The percentages by age for the returns of the 1989 cohort, completed fin 1994, were 3.3% age 3, 88.3% age 4 and 8.4% age 5.

Similar arrival timing at Lower Granite Dam of three groups of naturally-produced juvenile chinook salmon that were tagged with passive integrated transponders (PIT tags) suggested that season of tagging did not influence timing of seaward migration. Juveniles captured and PIT tagged at the screw trap from October to December 1993 and January to June 1994, and one group tagged in the creek in September 1993 all had arrival timing which peaked on the weeks ending 22 April and 29 April, 1994. Median arrival dates of the three groups were all within four days of one another.

Survival indices to Lower Granite Dam of juvenile chinook salmon from the 1992 cohort which was PIT-tagged in 1993 and 1994, increased with later tagging periods. Survival indices for groups tagged in September 1993, in October to December 1993 and in January to June 1994

were 17.5, 21.8 and 31.8%. Survival indices by month of PIT-tagging from September 1993 through June 1994 ranged from 17.5 to 42.1%. A trend of increasing survival each month was not evident.

Stream flows in the spring/summer in Lookingglass Creek were most similar to those which occurred in 1969, increasing March through mid-April, peaking at about 21 m^3/s. Flows decreased abruptly in late May and June, with flows about 2-3 m^3/s most of the remainder of the year. Peak summer water temperatures were about 13°C from late June through late July for 1994.

Introduction

The Grande Ronde River Basin historically supported large populations of fall and spring chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*) and coho (*O. kisutch*) salmon and steelhead (*O. mykiss*) (Nehlsen et al. 1991). Large losses of chinook salmon and steelhead and extirpation of coho and sockeye salmon in the Grande Ronde River Basin (Nehlsen et al. 1991) were, in part, a result of construction and operation of hydroelectric facilities, over fishing, and loss and degradation of critical spawning and rearing habitat in the Columbia and Snake rivers basins. Escapements of anadromous salmonids that have returned to the Grande Ronde River Basin (Oregon Department of Fish and Wildlife (ODFW), unpublished data), as well as escapements to the entire Snake River Basin (Nehlsen et al. 1991), have declined, several to the point of extinction. As a result, the National Marine Fisheries Service (NMFS) listed fall chinook salmon as "endangered" and spring/summer chinook salmon as "threatened" under the federal Endangered Species Act of 1973 on 22 April 1992. Hatcheries were built in Oregon, Washington and Idaho under the Lower Snake River Compensation Plan (LSRCP) to compensate for losses of anadromous salmonids due to the construction and operation of the lower four Snake River dams. Lookingglass Hatchery on Lookingglass Creek (Figure 1), a tributary of the Grande Ronde River, was completed under the LSRCP in 1982 and serves as the incubation and rearing site for the chinook salmon programs in Oregon.

Until this study was initiated in 1992, all adult spring chinook salmon captured at the Lookingglass Hatchery weir had been retained for broodstock with the exception of a few fish released above the weir in 1989. The upstream migration has been almost completely blocked by a picket weir located at the hatchery intake (Figure 1). Some fish escaped above the weir each year, as evidenced by redd counts during spawning surveys (ODFW, unpublished data).

This study was developed by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the ODFW in consultation with the Nez Perce Tribe to evaluate the potential for reestablishing natural production in Lookingglass Creek using Rapid River Hatchery stock spring chinook salmon (Lofy et al. 1994). Fishery managers believed that Lookingglass Creek was a good location to evaluate reintroduction of a non-endemic stock in the Grande Ronde River Basin. It was assumed that good quality habitat would provide an adequate opportunity for success, and the existence of the weir provided the ability to easily control adult escapement. From 1992 to 1994, adults have been placed above Lookingglass Hatchery.

The goal of this study is to determine the success of using a non-endemic hatchery stock for reestablishing natural production. We collected flow and temperature data from Lookingglass Creek to monitor basin stream flow and temperature regimes and make comparisons to similar data collected from 1964 to 1971 (Burck 1993). Detailed data were also collected on the endemic Lookingglass Creek stock from 1964 to 1974 (Burck 1993; Burck 1964-1974). Using these data, and data collected during this study, we will make comparisons of life history and production between the Rapid River stock and the Lookingglass Creek stock to evaluate the success of the reintroduction effort.

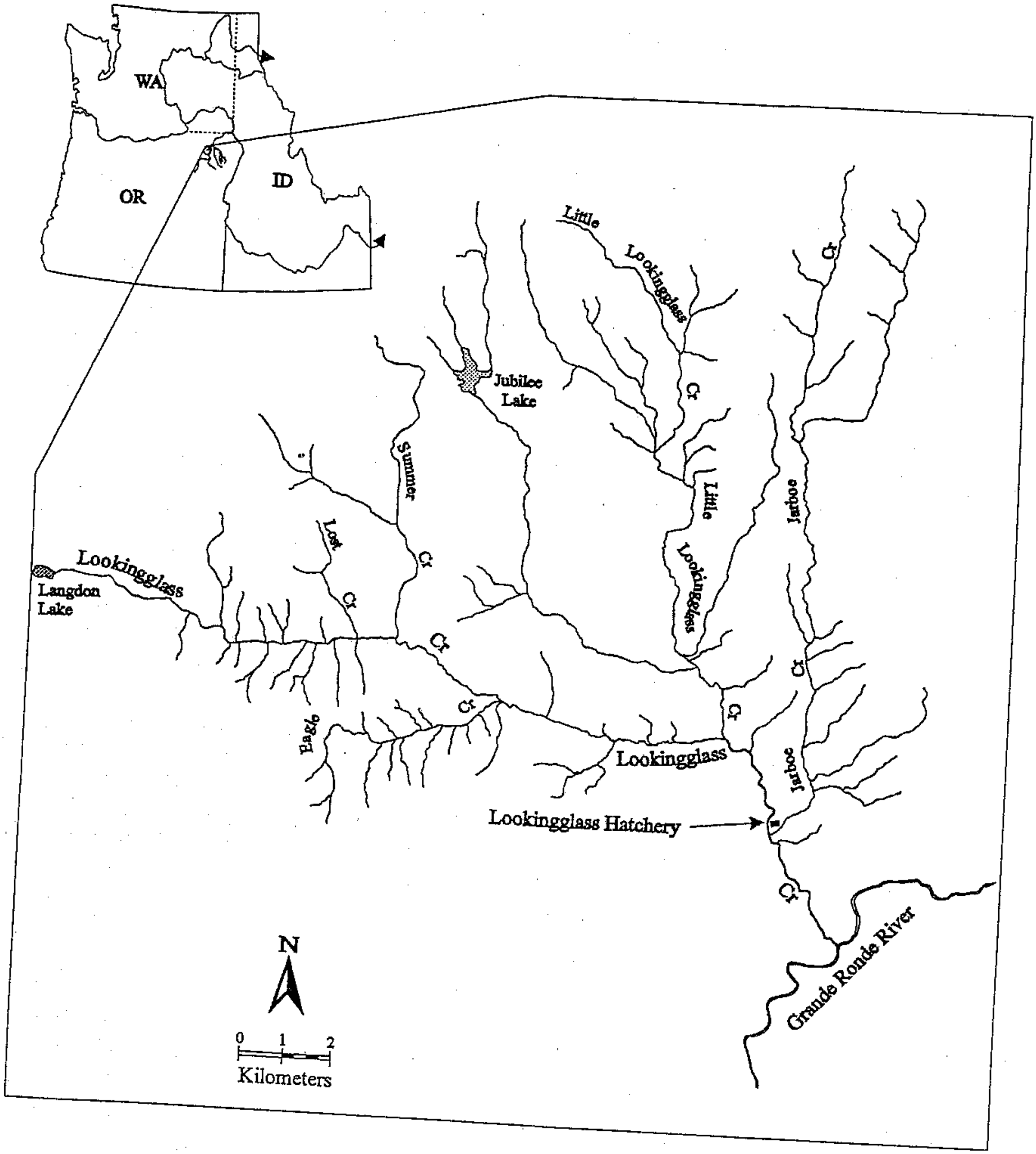

Figure 1. Map of the Lookingglass Creek basin.

Study Area

The headwaters of Lookingglass Creek are located in the Blue Mountains of northeast Oregon at Langdon Lake, elevation 1.48 kilometers above sea level (Figure 1). Lookingglass Creek flows to the southeast approximately 24 river kilometers (rkm) through the Umatilla National Forest and private land where it enters at approximately rkm 137 of the Grande Ronde River at an elevation of about 0.82 kilometers (Figure 1). Compared to other non-wilderness subbasins in the Grande Ronde River Basin, the fish habitat in the Lookingglass Creek basin has remained relatively undisturbed since 1974, with little logging and grazing occurring in the upper reaches of the system. Clear cutting and recreational development occurred in the upper Lookingglass Creek and Little Lookingglass Creek basins from 1964 to 1974 (Burck 1993). Currently, most of the small-scale logging and grazing occur on the privately-owned areas from about rkm 12.87 of Lookingglass Creek to the mouth. A short airstrip and hanger were constructed in the spring of 1994 from about rkm 7.64 to rkm 8.45 in 1994. A few trees along the existing road were cut, but the areas near the stream were not disturbed except to move machinery in and out for construction. Lookingglass Creek has three major tributaries, Eagle Creek (about rkm 13.27), Little Lookingglass Creek (just below rkm 6.48), and Jarboe Creek (just below rkm 3.62) (Figure 1). The hatchery intake and associated picket weir are located at about rkm 4.02, and Lookingglass Hatchery complex is located at about rkm 3.62. The framework for a new floating weir was installed about 5 meters above the main hatchery ladder in 1993. The floating weir was used for the first time in 1994 (Figure 1).

Lookingglass Creek and Little Lookingglass Creek, which is the largest tributary, were divided into four geographic units by Burck (1993) (Figure 2). Unit 1 extended from the mouth of Lookingglass Creek to Lookingglass Falls at rkm 4.02 (which is now the location of a picket weir and the hatchery water intake building). Unit 2 extended from the falls to the mouth of Little Lookingglass Creek, located just below rkm 6.84. Unit 3 extended from the mouth of Little Lookingglass Creek to just above the mouth of Lost Creek at about rkm 17.70. Unit 4, which was Little Lookingglass Creek, started at the mouth and extended upstream to about rkm 6.43. We used these same units and landmarks in our study, but we divided unit 3 into upper and lower sections (Figure 2).

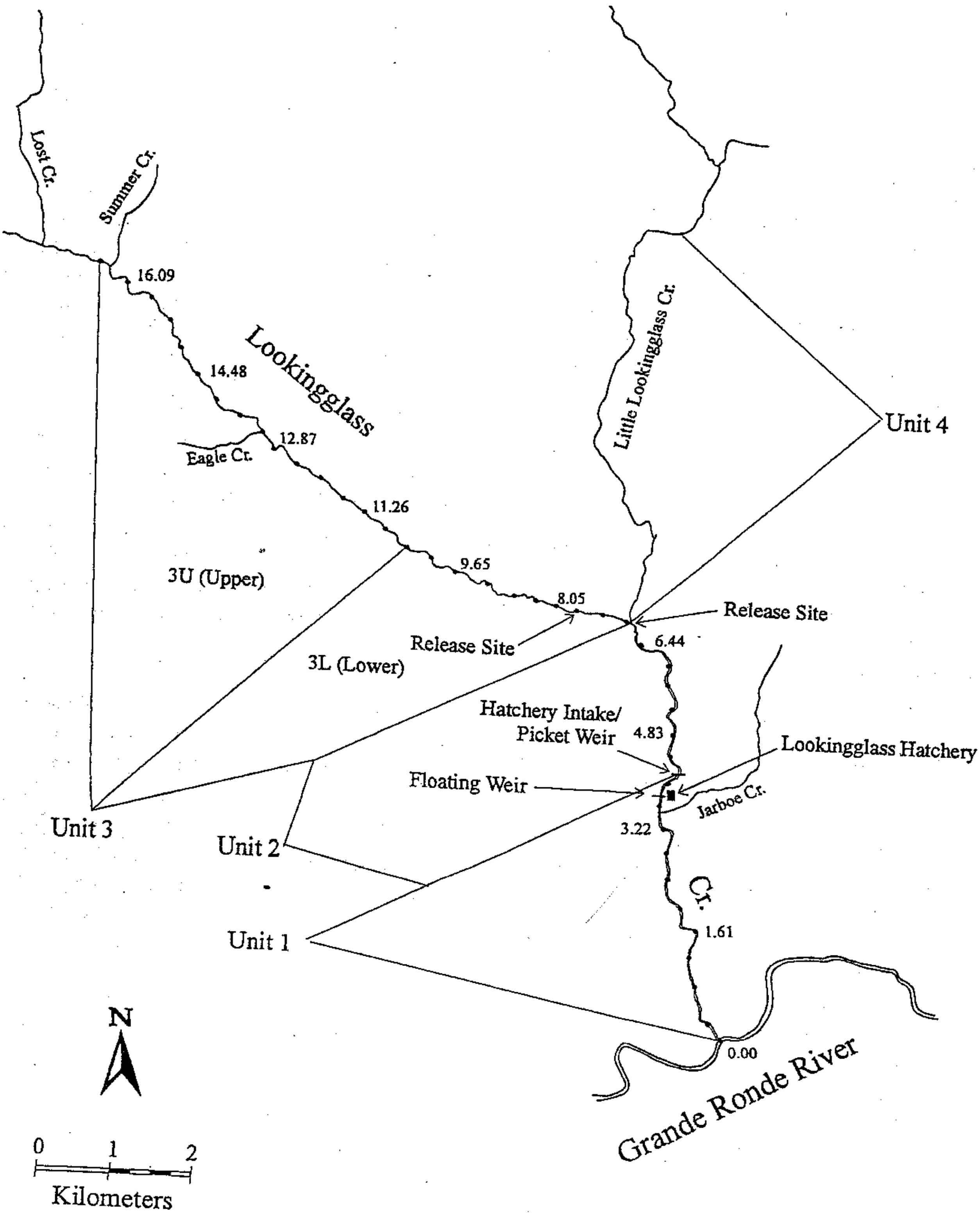

Figure 2. Locations of units and 0.4-river kilometer sections (·) in Lookingglass Creek basin.

Methods

Stream Flow and Temperature

Stream flows in Lookingglass Creek were summarized to characterize flow profiles in the watershed in 1994 and compare them to those from 1964 to 1971 (Burck 1993, McLean and Lofy 1995). Stream flow data for 1994 were summarized by grouping available daily data into 52 periods each corresponding to a week of the year to facilitate comparisons with flow data from 1964 to 1971. The maximum and minimum stream flow data were determined for each of the 52 periods. Each weekly period was referenced using the last date of the week. Data for 1994 were obtained from the United States Geological Survey (USGS) (Hubbard 1994,1995). Stream flows in 1994 were estimated every 0.5 hours at an electronic stream gaging station operated by the USGS. A mean daily stream flow was reported.

Stream temperatures in Lookingglass Creek were summarized to characterize temperature profiles in the watershed for 1994 for comparisons to stream temperatures in Lookingglass Creek from 1964 to 1971 (Burck 1993, McLean and Lofy 1995). Water temperature data were summarized by grouping yearly data into ranges for each week of the year. Each weekly period was referenced using the last date of the week. Data for 1994 were from unpublished summaries from the United States Forest Service (USFS), Walla Walla District. Stream temperatures measured in 1994 were recorded about rkm 12.07 in Lookingglass Creek by the USFS, Walla Walla District. Temperatures were measured hourly with an electronic thermograph. A daily range in stream temperature was reported.

Sampling and Release of Adults Above the Weir

The procedures outlined in the Annual Operations Plan for LSRCP hatcheries in Oregon for 1994 called for the release of 75 to 150 adult and 5 to 10 jack chinook salmon (release group) above the picket weir on Lookingglass Creek. The target composition of the release group was 47% adult male, 47% adult female, and 6% jacks. Chinook salmon less than 600 mm in fork length were classified as jacks. The hatchery trap began operation on 24 May. Fish captured in the trap were processed on a weekly basis. Because three- and four-year-old hatchery chinook salmon that returned to Lookingglass Hatchery in 1994 were nearly all marked with adipose and right pectoral fin clips as juveniles (Messmer et al. 1992, 1994), all unmarked fish within these age categories (as determined by fork-length categories for each age which were provided by ODFW) were presumed to be of natural origin, and were to be released above the weir. Marked hatchery four-year-olds were selected for passage above the weir with preference for right pelvic clips only to retain fish that were adipose fin-clipped (to retrieve coded-wire tags). Preference for five-year-old chinook salmon to pass above the weir was for unmarked fish, also to retain fish likely to have been coded-wire-tagged. About 50% of the hatchery returns of five-year-olds were expected to be unmarked (Messmer et al. 1994). Because the total return was expected to be very low, 50% of each sex that returned to the hatchery was scheduled to be passed above the weir, regardless of the sex ratio of the return to the hatchery. This method assured equal sex ratios for both the hatchery broodstock and the fish released above the weir.

Sampling of the fish released above the weir was done to compare age and sex composition to the total return to the hatchery. All chinook salmon released above the weir were assigned a sex (from morphological inspection) by hatchery personnel at trapping, measured (fork length to the nearest mm), and had 3 or 4 scales taken from each side in the key scale area for determination of age. Age was defined as the number of years from egg deposition (e.g., 5-year-old fish in 1994 was deposited as an egg in 1989). Age was determined by visually inspecting the scales.

Fish were tagged to allow identification of individuals when they were observed on spawning surveys, recycled through the hatchery trap, or recovered as carcasses. Chinook salmon were tagged just below the dorsal fin with numbered, 32-mm diameter red and white Peterson disc tags. We used tags 10 mm larger in diameter in 1994 in an effort to increase visibility of the numbers on the tags compared to 1992 or 1993. Fish were secondarily marked to determine sex assignment at release and for recognition as previously-handled fish. A small, round, piece of the operculum was removed with a paper punch (operculum-punched). The fish were released just below the mouth of Little Lookingglass Creek or at the next bridge upstream (Figure 2, release sites).

Spawning Surveys

Spawning surveys were conducted to document the distribution and timing of spawning activity, count live fish, recover carcasses and count the number of tagged fish that moved downstream below the weir. We completed surveys in all sections, every two weeks before the first digging activity was observed, and weekly after that date. A dig (initiation of redd-digging activity) was flagged and given a number on the date it was first observed. Occupation of the site by a chinook salmon was also recorded. Only new digs were flagged on each survey. Digs were categorized as incomplete or complete based solely on physical characteristics. That is, a dig could be designated as incomplete even if it was occupied (there was a fish on or near the redd). If a dig was still considered incomplete at the end of the survey season, it was not counted in the total number of complete redds for the year. Once a dig was designated as a completed redd by a surveyor, it was included in the total redd count from that date forward.

Marked and unmarked carcasses were sampled during spawning surveys, or after collection off of the picket or floating weirs. Carcasses were recovered to retrieve coded-wire tag information from adipose fin-clipped fish and to estimate the number of fish that escaped above the weir that were never handled using the ratio of tagged to untagged fish. In addition, scale samples were taken from unmarked fish. Some carcasses were too decomposed to collect scales, determine the sex, or record mark information.

The accuracy of the sex assignment at marking was calculated by examining gonads of marked carcasses. For each sex, the accuracy was calculated by dividing the number of carcasses recovered with the correct sex assignment by the total number of carcasses recovered that were assigned that sex.

Spawning Timing

Observations of live and dead fish and newly completed redds were used to index spawning timing. Numbers seen at each survey date were expressed as a percent of the total observed for the year. To describe variation in spawning timing between the Rapid River stock and the Lookingglass Creek stock, indices of spawning timing for 1994 were compared to 1966 to 1970 (Burck 1993, McLean and Lofy 1995). The surveys from 1966 to 1970 were used because the frequencies of the surveys were most similar to those during 1992 (Lofy and McLean 1995), 1993 (McLean and Lofy 1995), and 1994. From 1966 to 1970, unit 3 encompassed the primary spawning area and this unit was used to describe the spawning timing in Lookingglass Creek (Burck 1993, McLean and Lofy 1995).

Prespawning Mortality Index

In 1994, we determined prespawning mortality using the same methodology as that reported by Burck (1993). Only female carcasses that met all of the following criteria were included as prespawning mortalities in the index: 1) the carcass was recovered after the first redd was observed, 2) the carcass was recovered above the weir, and 3) the carcass retained more than an estimated 10% of the eggs. Comparisons of prespawning mortality among the years 1966 to 1970 (Burck 1993), 1992, and 1993 (McLean and Lofy 1995) and 1994 were made using a prespawning index calculated as:

$$\frac{\textit{number of females recovered during spawning surveys with 10\% of their eggs intact}}{\textit{total number of females that were recovered during spawning surveys}} * 100$$

Population Estimates for the Number of Fish Above the Weir

Estimates were made of the total number of chinook salmon that escaped above the weir because the weir has not been 100% effective at stopping all upstream migration in the past. We presumed that in 1994 some fish had passed the weir before it was installed on 24 May, as suggested by run timing data (see Run Timing). Separate male and female portions of the population above the weir were estimated with a mark-recapture technique (Brower and Zar 1977) using tagged and untagged carcasses. Only carcasses for which the presence of the operculum punch or Peterson discs could be determined were included among the tagged or the untagged carcasses that were used for population estimation.

An adjusted number of males or females released above the weir (M_a) was calculated for each sex based upon accuracy of sex assignment of fish captured at the Lookingglass Hatchery trap (see

Spawning Surveys). The number of assigned females released was multiplied by the sex assignment accuracy for females to calculate the adjusted number of females. To calculate the adjusted number of males released, the adjusted number of females was then subtracted from the total number fish released.

We made separate calculations of the number of male (which included jacks) and female portions of the chinook salmon population above the weir (N) because the ratios of marked to unmarked carcasses may be different between the sexes (Lofy and McLean 1995, McLean and Lofy 1995):

$$N = \frac{(M)(n)}{R} \qquad SEM = \sqrt{\frac{(M)(n)(M-R)(n-R)}{R^3}}$$

N = population estimate for the number of fish above the weir
M = adjusted number of tagged fish (M_a) minus marked fish of that sex observed below the weir
n = total carcasses recovered (tagged + untagged)
R = total tagged carcasses recovered
SEM = standard error of the mean for the estimate of the number of fish

The number of redds observed and the estimate of the total population above the weir were used to calculate a fish per redd estimate above the weir. A females per redd estimate above the weir was also calculated.

Sampling Adult Chinook Salmon for Pathogens

Carcasses recovered on surveys and any carcasses that were recovered on the picket weir, the floating weir, hatchery intake, or the hatchery adult trap, were sampled for pathogens. Pathologists from ODFW (Fish Pathology, La Grande, Oregon) sampled the carcasses for *Renibacterium salmoninarum* (bacterial kidney disease), *Ceratomyxa shasta* (whirling disease), aeromonad/pseudomonad bacteria (general septicemia) and *Yersinia ruckeri* (enteric redmouth disease). The data from ODFW are summarized in this report.

Fecundity Estimates

The fecundity of female Rapid River stock spring chinook salmon was estimated at Lookingglass Hatchery in 1994. Fecundity estimates will eventually be used to estimate the number of eggs deposited above the weir. Because there were low numbers of female chinook salmon of Rapid River stock spawned at the hatchery in 1994 (N=47), every female that had mature eggs was used for fecundity sampling. Fork length, prespawning fish weight and ovary weight were measured. Two samples of approximately 100 eggs each were weighed and counted. The number of eggs per gram was estimated for each sample. Eggs which appeared normal in size and coloration that remained in the body cavity or that fell on the floor were included in the fecundity estimate. Estimates of eggs per female were calculated with the formula:

$$\textit{Eggs per female} = (\textit{Ovary weight (g)} * \bar{x}\ \textit{eggs/g}) + (\textit{eggs in the body cavity or on the floor})$$

Sampler variability was calculated as a percent:

$$(((\textit{larger sample eggs/g}) / (\textit{smaller sample eggs/g})) - 1) * 100$$

Females with sampler variability greater than 5%, females whose eggs were not fully mature at the time of sampling (as evidenced by incomplete breakdown of the connective tissue around the eggs before spawning), and females that had lost a large number of eggs before they were spawned (as evidenced by particularly flaccid body cavities) were not used in the development of a regression equation because precision of the estimate of fecundity was considered questionable. A regression equation was developed with fork length to predict fecundity.

Run Timing

Comparisons of run timing of Rapid River stock to Lookingglass Hatchery were made between the total return and the 1994 release group. All run timing data were summarized as the percent of the total return to the hatchery trap for each week of the year.

Age Composition

Age compositions of individual cohorts of chinook salmon were compared among cohort years of the Lookingglass Creek stock and the Rapid River stock. Data were available from the 1968 and 1969 cohorts of the Lookingglass Creek stock (Burck 1972, 1973, 1974, 1975). These were the only cohorts that were complete and from which scales were taken from returning adults at the trap by Burck (1993). Data for the Rapid River stock was from the 1987 to 1989 cohorts (Messmer et al. 1992, 1994, 1995, in preparation). Age composition of the release group was compared to that of the total return to Lookingglass Hatchery. This was done to determine if the fish that were released represented the total return that was captured at the hatchery trap. Age composition for each group was determined by scale analysis completed by ODFW.

Redd Distribution and Density

To describe whether the adult chinook salmon of Rapid River stock utilized spawning areas in patterns similar to those which were used by the Lookingglass Creek stock, redd distribution for 1994 was determined and compared to redd distributions of 1964 to 1971 (Burck 1993). Data from Burck (1993) were summarized by graphing the maximum and minimum percentages for units 2, 3 and 4 of total redds above the weir for 1964 to 1971. We split unit 3 into upper (3U) and lower (3L) sections (Figure 2) in 1994 to better describe this large unit. Since completion of the hatchery, retention of fish for broodstock has resulted in the proportion of spawning below the weir being larger than would have occurred if all fish that were captured in the trap had been released above the weir. Therefore, differences in redd distribution did not include unit 1 below the weir.

Redd density in 1994 was compared to 1964 to 1971 (Burck 1993) for units 1 through 4 to characterize potential differences in intensity of utilization of the spawning areas. Redd density data (redds per kilometer) converted from Burck (1993) were summarized into ranges for 1964 to 1971 for each unit. Data points for 1994 were graphed for comparison.

Enumeration of Juvenile Chinook Salmon at the Rotary Screw Trap

We operated the rotary screw trap (trap) (McLean and Lofy 1995) year-round except when ice prevented turning of the cone. Periods of operation were occasionally interrupted (usually overnight) when a large piece of debris prevented the drum from turning. We recorded fork lengths on a subsample of the fish to characterize trapped juveniles each month. With completion of the outmigration of the 1993 cohort in 1995, we will estimate the number of fish that left Lookingglass Creek using data from trap efficiency tests.

Timing and Survival Indices of Juvenile Chinook Salmon

We tagged juveniles from Lookingglass Creek with passive-integrated-transponder (PIT) tags in order to index timing of arrival at and survival to Lower Granite Dam. Our goal for the 1992 cohort in 1994 was to tag 500 juveniles captured in the trap from 1 January to the end of the migration out of Lookingglass Creek (spring group). We captured juveniles from the 1992 cohort at the trap in July, August, and September. However, we did not PIT-tag any of these because swollen anal areas and dark coloration suggested that they were maturing and would not become smolts. Comparisons were made among juveniles from the 1992 cohort, PIT-tagged in 1993 (field group, winter group) (McLean and Lofy 1995), and at the trap in 1994 (spring group). Because the trap was not in operation before 28 October, 1993 (McLean and Lofy 1995), we did not PIT-tag any of the 1992 cohort before this date for the fall group. We also tagged juveniles from the 1993 cohort in 1994. However, we will report complete tagging and detection information when tagging is complete for this cohort in 1995.

Arrival timing to Lower Granite Dam for the three groups of juveniles from the 1992 cohort was indexed by grouping detections at the dam into weeks of the year. The timing of the three groups was graphed to illustrate differences. The interrogation system at Lower Granite Dam was functional from 1 April to 1 November in 1994.

Survival indices to Lower Granite Dam for each group were calculated by dividing the number of first time detections of fish from a group at all Snake and Columbia River dams by the total number of the juveniles tagged in that group. This represents a minimum survival index, because it does not account for fish which passed Lower Granite Dam but were never detected downstream. Survival indices for each month were also calculated to determine if a trend in survival was evident over time.

Monthly Sampling of Juvenile Chinook Salmon

Monthly sampling for the 1993 cohort of juvenile chinook salmon in Lookingglass Creek was scheduled around the 20th of each month similar to the target date for monthly sampling by Burck (1993). Sampling began April (the first month that fry were expected to be numerous enough to sample) through October (the last month when enough fish were available to obtain a sample of at least 50 fish). Fork lengths from about 50 juvenile chinook salmon was the goal of the sampling at each sampling location. Burck (1993) described 4 locations where monthly samples were collected in Lookingglass Creek: an upper area, rkm 16.09 to 16.49; a standard area, rkm 7.24 to 7.64; a lower area, at rkm 0.00 to 0.40 and within Little Lookingglass Creek about 2.82 rkm from its mouth (Figure 2). Juveniles were also sampled by Burck (1993) at the bypass trap located at rkm 3.62 (near the present site of the hatchery intake). We attempted to sample as close as possible to these locations. However, with the reduced densities of redds that we have observed, we had to adjust our sampling sites. We moved our upper sampling site downstream to about rkm 11.26 to 11.67. Our lower sampling site was moved upstream to be adjacent to the hatchery complex at about rkm 3.62 to 4.02. We sampled juveniles within Little Lookingglass Creek in scattered areas throughout the lower 4.02 rkms (Figure 2), wherever we could find them.

In order to compare our monthly samples in the field to that at the rotary screw trap during the same time period, we used lengths from fish captured about the same dates. We used the same dates as the monthly samples in the field if the sample size at the trap was greater than 50. If the sample size at the trap was less than 50, we included data from plus and minus one day until a total of at least 50 fish with fork lengths were selected, or a maximum range of 11 days had been encompassed.

Genetic Monitoring

As part of a genetic monitoring program, the NMFS requested that we collect a minimum of 60 juvenile chinook salmon from Lookingglass Creek. These fish were sacrificed, placed on ice, and transported to La Grande for storage in a freezer at -80°C. Samples were sent to the NMFS laboratory in Seattle for electrophoretic and morphometric.

Results

Stream Flow and Temperature

During most of 1994, the flow in Lookingglass Creek was 2 to 3 m^3/s. Spring flows started increasing in late February, peaked at a little more than 21 m^3/s during the week of 22 April, and decreased dramatically from May through June to summer/fall low flows below 5 m^3/s for the duration of the year (Figure 3). Because thermographs were lost or exposed to the air, the temperature data for 1994 were incomplete. During the dates when stream temperatures were recorded in 1994, they peaked in late June through late July at around 13 °C (Figure 3). The widest weekly temperature ranges occurred during this time.

Sampling and Release of Adults Above the Weir

We released 112 chinook salmon in 1994 which were assigned as 43 males, 66 females and 3 jacks. Fork length, sex, age, and origin were summarized (Table 1, Appendix Table A-1). Percentages for each group assigned at release were 38.4% adult males, 58.9% adult females, and 2.7% jacks.

Spawning Surveys

Spawning surveys for 1994 began 18 July and ended 21 September (Figures 4-6). Spawning surveys were conducted weekly from 1 August to 21 September. The first completed redds were observed on 15 August in unit 3, 17 August in unit 1, and 30 August in units 2 and 4 (Figures 4-6). The last new completed redds were observed 7 September in unit 1, 12 September in units 2 and 4, and 20 September in unit 3 (Figures 4-6). Completed redds above the weir totaled 40, while those below the weir totaled 8.

We summarized fork length, sex, and age from carcasses recovered during spawning surveys and from the picket and floating weirs (Table 2, Appendix Table A-2). The accuracy of the sex assignment at the time of trapping was checked against the actual sex from internal inspection upon the recovery of carcasses. There were 36 previously-tagged adult chinook salmon carcasses (tagged and/or operculum-punched at recovery) for which the sex could be positively identified (actual sex: 14 males and 22 females) (Appendix Table A-2).

Spawning Timing

Peaks in the number of new redds observed in unit 3 occurred on 29 August (Figure 4) and 7 September below the weir (Figure 5). The peak in the numbers of live fish observed in unit 3 occurred on 29 August (Figure 7) and 7 September below the weir (Figure 8). A peak in carcass recovery in unit 3 occurred 6 September (Figure 7, Appendix Table A-2) and one fish was recovered each date from 22 August, 30 August, to 7 September, and 21 September below the weir (Figure 8, Appendix Table A-2).

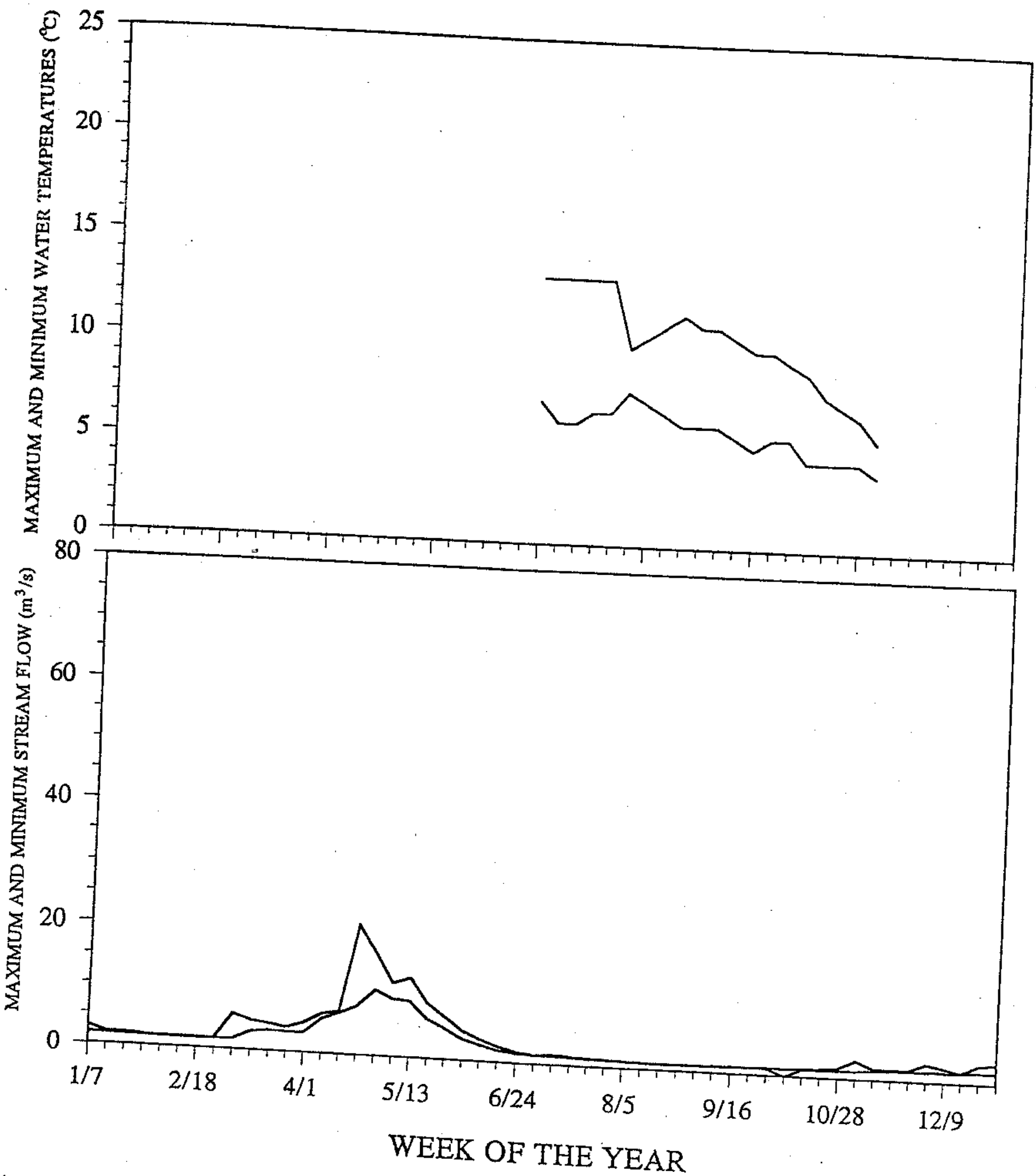

Figure 3. Weekly stream temperatures (USFS unpublished data) and flows (USGS unpublished data) for Lookingglass Creek in 1994. Flow data were a weekly range of 48 daily flows measured at a stream gaging station. Temperature data were a weekly range of 24 daily temperatures taken at the downstream end of the Umatilla National Forest boundary, about river kilometer 12.07. The weekly periods end on the dates shown.

Table 1. Origin, age, assigned sex, and fork length information from disc-tagged spring chinook salmon released above the weir on Lookingglass Creek in 1994.

Age	Sex[a]	N	%[b]	Fork Length (mm) Range	Mean	± SD
3	Male	3	2.7	490-540	507.7	22.9
4	Male	34	30.4	659-790	728.9	37.0
4	Female	51	45.5	610-788	709.6	39.9
5	Male	9	8.0	758-867	829.0	41.1
5	Female	15	13.4	655-867	817.2	51.6

[a] The sex of the fish was assigned at the time of tagging.
[b] Percent of the total released.

Table 2. Origin, age, sex at recovery, and fork length information from spring chinook salmon recovered on Lookingglass and Little Lookingglass creeks during spawning surveys or at the picket or floating weirs in 1994.

Age	Sex[a]	N	%[b]	Fork Length (mm) Range	Mean	± SD
3	Male	2[c]	4.9	505	---	---
4	Male	10[d]	24.4	600-765	692.3	47.9
4	Female	19[e]	46.3	625-778	696.53	35.8
5	Male	3	7.3	804-890	844.7	35.3
5	Female	7	17.1	755-855	837.5	35.2

[a] The sex of the fish was assigned at the time of tagging. One fish recovered was of unknown sex and was not included in this table.
[b] The percent of the total recovered for which both age and sex could be determined.
[c] Sample size for fork length was 1.
[d] Sample size for fork length was 9.
[e] Sample size for fork length was 17.

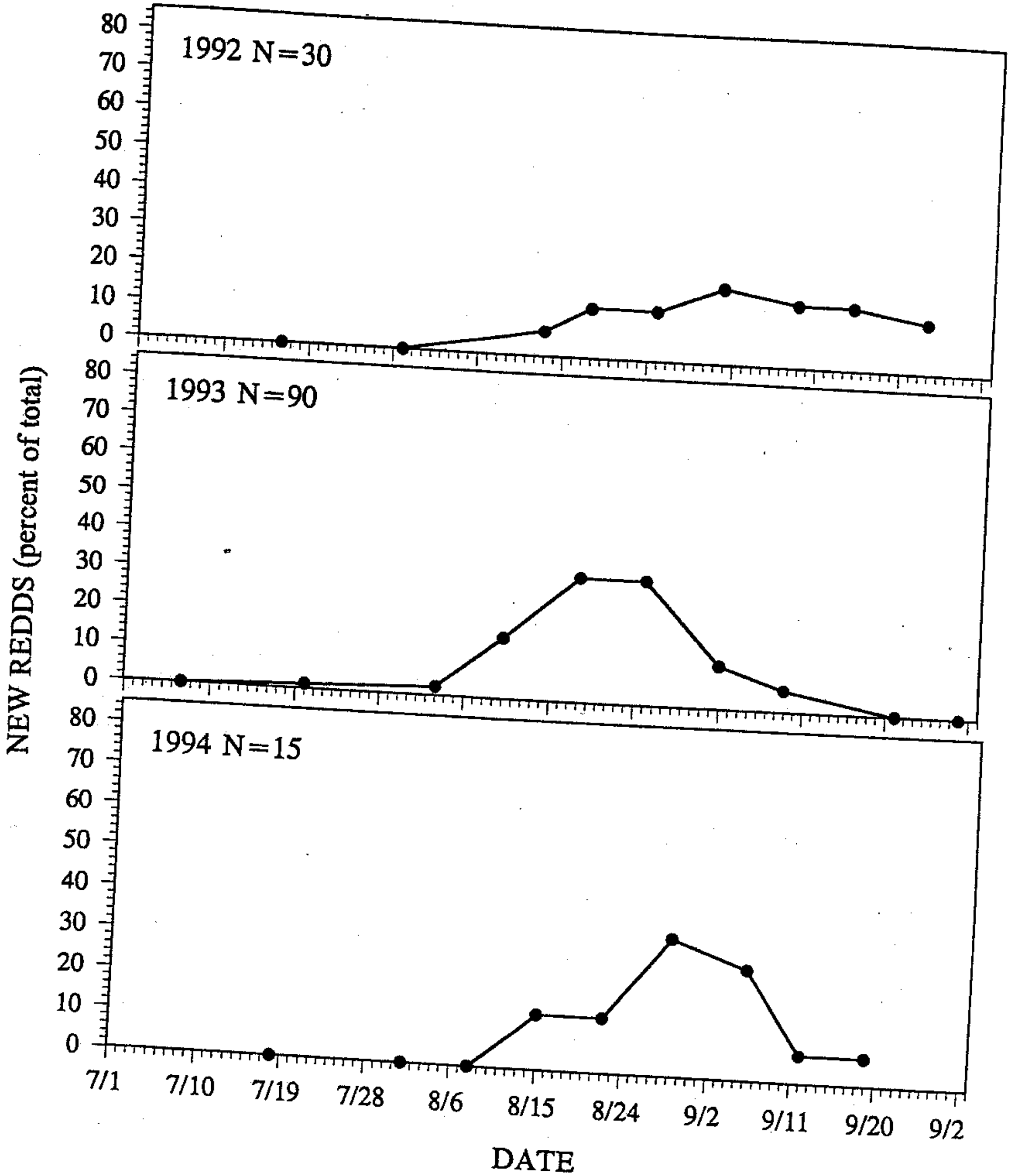

Figure 4. New redds (percent of the total) observed on each survey date in unit 3 (above the weir) of Lookingglass Creek for 1992, 1993, and 1994.

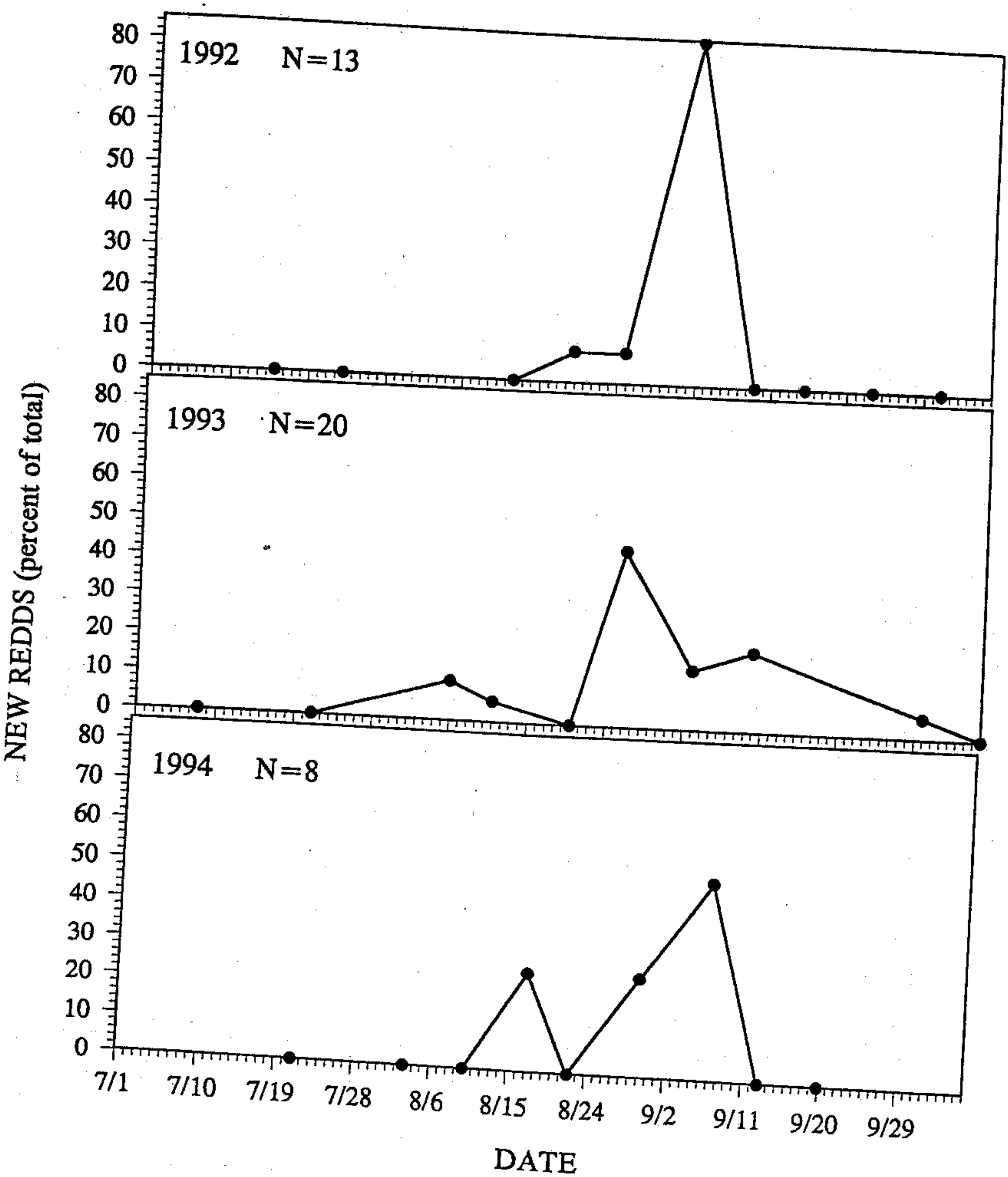

Figure 5. New redds (percent of the total) observed on each survey date in unit 1 (below the weir) of Lookingglass Creek for 1992, 1993, and 1994.

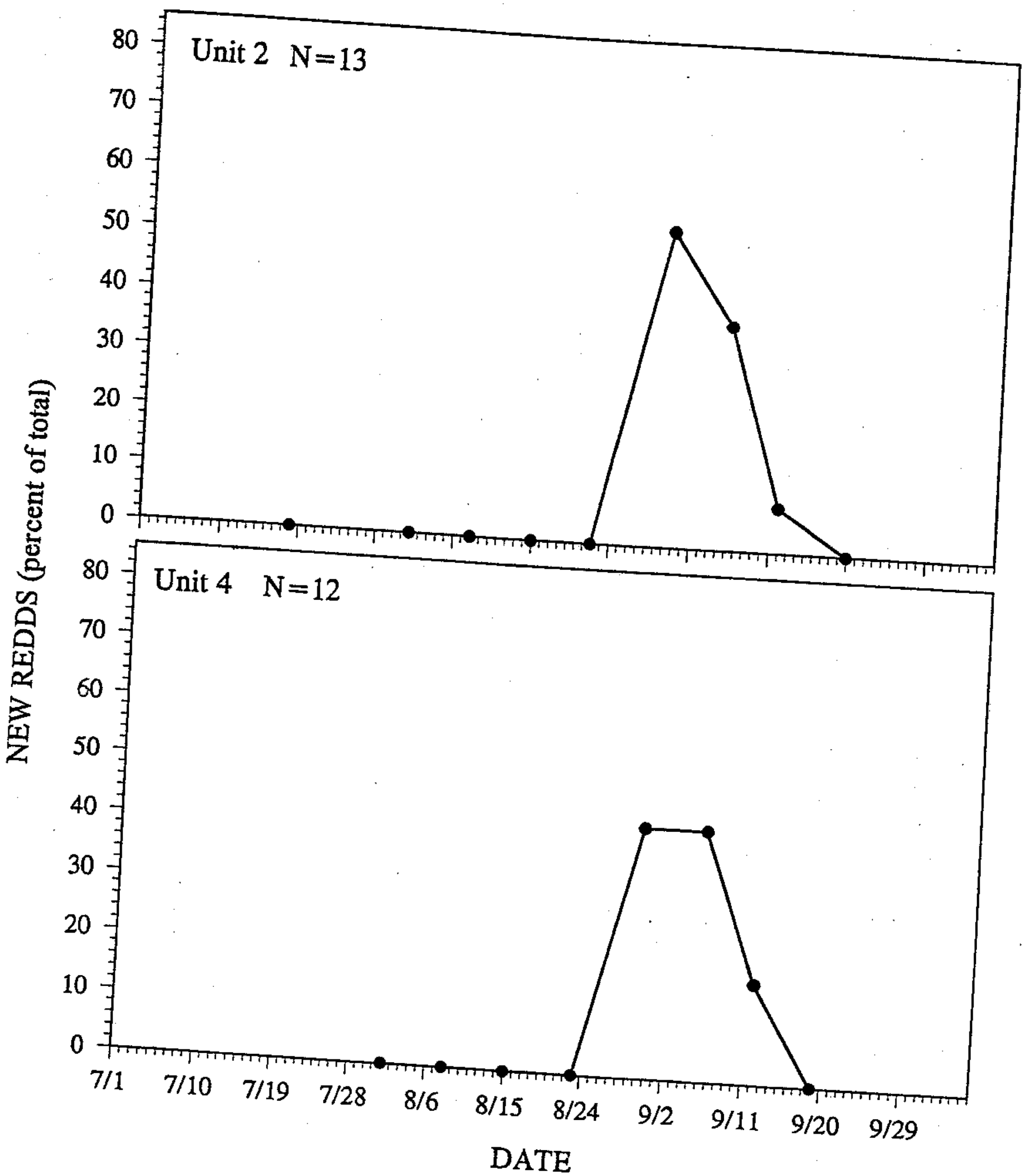

Figure 6. New redds (percent of the total) observed on each survey date in 1994 for units 2 (of Lookingglass Creek) and 4 (Little Lookingglass Creek).

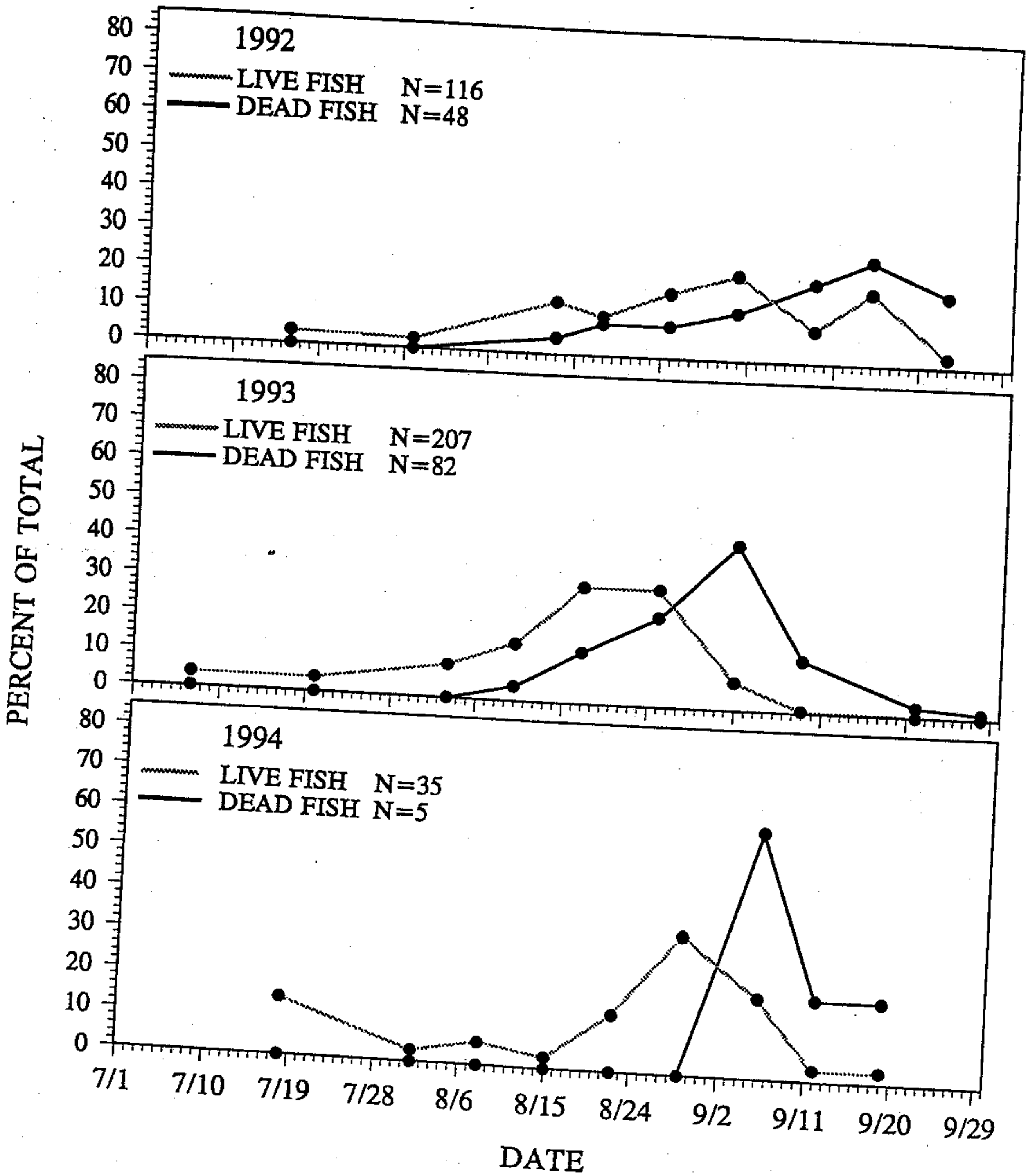

Figure 7. Percent of the total live and dead fish seen by date in unit 3 (above the weir) of Lookingglass Creek for 1992, 1993, and 1994.

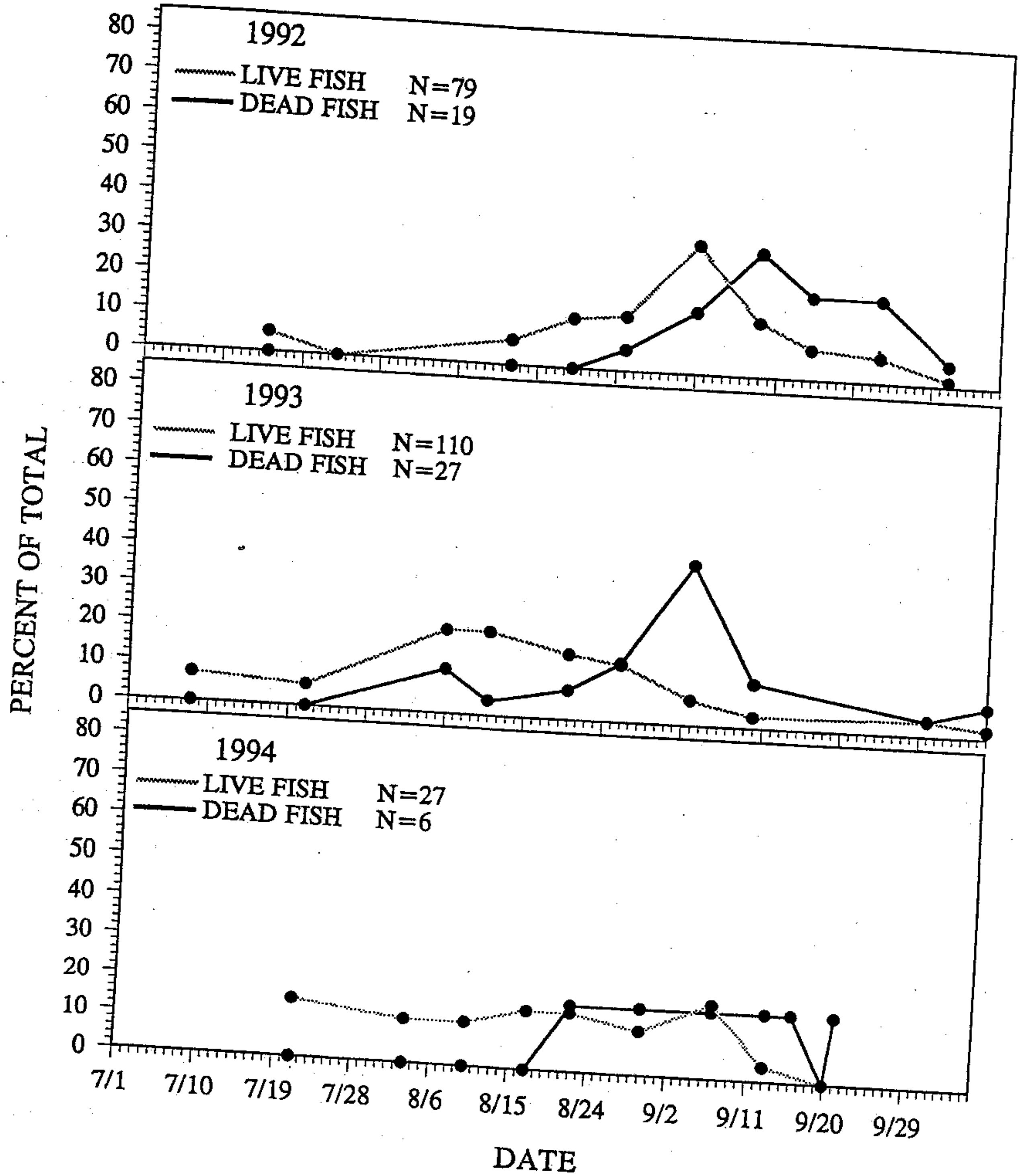

Figure 8. Percent of the total live and dead fish seen by date in unit 1 (below the weir) of Lookingglass Creek for 1992, 1993, and 1994.

Prespawning Mortality Index

The prespawning mortality index for 1994 was 6.3% for tagged females (N=16) (Table 3). The index was 0.0% for untagged females (N=3) (Table 3). The overall prespawning mortality index was 5.3% (N=19) (Table 3).

Population Estimates for the Number of Fish Above the Weir

The sex assignment accuracy of the females was calculated as 22 (females correctly assigned as females) divided by 26 (carcasses assigned as females) multiplied by 100, for an accuracy of 84.6%. The sex assignment accuracy of the males was 10 (males correctly assigned as males) divided by 10 (carcasses assigned as males) multiplied by 100, for an accuracy of 100.0%. Four chinook salmon recovered as carcasses were not assigned the correct sex at the time of tagging for an overall accuracy of 88.8%.

Because the accuracy in assigning the sex to female chinook salmon at the time of trapping (4 males were assigned as females) was not 100% accurate, and because the accuracies for the two sexes were dissimilar, an adjusted number for males and females released above the weir was calculated. The sixty-six females placed above the weir was adjusted to 56 (M_a in population calculations) by multiplying 66 by 0.846 and rounding to the nearest whole fish (the effect subtracted ten fish). Two tagged females were recovered below the weir for an estimated 54 marked females above the weir. Four unmarked females were recovered above the weir. The total number of females above the weir was estimated to be 64 (M_a) (Table 4, Appendix Table A-3). The forty-six males placed above the weir was adjusted to 56, adding an estimated 10 males. Two tagged males were recovered below the weir for an estimated 54 marked males above the weir. One unmarked male was recovered above the weir. The total number of males above the weir was estimated to be 58 (Table 4, Appendix Table A-3). There were an estimated 3.10 fish per redd and 1.65 females per redd above the weir (Appendix Table A-3).

Sampling Adult Chinook Salmon for Pathogens

Personnel from ODFW Fish Pathology laboratory were provided with 19 chinook salmon carcasses in 1994 (Appendix Table A-4). Of the 19 adult chinook salmon sampled, 9 fish had clinical levels of infection of *Renibacterium salmoninarum* (bacterial kidney disease, BKD) by ELISA. All other fish had ELISA levels that were considered low (Appendix Table A-4). Of the 10 fish sampled for *Ceratomyxa shasta* (whirling disease), nine had low to high infection levels (spores were present) and two were negative (Appendix Table A-4). Aeromonad-pseudomonad bacteria (general septicemia) were the most prevalent bacteria in the culture for 9 of the 17 fish sampled (Appendix Table A-4). *Yersinia ruckeri* (enteric redmouth disease) were the most prevalent bacteria in the other 8 fish sampled.

Table 3. Prespawning mortality indices of females collected during weekly spawning surveys for 1964-1971 and 1992-1994.

Year	Group[a]	Number of prespawn females	Total sample of females	Prespawning mortality index[b]
1964		1	151	0.7
1965		1	82	1.2
1966		4	204	2.0
1967		3	72	4.2
1968		0	43	0.0
1969		2	99	2.0
1970		6	127	4.7
1971		0	18	0.0
1964-1971		17	796	2.1
1992	tagged	1	13	7.7
1992	untagged	0	3	0.0
1992	overall	1	16	6.3
1993	tagged	3	26	11.5
1993	untagged	5	62	8.1
1993	overall	8	88	9.1
1994	tagged	1	16	6.3
1994	untagged	0	3	0.0
1994	overall	1	19	5.3
1992-1994	overall	10	123	8.1

[a] In recent years we have had tagged and untagged females.

[b] Prespawning mortality index =(# prespawning female carcasses/total female carcasses). Index only includes female carcasses observed during weekly spawning ground surveys above the weir.

Table 4. Population equation variables and estimates for the number of adult spring chinook salmon above the weir on Lookingglass Creek in 1994.

MALE

M = adjusted # of tagged fish placed above the weir (M_s) - # carcasses observed below the weir
M = 56 - 2
M = 54
n = 15
R = 14
N = (54*15)/14

$$SEM_m = \sqrt{\frac{(54)(15)(54-14)(15-14)}{14^3}} \qquad SEM_m = 3$$

N = 58 total male chinook salmon population above the weir

FEMALE

M = Adjusted # of tagged fish placed above the weir (M_s) - # carcasses observed below the weir
M = 56 - 2
M = 54
n = 26
R = 22
N = (54*26)/22

$$SEM_f = \sqrt{\frac{(54)(26)(54-22)(26-22)}{22^3}} \qquad SEM_f = 4$$

N = 64 total female chinook salmon population above the weir

Fecundity Estimates

Forty-one adult female Rapid River stock spring chinook salmon were sampled for fecundity in 1994. Six females were not used in the regression model because they had immature eggs, were partially spawned, or had sampler variability greater than 5%. A regression model was build to predict fecundity from fork length (Figure 9). The sample contained 3 five-year-old and 38 four-year-old females. The relationship had a positive slope, $P \leq 0.05$, and $r^2 = 0.60$.

Run Timing

Despite installation of the weir later than we had planned, it was evident that the run timing of the total return in 1994 of Rapid River stock to Lookingglass Creek was different from that of the Lookingglass Creek stock (Figure 10, Appendix Table A-5). The peak return probably occurred the last week of May or the first week of June in 1994 while from 1967 to 1974 the peaks occurred from mid to late June with the exception of 1968 (Burck 1964-1974, Lofy and McLean 1995). It appeared that we took fish for release above the weir in similar proportions to that of the total return captured at the hatchery trap (Figure 10, Appendix Table A-5).

Age Composition

Although the age compositions of the 1968 and 1969 cohorts of the Lookingglass Creek stock appeared to have been different from those of the 1987 and 1988 cohorts of Rapid River stock (McLean and Lofy 1995), the age composition of the 1989 cohort of Rapid River stock appeared more similar to those of the Lookingglass Creek stock (Figure 11, Appendix Table A-6). The percentage of jacks for the 1989 cohort (3.3%) fell within the range for the previous two cohorts of Rapid River stock. However, the percentage of 4-year-olds returning from the 1989 cohort (88.3%), was the highest observed from the 1968, 1969, 1987, 1988 and 1989 cohorts (Figure 11, Appendix Table A-6). This was much higher than those observed for the 1987 and 1988 Rapid River cohorts. The percentage of 5-year-olds of the 1989 cohort of Rapid River stock (8.4%) appeared to have been about the same as those of the Lookingglass Creek stock (Figure 11, Appendix Table A-6).

Age composition of Rapid River stock chinook salmon which were released for natural production appeared similar to that observed for the total return (Figure 11, Appendix Table A-7). The percentage of 4-year-olds released into Lookingglass Creek was 75.9% while that of the total return was 83.3%. The percentage of the 5-year-olds released was 21.4% while than of the total return was 14.0%. The percentages of jacks placed above the weir and the total return were both 2.7%.

Redd Distribution and Density

In 1994, 32.5% of total redds counted above the weir were in unit 2, 27.5% were in unit 3L, 10.0% were in unit 3U and 30.0% were in unit 4 (Figure 12). Densities of redds observed from

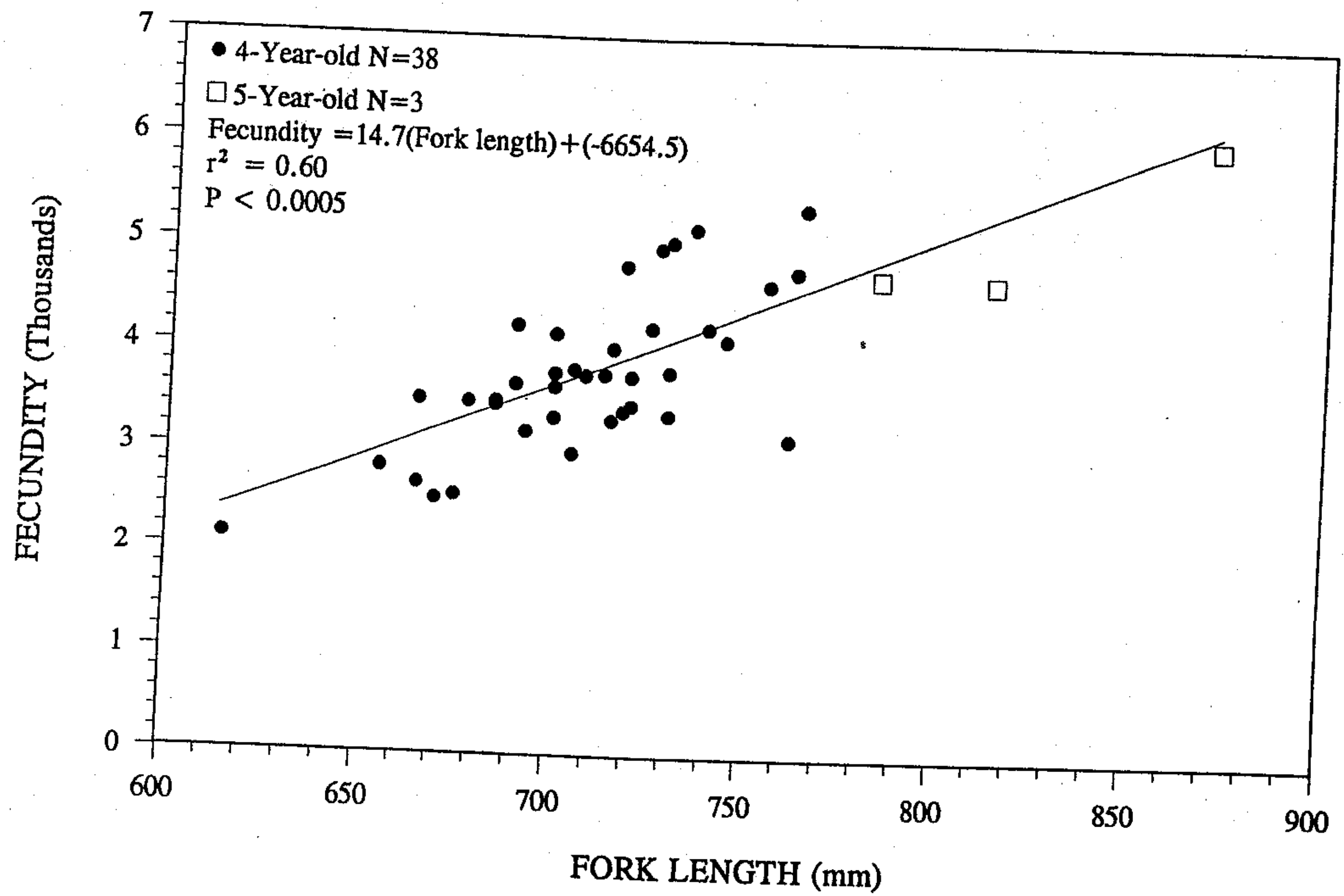

Figure 9. Relationship between fork length and fecundity estimates for Rapid River stock spring chinook salmon at Lookingglass Hatchery in 1994.

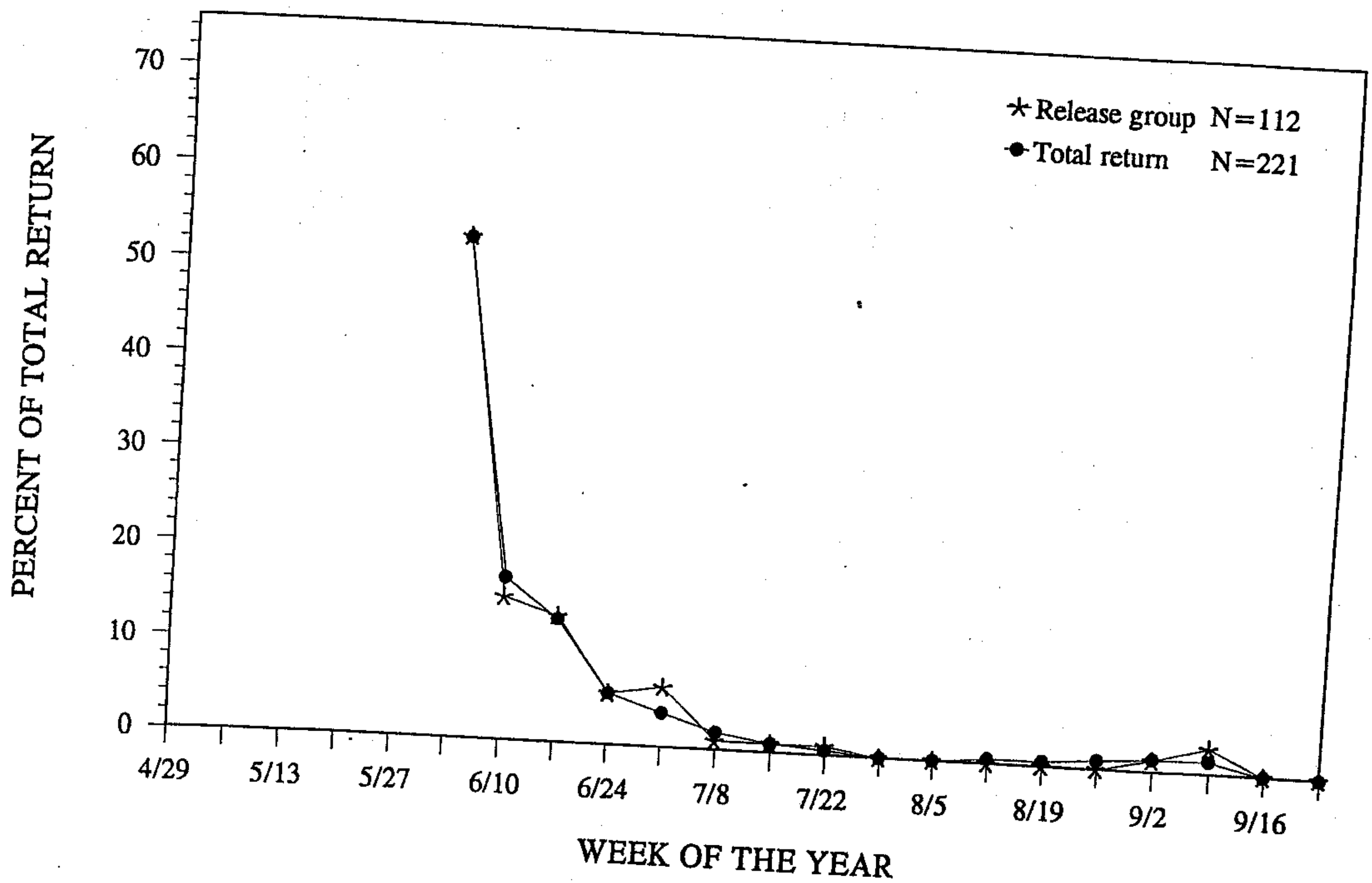

Figure 10. Run timing of spring chinook salmon to Lookingglass Hatchery for the total return and for the release group in 1994. The weekly periods end on the dates shown.

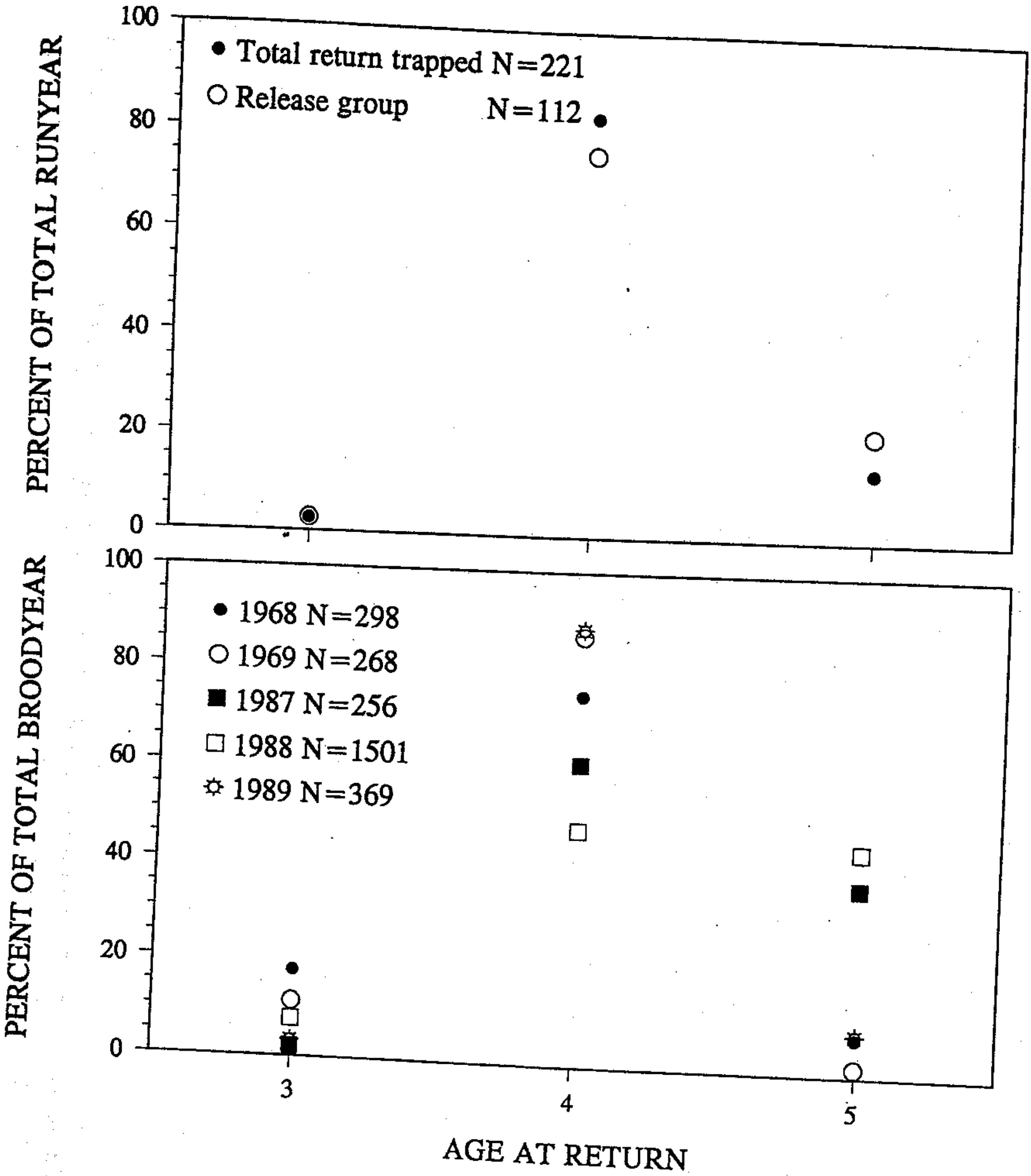

Figure 11. Age compositions for the total return and the release group for 1994 and age compositions of the 1968 (●) and 1969 (○) cohorts of the Lookingglass Creek stock and the 1987 (■), 1988 (□) and 1989 (✡) cohorts of the Rapid River stock that returned to weirs on Lookingglass Creek (Burck 1993; Messmer et al. 1992, 1994, 1995, in preparation).

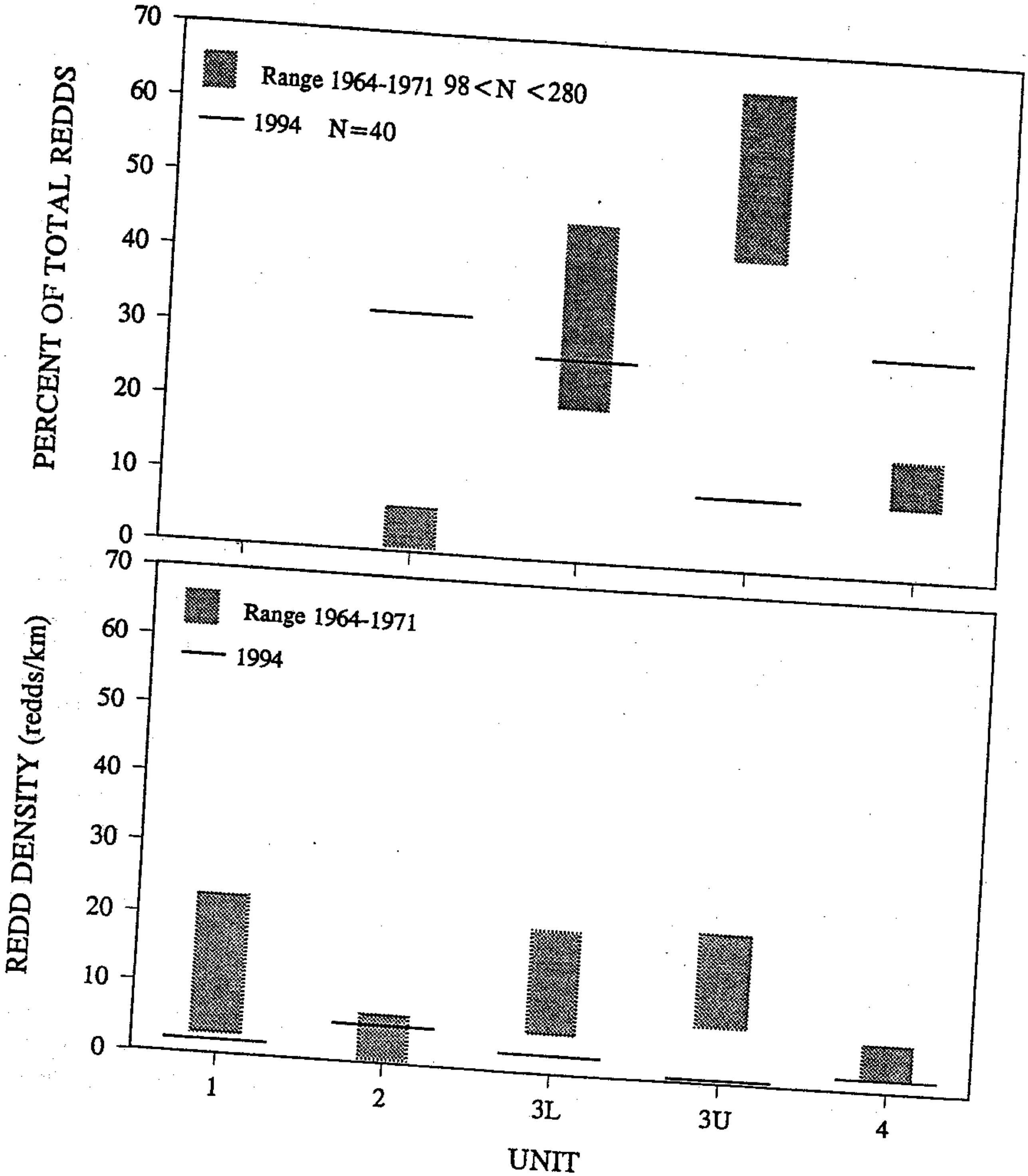

Figure 12. Percentages of the total redds above the weir and redd densities by unit in Lookingglass Creek: range for the Lookingglass Creek stock (1964-1971) (Burck 1993) and data points for the Rapid River stock (1992-1994) (Lofy and M[c]Lean 1995; M[c]Lean and Lofy 1995).

1964 to 1971 ranged from 3.0 to 22.9 redds per kilometer in unit 1, 0.4 to 7.0 in unit 2, 5.7 to 20.6 in the unit 3L, 8.1 to 21.6 in unit 3U and 1.9 to 7.0 redds per kilometer in unit 4 (Figure 12). In 1994 the redds per kilometer in units 1, 2, 3L, 3U and 4 were 2.0, 5.4, 2.7, 0.6, and 1.9 redds per kilometer, respectively (Figure 12).

Enumeration of Juvenile Chinook Salmon at the Rotary Screw Trap

We captured 1,898, 1992 cohort juvenile chinook salmon from October through December 1994, and 737 juveniles from January to July 1994 (Figure 13). Most of the juveniles were captured in the month of November. The data from October were not indicative of the number of juveniles passing the trap the whole month because the trap was not in operation until 28 October. We captured 16,029, 1993 cohort juvenile chinook salmon from February to December in 1994 (Figure 14).

Timing and Survival Indices of Juvenile Chinook Salmon to Lower Granite Dam

We PIT-tagged three groups of juvenile chinook salmon from the 1992 cohort to index survival to and arrival timing at Lower Granite Dam. We tagged 1,022 juveniles in Lookingglass Creek from 22 to 29 September, 1993 in the rearing areas above and just below the picket weir (field group) (McLean and Lofy 1995). From juveniles captured in the trap, we tagged 934 juveniles from 29 October to 31 December, 1993 (winter group) (McLean and Lofy 1995), and 359 juveniles that from 1 January to 6 June (spring group). No fish were captured for the rest of the month of June, and the migration season was considered to have ended. Juveniles from the 1992 cohort captured in the trap from July through September were not PIT-tagged.

Juvenile chinook salmon PIT-tagged in Lookingglass Creek first arrived at Lower Granite Dam the week of 8 April, with the last fish arriving the week of 10 June. The arrival timing of the field, winter, and spring groups were all very similar with peaks at Lower Granite Dam in late April. Median arrival dates were all within 4 days of one another (29 April to 3 May). The number of fish detected at Lower Granite Dam for the field, winter, and spring groups were 103, 140 and 69, respectively (Figure 15).

Survival indices of PIT-tagged juvenile chinook salmon for the field group, winter group, and spring group were 17.5, 21.8 and 31.8%, respectively. Survival indices of fish captured at the trap by month for the months with more than 50 tagged fish released, ranged from 19.7 to 42.1% (Figure 16).

Monthly Sampling of Juvenile Chinook Salmon

Monthly sampling of juvenile chinook salmon was completed from April through October at four sites in the creek, and a comparable sample was taken from the trap to index growth. During sampling in the creek in April, we were only able to locate juveniles at the standard sampling site (Figure 17). We caught very few fish in November and could not locate any in December. We

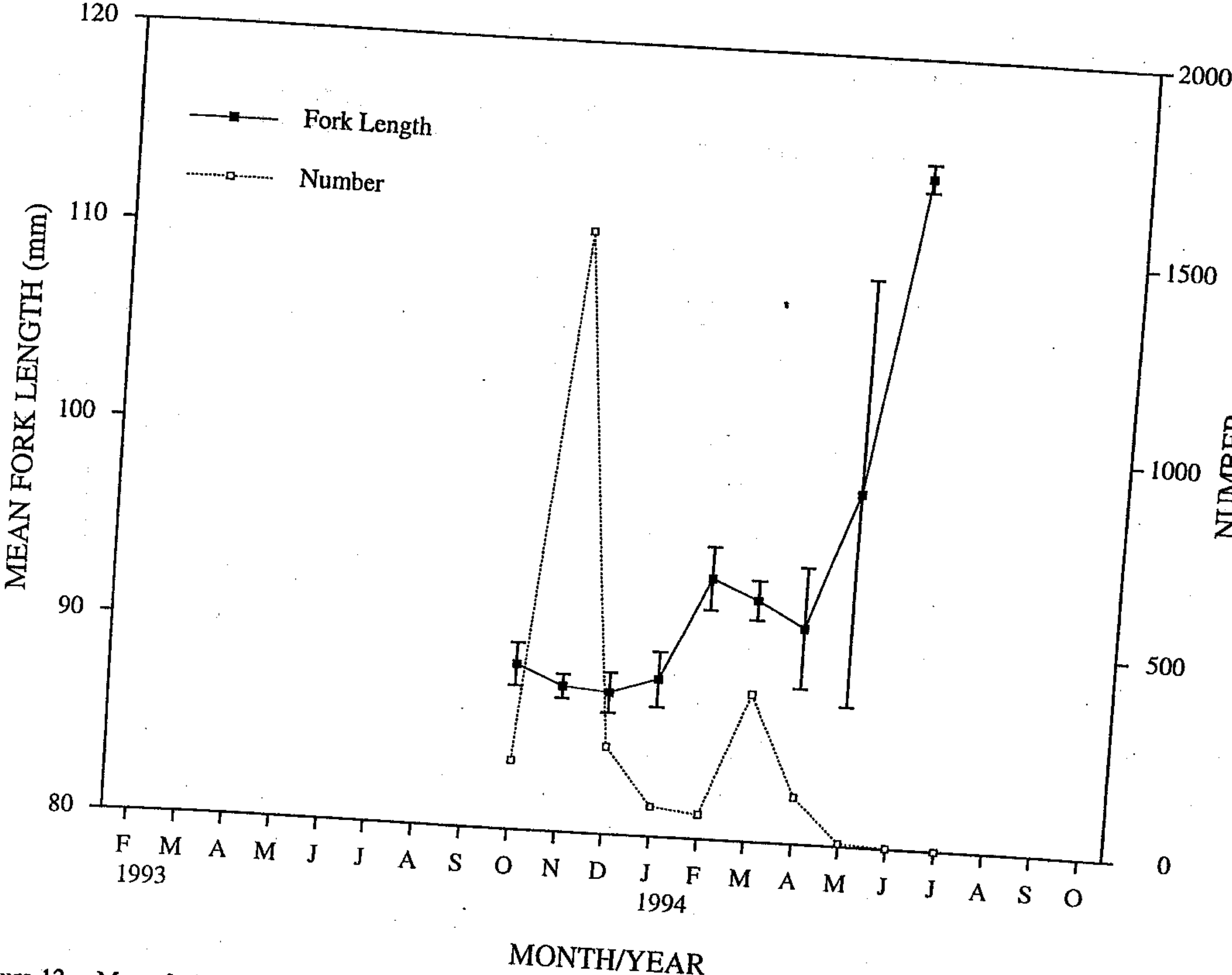

Figure 13. Mean fork lengths (±95% CI) from a subsample and numbers of 1992 cohort juvenile chinook salmon captured at the screw trap on Lookingglass Creek during 1994.

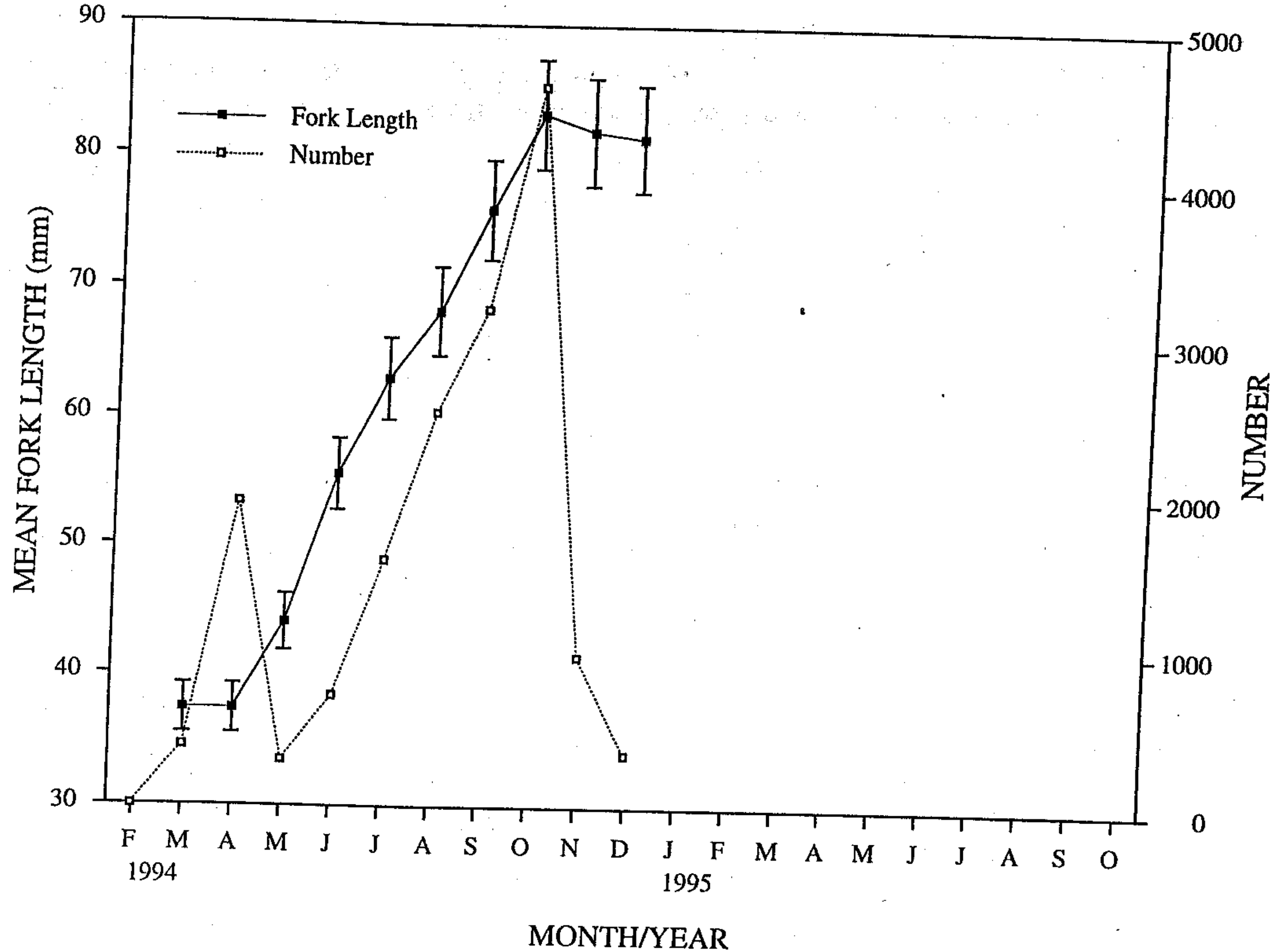

Figure 14. Mean fork lengths (±95% CI) from a subsample and numbers of 1993 cohort juvenile chinook salmon captured at the screw trap on Lookingglass Creek during 1993 and 1994.

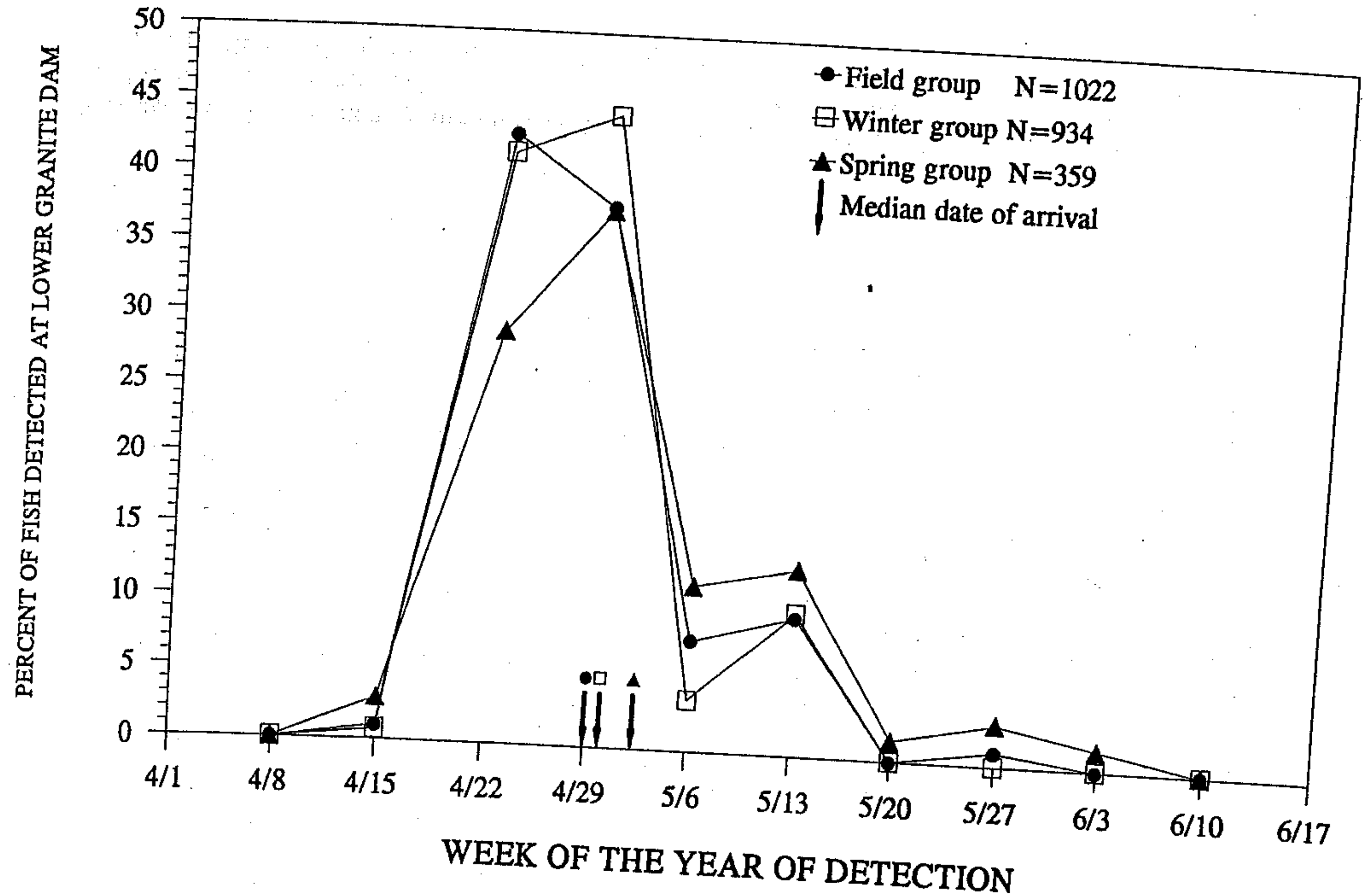

Figure 15. Arrival timing and median arrival dates at Lower Granite Dam of groups of juvenile chinook salmon that were PIT-tagged in the creek in September 1993 (field group) or at the trap from 4 November to 31 December, 1993 (winter group) or 1 January to 6 June, 1994 (spring group). Week of the year is represented by the last date of the week.

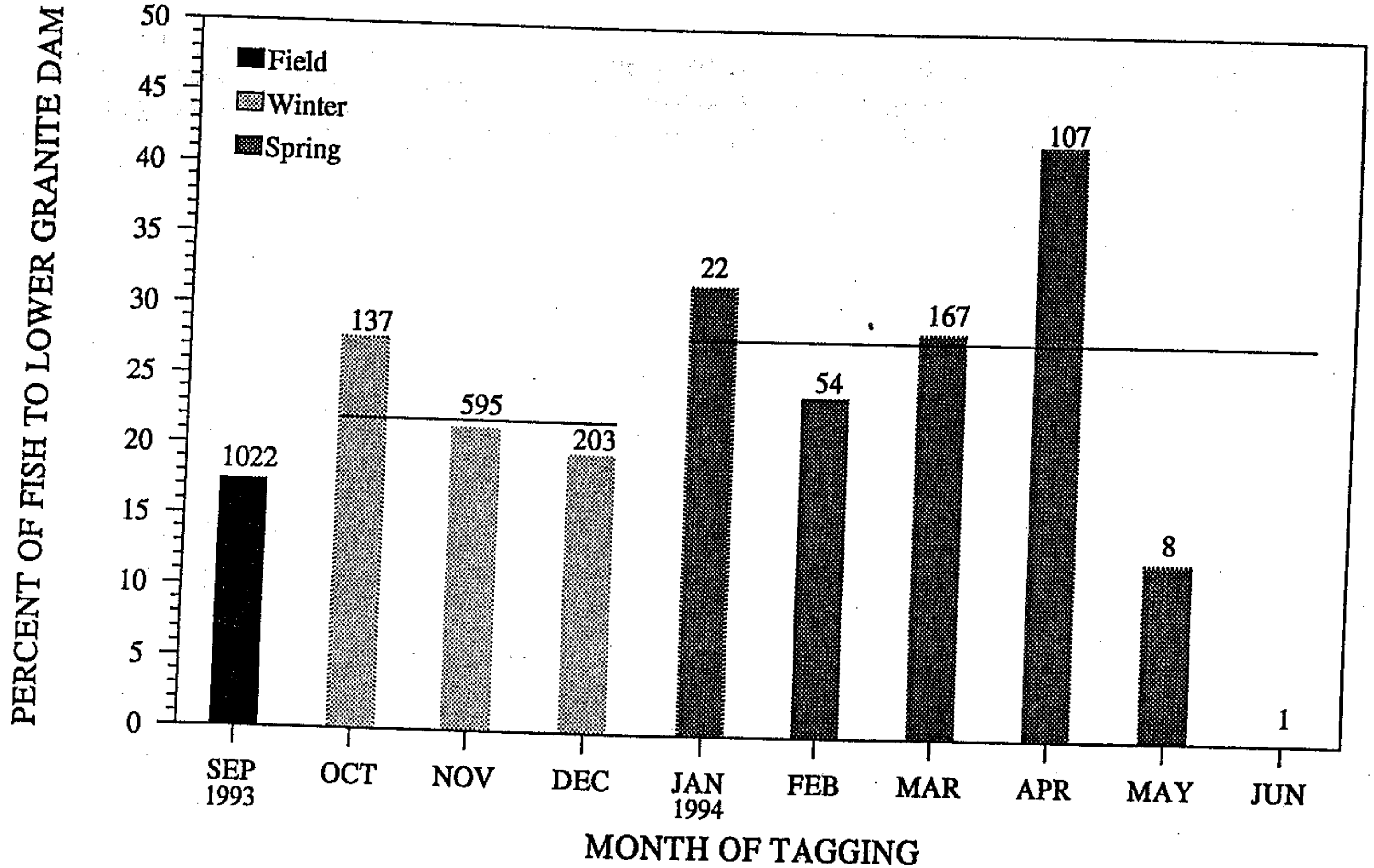

Figure 16. Percent of fish detected by month (total tagged above each month) and by group (lines) at all Snake and Columbia river dams. Juvenile chinook salmon the were PIT-tagged in the creek in September 1993 (field group) or at the trap from 29 October to 31 December, 1993 (winter group) or 1 January to 6 June, 1994 (spring group). Sample sizes are above bars.

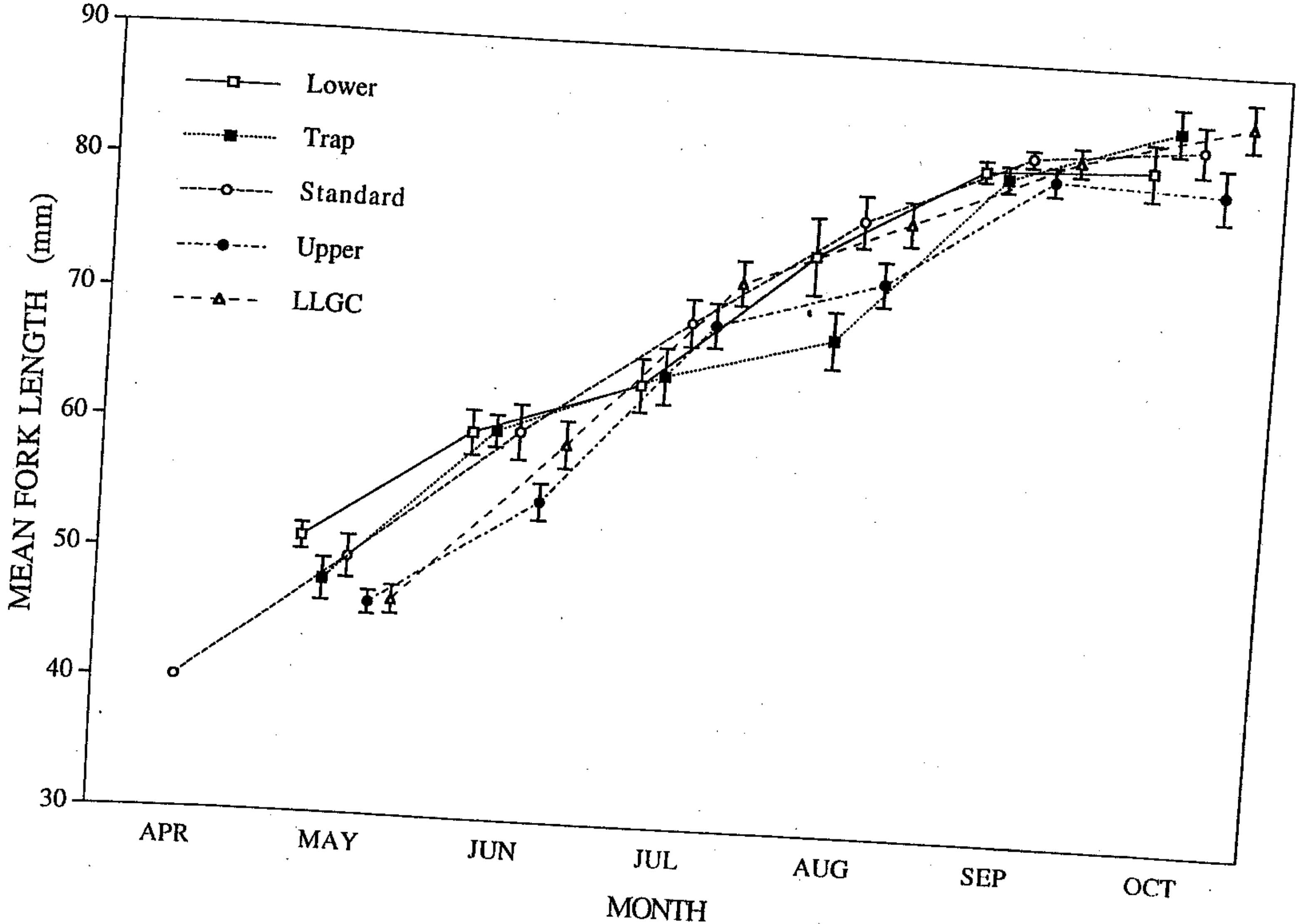

Figure 17. Mean fork length (± 95% CI) for juvenile chinook salmon captured at 5 sites in Lookingglass Creek and Little Lookingglass Creek (LLGC) from April to October 1994. Field samples were collected around the 20th of each month. Screw trap samples were collected around the same dates up to a maximum of ±5 days.

obtained samples from the screw trap through December. Fish grew from about 40 mm in April to about 85 mm in October. Little or no growth was observed from September to October. No consistent difference in fork length by month was observed among sites (Figure 17).

Genetic Monitoring

We collected 62 juveniles for genetic analysis for the NMFS genetics monitoring program in 1994. The results from genetic analysis by NMFS are not yet available.

Discussion

The flow pattern in Lookingglass Creek in 1994 was within the ranges that have been observed in the past. It was most like that of 1969, with a single peak week relatively early in the year (Burck 1993, McLean and Lofy 1995). Peak flows were not as high as those that were usually observed from 1964 to 1971 (Burck 1993, McLean and Lofy 1995).

Comparisons of water temperature data to the historic data were somewhat difficult because the data for the site at rkm 12.07 was relatively sketchy in 1994. However, consistent high temperatures were recorded for the first five weeks that data were available, and the peak high temperatures for 1994 were observed earlier than for either the historic data or during the past two years of the current study (Burck 1993, McLean and Lofy 1995). Consistent with data recorded by the USFS at this site in 1992 and 1993, these peak temperatures were lower than peak temperatures recorded from 1964 to 1971 at about rkm 6.84 (Burck 1993). Maximum stream temperatures usually reached peaks around mid-July from 1964 to 1971, although temperatures sometimes peaked as early as late June (e.g., 1968) (Burck 1993, McLean and Lofy 1995). High temperatures that fluctuated around yearly peaks in the summer were common historically. Peak temperatures in 1994 were around the same dates, but were consistently at least 3 to 4°C lower than those from 1964 to 1971 (Burck 1993, McLean and Lofy 1995). The differences in temperature may have been due to differences in sampling sites during the two time frames. We plan to collect additional data in the future will help determine if the sampling location may have influenced temperatures that the USFS have been recording at the upstream site. In 1995, we are planning to install an electronic thermograph at about the same site as that where temperature data were taken from 1964 to 1971 (Burck 1993).

Trapping, tagging and/or transport of adults at the hatchery trap (i.e., handling) may have resulted in increased mortality, as evidenced by lower prespawning mortality indices of unhandled females compared to handled females. Effects from these handling procedures, however, could not be distinguished from any effect that return timing might have had on prespawning mortality. Most of the unhandled females were presumed to had passed the weir(s) before installation in 1993 and 1994. In 1992 we presumed that fish passed the weir early in the season when the water was high and passage may have been more easily accomplished.

Higher prespawning mortality indices for Rapid River stock compared to the Lookingglass Creek stock may mean that efforts to use artificially-reared progeny of this hatchery stock for natural production may encounter some impediments. Potential problems with mortality were suggested with prespawning mortality indices for Rapid River females above the weir in all years from 1992 to 1994 that were generally higher than those of the Lookingglass Creek stock. The effect on production redds was reflected in fish-per-redd ratios that were higher than a standard 2.4 fish-per-redd during two of the three years.

A lower prespawning mortality index for untagged females of the Rapid River stock may indicate that handling increased mortality or fish that migrated past the weirs were in better condition than fish captured later in the hatchery trap. Results of sampling for pathogens of adult chinook salmon that were recovered from Lookingglass Creek did not suggest that *R. salmoninarum* disease was a major factor in death of females. Clinical levels of *R. salmoninarum* were found in only 3 of the 11 females that were sampled in 1994, with the remainder being classified as low. Similarly in 1992, a high prespawning mortality index was not associated with a high incidence of individuals with clinical levels of *R. salmoninarum* (1 in 7 adults) the remainder were negative or very low (Lofy and M[c]Lean 1995). No adults above the weir were injected with the antibiotic erythromycin to reduce the severity of bacterial kidney disease in any year from 1992 to 1994. In 1994, *Y. ruckeri* may have contributed somewhat to poor condition of the fish that resulted in prespawning mortality, as 3 of 11 females that were sampled had the bacteria. This was similar to the incidence observed in 1993 (4 of 14). Sampling for *Y. ruckeri* was done on only one fish in 1992. This fish had a *Y. ruckeri* infection. No disease data were available for the Lookingglass Creek stock, but lower prespawning mortality indices probably indicate that mortality after adults entered Lookingglass Creek was not as much of a factor for the Lookingglass Creek stock as it may be for the Rapid River stock.

We have no indications that the larger percentages of the 1987 and 1988 cohorts that were five-year-olds for the Rapid River stock were an artifact of harvest. Coded-wire-tag data for the harvest of the 1991 through 1994 return years of the Rapid River stock that originated from Lookingglass Hatchery did not suggest that the four-year-olds were harvested at a higher rate than five-year-olds, nor were any trends evident in harvest in 1993 and 1994 that might have caused the shift seen in the Rapid River stock with the 1989 cohort (Rhine Messmer, ODFW, personal communication). No harvest data were available for the Lookingglass Creek stock. Environmental conditions, fish condition (e.g., size at release for hatchery fish, size at migration for natural fish), and genetic differences between stocks (Waples et al. 1993) may have accounted for the differences that we observed. But it is apparent that with the additional data that were available with the 1989 cohort, year-to-year variability within a stock may be quite large.

If the Rapid River stock returns as older fish more often, as was the case for the 1987 and 1988 cohorts, and if larger females are equally successful in depositing eggs as smaller females, age at return may influence the success of natural production of this stock in Lookingglass Creek. Our data suggested that the larger females had a greater number of eggs. If this is the case, Rapid River stock females that return at an older age may produce more eggs per female on average than Lookingglass Creek stock females. However, if our prespawning mortality indices are indicative of actual losses of the two stocks, increased fecundity of the Rapid River stock may be offset by higher prespawning mortality. Age at return data for the 1989 cohort were more consistent with the mean percentage of Rapid River stock five-year-olds that returned to Rapid River Hatchery from the 1966 to 1978 cohorts (19%) (Howell et al. 1985). The variability we have observed in age at return may indicate a good deal of plasticity, with environmental variables, rather than a genetic determination taking precedence. Data from future years for the Rapid River stock will indicate whether the smaller proportion of five-year-olds we observed for the 1989 cohort (compared to the 1987 and 1988 cohorts) was unusual, or whether we are simply seeing a spectrum of the variability that is naturally inherent.

The Rapid River stock adults may be spawning in a somewhat different pattern than did the Lookingglass Creek stock. This was suggested by both the consistently higher percentage of redds observed immediately above the hatchery intake in unit 2 in 1992 (Lofy and McLean 1995), 1993 (McLean and Lofy 1995) and again in 1994, compared to the range observed from 1964 to 1971. Percent of the total redds in the three units closest to the hatchery above the weir were within the range (unit 3L) or much higher than the range (units 2 and 4) observed from 1964 to 1971. The proportion of redds in the unit farthest from the hatchery (unit 3U) was particularly low in 1994. At least two potential causes are plausible. Incomplete recovery from anesthetization of the fish in 1994 may have caused some of the fish to drift downstream or discourage upstream migration after release, resulting in higher redd distributions in the lower 3 units than those which occurred in Burck (1993). Alternately, homing of the release group to the site of juvenile rearing and release at Lookingglass Hatchery may have inhibited migration of adults further upstream, thereby increasing the number of redds in areas closest to the hatchery. If homing caused Rapid River stock adults to spawn nearer to the hatchery, we would expect that as natural production increases, and spawning occurs in upper areas more frequently, adults of natural origin may be more likely to spawn higher in the Lookingglass Creek basin.

The relationship developed to predict fecundity using fork length in 1994 explained a greater proportion of the variability of the data compared to the relationship developed in 1992 ($r^2 = 0.34$, Lofy and McLean 1995), but not as much as was explained in 1993 ($r^2 = 0.76$). We attributed the better fit in 1993 compared to 1992 to the greater proportion of five-year-old females in 1993. However, we obtained a better fit in 1994 than 1992 with fewer five-year- old females than in 1992. This was due to the fact that the fecundity estimates for the three five-year-old females deviated little from the regression line.

Spawning timing of Rapid River stock in 1994, as indicated by the three spawning timing indices, appeared to have been later than that observed for the Lookingglass Creek stock from 1966 to 1970 (Burck 1993). Observations of live and dead fish and appearance of new redds appeared to have been closer to a normal curve in 1993 (McLean and Lofy 1995) and 1994 compared to 1992 (Lofy and McLean 1995). The number of observations of live fish peaked on the same day as the peak for new redds, while the peak for recoveries of carcasses was 7 days later. This contrasts with the patterns of the Lookingglass Creek stock, where the number of new redds peaked first, then the number of observations of live fish, then the number of carcasses (Burck 1993, McLean and Lofy 1995).

Detections of PIT-tagged juveniles suggested that the timing of movement out of Lookingglass Creek for juvenile chinook salmon did not affect the timing of seaward migration. This was evidenced by similar distributions of arrival timing and median arrival dates at Lower Granite Dam of the three groups which were within 4 days of one another. The field group had one of the earliest median arrival dates among the juvenile chinook salmon that were PIT-tagged in the fall in Grande Ronde River tributaries. The arrival timing was most similar to that exhibited by the juvenile chinook salmon from the Wenaha River, the only tributary which had PIT-tagged juveniles in the Grande Ronde River that was downstream of Lookingglass Creek (Walters et al. 1995).

Survival indices of juvenile chinook salmon exhibited a wide range of variability. As might be expected, the later that a group was PIT-tagged, the higher the survival rate. Presumably this was at least partially because mortality earlier in the life cycle had occurred between the time of tagging of early groups and later groups. The field group for Lookingglass Creek was among those tributaries with the highest survival rate for populations of juveniles PIT-tagged in the fall of 1993 in the Grande Ronde River (Walters et al. 1995). Although sample sizes were small, our data seemed to indicate that survival indices of fish that moved past the trap during different months was also variable. Interestingly, survival of fish tagged during November and December had lower survival indices than those tagged in October.

The large number of juveniles that we captured in our trap in 1994 from the 1993 cohort suggested that Rapid River stock spring chinook salmon seem to be producing a large number of juveniles from spawning the previous year. Because we have no trapping information for the 1992 cohort from February through most of October in 1993, we cannot fully compare cohorts. However, comparing the ratio of juveniles captured from the 1993 cohort to that of the 1992 cohort for the months November to December (2.7:1.0) showed a similar trend to the ratio of redds from which these two cohorts were hatched (132:49, i.e., 2.69:1.00), suggesting that survival from egg to migrant may have been similar between years. More detailed analyses will be completed when migration of the 1993 cohort is complete in 1995.

Acknowledgments

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Special thanks go to Rhine Messmer (ODFW) for the decade of work he has contributed to the fish resources of the Grande Ronde and Imnaha river basins. Rhine has accepted a position as assistant district fish biologist in Klamath Falls, OR. His knowledge and assistance have contributed significantly to the development and implementation of tribal research in Northeastern Oregon.

Literature Cited

Brower J.E. and J.H. Zar. 1977. Field and laboratory methods for general ecology. Wm. C. Brown Company Publishers. Dubuque, Iowa.

Burck, W.A. 1964-1974. Unpublished field notes and summarizations of data from the Lookingglass Creek study. Available from Oregon Department of Fish and Wildlife, Research and Development Section, La Grande, Oregon.

Burck, W.A. 1967. Results of spawning ground surveys in 1966. Lookingglass Creek Summary Report Number 10. Fish Commission of Oregon, Research Division, Portland. March 1967.

Burck, W.A. 1968. Results of spawning ground surveys in 1967. Lookingglass Creek Summary Report Number 16. Fish Commission of Oregon, Research Division, Portland. October 1968.

Burck, W.A. 1969. Results of spawning ground surveys in 1968. Lookingglass Creek Summary Report Number 21. Fish Commission of Oregon, Research Division, Portland. September 1969.

Burck, W.A. 1970. Results of spawning ground surveys in 1969. Lookingglass Creek Summary Report Number 29. Fish Commission of Oregon, Research Division, Portland. April 1970.

Burck, W.A. 1971. Results of spawning ground surveys in 1970. Lookingglass Creek Summary Report Number 34. Fish Commission of Oregon, Research Division, Portland. June 1971.

Burck, W.A. 1972. Results of upstream migrant trapping in 1971. Lookingglass Creek Summary Report Number 35. Fish Commission of Oregon, Research Division, Portland. January 1972.

Burck, W.A. 1973. Results of upstream migrant trapping in 1972. Lookingglass Creek Summary Report Number 37. Fish Commission of Oregon, Research Division, Portland. October 1973.

Burck, W.A. 1974. Results of upstream migrant trapping in 1973. Lookingglass Creek Summary Report Number 38. Fish Commission of Oregon, Research Division, Portland. March 1974.

Burck, W.A. 1975. Results of upstream migrant trapping in 1974. Lookingglass Creek Summary Report Number 39. Fish Commission of Oregon, Research Division, Portland. January 1975.

Burck, W.A. 1993. Life history of spring chinook salmon in Lookingglass Creek, Oregon. Information Report 94-1. Oregon Department of Fish and Wildlife, Portland.

Howell, P., K. Jones, D. Scarnecchia, L. Lavoy, W. Kendra, D. Ortmann, C. Neff, C. Petrosky, and R. Thurow. 1985. Stock assessment of Columbia River anadromous salmonids: Volume 1: chinook, coho, chum and sockeye salmon stock summaries. Final Report to Bonneville Power Administration, Project Number 83-335.

Hubbard, L.E., T.A. Herrett, R.L. Kraus, G.P. Ruppert, and M.L. Courts. 1994. Water resources data - Oregon - water year 1993. United States Geological Survey Water-Data Report OR-92-1. Water Resources Division, United States Geological Survey, Portland.

Hubbard, L.E., T.A. Herrett, R.L. Kraus, G.P. Ruppert, and M.L. Courts. 1995. Water resources data - Oregon - water year 1994. United States Geological Survey Water-Data Report OR-93-1. Water Resources Division, United States geological Survey, Portland.

Lofy, P.T. and M.L. McLean. 1995. Evaluation of reestablishing natural production of chinook salmon in Lookingglass Creek, Oregon, using a non-endemic hatchery stock. Section II. Annual Progress Report for 1 January to 31 December, 1992, for the Lower Snake River Compensation Plan. CTUIR Project Number 63, Contract Number 14-16-0001-92502, U.S. Fish and Wildlife Service Report Number AFF1/LSR 95-02. Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon.

Lofy, P.T., R.W. Carmichael and W.J. Groberg. 1994. Evaluation of efforts to re-establish natural production of chinook salmon in Lookingglass Creek, using a non-endemic stock. Proposal to U.S. Fish and Wildlife Service, Lower Snake River Compensation Plan. Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon.

McLean, M.L and P.T. Lofy. 1995. Evaluation of reestablishing natural production of spring chinook salmon in Lookingglass Creek, Oregon, using a non-endemic hatchery stock. Section I. Annual Progress Report for 1 January to 31 December, 1993, for the Lower Snake River Compensation Plan to the U.S. Fish and Wildlife Service. CTUIR Project Number 63, Contract Number 14-48-0001-93515. Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon.

Messmer R.T., R.W. Carmichael, M.W. Flesher. 1991. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Annual Progress Report for July 1989 to June 1990. Oregon Department of Fish and Wildlife, Fish Research Project AFF1-LSR-91-1, Portland.

Messmer R.T., R.W. Carmichael, M.W. Flesher, and T.A. Whitesel. 1992. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Annual Progress Report July 1990 to December 1991. Oregon Department of Fish and Wildlife, Fish Research Project AFF1-LSR-92-10, Portland.

Messmer R.T., R.W. Carmichael, M.W. Flesher, and T.A. Whitesel. 1994. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Annual Progress Report January to December, 1992. Oregon Department of Fish and Wildlife, Fish Research Project AFF1-LSR-94-06, Portland.

Messmer R.T., R.W. Carmichael, M.W. Flesher, and T.A. Whitesel. 1995. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Annual Progress Report January to December 1993. Oregon Department of Fish and Wildlife, Fish Research Project, Portland.

Messmer R.T., R.W. Carmichael, M.W. Flesher, and T.A. Whitesel. In preparation. Evaluation of Lower Snake River Compensation Plan facilities in Oregon. Annual Progress Report January to December 1994. Oregon Department of Fish and Wildlife, Fish Research Project, Portland.

Nehlsen W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at a crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries 16 (2):4-20.

Walters, T. R., R.W. Carmichael, and M. Keefe. 1995. Smolt migration characteristics and mainstem Snake and Columbia River detection rates of PIT-tagged Grande Ronde and Imnaha River naturally produced spring chinook salmon. Annual Progress Report January to December 1994. Oregon Department of Fish and Wildlife, Fish Research Project, Portland.

Waples, R.S., O.W. Johnson, P.B. Aebersold, C.K. Shiflett, D.M. VanDoornik, D.J. Teel and A.E. Cook. 1993. A genetic monitoring and evaluation program for supplemented populations of salmon and steelhead in the Snake River Basin. Annual Report to Bonneville Power Administration, Project Number 89-096.

SECTION II

Assistance provided to LSRCP Cooperators

We provided assistance to ODFW in 1994 for ongoing hatchery evaluation research. Project personnel completed extensive spawning ground surveys for spring chinook salmon in the Grande Ronde and Imnaha river basins. We provided assistance in pre-release sampling of juvenile summer steelhead at Irrigon Hatchery and the Little Sheep and Big Canyon acclimation facilities and spring chinook salmon at Lookingglass Hatchery and the Imnaha River Facility. In addition, project personnel provided assistance in sampling adult spring chinook salmon at Oregon LSRCP facilities. Assistance was provided in data summarization and analysis for ODFW monthly and annual progress reports. Data used in scale pattern analysis to differentiate hatchery and natural adult chinook salmon were summarized and provided to the ODFW scale reading laboratory in Corvallis. Details of data collection, summarization and analysis are not included in this report and are available in ODFW reports.

Appendices

Appendix Table A-1. Adult spring chinook salmon disc-tagged and released above the weir in Lookingglass Creek in 1994.

Date tagged	Fork length (mm)	Assigned sex[a]	Mark[b]	Disc tag number	Secondary mark[c]	Age	Cohort year
06/03	710	F	RV	1	2LOP	4	90
06/03	720	F	RV	2	2LOP	4	90
06/03	725	M	AD	3	1LOP	4	90
06/03	820	F	--	4	2ROP	5	89
06/03	740	M	RV	5	1LOP	4	90
06/03	735	M	AD	6	1LOP	4	90
06/03	720	F	RV	7	2LOP	4	90
06/03	840	F	AD	8	2LOP	5	89
06/03	750	M	--	9	1ROP	4	90
06/03	760	F	RV	10	2LOP	4	90
06/03	760	M	AD	11	1LOP	4	90
06/03	615	F	RV	12	2LOP	4	90
06/03	640	F	RV	13	2LOP	4	90
06/03	643	F	RV	14	2LOP	4	90
06/03	733	F	RV	15	2LOP	4	90
06/03	678	F	RV	16	2LOP	4	90
06/03	700	F	RV	17	2LOP	4	90
06/03	709	F	AD	18	1LOP	4	90
06/03	729	M	AD	19	1LOP	4	90
06/03	719	F	AD	20	2LOP	4	90
06/03	700	M	RV	21	1ROP	4	90
06/03	635	F	RV	22	2LOP	4	90
06/03	830	F	--	23	2ROP	5	89
06/03	867	F	--	24	2ROP	5	89
06/03	775	M	RV	25	1LOP	4	90
06/03	665	M	RV	26	1LOP	4	90
06/03	778	F	AD	27	2LOP	4	90
06/03	684	F	RV	28	2LOP	4	90
06/03	790	M	--	29	1ROP	4	90
06/03	715	F	AD	30	2LOP	4	90
06/03	795	F	--	31	2ROP	5	89
06/03	790	M	RV	32	1LOP	4	90

Appendix Table A-1 (cont.). Adult spring chinook salmon disc-tagged and released above the weir in Lookingglass Creek in 1994.

Date tagged	Fork length (mm)	Assigned sex[a]	Mark[b]	Disc tag number	Secondary mark[c]	Age	Cohort year
06/03	855	F	--	33	2ROP	5	89
06/03	753	M	RV	34	1LOP	4	90
06/03	765	M	--	35	1ROP	4	90
06/03	700	F	RV	36	2LOP	4	90
06/03	725	F	--	37	2ROP	4	90
06/03	804	F	--	38	2ROP	5	89
06/03	855	F	--	39	2ROP	5	89
06/03	780	M	--	40	1ROP	4	90
06/03	760	M	RV	41	1LOP	4	90
06/03	738	M	RV	42	1LOP	4	90
06/03	765	M	--	43	1ROP	4	90
06/03	670	M	RV	44	1LOP	4	90
06/03	690	F	RV	45	2LOP	4	90
06/03	749	F	--	46	2ROP	4	90
06/03	659	M	RV	47	1LOP	4	90
06/03	705	F	AD	48	2LOP	4	90
06/03	820	F	--	49	2ROP	5	89
06/03	670	F	RV	50	2LOP	4	90
06/03	788	F	RV	51	2LOP	4	90
06/03	793	M	--	52	1ROP	5	89
06/03	708	M	RV	53	1LOP	4	90
06/03	725	M	RV	54	1LOP	4	90
06/03	755	F	RV	55	2LOP	4	90
06/03	750	F	RV	56	2LOP	4	90
06/03	680	F	RV	57	2LOP	4	90
06/03	820	F	AD	58	2LOP	5	89
06/03	838	F	--	59	2ROP	5	89
06/07	735	M	--	60	1ROP	4	90
06/07	678	M	RV	61	1LOP	4	90
06/07	695	M	RV	62	1LOP	4	90
06/07	732	F	RV	63	2LOP	4	90
06/07	755	F	--	64	2ROP	5	89

Appendix Table A-1 (cont.). Adult spring chinook salmon disc-tagged and released above the weir in Lookingglass Creek in 1994.

Date tagged	Fork length (mm)	Assigned sex[a]	Mark[b]	Disc tag number	Secondary mark[c]	Age	Cohort year
06/07	768	M	--	65	1ROP	5	89
06/07	730	M	RV	66	1LOP	4	90
06/07	699	F	RV	67	2LOP	4	90
06/07	700	F	RV	68	2LOP	4	90
06/07	662	F	--	69	2ROP	4	90
06/07	746	F	RV	70	2LOP	4	90
06/07	739	M	RV	71	1LOP	4	90
06/07	755	M	--	72	1ROP	4	90
06/07	867	M	--	73	1ROP	5	89
06/07	732	F	RV	74	2LOP	4	90
06/07	775	F	RV	75	2LOP	4	90
06/07	730	F	RV	76	2LOP	4	90
06/14	728	M	RV	77	1LOP	4	90
06/14	722	F	RV	78	2LOP	4	90
06/14	855	M	--	79	1ROP	5	89
06/14	708	M	RV	80	1LOP	4	90
06/14	744	F	RV	81	2LOP	4	90
06/14	493	J	ADRV	82	1LOP	3	91
06/14	775	M	RV	83	1LOP	4	90
06/14	758	M	--	84	1ROP	5	89
06/14	610	F	RV	85	2LOP	4	90
06/14	718	F	RV	86	2LOP	4	90
06/14	693	M	RV	87	1LOP	4	90
06/14	540	J	ADRV	88	1LOP	3	91
06/14	695	F	RV	89	2LOP	4	90
06/14	720	M	RV	90	1LOP	4	90
06/14	670	M	--	91	1ROP	4	90
06/21	857	M	--	92	1ROP	5	89
06/21	840	M	--	93	1ROP	5	89
06/21	748	F	RV	94	2LOP	4	90
06/21	718	F	RV	95	2LOP	4	90
06/21	735	F	RV	96	2LOP	4	90

Appendix Table A-1 (cont.). Adult spring chinook salmon disc-tagged and released above the weir in Lookingglass Creek in 1994.

Date tagged	Fork length (mm)	Assigned sex[a]	Mark[b]	Disc tag number	Secondary mark[c]	Age	Cohort year
06/21	490	J	ADRV	97	1LOP	3	91
06/28	672	F	--	98	2ROP	4	90
06/28	860	F	--	99	2ROP	5	89
06/28	717	F	RV	100	2LOP	4	90
06/28	865	M	--	101	1ROP	5	89
06/28	734	F	AD	102	2LOP	4	90
06/28	775	F	--	103	2ROP	4	90
06/28	858	M	--	104	1ROP	5	89
07/06	673	F	AD	105	2LOP	4	90
07/12	670	F	RV	106	2LOP	4	90
07/12	655	F	--	107	2ROP	5	89
08/31	844	F	--	109	2ROP	5	89
08/31	700	F	--	110	2ROP	4	90
09/08	675	M	--	112	1ROP	4	90
09/08	690	F	--	113	2ROP	4	90
09/08	720	F	--	114	2ROP	4	90

[a] The sex of the fish assigned at the time of tagging.
[b] AD = adipose-fin-clipped, RV = right ventral-fin-clipped.
[c] One or two punches, ROP = right opercle, LOP = left opercle,

Appendix Table A-2. Adult spring chinook salmon recovered on Lookingglass and Little Lookingglass creeks in 1994.

Date recovered	Date tagged	Fork length (mm)	Sex[a]	Mark[b]	Snout number[c]	Disc tag no.[d]	Age	Cohort year	Recovery unit[e]
08/22	06/03	670	M	RV		44	4	90	1
09/16	06/03	670	F	RV		50	4	90	1
06/27	06/03	643	F	RV		14	4	90	MW
09/14	06/03	725	M	AD	94G1328	6	4	90	MW
06/14	06/03	855	F	--		33	5	89	PW
07/13	06/03	659	M	RV		47	4	90	PW
07/21	06/28	672	M[a]	--		98	4	90	PW
08/12	06/03	855	F	--		39	5	89	PW
07/19	06/03	778	F	AD[f]		27	4	90	IN
07/19	06/14	718	M[a]	RV		86	4	90	IN
09/12	09/08	675	M	--		112	4	90	2
09/14	08/31	844	F	--		109	5	89	2
09/19	09/08	690	F	--		113	4	90	3
08/08	06/03	765	M	--		43	4	90	5
09/12	06/03	810	M[a]	--		38	5	89	5
09/12	09/08	725	F	--		114	4	90	5
09/13		737	M	--		TL	4	90	1
09/21		690	F	RV		TL	4	90	1
08/24		505	M	ADRV[f]		TL	3	91	AT
07/15		840	M	--		TL	5	89	MW
09/19		UNK	F	--		TL	4	90	MW
08/11		720	F	RV		TL	4	90	PW
08/31		680	F	RV		TL	4	90	PW
08/22		600	M[a]	RV		TL	4	90	2
09/06		755	F	--		TL	5	89	2
09/12		690	F	RV		TL	4	90	2
09/12		750	F	AD	94G1018	TL	4	90	2
09/12		820	F	--		TL	5	89	2
09/12		UNK	M	RV		TL	4	90	2
09/12		UNK	F	--		TL	5	89	2
09/06		665	F	RV		TL	4	90	3
09/06		805	F	AD	94G1016	TL	5	89	3

Appendix Table A-2 (cont.). Adult spring chinook salmon recovered on Lookingglass and Little Lookingglass creeks in 1994.

Date recovered	Date tagged	Fork length (mm)	Sex[a]	Mark[b]	Snout number[c]	Disc tag no.[d]	Age	Cohort year	Recovery unit[e]
09/06		890	M	--		TL	5	89	3
09/12		UNK	F	RV		TL	4	90	3
09/12		705	F	RV		TL	4	90	5
09/12		695	F	RV		TL	4	90	5
08/30		625	F	RV		NT	4	90	1
07/19		UNK	M	ADRV[f]		NT	3	91	MW
09/20		685	F	--		NT	4	90	2
09/12		715	F	RV		NT	4	90	5
09/12		720	F	RV		NT	4	90	5
09/07		UNK*	UNK	AD[f]		UNK	5	89	1

[a] Sex of fish at recovery (M) was different from the assigned sex at tagging (F).

[b] AD = adipose-fin-clipped. RV = Right pelvic fin clip (Rapid River Hatchery stock). (--)= there was no mark.

[c] Coded-wire-tag number.

[d] NT = the fish had no punches or disc tags. TL = the fish lost the disc tag. UNK = unknown whether the fish had been tagged or not.

[e] The unit in which the fish was recovered. AT = collected in the adult trap at the upstream end of unit 1. MW = collected on the Mitsubishi weir just above the adult trap entrance. PW = collected on the picket weir at the downstream end of unit 2. IN= collected off of the hatchery intake screen.

[f] The snout was eaten or deteriorated and not available.

Appendix Table A-3. Estimates of males and female portions of the populations, fish /redd and females per redd above the weir in Lookingglass Creek basin 1992-1994.

Year	Male Estimate	Male SEM	Female Estimate	Female SEM	Fish/redd	Females/redd
1992	121	37	81	10	4.12	1.65
1993a	149	24	159	18	2.33	1.21
1994	58	3	64	4	3.05	1.60

[a] Revised from (M[c]Lean and Lofy 1995).

Appendix Table A-4. Results of analyses by ODFW Fish Pathology for pathogens of adult spring chinook salmon recovered above the weir on Lookingglass Creek in 1994.

Date recovered	Sex	*Renibacterium salmoninarum* OD[a] level	*Renibacterium salmoninarum* ELISA level[b]	*Ceratomyxa shasta* infection	Aeromonad-pseudomonad (APS) infection and *Yersinia ruckeri* (ERM-1)[c]
06/14	F	0.109	Low	Low	ERM-1
06/29	F	0.101	Low	Moderate	ERM-1
07/13	M	0.127	Low	High	ERM-1
07/19	M	1.738	Clinical	Moderate	ERM-1
07/21	M	1.724	Clinical	Moderate	ERM-1
08/08	M	2.929	Clinical	ND	ND
08/11	F	2.316	Clinical	Negative	ERM-1
08/22	M	2.945	Clinical	Low	ERM-1
08/30	F	0.188	Low	ND	APS
08/30	M	3.013	Clinical	ND	APS
08/31	F	0.204	Low	High	APS
09/06	F	0.167	Low	ND	APS
09/06	M	0.181	Low	ND	ERM-1
09/06	F	0.174	Low	ND	APS
09/06	F	0.132	Low	ND	APS
09/14	F	0.211	Low	Negative	APS
09/14	M	0.288	Low	High	APS
09/16	F	2.058	Clinical	ND	APS
09/19	F	3.095	Clinical	ND	ND

a ELISA = Enzyme-linked immunosorbent assay; OD=optical density.

b ND = analyses not done. Low, Moderate or High = *C. shasta* spores were observed. Negative = no spores were observed.

c The most common bacteria type in the culture is shown.

Appendix Table A-5. Percent of the spring chinook salmon by week of the year that returned to Lookingglass Creek weirs from 1964-1974, 1992-1994.

Run Year	Group[b]	Week of the year[a] 5/6	5/13	5/20	5/27	6/3	6/10	6/17	6/24	7/1	7/8	7/15	7/22	7/29	8/5	8/12	8/19	8/26	9/2	9/9	9/16	N
1964	LG	0.0	0.0	0.0	0.0	1.4	5.6	9.9	21.1	28.2	11.3	14.1	4.2	1.4	0.0	1.4	0.0	0.0	1.4	0.0	0.0	71
1965	LG	0.0	0.0	0.0	0.0	5.3	10.5	10.5	13.2	13.2	21.1	2.6	2.6	5.3	0.0	2.6	7.9	5.3	0.0	0.0	0.0	38
1966	LG	0.0	0.0	1.1	21.2	8.3	2.3	41.0	5.2	10.6	2.0	2.0	0.3	0.0	0.3	0.6	2.6	1.7	0.9	0.0	0.0	349
1967	LG	0.0	0.0	0.0	0.0	6.1	12.3	15.2	16.4	16.4	12.7	11.1	3.3	0.8	0.8	0.4	0.8	1.6	0.8	1.2	0.0	243
1968	LG	0.0	0.0	3.4	7.5	19.4	16.0	18.1	16.8	7.0	6.2	1.8	0.8	1.3	0.3	0.3	0.0	0.8	0.3	0.3	0.0	387
1969	LG	0.0	0.0	0.0	0.5	5.7	36.8	16.7	19.5	5.7	5.1	3.3	1.8	1.1	0.0	0.3	1.2	1.7	0.6	0.0	0.0	663
1970	LG	0.0	0.0	0.0	0.0	3.4	10.5	5.4	31.5	10.0	23.2	7.3	4.4	0.8	0.6	0.3	0.8	0.8	0.3	0.6	0.1	727
1971	LG	0.0	0.0	0.0	0.0	0.0	1.2	5.9	20.6	12.0	22.8	20.1	12.5	1.0	1.0	0.5	0.0	1.0	1.2	0.2	0.0	408
1972	LG	0.0	0.0	0.0	0.0	1.4	9.7	7.2	21.7	24.9	16.2	9.7	6.1	2.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	277
1973	LG	0.0	0.0	17.2	14.2	21.9	29.9	1.1	10.2	2.2	1.5	0.7	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	273
1974	LG	0.0	0.0	0.0	0.0	0.0	0.0	1.3	25.6	11.5	15.4	25.6	12.8	6.4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	78
1990	RR	0.0	0.0	0.0	31.8	28.5	12.0	7.1	5.7	4.1	1.6	0.0	1.2	0.0	0.0	0.0	1.4	1.2	4.5	0.4	0.2	519
1991	RR	0.0	0.0	0.0	0.0	0.0	1.4	22.8	20.6	23.1	11.3	3.6	2.5	0.0	0.5	2.5	0.0	8.8	1.9	0.0	1.1	362
1992	RR	0.0	18.2	4.7	40.0	20.9	4.6	3.4	3.9	0.6	0.2	0.4	0.0	0.4	0.0	0.7	1.2	0.0	0.0	0.7	0.0	912
1992	Rel[c]	0.0	0.0	0.0	25.8	26.9	21.5	15.1	0.0	3.2	0.0	1.1	0.0	2.1	0.0	1.1	3.2	0.0	0.0	0.0	0.0	93[e]
1993	RR[d]					--	48.8	8.3	25.2	6.4	1.7	1.3	--	--	2.2	1.0	1.0	2.3	0.8	0.6	0.4	1020
1993	Rel							39.4	19.2	22.2	7.1	4.0	0.0	0.0	3.0	3.0	2.0	0.0	0.0	0.0	0.0	99
1994	RR					53.0	15.2	13.4	5.4	6.3	0.9	0.9	0.9	0.0	0.0	0.0	0.0	0.0	1.3	2.7	0.0	221
1994	Rel					53.0	17.2	13.1	5.4	3.6	1.8	0.9	0.5	0.0	0.0	0.5	0.5	0.9	1.3	1.3	0.0	112

[a] Week of the year which ended on the date shown.

[b] LG = Lookingglass Creek stock, summarized from Burck (1964-1974). RR = Rapid River stock returning to Lookingglass Hathcery, summarized from Messmer (1992, 1994). Rel = Rapid River group of fish released above the weir.

[c] Does not include 40 fish released 10 September, 1993.

[d] (--) = Trap was in operation but holding pond was not checked. Trap was put into operation on 28 May in 1993.

Appendix Table A-6. Age composition of chinook salmon that returned to Lookingglass Creek from the 1968, 1969, 1987, 1988 and 1989 cohorts.

Cohort year	Stock[a]	Age at return: Number that returned 3	4	5/6	Percent of the total return 3	4	5/6
1968	Lookingglass	52	223	23	17.5	75.8	7.7
1969	Lookingglass	30	233	5	11.2	86.9	1.9
1987	Rapid River	5	154	97	1.9	60.2	37.9
1988	Rapid River	113	801	672	7.1	50.5	42.4
1989	Rapid River	12	326	31	3.3	88.3	8.4

[a] Lookingglass Creek stock age composition was summarized from Burck (1972, 1973, 1974, 1975). Rapid River stock age composition was summarized from Messmer et al. (1992, 1994, 1995, in preparation).

Appendix Table A-7. Age composition of chinook salmon that returned to Lookingglass Creek 1971-1974 and 1990-1994, as well as the 1992-1994 release groups.

Run year	Group[a]	Age at return: Number that returned			Age at return: Percent of the total return		
		3	4	5/6	3	4	5/6
1971	Lookingglass	52	327	17	13.1	82.6	4.3
1972	Lookingglass	30	223	24	10.8	80.5	8.7
1973	Lookingglass	10	233	23	3.8	87.6	8.6
1974	Lookingglass	6	64	5	8.0	85.3	6.7
1990	Rapid River	5	491	23	1.0	94.6	4.4
1991	Rapid River	113	154	95	31.2	42.5	26.3
1992	Rapid River	15	801	96	1.7	87.8	10.5
1992	Release	4	113	16	3.0	85.0	12.0
1993	Rapid River	22	326	672	2.1	32.0	65.9
1993	Release	3	12	84	3.0	12.1	84.9
1994	Rapid River	6	184	31	2.7	83.3	14.0
1994	Release	3	85	24	2.7	75.9	21.4

[a] Lookingglass Creek stock age composition was summarized from Burck (1972, 1973, 1974, 1975). Rapid River stock age composition was summarized from Messmer et al. (1992, 1994, 1995, in preparation). Release group was placed above the weir and allowed to spawn naturally.