Annual Progress Report

Lower Snake River Compensation Plan
Confederated Tribes of the Umatilla Indian Reservation
Evaluation Studies for 1 January to 31 December 1992

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Effects of acclimation on smoltification and stress of juvenile summer steelhead and spring chinook salmon

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

Section III
Assistance provided to LSRCP Cooperators

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SECTION I

EFFECTS OF ACCLIMATION ON SMOLTIFICATION AND STRESS OF JUVENILE SUMMER STEELHEAD AND SPRING CHINOOK SALMON

Abstract

To determine if smoltification and stress indices differed between acclimated and non-acclimated treatment groups (treatments) of anadromous juvenile salmonids, we conducted the second and final experiments concomitant with ongoing Oregon Department of Fish and Wildlife (ODFW) acclimation facility evaluations. During March and April of 1992, 12-month-old summer steelhead trout (*Oncorhynchus mykiss*) were sampled at the Big Canyon and Little Sheep acclimation facilities and Irrigon Hatchery in northeast Oregon. We sampled 20-month-old spring chinook salmon (*O. tshawytscha*) from the Imnaha Acclimation Facility in March of 1992.

Juvenile steelhead were sampled for stress indices. Plasma cortisol concentrations and plasma chloride concentrations were measured 8 hours before release and at release as well as 1, 4, 12, 24 or 48 hours after the scheduled release. A standardized stress challenge (suspension in a net for 30 s) was administered to steelhead that were retained for sampling after the scheduled release. Sample sizes for treatments were generally about 20 fish.

Lower stress levels in acclimated treatments of steelhead, as indicated by lower plasma cortisol concentrations and higher plasma chloride concentrations, were observed at both the Big Canyon and Little Sheep facilities. Differences between treatments in plasma chloride concentrations were observed as early as 8 hours before release. After a stress challenge, plasma cortisol concentrations and plasma chloride concentrations generally differed between treatments started 1 or 4 hours after the stressor was applied and continued for 12 to 24 hours after the stressor, depending upon the facility. Because increases in plasma cortisol concentrations and decreases in plasma chloride concentrations occurred in the acclimated treatments after 12 to 24 hours, we found no differences between treatments at the Little Sheep Facility thereafter. Acclimated treatments at the Big Canyon Facility continued to exhibit lower stress levels than the non-acclimated treatment. Our data seemed to indicate there were demonstrably lower stress levels in acclimated compared to non-acclimated treatments of steelhead after a stressor. Lower stress levels before and during release, and at least 12 hours after a stress challenge may indicate stress as one of the factors in the higher survival rates of acclimated treatments compared to non-acclimated treatments. Changes in release procedures at acclimation facilities may lower stress at release.

We did not observe either acclimated or non-acclimated treatments recover from the stress challenge within 48 hours. Smaller stress responses of acclimated treatments suggested that

acclimated fish may have been more likely to recover first, had the experiment extended beyond 48 hours.

Gill $Na^{+}K^{+}$- ATPase activity (ATPase) and skin guanine concentrations were measured to index smoltification at three (salmon) or four (steelhead) dates spread throughout the experimental period. Sampling dates depended upon the species and duration of the acclimation period. For steelhead dates were: once before transfer of the fish to the acclimation facilities (from 12 to 25 March), twice during acclimation (25 March to 5 April, then 9 to 12 April), and once within 2 days of release (21 and 26 April). For salmon, sampling dates were: twice during acclimation (on 10 and 18 March) and once within two days of release (30 March). Sample sizes for treatments were generally about 20 fish.

Acclimation of juvenile steelhead at the Big Canyon or Little Sheep acclimation facilities and juvenile spring chinook salmon at the Imnaha Acclimation Facility did not accelerate smoltification. ATPase and skin guanine concentrations of acclimated treatments were similar to those of non-acclimated treatments for steelhead and chinook salmon. Changes in ATPase and skin guanine over time within a treatment were inconsistent among facilities and no clear trend over the sample dates was observed. Using current facilities and acclimation procedures did not accelerate smoltification. Modification of acclimation procedures or facilities may be necessary if acceleration of smoltification is desired.

Introduction

To mitigate for the losses of anadromous salmonids caused by the construction and operation of the four lower Snake River dams the Lower Snake River Compensation Plan (LSRCP) was developed. As part of the LSRCP, satellite facilities that were designed and built in Oregon, Washington, and Idaho to rear juvenile summer steelhead (*Oncorhynchus mykiss)* and spring chinook salmon (*O. tshawytscha*) in water at the site where they are released. The Wallowa Acclimation Facility (Wallowa Facility) has been operated in Northeast Oregon under the LSRCP since 1987. Since 1987, three additional facilities, the Big Canyon Creek Acclimation/Adult Collection Facility (Big Canyon Facility), Little Sheep Creek Acclimation/Adult Collection Facility (Little Sheep Facility), and the Imnaha River Acclimation/Adult Collection Facility (Imnaha Facility), were built and have been operated in the Grande Ronde and Imnaha river basins.

Experiments to determine the effects of acclimation on juvenile migration performance and survival to adulthood began with spring releases of acclimated and non-acclimated treatments of summer steelhead from 1988 to 1990 at the Wallowa Facility. Juveniles were cold-branded about 9 months before release so that travel time, migration timing, and juvenile survival to Lower Granite Dam, the first collection site on the Snake River, could be indexed. They were also coded-wire-tagged the fall before release to estimate juvenile-to-adult survival rates for each treatment (Carmichael et al. 1990; Messmer et al. 1991a; Messmer et al. 1991b). Preliminary findings from the Wallowa Facility suggested that survival rates from the time of juvenile release to adulthood of groups that were acclimated (acclimated treatments) were equal to or greater than groups that were not acclimated (non-acclimated treatments) (Messmer et al. 1992). Experimental comparisons between acclimated and non-acclimated treatments for juvenile summer steelhead were initiated in 1991 at the Big Canyon and Little Sheep acclimation facilities. Experimental comparisons between acclimated and non-acclimated treatments for spring chinook salmon at the Imnaha Facility began in 1992. We initiated our experiments in 1991 at the facilities where the steelhead were released and in 1992 at the facility where the chinook salmon were released to determine if two of the potential benefits of acclimation, decreased stress and accelerated smoltification, were occurring, and might possibly explain a survival advantage for acclimated juvenile salmonids.

Stress around the time of release may be an important factor in survival of juvenile anadromous salmonids released in the Grande Ronde and Imnaha river basins. All steelhead from Irrigon Hatchery and all chinook salmon of Imnaha River origin from Lookingglass Hatchery are typically transported by truck before being released into an acclimation facility or a stream. Handling and restriction of movement have been shown to produce an acute stress response (change from baseline) in salmonids (Barton et al. 1980). Therefore, the crowding and loading associated with the necessary transportation are probably stressful to the fish. Acclimated fish have weeks to recover from transportation in the acclimation facility, while non-acclimated fish have no such opportunity. In addition, stress level after release may be the result of a response to a combination of previous stressors and additional, unfamiliar stressors associated with coping with the natural environment. By the time fish are released, non-acclimated treatments have been exposed to a larger number of recent stressors than acclimated treatments. For example, release directly from a truck typically involves crowding, movement through narrow passages, and changes in water velocity or pressure before juveniles even reach the stream. Added to the stressors at release, those encountered by both treatments after release (e.g. much higher water velocities than were normally encountered in facilities, obstacles to movement, and encounters with predators), and it is evident that fish must deal with multiple stressors. Multiple stressors have been shown to produce an increased acute stress response (Barton et al. 1986), which suggested that stress responses may have been additive or synergistic. Thus, acclimation may be advantageous for hatchery fish because it allows recovery from the inevitable stress of transport before release.

The degree of smoltification around the time of release may also influence the survival of hatchery juvenile salmonids. Faster migration of juvenile anadromous salmonids through the Columbia and Snake rivers may result in increased survival to adulthood. Raymond (1979) found a decrease in the survival rate of natural and hatchery steelhead and hatchery chinook salmon associated with an increase in the length of time that juvenile salmonids required to migrate from the upper Snake River to Little Goose, Ice Harbor, and The Dalles dams. Presumably, hatchery juvenile anadromous salmonids released in tributaries of Northeast Oregon that are accelerated in smoltification would be more likely to begin their seaward migration at release and migrate faster. Alternately, fish that are not as developed might take longer before initiating migration or migrate more slowly. Thus, the degree of smoltification may be useful in predicting readiness to migrate and, consequently, be positively related to probability of survival. We determined smoltification indices for steelhead at four sampling dates, which encompassed periods from before transfer of the acclimated treatment to just before release of both treatments. For salmon, we determined smoltification indices only during the three sampling dates.

Stress of acclimated treatments may be important at several levels in determining survival to adulthood. We used plasma cortisol concentrations and plasma chloride concentrations as stress indices. Increases in plasma cortisol concentrations have long been used as an index of stress in numerous fish species, including salmonids (Schreck 1981). A reduction in plasma chloride concentrations has also been used as an index of acute stress response in juvenile steelhead and coho salmon (Wedemeyer 1972). We determined stress indices about 8 hours before loading of the non-acclimated treatments on transport trucks to determine if differences in stress levels between treatments was evident before the stressors of transport had occurred. Our null hypothesis was that there was no difference in stress indices between treatments before the non-acclimated treatment was transported. We determined stress indices at release to determine if differences between treatments were evident after the non-acclimated treatment had been transported to the release site. Our null hypothesis was that there was no difference in stress indices between treatments just before release. Because multiple stressors can elicit increased stress responses, and acclimated treatments have the opportunity to recover from the stress of transportation, acclimated treatments may elicit a smaller stress response during and after release compared to non-acclimated treatments. If non-acclimated treatments had higher stress levels than non-acclimated treatments after transport, the differences between treatments might be expected to be exacerbated by the additional stressors associated with release. We therefore subjected acclimated and non-acclimated treatments to a stress challenge to compare stress levels between treatments within 48 hours after the scheduled release time. Our null hypothesis was that there was no difference between treatments at 1, 4, 12, 24 or 48 hours after a stress challenge. Lastly, data from multiple stressors (Barton et al. 1986) suggested that fish which recover from stressors were better able to handle additional stressors. Because the stress response during and after release would involve coping with multiple stressors, we investigated an additional index of stress, the difference between treatments in the length of time required by a treatment to recover from the stress challenge. Recovery was defined as returning to and remaining at baseline stress levels. Our null hypotheses for each of the post-challenge time periods were that plasma cortisol concentrations were equal to or lower than those at baseline sampling or that plasma chloride concentrations were equal to or higher than those at baseline sampling.

Both differences between treatments and changes over time within a treatment may be important indices of smoltification. Changes in smoltification are slow, occurring over days. We investigated differences between treatments at each sample date to determine whether acclimation resulted in accelerated smoltification compared to fish retained at the hatcheries. Our null hypothesis was that there were no differences in smoltification indices between treatments at each sample date. To explain development of a difference between treatments we investigated changes within a treatment over the sample dates. For instance, there are several ways that might result in differences between treatments. Although a higher smoltification index in the acclimated treatment compared to the non-acclimated might occur by the end of the experiment (assuming that they both started out similar), implications of the influence of acclimation on smoltification would differ if the smolt index rose in the acclimated treatment fish rather than if it fell in the non-acclimated treatment. Our null hypothesis was that there were no differences in smoltification indices among the sample dates within a treatment.

We used both gill $Na^{+}K^{+}$adenosine triphosphatase activity (ATPase) and concentrations of guanine in the skin as smoltification indices. Changes in both physiology and silvering in the body have been used as indicators of smoltification. Increases in ATPase have been observed in some juvenile anadromous salmonids during downstream migration (Zaugg et al. 1985). And increases in ATPase in hatchery steelhead have been observed to coincide with increased readiness to leave raceways (Zaugg and Wagner 1973). Guanine in the skin of juvenile anadromous salmonids has been used as a smoltification index because it is the main purine that causes silvering in the skin and scales during smolt transformation (Vanstone and Markert 1968).

Smoltification and stress experiments were completed with activities in 1992. We collected our second year of data to compare acclimated to non-acclimated treatments of juvenile steelhead at the Big Canyon and Little Sheep facilities. We did not collect stress and smoltification data from the Wallowa Facility in 1992. We collected smoltification data from juvenile spring chinook salmon at the Imnaha Facility in 1992 to compare acclimated to non-acclimated treatments. This report covers activities for the experiments conducted in 1992. However, because this is a final report for our smoltification and stress experiments, we have also included methods, results and discussion from acclimated versus non-acclimated experiments conducted in 1991, as appropriate.

Methods

Methods for 1992 were generally similar to those in 1991 (Lofy and McLean 1994). In those instances where methods differed between years, they were described for each year. In both 1991 and 1992 we sampled the acclimated and non-acclimated treatments of juvenile summer steelhead at the Big Canyon and Little Sheep facilities (Table 1). We sampled summer steelhead at the Wallowa Facility in 1991, and results were reported previously (Lofy and McLean 1994). In 1992 we added sampling of spring chinook salmon that were acclimated at the Imnaha Facility (Table 1).

Table 1. Transfer and release dates (acclimated) or transport/release dates (non-acclimated) for juvenile steelhead and chinook salmon released at the Grande Ronde and Imnaha river acclimation facilities in 1991 and 1992.

Species[a]	Year	Facility	Treatment	Transfer Date(s)[b]	Release Date(s)[c]	Mean Weight (g)[d]
STS	1991	Big Canyon	Acclimated	3/15	4/26	101.7
			Non-acclimated	---	4/26	84.7
	1991	Little Sheep	Acclimated	3/15	4/23-24	100.0
			Non-acclimated	---	4/23	77.4
	1992	Big Canyon	Acclimated	3/26-27	4/23	90.7
			Non-acclimated	---	4/23	85.3
	1992	Little Sheep	Acclimated	3/23-24	4/27-28	77.1
			Non-acclimated	---	4/27	75.8
CHS	1992	Imnaha	Acclimated	2/28	4/26	21.6
			Non-acclimated	---	4/26	21.3

[a] STS = summer steelhead; CHS = spring chinook salmon
[b] Non-acclimated fish had no transfer date, only a release date.
[c] Acclimated steelhead at the Little Sheep Facility were released overnight.
[d] Adapted from Messmer et al. 1992 (Table 32) and Messmer et al. 1994 (Tables 26 and 28).

Fish Rearing and Release

Juvenile anadromous salmonids sampled for this study were from groups already being used to evaluate potential differences in juvenile migration performance, survival to adulthood and contribution to fisheries between acclimated and non-acclimated treatments. Experiments were conducted with steelhead that were about 12 months old (1990 brood, 1991 release; 1991 brood, 1992 release) with two stocks at two facilities. Acclimated treatments of steelhead were transferred by truck to Big Canyon and Little Sheep facilities. Non-acclimated treatments were transported directly to the release site from Irrigon Hatchery near Irrigon, Oregon. The Wallowa Hatchery steelhead stock was used at the Big Canyon Facility located on Deer Creek, a tributary to the Wallowa River (Figure 1). Stress and smoltification indices for steelhead acclimated at the Big Canyon Facility were compared to the non-acclimated treatment that was reared at Irrigon Hatchery until release in Deer Creek (Table 1). The endemically-derived Little Sheep Creek steelhead stock was used at the Little Sheep Facility located on Little Sheep Creek, a tributary of Big Sheep Creek, in the Imnaha River basin (Figure 1). Stress and smoltification indices for steelhead acclimated at the Little Sheep Facility were compared to the non-acclimated treatment reared at Irrigon Hatchery until release into Little Sheep Creek (Table 1).

Juvenile steelhead released from the Wallowa and Big Canyon Facilities were progeny of Wallowa Hatchery stock adults. Steelhead released from the Little Sheep facility were progeny of a mixture of naturally-produced and hatchery fish that had returned to that facility. Eyed eggs were incubated at Wallowa Hatchery, then transferred to, and hatched and reared at Irrigon Hatchery. Juveniles from each experimental treatment were cold-branded (in February) and coded-wire-tagged (the previous fall) as part of the acclimation evaluation experiment (Messmer et al. 1992, Messmer et al. 1994).

The growth schedules at Irrigon Hatchery for the acclimated steelhead treatments were designed to achieve a size near 5.0 /lb. (~91 g) before transfer to the acclimation facility. Little or no growth was expected at the acclimation facility. The non-acclimated treatment was placed on a growth schedule at Irrigon Hatchery which was also designed to produce fish that were about 91 g at release. However, estimated size at release varied around 91g (Table 1).

Experiments were conducted with spring chinook salmon that were about 20 months old (1990 brood, 1992 release). Acclimated treatments were transferred by truck to the Imnaha Facility. Non-acclimated treatments were transported directly to the release site from Lookingglass Hatchery near Elgin, Oregon, on the same day as the acclimated treatment was released (Table 1). Juvenile spring chinook salmon used in this study were endemically-derived hatchery fish. These fish were yearling progeny of naturally-produced and hatchery Imnaha stock adults. Eggs were hatched and the fish were reared at Lookingglass Hatchery, then transported back to the Imnaha Facility for acclimation or release (Messmer et al. 1994). Growth schedules for acclimated and non-acclimated treatments of Imnaha spring chinook salmon at Lookingglass Hatchery and at the Imnaha Facility were the same. The target size was 25 fish per pound (fpp)(~18 g), but both acclimated and non-acclimated treatments were larger (Table 1).

General Sampling Protocol

All fish were taken off feed for 36 to 48 hours before they were haphazardly sampled. Fish were removed from the transport trucks (for non-acclimated treatments at release), hatchery raceways

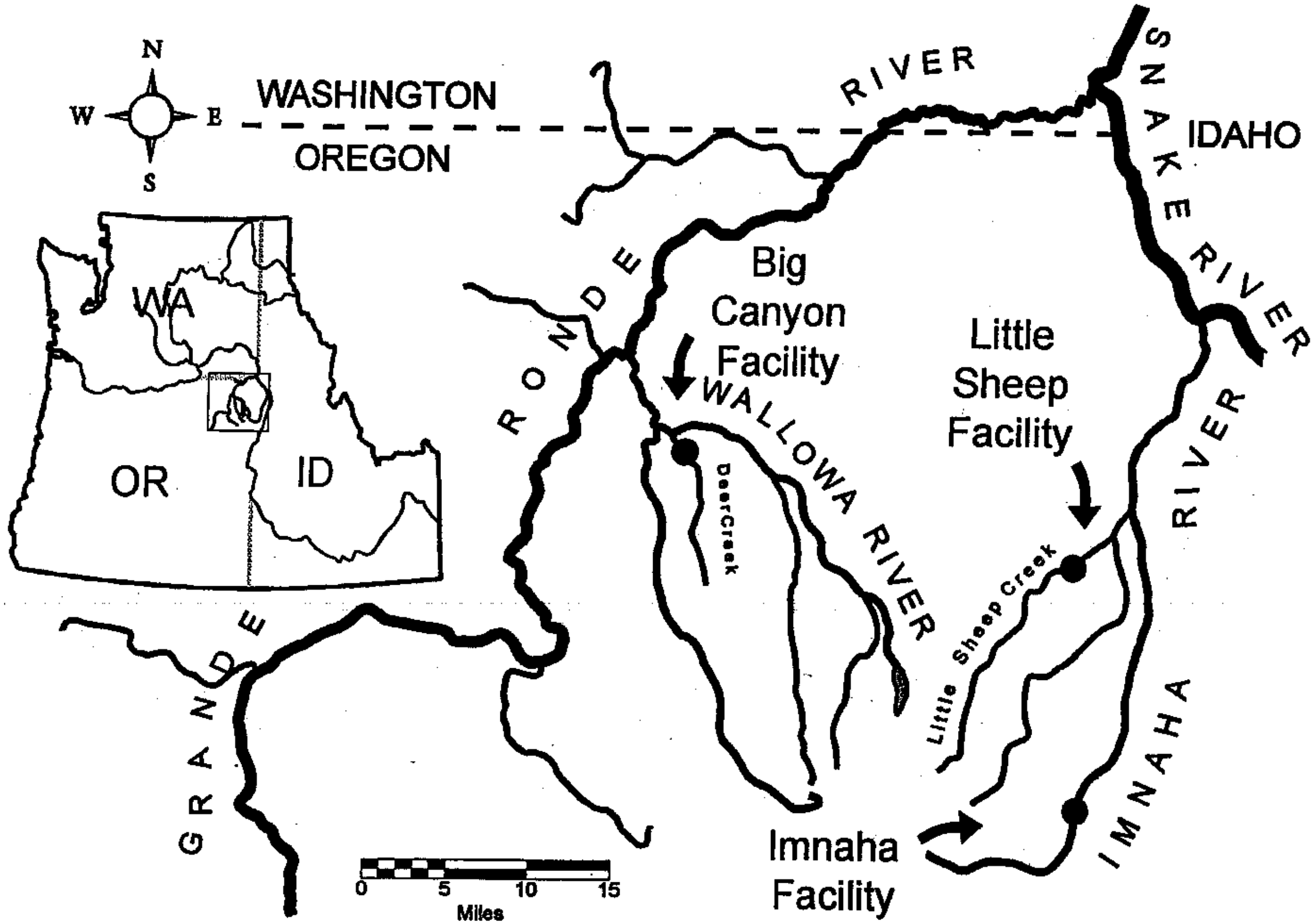

Figure 1. Location of acclimation facilities on the Grande Ronde and Imnaha river basins.

or acclimation ponds with a dip net. They were then either placed directly into anaesthetic (150 mg/l methane tricainesulfonate, MS-222) and sampled within a few minutes, or administered a stress challenge and placed in a holding container at the facility or the hatchery, for subsequent sampling. Once fish had lost equilibrium, fork length (mm) and weight (0.1 g) were measured and recorded. Tissues and blood samples were then removed for physiological analyses. Collection methods were slightly different and depended upon the site. In hatchery raceways, fish were herded by walking along the walls which separated raceways. This allowed concentrations of fish to form so as to facilitate capture. Fish were never crowded. In instances where fish at the hatcheries destined for an acclimation facility were held in several raceways, the number of fish sampled from each raceway was proportional to the number that were transferred to the acclimation facility from that raceway. Fish were generally taken from at least 3 different locations in the raceway or acclimation pond. Non-acclimated fish were removed from compartments in the transport trucks proportional to the number of fish in each of the compartments.

Fish that were part of our experimental group were sorted to identify fish that were part of the acclimated treatment once they were in the acclimation facility because non-experimental fish were also held there. Fish that were to be sampled immediately were netted directly into the buckets with anaesthetic and sorted for brands after equilibrium was lost. For fish that were not killed immediately (i.e. those administered a stress challenge and held for stress sampling later), exhaustion from that procedure served to slow the fish to the extent that they could easily be handled and sorted for brands without anaesthetic. To retain individuals of the appropriate brand groups, the net was suspended in a bucket of recovery water, and the fish were inspected for brands (usually in less than 10 seconds). When acclimated fish were sorted for brands at the acclimation facility, non-acclimated fish taken from the transportation trucks were handled as if to inspect for brands to equalize any potential stressor of inspection.

Sampling for Stress Indices

Because rearing conditions differ between acclimation facilities and hatcheries, stressors may result in differences in stress level, or stress response. We investigated physiological indicators of stress level before release (when each treatment was at the acclimation facility or the hatchery, prior to transport of the non-acclimated treatments), at release (after the non-acclimated treatment had been loaded onto the transport truck and hauled to the release site), and after the release of the cohort had occurred (a portion of the release group was retained for later sampling, and the rest of the fish from the treatment were released). Two physiological parameters were used as indices of stress, plasma cortisol concentrations and plasma chloride concentrations. Groups of fish collected for comparisons between treatments were generally sampled within 3-4 hours of one another to control for potential diel fluctuations (Appendix Table A-1).

Differences between acclimated and non-acclimated treatments were tested during three different time frames (Appendix Figure B-1): "baseline" (early in the morning; no stress challenge), "pre-stressed" (without a stress challenge) and "post-challenge" (after a stress challenge had been administered). The "baseline" group was sampled near 0700 hours on the day of (acclimated treatment) or the days before (non-acclimated treatment) release. Sample time of the "pre-stressed" group was dependent upon arrival time of trucks that transported the non-acclimated treatment on the day of release. Fish were sampled a few minutes after the last of the post-challenged groups was administered the stress challenge, usually between about 1200 and 1800 hours. Fish in the "post-challenged" groups were administered a standardized stress challenge (held out of the water in a net for 30 seconds) (Barton et al. 1985). Each of the 5 post-challenge groups was then placed in a separate, covered container. In 1991 this container was a floated 114-l plastic trash can. To allow water circulation, each trash can had two windows, each about 452 cm^2 of 0.64 cm mesh screening. Because of concerns about container effects in 1991 (Lofy and M^{c}Lean 1994), in 1992, we changed the container to a floated net pen with a styrofoam lid (about 61 cm x 90 cm x 61 cm deep). Resulting densities were about 2.2 to 2.7 g/l for steelhead and 1.2 to 1.3 g/l for salmon in 1992. All fish within a container were sampled about 1, 4, 12, 24 or 48 hours after the stress challenge. When post-challenge groups were sampled in 1991, the water was drained from the trash can to a depth of 18 cm through the screening on the sides. Fish were then poured from the trash cans, straining off the remainder of the water, directly into the bucket with anaesthetic. In 1992, the net pen was removed from the water and the fish poured along one edge of the rectangular net into the bucket with anaesthetic. Fish from the acclimation facility were then taken in a similar manner.

Fish for the pre-stressed and post-challenged samples were removed from the two transportation trucks first, then fish from the acclimation facility were sampled. Non-acclimated fish were taken from each compartment in each truck, administered the stress challenge, and placed into one of five buckets (for each of the five post-challenge groups). Then juveniles were netted from each compartment for the pre-stressed sample, placed directly into anaesthetic and sampled after loss of equilibrium.

The trucks that delivered the steelhead arrived about 15 or 105 minutes apart and were sampled in the order of arrival. Steelhead were removed from each of the five 3800-liter compartments in the two transport trucks (10% from each compartment were placed in a bucket, i.e. 50% from each truck). Fish from each bucket were transferred into 1 of 10 containers (5 for each truck). Five groups of steelhead from the acclimation facility taken for post-challenged samples were then administered the stress challenge and placed in 1 of 5 trash cans in 1991 or 1 of 10 net pens in 1992. At the Big Canyon Facility acclimated fish were taken after about half of the fish were visually estimated to remain. Containers were held in a pond adjacent to the acclimation pond. The Little Sheep Facility was drawn down very slowly overnight. Therefore acclimated fish were taken from these facilities before half of the fish had left to facility. Containers were held in sections of the adult holding ponds separated from adults. Sample size for groups of steelhead was generally 10 fish in 1991 and 20 fish in 1992 (Appendix Table A-1).

The non-acclimated treatment of chinook salmon was transported in a 10,600-liter tanker (~20% from each of 3 compartments) and a 7600-liter gallon tanker (~10% from each of 4 compartments). Both trucks arrived about the same time. Non-acclimated salmon from each post-challenged group were placed in one of five net pens. The acclimated treatment was sampled in a similar manner and was to be placed in nets pens. At the Imnaha Facility, containers were held in an area immediately upstream of the acclimation pond. This was the only place at the facility where the water level could be maintained while juveniles were released.

At the Imnaha Facility we planned to sample in the same manner as that at the Big Canyon Facility, after about half of the salmon had been crowded out. However, this was not accomplished. Unfortunately water was drawn down very quickly while we sampled the non-acclimated treatment and most of the fish had already been released before we were informed. The only option available was to sample the remaining fish which were already displaying visual signs of stress (labored breathing, loss of equilibrium). In addition, both the acclimated and non-acclimated treatments were inadvertently placed in the same net pen for 12, 24 and 48-hour post-challenge groups. Fish density was essentially doubled (2.5 g/l) compared to 1 and 4-hour post-challenge groups (1.2 to 1.3 g/l). The data are presented in Appendix Figure B-4. However, no analyses or interpretation are presented. Sample size for groups of salmon was generally 20 fish (Appendix Table A-1).

Anaesthetized fish were wrapped in a paper towel. The caudal peduncle was severed and blood from the caudal vasculature was collected in a 250-μl ammonium-heparinized capillary tube. Blood was then aspirated into an ice-cooled, 0.4 ml microcentrifuge tube, generally within about 0.5 hours after we began collecting blood. Tubes were centrifuged at 1720 *g* at ambient temperature for 4 minutes. Plasma was pipetted off into another ice-cooled, 0.4 ml microcentrifuge tube and stored at temperatures which ranged from -70°C to -196°C. Plasma was analyzed for chloride concentration using a 10-μl sample in a Haake-Buchler Digital Chloridometer. Plasma was refrozen to -70°C until analyses for cortisol concentration which followed those of Redding et al. (1984).

In addition to sampling around the time of release, we took both pre-stress and post-challenge samples before transfer of the acclimated treatment for both steelhead and salmon. Pre-transfer groups (PT) were sampled no more than 2 days prior to transfer of the acclimated fish to acclimation facilities. Fish for the pre-transfer, pre-stressed samples (PT-0) were placed directly into MS-222. Post-challenged fish (PT-1) were sampled about 1 hour after the standard stress challenge. Sample sizes were generally 20 fish in 1992 (Appendix Table A-1) and 1991. Pre-transfer samples for chinook salmon in 1992 were lost when liquid nitrogen in our container evaporated.

Sampling for Smoltification Indices

Two physiological parameters were used as indices of smoltification for these experiments, gill ATPase and guanine concentrations in the skin. Physiological indices of smoltification were monitored for both acclimated and non-acclimated treatments at the Big Canyon and Little Sheep Facilities in 1991 and 1992 and the Imnaha Facility in 1992. Fish were sampled at four dates in 1992: 22 March through 27 April for the Little Sheep Facility; 23 March through 23 April for the

Big Canyon Facility; and 25 February through 30 March for the Imnaha Facility (Appendix Table A-2). Length of acclimation for the steelhead was about 4-5 weeks (1-2 weeks shorter than in 1991) (Table 1). Sample dates were categorized as: pre-transfer (PT), when both acclimated and non-acclimated treatments were still at the hatchery but within 2 days prior to transfer of the acclimated treatment; one-third (1/3), when fish were approximately one-third of the way through acclimation; two-thirds (2/3), when fish were approximately two-thirds of the way through acclimation; and within two days prior to release (RE). Sample sizes were generally 20 for each treatment in both 1992 (Appendix Table A-2) and 1991. After the fish were anaesthetized, gill filaments from the second and third gill arches on the left side of the fish were removed and placed in a fixative solution of sucrose, Na_2 EDTA and imidazole. The sample was shaken to coat the tissue with fixative, then the sample was frozen in liquid nitrogen at -196°C until being transferred to -70°C for storage. The samples were analyzed following Zaugg (1982).

Skin samples were taken from the same fish after gill samples were removed. Whole fish were frozen using liquid nitrogen. A circular plug of skin on the left side of the fish immediately ventral to the lateral line bisected by the anterior insertion of the dorsal fin was removed from each fish (Figure 2). For steelhead, the cut was made with a standard #9 cork borer (~201 mm^2) and skin removed with tweezers. Any adhering muscle tissue was removed from the skin, then the sample was placed in a vial which was frozen in liquid nitrogen. When a #9 cork borer would not produce a symmetrical circle (because the fish was too small), a #7 cork borer was used (~154 mm^2). All chinook salmon were sampled using the smaller borer. Samples were transported at -196°C and transferred to -70°C for storage. Analyses followed those described by Staley (1984).

Pre-transfer samples of chinook salmon were lost when liquid nitrogen in our container evaporated. Therefore, chinook salmon smoltification is represented by only three dates for both acclimated and non-acclimated treatments.

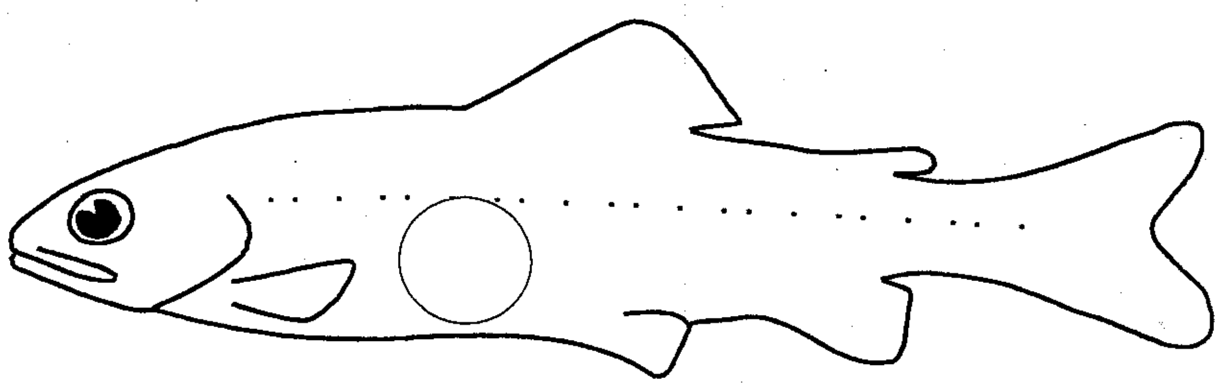

Figure 2. Area on juvenile steelhead and chinook salmon where skin samples were taken.

Statistical Analyses

We transformed smoltification data in 1992 to make variances homogeneous. Transformations yielded homogeneous variances for both the skin guanine [$y = \ln(100*\text{guanine})$] and ATPase [$y= \ln(10*\text{ATPase})$] data. Transformed smoltification data were analyzed using analysis of variance (ANOVA). A Tukey post-hoc test was performed for comparisons between treatments at each of the four dates (three dates for chinook salmon) and among dates within each treatment. Differences between treatments or dates were tested using $\alpha \leq 0.05$. Data distributions were illustrated as means $\pm$ 95% confidence intervals. Back transformation resulted in confidence intervals which were asymmetric.

We used distribution-free tests for all comparisons of stress indices because arcsine and log transformations of plasma cortisol and plasma chloride data did not produce homogeneous variances. Stressed fish generally had much higher variances. Mann-Whitney tests were used to compare treatments at individual sample times. Differences between treatments were tested using $\alpha \leq 0.05$. We used a Kruskal-Wallis Test to compare baseline (Time -8) and individual post-challenge samples (Times 1, 4, 12, 24 and 48). When a significant difference between the baseline and at least one of the post-challenge times occurred, we used Dunn's post-hoc comparison to determine which of the post-challenge groups were not significantly different from the baseline. Recovery was defined as stress-challenged groups that returned to and remained at or below baseline concentrations for plasma cortisol, or at or above baseline concentrations for plasma chloride. Because we considered a Type II error more serious in determining when stress indices had returned to baseline concentrations, and because a higher α is normally used for multiple simultaneous comparisons (Daniel 1978), we used $\alpha \leq 0.30$ for comparisons between baseline samples and individual post-challenged samples. We illustrated these data as medians and interquartile ranges.

Results

Stress Indices

Steelhead

Baseline plasma cortisol concentrations of acclimated and non-acclimated treatments were similar at the Little Sheep Facility (Figure 3). At the Big Canyon Facility baseline plasma cortisol concentrations of the acclimated treatment were lower than the non-acclimated treatment (Figure 3). Plasma cortisol concentrations at pre-stressed sampling of the acclimated treatment were lower than those of the non-acclimated treatment at the Little Sheep Facility (Figure 3). Plasma cortisol concentrations of the acclimated and non-acclimated treatments at pre-stressed sampling at the Big Canyon Facility were similar (Figure 3). After the stress challenge, plasma cortisol concentrations of acclimated treatments at the Little Sheep Facility were lower than the non-acclimated treatments two of the three time periods (Time 1, $p \leq 0.001$; Time 4 $p \leq 0.348$; Time 12 $p \leq 0.040$). A downward trend in plasma cortisol concentrations of the non-acclimated treatment at the Little Sheep Facility 24 hours after the stress challenge resulted in the treatments that were similar after that (Times 24 and 48). At the Big Canyon Facility, plasma cortisol concentrations of the acclimated treatment were lower than the non-acclimated treatment two of the three time periods from 1 to 12 hours after the stress challenge (Time 1, $p \leq 0.025$; Time 4, $p \leq 0.593$; Time 12, $p \leq 0.000$). A downward trend in plasma cortisol concentrations in the acclimated treatment from 4 through 48 hours after the stress challenge resulted in the acclimated treatment having lower plasma cortisol concentrations at the end of the experiment (Figure 3). We consistently observed lower plasma cortisol concentrations during baseline sampling compared to stress-challenged groups for both treatments at both the Big Canyon and Little Sheep facilities (Figure 3).

Plasma chloride concentrations of the acclimated treatments were higher than those of the non-acclimated treatments during baseline sampling for the Big Canyon Facility (Figure 4). Acclimated and non-acclimated treatments were similar at baseline sampling at the Little Sheep Facility (Figure 4). At the pre-stressed sampling, plasma chloride concentrations of acclimated treatments were higher than those of non-acclimated treatments at both facilities (Figure 4). Plasma chloride concentrations of the acclimated treatments were higher than the non-acclimated treatments during every post-challenge period at the Big Canyon Facility. At the Little Sheep Facility plasma chloride concentrations of the acclimated treatments were higher than the non-acclimated treatments from 1 to 12 hours after the stress challenge. A downward trend in plasma chloride concentrations of the acclimated treatment at 24 and 48 hours after the stress challenge resulted in plasma chloride concentrations that were significantly lower for the acclimated than the non-acclimated treatment at the end of the experiment (Figure 4). We consistently observed higher plasma chloride concentrations during baseline sampling compared to stress-challenged groups for both treatments at both the Big Canyon and Little Sheep facilities (Figure 4). Results for all statistical comparisons for plasma cortisol concentrations and plasma chloride concentrations are in Appendix Tables A-3 and A-4.

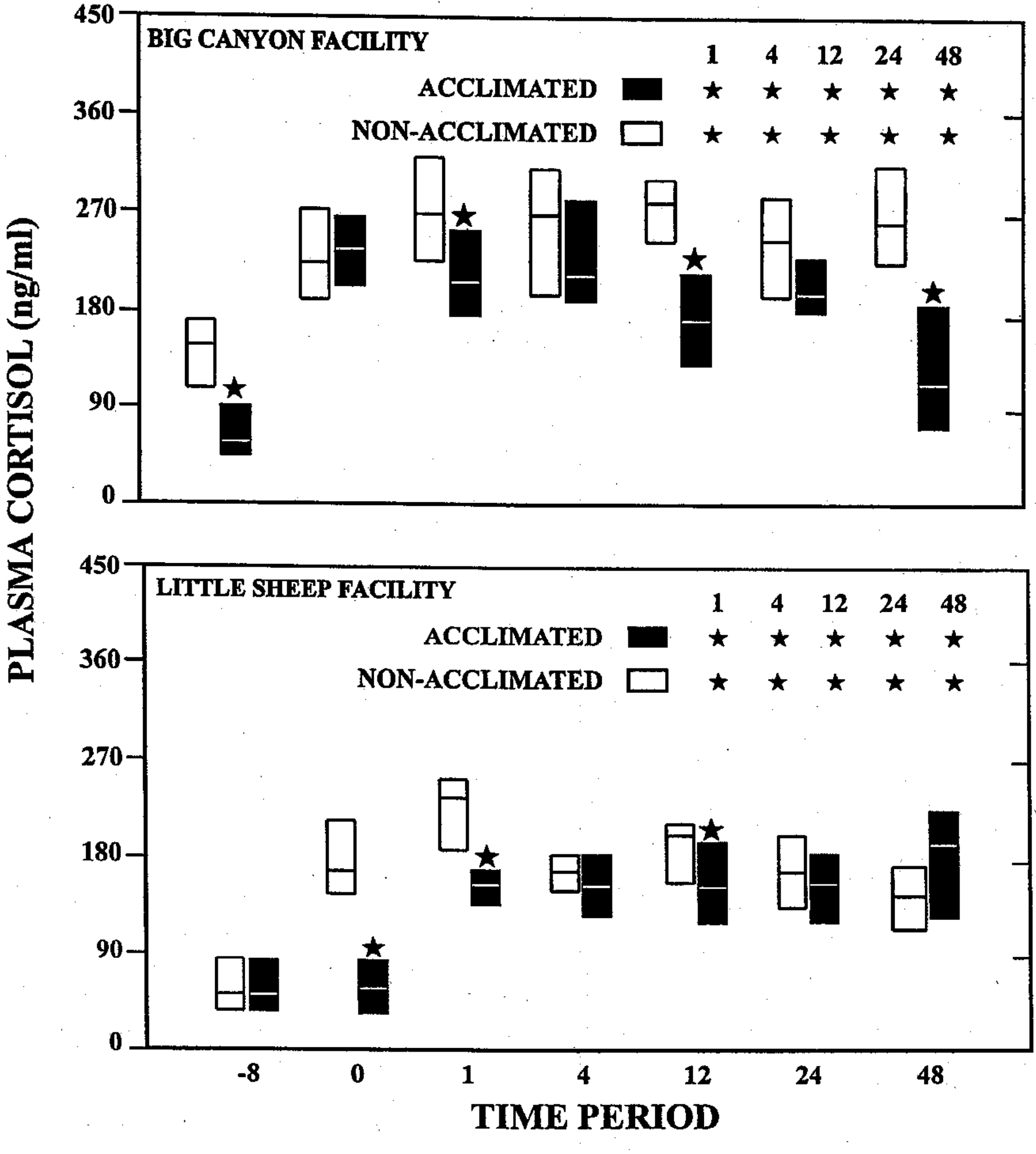

Figure 3. Medians and interquartile ranges of plasma cortisol concentrations of acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1992. Large stars above medians indicate significant differences between treatments ($\alpha \leq 0.05$) at that time. Small stars to the right of the legend indicate significant differences ($\alpha \leq 0.30$) between that time period and baseline samples (-8) within a treatment.

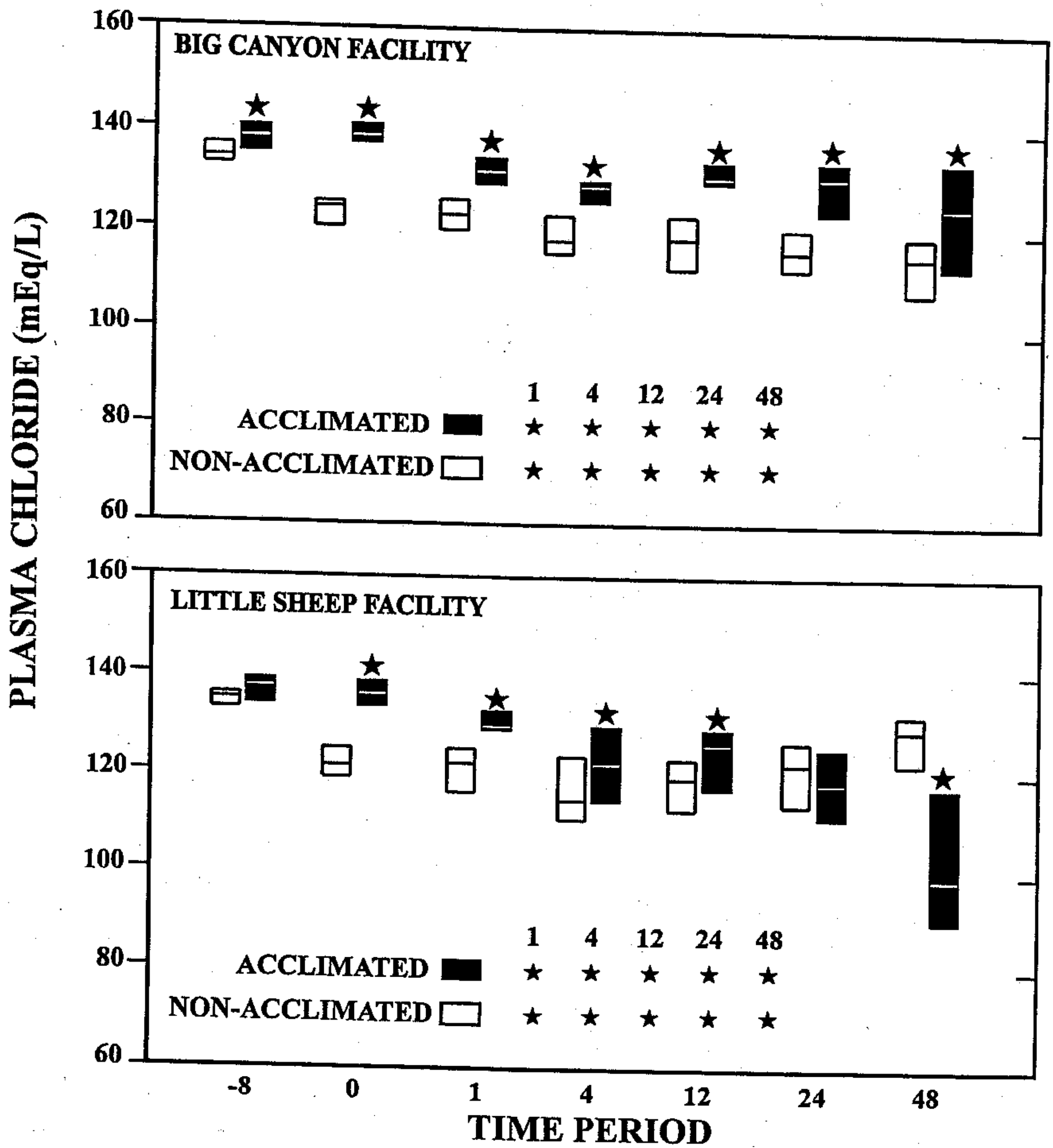

Figure 4. Medians and interquartile ranges of plasma chloride concentrations of acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1992. Large stars above medians indicate significant differences between treatments ($\alpha \leq 0.05$) at that time. Small stars to the right of the legend indicate significant differences ($\alpha \leq 0.30$) between that time period and baseline samples (-8) within a treatment.

Chinook Salmon

Graphical results from chinook salmon are presented in Appendix Figure B-3. No statistical analyses were performed on these data because the experimental design was not followed. Acclimated fish were probably stressed to a much greater extent due to crowding and very shallow water in the facility than was intended for the experiment.

Smoltification Indices

Steelhead

ATPase of acclimated and non-acclimated treatments were similar to one another for all dates at both the Little Sheep and Big Canyon facilities, except at the Little Sheep Facility just before release (Figure 5). The lower ATPase of the acclimated treatment compared to the non-acclimated at the Little Sheep Facility at release was apparently a consequence of a decrease in ATPase of the acclimated treatment from pre-transfer to release. No consistent trend was observed in changes over time within treatment groups. Values fluctuated around those at pre-transfer. An exception was a decrease in the acclimated treatment at the Little Sheep Facility (Figure 5).

Skin guanine concentrations of acclimated and non-acclimated treatments were similar to one another at every sample date at both the Little Sheep and Big Canyon facilities (Figure 6). Guanine concentrations were relatively stable over the experimental sampling dates, except for an increase which occurred from pre-transfer to release in the acclimated treatment at the Little Sheep Facility (Figure 6).

Chinook Salmon

There were no significant differences between acclimated and non-acclimated treatments of chinook salmon at any of the three sample dates nor over dates within a treatment (Figure 7). No differences in skin guanine concentrations between acclimated and non-acclimated treatments of chinook salmon were observed (Figure 7). Skin guanine concentrations increased from the 1/3 to the release sample date in the non-acclimated treatment (Appendix Table A-6). No increase in skin guanine was noted in the acclimated treatment over the sample dates (Figure 7).

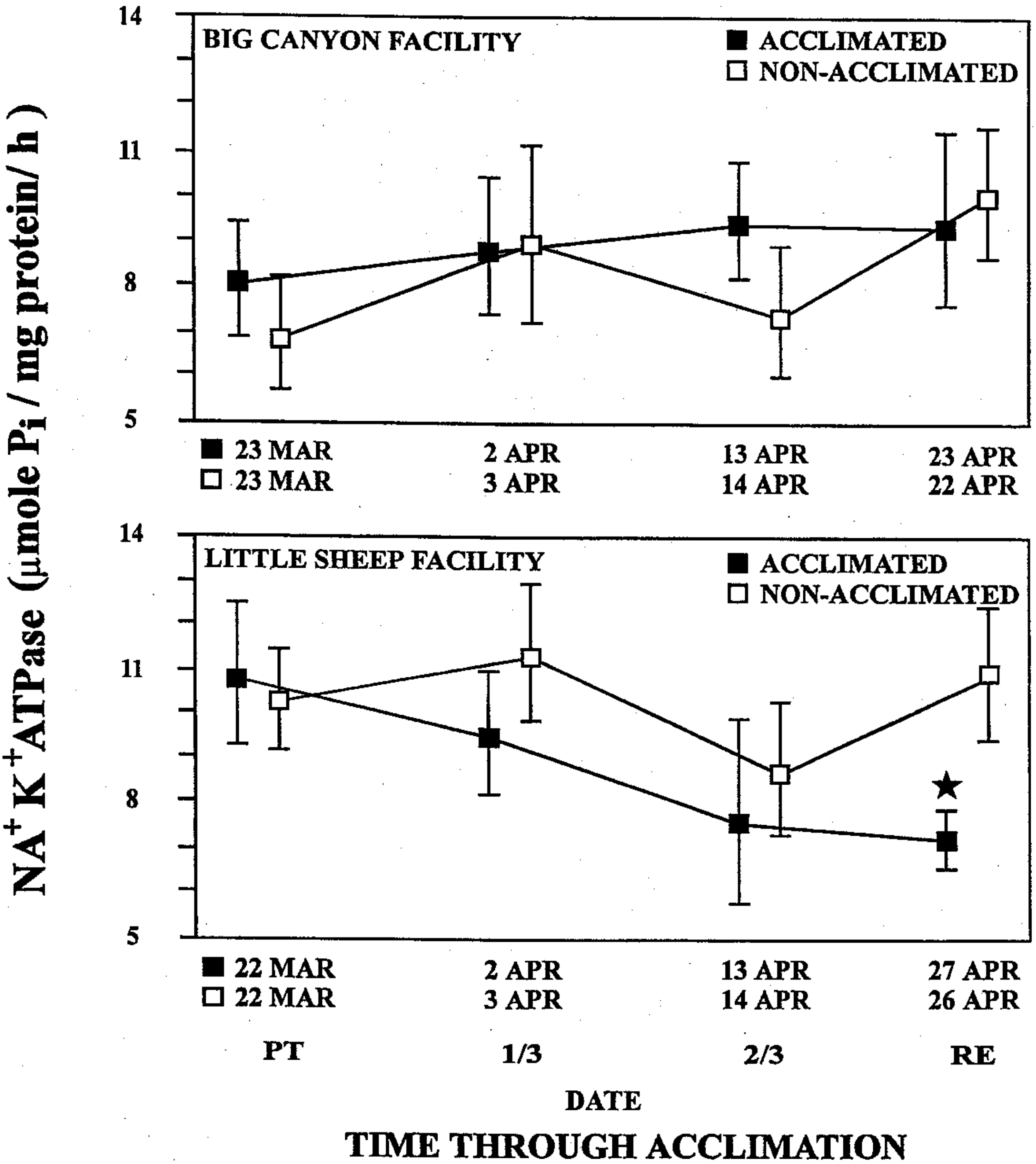

Figure 5. Mean gill $Na^{+}K^{+}$-ATPase activities and 95% confidence intervals (bars) for acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1992. Stars above means indicate significant differences between treatments ($\alpha \leq 0.05$) at that date. PT = pre-transfer; ⅓ = after one-third of the acclimation time; ⅔ = after two-thirds of the acclimation time; RE = within 2 days of release.

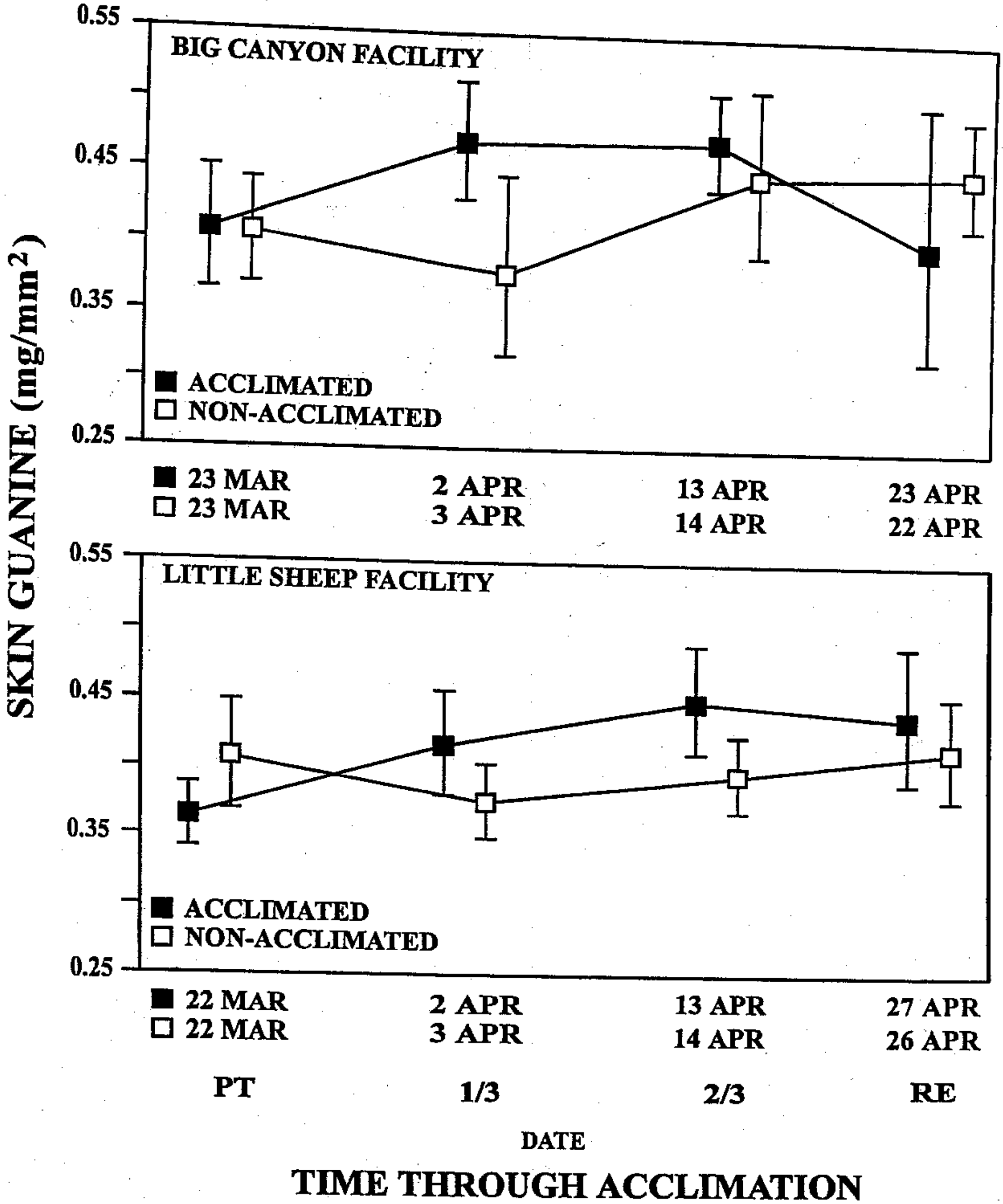

Figure 6. Mean skin guanine concentrations and 95% confidence intervals (bars) for acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1992. Stars above means indicate significant differences between treatments ($\alpha \leq 0.05$) at that date. PT = pre-transfer; ⅓ = after one-third of the acclimation time; ⅔ = after two-thirds of the acclimation time; RE = within 2 days of release.

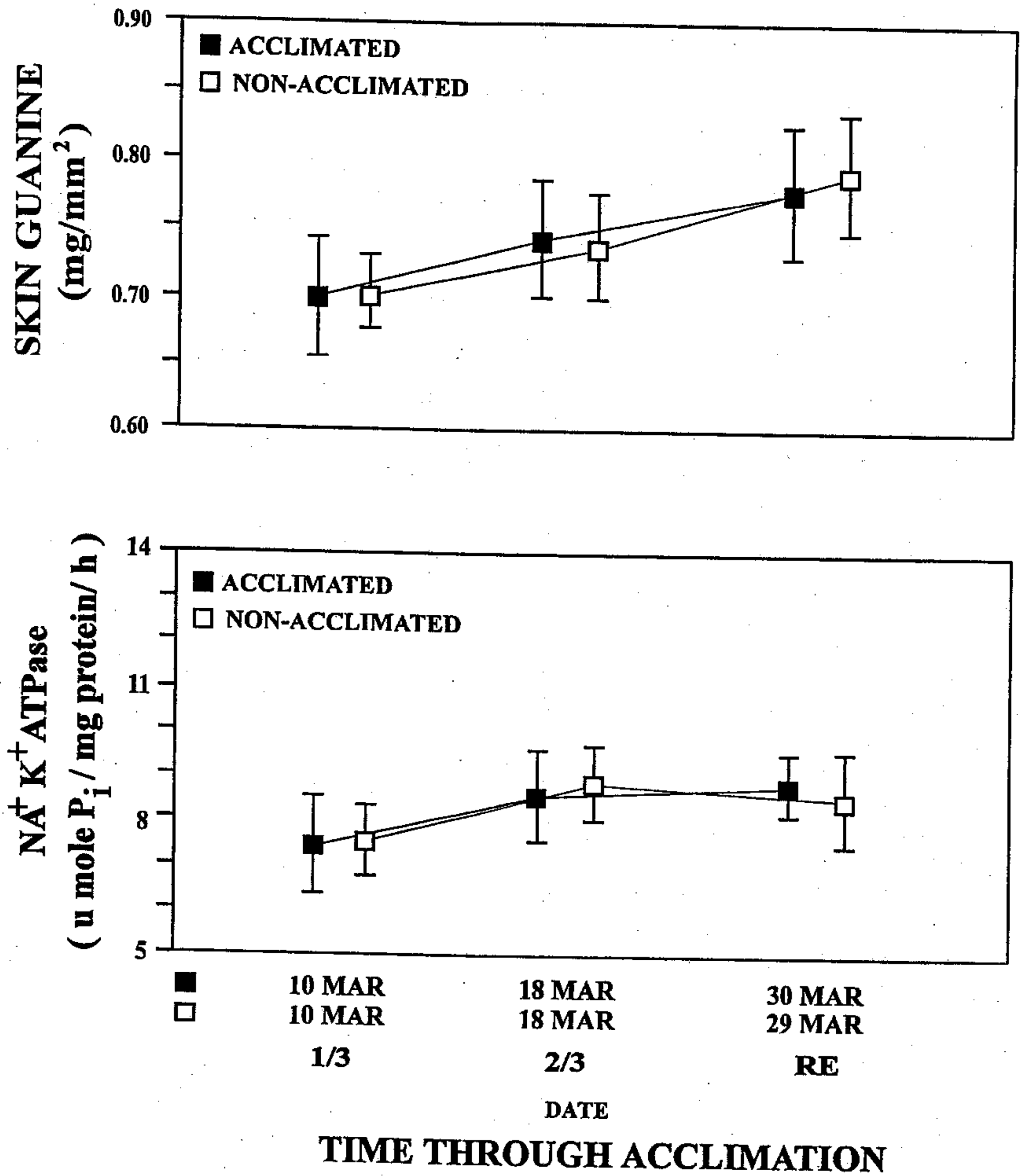

Figure 7. Mean skin guanine concentrations and gill Na^+K^+-ATPase activities and 95% confidence intervals (bars) for acclimated and non-acclimated juvenile chinook salmon at Imnaha Facility and Lookingglass Hatchery in 1992. There were no significant differences ($\alpha \leq 0.05$) at any date between treatments. ⅓ = after one-third of the acclimation time; ⅔ = after two-thirds of the acclimation time; RE = within 2 days of release.

Discussion

Lower stress levels of juvenile summer steelhead at Little Sheep and Big Canyon acclimation facilities before the non-acclimated treatment was transported to the release site were illustrated by higher plasma chloride concentrations of the acclimated treatments. This was similar to our findings in 1991 (Lofy and McLean 1994). Low plasma chloride concentrations (hyperchloremia) have been observed in response to both acute stressors in juvenile steelhead and coho salmon (Wedemeyer 1972) and in response to the chronic stressor of acidic water in adult Atlantic salmon (Brown et al. 1990). There were no indications from hatchery personnel at Irrigon Hatchery that any unusual activities might have occurred which would have resulted in an acute stress response. Lack of evidence for the occurrence of an acute stressor, and evidence of hyperchloremia in three of the four raceways of non-acclimated treatments over the two years of our experiments, pointed to the possibility that the environments at the acclimation facilities are, in general, less stressful than that at Irrigon Hatchery.

Because the crowding and handling associated with transport have been shown to be stressful (Barton et al. 1980), we expected differences between treatments, if they occurred, to be most evident during, or immediately after release. Acclimated treatments at the Little Sheep Facility had lower stress levels than non-acclimated treatments at the time of release as evidenced by higher plasma chloride concentrations and lower plasma cortisol concentrations of the acclimated treatments. Fish that were transported from Irrigon Hatchery were crowded and pumped into the transport truck. Despite the fact that these fish had some time to recover in the transport truck from handling, the few hours between loading and release were apparently insufficient to allow recovery to baseline levels. Similarly, Barton et al. (1980) found that plasma cortisol concentrations of fingerling rainbow trout (*O. mykiss*) were elevated after loading for transport, but started to decrease during transport. They concluded that handling at the hatchery to load the truck was the most stressful part of the transport process.

The acclimated fish at the Big Canyon Facility may have experienced somewhat different stressors just prior to release than those experienced by the acclimated treatment at the Little Sheep Facility. At the Big Canyon Facility, plasma chloride concentrations of the acclimated treatment were higher than non-acclimated treatments in both years at release. This suggested that a combination of the effects of the chronic stressors at the hatchery and the acute stressors of loading were still affected the non-acclimated treatment. However, unlike the Little Sheep Facility, plasma cortisol concentrations of the acclimated treatment had increased to such an extent by release time at the Big Canyon Facility that they were similar to those of the non-acclimated treatment. Increases in plasma cortisol concentrations in the acclimated treatment are consistent with a stress response to acute stressors shortly before release. A stress response has been demonstrated in plasma cortisol concentration in as little as five minutes after an acute stressor (Barton et al. 1980). Decreases in plasma chloride concentrations may take longer to become evident (Wedemeyer 1972). Crowding of the acclimated treatment out of the pond at the Big Canyon Facility was a possible stressor that could explain the differences that were observed in changes of plasma cortisol concentrations between the Little Sheep and Big Canyon facilities. Alternatively, differences in stress levels of the acclimated treatments at release could be attributed to the use of different hatchery stocks. However, the evidence for a stock effect was lacking. In 1991 we released the Wallowa stock from the Wallowa Facility and development of plasma cortisol concentrations appeared more similar to those of steelhead at the Little Sheep Facility than those at the Big Canyon Facility. The acclimated juvenile steelhead released from the Big Canyon Facility had higher plasma cortisol concentrations at release than those at the Wallowa Facility (Lofy and McLean 1994).

Acclimated treatments continued to be less stressed during the early part of the post-challenge period as evidenced by generally lower plasma cortisol concentrations and higher plasma chloride concentrations in the acclimated treatments at both facilities. Despite the apparent stress response of the acclimated treatment at the Big Canyon Facility at release, the advantage of having been acclimated was still generally apparent as evidenced by lower stress levels than those of the non-acclimated treatment during the first three post-challenge time periods.

Differences between acclimated and non-acclimated treatments were not as evident 24 to 48 hours after the stress challenge. What appeared to have been stress responses of acclimated treatments made interpretation of differences between treatments after Time 12 difficult. We observed consistent increased stress levels in acclimated treatments during either one or both of the two latter post-challenge periods in 1991. Possible explanations were that different densities in the containers (acclimated treatments, 10.6 g/l; non-acclimated treatments, 4.3 g/l), or the "perceived" densities of fish when they were all at the bottom of the trash cans, might have caused changes in the acclimated treatments that were not observed in non-acclimated treatments. In 1991, all three of the acclimated treatments (Wallowa, Big Canyon and Little Sheep facilities) experienced increased stress levels while neither of the two non-acclimated treatments did (the Wallowa Facility had no non-acclimated treatment) (Lofy and McLean 1994). The use of net pens (with more volume and bottom surface area) and doubling the number of containers for the acclimated treatments (producing equivalent densities for both treatments) in 1992 resulted in inconsistent trends in stress levels of the acclimated treatments at the two acclimation facilities. We saw continued recovery of the acclimated treatment at the Big Canyon Facility. However, we saw a similar increase in stress level of the acclimated treatment at the Little Sheep Facility in 1992 as that observed in 1991. These inconsistent results suggested that we had not eliminated the source of the latent stress response in acclimated fish, and that densities or containers may not have been the source of the problem. Latent increases in plasma cortisol concentrations have been observed in juvenile coho (Avella et al. 1991) and chinook salmon that were crowded, (Congleton et al. 1984), however densities were about 10 to 150 times the densities we used.

None of the treatments appeared to have recovered from the stress challenge within the time frame of our experiments. Therefore we could not compare the length of time it took to recover between acclimated and non-acclimated treatments. Results in 1992 were more consistent than in 1991. Not one of the treatments ever returned to baseline levels at either of the facilities for either stress index in 1992. However, there are three indicators that suggested that the acclimated treatments may have had the capacity to recover more quickly tan the non-acclimated treatments, given preclusion of additional stressors and/or additional time. First, the stress responses appeared to have been, in general, smaller in the acclimated treatments compared to the non-acclimated treatments. A smaller stress response would mean a smaller change was necessary to return to baseline levels, possibly occurring in a shorter period of time. Secondly, of the four treatments that had transitory changes in stress level to baseline levels in 1991, three were acclimated treatments (Lofy and McLean 1994). And lastly, in 1992, generally lower stress levels of the acclimated treatments continued through the end of the experiment at the Big Canyon Facility where no latent stress response of the acclimated was observed. If the differences between treatments continued after the end of our experiment, the acclimated treatment would have recovered before the non-acclimated treatment.

We conclude that lower stress levels of juvenile summer steelhead acclimated at Oregon LSRCP facilities were evident while both treatments were still at their respective facilities and continued through release. Lower stress levels of the acclimated treatments at release may have been due to a combination of the chronic stressors experienced by non-acclimated treatments at Irrigon Hatchery and the acute stressors of crowding and loading for transport of the non-acclimated treatments destined for release in the Grande Ronde River basin. Vulnerability of the non-acclimated treatment to additional stressors may extend until at least 12 hours after release. After that, we could not clearly demonstrate lower stress levels of acclimated fish. This may have been an artifact of our acclimated fish having been exposed to latent stressors that were not experienced by the non-acclimated treatments. Alternatively, there may be some latent effect to which acclimated treatments responded and non-acclimated treatments did not. What does appear to be generally evident is that in non-acclimated treatments did not fully recover during the 48 hours allowed in our experiments.

Lower stress levels of the acclimated fish at release and the ability to better handle additional stressors after release were possible causes of the survival advantage of acclimated treatments compared to non-acclimated treatments. Stressors to which fish are not able to adapt may affect osmotic and ionic regulation (Eddy 1981), immune function and disease resistance (Pickering and Pottinger 1989; Maule et al. 1989) and survival (Pickering 1989; Strange and Schreck 1978). At a time when juvenile hatchery steelhead are about to start their migration toward the ocean, they may be particularly vulnerable to stressors from the natural environment to which they have never been exposed. Given the myriad of effects of stressors which may compromise survival, lowering stress levels may increase survival in hatchery steelhead. When possible, it may be advisable to modify or eliminate procedures which may be causing stress. One of these stressors may be release procedures at the Big Canyon Facility. Because we had no volitional releases (uncrowded), we have not unequivocally shown that volitional releases will lower stress levels compared to forced releases. Our data suggested that lower stress levels during volitional releases may result. However, a controlled experiment needs to be performed to validate the benefits of a volitional release strategy.

Acclimation of juvenile steelhead at LSRCP facilities did not appear to accelerate smoltification of acclimated compared to non-acclimated treatments. Survival advantages ascribed to increased smoltification could include faster travel time of the more smolted fish. In fact, however, juvenile steelhead from acclimated treatments in 1991 and 1992 had median travel times that were similar to, or slower than, non-acclimated treatment (Messmer et al. 1992, 1994). This evidence concurs with that collected during our experiment which suggested increased smoltification of acclimated treatments at release was probably not associated with the increased survival of acclimated summer steelhead.

Consistent with the results we obtained for steelhead, acclimation of juvenile chinook salmon at Imnaha Acclimation Facility did not appear to accelerate smoltification in acclimated treatments during acclimation in 1992. Thus increased smoltification of the acclimated treatment while in the acclimation facility probably did not contribute to any survival advantage that might be observed. Although we did not observe differences between acclimated and non-acclimated treatments in our studies, this may have been due to the fact that these chinook salmon may have been released before changes in smoltification might have been expected to have occurred. In the Deschutes River, Oregon, significant increases in ATPase in spring chinook salmon reared in Pelton ladder were monitored monthly from February through August. Increases in ATPase activity were not observed until May or June (Hart et al. 1981). On the Rogue River, an Oregon coastal stream, numerous peaks in ATPase were observed, which included a fall peak which coincided with a fall migration that was documented to have contributed to adult returns (Buckman and Ewing 1977). For some stocks there may be numerous "appropriate" times in which spring chinook salmon may choose to migrate, perhaps depending upon distance to the ocean. It might be argued that if there is a "window of opportunity" for ocean entry to the Columbia River estuary, stocks higher in the system (e.g. Imnaha spring chinook salmon) may need to leave tributaries somewhat earlier than stocks farther down river (e.g. the Deschutes River). Evidence which suggested this generalization may not hold true are ATPase activities for spring chinook salmon at Leavenworth Hatchery. ATPase of spring chinook salmon held until after release at Leavenworth Hatchery peaked in May (and were magnitudes higher for individuals captured near the estuary at Jones Beach) (Zaugg et al. 1985). However, the effects of stock and rearing conditions may have also influenced ATPase development. Evidence that the natural populations left the Imnaha River relatively early (Gaumer 1968) has suggested to managers that release of hatchery Imnaha stock in late March. Recent information from trapping of juvenile chinook salmon in the Imnaha River suggested that this pattern of relatively early migration is still evident (Ashe et al. 1995). Physiological data from 5 April through 4 May, 1994, at a downstream outmigrant trap on the lower Imnaha River showed similar ATPase values in hatchery spring chinook salmon released from or near the Imnaha Facility as we observed in acclimated and non-acclimated treatments before release in 1992. ATPase values of naturally-produced and hatchery spring chinook salmon collected at the trap were also similar to one another (Ashe et al. 1995).

There are a variety of acclimation pond configurations, environmental conditions, feeding programs and fish stocks that are used in LSRCP acclimation facilities in Idaho, Washington and Oregon, and the success in accelerating smoltification in steelhead may not be the same for all of them. ATPase from steelhead acclimated in Curl Lake and Dayton Pond (large earthen-bottom acclimation ponds in Washington) and non-acclimated treatments retained at Lyon's Ferry Hatchery, suggested smoltification was accelerated in acclimated treatments compared to non-acclimated treatments by mid-April in 1989 (Schuck et al. 1990). If acceleration of smoltification is attainable in Washington, it may be attainable in Oregon as well. Any one of the factors that comprise the acclimation program for ponds in Oregon may be failing to produce accelerated smoltification of juveniles. If accelerated smoltification is desired, and if modification of existing ponds are investigated, or additional ponds are suggested for construction, consideration of pond configuration, water source, and other factors that may differ from those we have traditionally chosen for acclimation sites in Oregon could be investigated. Alternatively, the differences in growth schedules between the acclimated and non-acclimated treatments of steelhead in Oregon may have masked any stimulation of smoltification. Development of ATPase was different in groups of chinook salmon that were fed relatively high, moderate and low daily rations (Ewing et al. 1980). If putting acclimated steelhead treatments on restricted diets after transfer retards smoltification, perhaps both acclimated and non-acclimated treatments could be put on similar growth schedules, adjusting feeding at Irrigon Hatchery to mimic growth rates observed at the acclimation facilities. However, variability in size-at-release among years, would invalidate year-to-year comparisons.

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SECTION II

EVALUATION OF REESTABLISHING NATURAL PRODUCTION OF CHINOOK SALMON IN LOOKINGGLASS CREEK, OREGON, USING A NON-ENDEMIC HATCHERY STOCK

Abstract

This was the first year of a study to evaluate the reestablishment of natural production in Lookingglass Creek using a non-endemic hatchery stock (Rapid River). One hundred and thirty-three adult Rapid River stock spring chinook salmon were released above the Lookingglass Hatchery weir in 1992. During spawning ground surveys, we observed a total count of 49 redds above the weir and 13 below the weir. Age structure of fish released above the weir was 12% age 5, 85% age 4, and 3% age 3 chinook salmon. We found a positive relationship ($P \leq 0.05$) using fork length to predict fecundity ($r^2=0.33$). Stream flow and temperature data from 1992 had earlier peaks than those observed from 1964-1974. The run timing of Rapid River stock in 1992 was earlier than in 1990 and 1991 and earlier than the endemic stock from 1967-1970. By 27 May, 26% of the fish which had returned were released above the weir, even though greater than 60% of the total return in 1992 had been trapped. The range of percentages within age groups for the Rapid River stock that returned from 1990 and 1991 was highly variable, with 1 to 13%, 43 to 94%, and 5 to 26% for fish ages 3, 4, and 5 respectively. This range did, however, overlap the range of age composition seen from 1971-1974 of 4 to 13%, 80 to 87% and 4 to 9% for fish age 3, 4, and 5 respectively. Peak observations of occupied, and unoccupied redds, and live and dead fish in 1992 were 1 or 2 weeks later than peaks of the ranges seen from 1966-1970. The percentage of redds in lower areas of Lookingglass Creek above the weir was higher than those observed 1966-1970, while the percentage in the upper area of Lookingglass Creek was lower than during those years. The percentage of redds in Little Lookingglass Creek was similar to earlier years. Redd density in 1992 was lower than historic levels in all areas except immediately above the weir, where it was near the upper end of the range seen from 1964-1971.

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*) (Olsen et al. 1994). Construction of hydroelectric facilities, over fishing, and loss of critical spawning and rearing habitat in the Columbia and Snake rivers basins, produced large losses of chinook salmon and steelhead and extirpation of coho and sockeye in the Grande Ronde Rive Basin (Olsen et al. 1994). Escapements of anadromous salmonids that have returned to the Grande Ronde River Basin have declined (Oregon Department of Fish and Wildlife unpublished data), as well as escapements to the entire Snake River Basin, 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 the basin in an effort to increase anadromous salmonid production. Lookingglass Hatchery on Lookingglass Creek (Figure 8), a tributary of the Grande Ronde River, was completed in 1982 and serves as the incubation and rearing site for the chinook salmon programs in Oregon under Lower Snake River Compensation Plan (LSRCP).

Since 1982, all adult spring chinook salmon that returned to Lookingglass Hatchery have been retained for broodstock, with the exception of a few fish of endemic stock in 1989. The upstream migration has been almost completely blocked by a picket weir located above the hatchery at approximately rivermile (RM) 2.5 (Figure 8). Every year since the hatchery was constructed, some fish escaped above the weir as evidenced by redd counts during spawning ground surveys conducted by Oregon Department of Fish and Wildlife (ODFW) (ODFW unpublished data). Since the release of a few spring chinook salmon in 1989 there has been no effort to release fish above the weir to spawn naturally.

A study was developed by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Nez Perce Tribe (NPT) and the Oregon Department of Fish and Wildlife (ODFW), to evaluate the reestablishment of natural production in Lookingglass Creek using Rapid River stock spring chinook salmon (Lofy et al. 1992). In 1992, Rapid River stock was being used for production at Lookingglass Hatchery. It was the opinion of fishery managers that if reintroduction of a non-endemic stock might be successful anywhere in the Grande Ronde River Basin, that Lookingglass Creek was a good location, because of a good quality habitat and the ability to easily control the experiment with an existing weir. A detailed historic data base on production of the endemic stock (previous study) would allow comparison with previous production levels.

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 and compared it to what was seen historically. We also collected life history data on spring chinook salmon released above the weir in 1992 and compared it to data collected from 1964-1974 by the ODFW. The historic study was used as a point of reference to evaluate the success of the reintroduction above the weir.

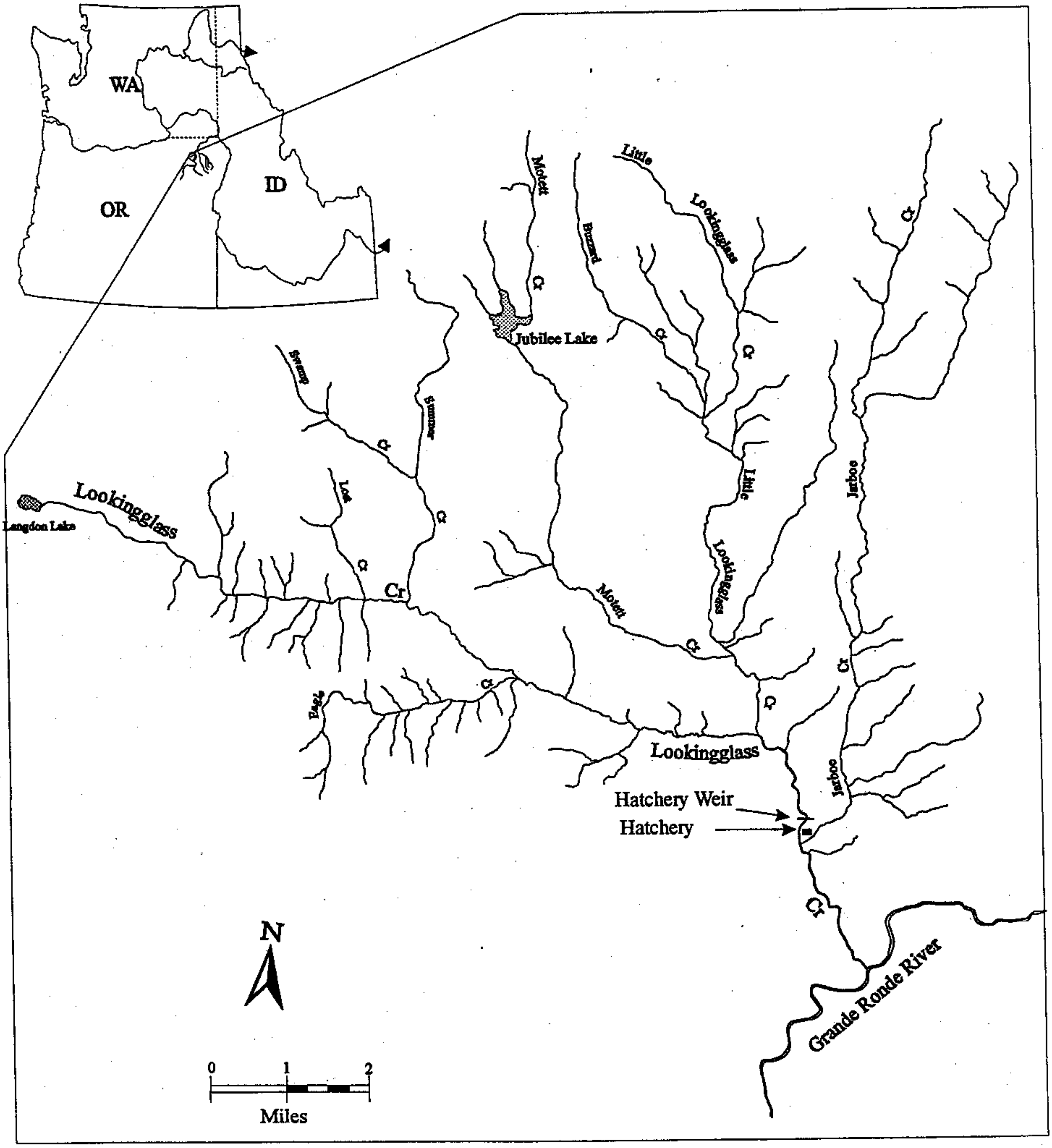

Figure 8. Map of the Lookingglass Creek basin.

Study Area

The headwaters of the Lookingglass Creek subbasin are located in the Blue Mountains of northeast Oregon at Langdon Lake, elevation 4,870 feet (Figure 8). Lookingglass Creek flows to the southeast approximately 15.0 river miles (RM) through the Umatilla National Forest and private land where it enters the Grande Ronde River at approximately RM 85.0, elevation 2700 feet (Figure 8). Compared to other non-wilderness subbasins in the Grande Ronde River Basin, the fish habitat in the Lookingglass Creek has remained relatively undisturbed since 1974, with little logging and grazing occurring in the upper reaches of the system. Currently, most of the small scale logging and grazing operations occur on the privately-owned areas from RM 8.0 of Lookingglass Creek to the mouth. Clear cutting and recreational development occurred in the upper Lookingglass Creek and Little Lookingglass Creek basins from 1964-1974 (Burck 1993). Lookingglass Creek has 3 substantial tributaries, Eagle Creek, which enter at about RM 8.25, Little Lookingglass Creek, which enters just below RM 4.25, and Jarboe Creek, which enters just below RM 2.25 (Figure 8), the largest of which is Little Lookingglass Creek. The hatchery weir is located at about RM 2.50, and Lookingglass Hatchery is located at about RM 2.25 (Figure 8).

During the previous study, Lookingglass and Little Lookingglass creeks were divided into four geographic units (Burck 1993)(Figure 9). Unit 1 extended from the mouth of Lookingglass Creek to Lookingglass Falls at RM 2.50 (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 RM 4.25. Unit 3 extended from the mouth of Little Lookingglass Creek to just above the mouth of Lost Creek at about RM 11.0. Unit 4, which was Little Lookingglass Creek, started at the mouth and went upstream to about RM 4.0 (Burck 1993). We used these same units and landmarks in the current study (Figure 9).

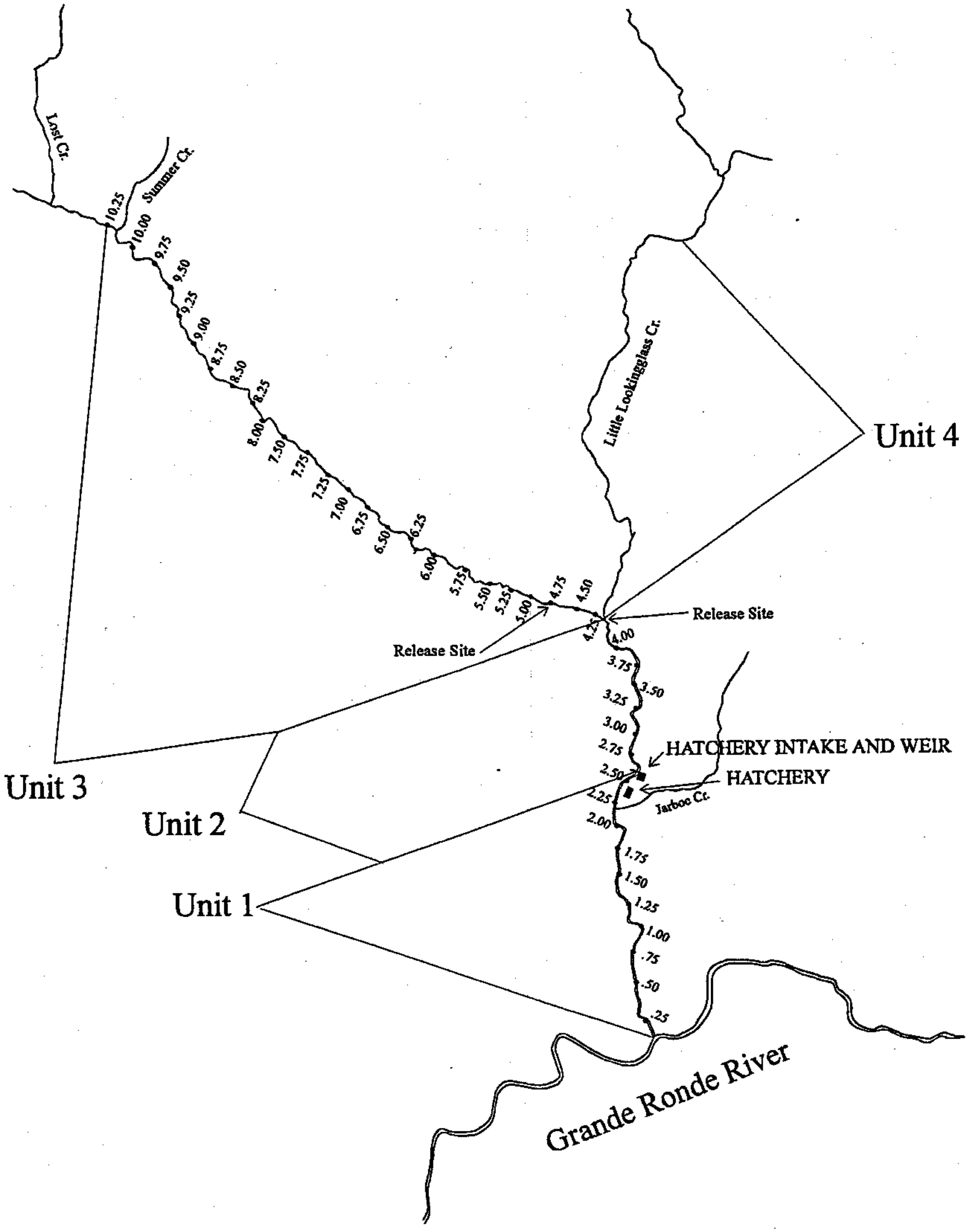

Figure 9. Approximate rivermile locations and the units in the previous study and the current study.

Methods

Stream Flow and Temperature

Stream flows in Lookingglass Creek were summarized for 1964-1971 from Burck (1993) and for 1992 from Hubbard et al. (1993,1994) to evaluate possible changes in the watershed stream flows that may have occurred over time. All stream flow data collected were summarized by grouping yearly data into 52 periods which corresponded to a week of the year. The maximum and minimum stream flows in each of the 52 periods were summarized. During the previous study (1993) stream flows were measured only once daily and only when the stream was visited. Methods of calculating flow from 1964-1971 are described in Burck (1993). Stream flows in 1992 were calculated every ½ hour at an electronic stream gaging station operated by the United States Geological Survey (USGS) just below the hatchery. A mean daily stream flow was calculated by USGS (Hubbard et al. 1993, 1994).

Stream temperatures in Lookingglass Creek were summarized for 1964-1971 (Burck 1993) and for 1992 (unpublished data, United States Forest Service (USFS) Walla Walla District) to evaluate possible changes in the watershed stream temperatures. All stream temperature data were daily maximum and minimum temperatures. The maximum and minimum stream temperatures for each week of the year were then determined. Stream temperatures from the previous study (Burck 1993) were measured with a continuous-recording 7-day thermograph in Lookingglass Creek just above Little Lookingglass Creek. The water from Little Lookingglass Creek did not influence the thermograph. The daily maximum and minimum stream temperatures were determined from the thermograph (Burck 1993). Stream temperatures measured in 1992 were recorded at RM 7.5 in Lookingglass Creek by the USFS Walla Walla District. Temperatures were measured electronically every hour. A maximum and minimum daily stream temperature was then calculated by the USFS.

Sampling and Release of Adults Above the Weir

The procedures outlined in the Annual Operations Plan for LSRCP hatcheries in Oregon for 1992 called for the release of 100 adult chinook salmon, trapped at Lookingglass Hatchery, above the weir on Lookingglass Creek. The target composition of the release group was 45 adult male, 50 adult female and 5 jack chinook salmon. These proportions were chosen to keep the number of males and females the same, and allow some jacks to spawn naturally. Chinook salmon less than 600 mm in fork length were classified as jacks. The hatchery trap began operation on 24 April. Fish captured in the trap were processed on a weekly basis. On 10 September, when it was determined that there were more adults than needed for broodstock, we released an additional 40 adult chinook salmon (late group) above the weir. All fish released before 10 September were the early group. Sampling of the fish released above the weir was done to characterize the population for comparison to the endemic stock. All chinook salmon released above the weir were assigned a sex by hatchery personnel at trapping, measured (fork length to the nearest 5mm), and had scale samples taken (3 or 4 scales from each side of the fish in the key scale area) for determination of age and origin (hatchery or natural). Age was defined as the number of years from egg deposition (e.g. 5-year-old fish in 1992 was deposited as an egg in 1987). Origin of the fish was determined by discriminant analysis of scales (ODFW unpublished data). Scale models to determine origin of the fish were developed from coded-wire-tagged hatchery fish which returned to the Grande Ronde River basin each year and unmarked fish collected from 1976 until 1984, when few hatchery fish were released and few "out of river" strays were presumed to have been present.

Fish were tagged to allow identification of individuals during spawning ground surveys, carcass recovery, and recycling through the hatchery trap. The chinook salmon that were released were tagged just below the dorsal fin with numbered 7/8" diameter red and white Peterson discs, and a small round piece of the operculum was removed with a paper punch (operculum-punched). The white disc tag and the operculum punch were placed on the right side if the chinook salmon was assigned male and on the left side if assigned female. The majority of the release group was trucked upstream to approximately RM 4.0 and released into the stream. Because there was concern that some of the chinook salmon released later in the run would return to the picket weir, those fish trapped after 30 June, were generally released at the first bridge above Little Lookingglass Creek (approximately RM 4.75).

Spawning Ground Surveys

Pre-spawning surveys were conducted to document pre-spawning mortality that might not be observed during regular spawning surveys. Spawning ground surveys were conducted to document distribution and timing of spawning activity, and recover carcasses. Surveys were also conducted to document the number of tagged fish, alive and dead, that moved downstream below the weir. Carcasses were recovered to retrieve coded-wire-tag information on adipose-clipped fish, estimate the accuracy of the sex assignment by hatchery personnel, and to estimate the number of fish that escaped above the weir and were never handled. Only chinook salmon from the early group were used to validate the accuracy of the sex assignment because the chinook salmon in the late group were assumed to have been accurately assigned sex because they exhibited advanced sexual dimorphism that is characteristic of chinook salmon at maturation.

Surveys began 15 July after the release of the first tagged chinook salmon and were conducted every other week (pre-spawning) until the first chinook salmon spawning activity was observed. After the first spawning activity was observed, the spawning surveys were conducted on a weekly (spawning) basis until no live chinook salmon were seen. Data collected during the surveys are shown in Appendix Table C-1. Redds and test diggings were flagged and given a number on the date the digging was first seen. Occupation of the site by a chinook salmon was also recorded on the flagging the first date the digging was observed. Only diggings that were not previously flagged (new since the last survey) were flagged on each survey. The diggings had 2 designations, incomplete redd (test redd) and complete redd. Incomplete redds were monitored every survey to be certain there was no change in the designation to complete redd. We designated diggings as a redd based solely on physical characteristics. That is, a digging could be designated as incomplete even if a fish was on the digging. If the incomplete redd was still considered a test redd at the end of the survey season, it was not counted in the total number of complete redds for the year. A digging designated as an incomplete redd was usually unoccupied and did not yet have a distinct depression and clean gravel tailout. The second designation was a complete redd which was often occupied by one or more chinook salmon and had a distinct depression and clean gravel tailout. Once a redd was designated as complete by a surveyor it was included in the total redd count for the season.

Scales, sex and any mark information were recorded for untagged chinook salmon carcasses encountered on surveys or recovered off of the picket weir. Sex determination and mark information was recorded for tagged or operculum-punched chinook salmon carcasses encountered. Scales were not removed from tagged or operculum-punched chinook salmon because they had already been taken at the time of passage above the weir. On some carcasses it was not possible to collect scales, determine the sex, or record mark information because the carcass was too decomposed.

Male chinook salmon that were recovered before redds were observed, and female chinook salmon that retained more than 60% of their eggs, were designated as pre-spawning mortalities. Maximum percentage survival to spawning above the weir was calculated using the equation:

*((#tagged - tagged pre-spawning mortality) / # tagged) * 100*

Because the weir is not 100% effective at stopping all upstream migration, we calculated the total number of chinook salmon above the weir. Total male and female portions of the population above the weir were estimated with a mark-recapture technique (Brower and Zar 1977) with tagged and untagged carcasses recovered during the spawning season. Carcasses were not included in the tagged or the untagged group for population estimation where the presence of the operculum punch could not be determined. We made separate calculations of the number of male (which included jacks) and female chinook salmon above the weir because recoverability of carcasses differed by sex. We also calculated the numbers of male and female chinook salmon above the weir using only tagged carcasses from the early group because the recoverability of fish in the early and late groups differed. There were only two female chinook salmon recovered after 10 September for which the date of tagging could not be determined, so they were included in the early group. The number of male and female chinook salmon from the late group, which were not observed below the weir, were then added to the population estimates of the early group. Population estimates for male or female chinook salmon $N_{(m\ or\ f)}$ above the weir were:

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

$N_{(m\ or\ f)}$ = population estimate (early group) + all late group (not carcasses) not observed below the weir
$M_{(m\ or\ f)}$ = total tagged chinook salmon (early group) not observed below the weir
$n_{(m\ or\ f)}$ = total carcasses recovered (early group+untagged)
$R_{(m\ or\ f)}$ = total tagged carcasses recovered (early group)
$SEM_{(m\ or\ f)}$ = standard error of the mean

We assumed the probability of recovery for untagged (never handled) carcasses was the same as tagged carcasses from the early group.

Total population above the weir was used with the total number of redds to calculate fish-per-redd estimates above the weir (total population above the weir divided by the total redds above the weir). Female-per-redd estimates were also calculated with the total female population above the weir (total female population above the weir divided by the total redds above the weir).

Sampling Adult Chinook Salmon for Pathogens

Pre-spawning carcasses recovered on surveys and any carcasses that were recovered on the picket weir were frozen for sampling of pathogens. Dr. Warren Groberg, ODFW Pathology, La Grande, OR sampled the carcasses for *Renibacterium salmoninarum* and *Ceratomyxa shasta*. Results of analyses were summarized.

Fecundity Estimates

The fecundity of female Rapid River stock spring chinook salmon was estimated at Lookingglass Hatchery in 1992. Fecundity estimates will eventually be used to estimate the number of eggs deposited above the weir. Among each group of 10 ripe female chinook salmon, we selected the 2 longest and 2 shortest. These fish were then operculum punched, weighed, and their fork lengths were measured and recorded. The eggs were placed into a pre-weighed plastic colander and weighed, and ovary weight was determined. Two samples of approximately 100 eggs were weighed. Eggs-per-gram was estimated for each sample. Eggs which remained in the body cavity or that fell on the floor that appeared viable were included in the fecundity estimate. Estimates of eggs-per-female were calculated with the formula:

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

Sampler variability was calculated as:

(larger sample eggs-per-gram /smaller sample eggs-per-gram - 1) *100

Females with sampler variability greater than 5% were not used in the development of a regression equation because the precision of the estimate was considered questionable. A regression equation was developed with fork length to predict fecundity.

Run Timing

Comparisons of run timing to the collection site on Lookingglass Creek were made among the endemic stock, Rapid River stock which returned to Lookingglass Hatchery, and the 1992 release group. All run timing data were summarized as the percent of the total return for each week of the year in order to make the run sizes comparable between years. Only the 1967-1974 run years were used because during the 1964-1966 run years a large portion of the run was able to ascend the falls and avoid the trap (Burck 1993). Data from unpublished field notes for 1967-1974 were summarized by grouping the daily numbers into weeks of the year. Data from total return to the hatchery in 1990-1992 were based upon weekly checks of the trap (Messmer et al. 1992, 1994). Weekly percentages of the fish released above the weir were calculated to compare the run timing of the fish placed above the weir with run timing of the 1992 return. Fish released 10 September were not used when run timing was described because it was not possible to determine the time period during which these fish entered the trap.

Age Structure

Age structure of trapped chinook salmon which returned to Lookingglass Creek was compared among the endemic stock, the Rapid River stock which returned to the hatchery, and the 1992 release group to describe variation in age composition. Age structure data were summarized from Burck (1972,1973,1974,1975) for the 1971-1974 return years, which were the only years in which scales were taken during 1964-1974. Data for the 1990-1992 return years were from Messmer et al. (1992, 1994). Data for the release group was determined by scale analysis. We used percentages rather than numbers to make data comparable between years. The range of percentages in each age group was determined for the 1971-1974, and 1990-1992 return years, as well as for the percentages for the release group in 1992.

Spawning Timing

Comparisons of occupied redds, live fish, unoccupied redds, and dead fish observed were used to index spawning timing. Indices for 1992 were compared to the previous study for 1966-1970 (Burck 1967,1968,1969,1970,1971) to describe variation in spawning timing between the Rapid River stock and the endemic stock, and evaluate the relative success of the hatchery fish on the spawning grounds. The 1966-1970 surveys were used because the frequencies of the surveys were most similar to those in 1992. From 1966-1970, unit 3 encompassed the primary spawning area and was used to describe the spawning timing in Lookingglass Creek (Burck 1993). Data for these indices were summarized by grouping yearly survey data into 7-day periods (spawning weeks) which did not correspond with week of the year. When two surveys during a year were conducted during the same period, a mean was used to represent that period. The percent of the total for each index, for each year, was then calculated using each period in the total counts. The range of percentages was described for 1966-1970. Data for 1992 were graphed for comparison. The early and late surveys in 1992 did not fall within the periods selected and were not used in the analyses.

Redd Distribution and Density

Redd distribution for 1992 return year was compared to 1964-1971 to describe whether the adult chinook salmon of Rapid River stock origin utilized the same areas that were used by the endemic stock. Data from Burck (1993) were summarized by summarizing the maximum and minimum percentage of total redds for units 2-4 for the years 1964-1971 to create a range. Only units 2-4 were used in the comparison of redd distribution because distributions in these units were all affected similarly by removal of a portion of the returning adults for broodstock for the hatchery in 1992. Unit 1 was not affected by broodstock removal, and was therefore not directly comparable.

Redd density in 1992 was compared to 1964-1971 for units 1-4 to characterize distributions of redds during the current study and the previous study. Redd density data (redds-per-mile) from Burck (1993) were summarized into ranges for 1964-1971 for each unit.

Results

Stream Flow and Temperature

During the period 1964 to 1971 flows in Lookingglass Creek typically rose in the spring around the week of 25 March and returned to low summer flows around the week of 27 July (Figures 10 and 11). In 1992, flows began to rise around the week of 4 February and did not recede to low summer flows until the week of 10 June (Figure 12).

Maximum stream temperatures usually reached the peak around the week of 15 July from 1964-1971 (Figure 13). Collection of stream temperature data in 1992 began the week of 24 June (Figure 13). The maximum temperature recorded for 1992 occurred the first week the thermograph was in operation, which indicated that the peak maximum temperature had already occurred (Figure 13).

Sampling and Release of Adults Above the Weir

We released 133 chinook salmon assigned as 64 females, 66 males and 3 jacks (Appendix Table C-2). Summaries of fork length, sex, age, and origin are Table 2. Sex ratios for this release were 50% adult male, 48% adult female, and 2% jack chinook salmon.

Spawning Timing

Spawning ground surveys for 1992 began on the week of 15 July and ended on the week of 7 October (Appendix Table C-3). The first redd which was observed in section 5 (unit 4) in the week of 29 July and the last redds were observed in sections 3 and 4 (unit 4) in the week of 23 September (Appendix Table C-3). Peak redd numbers were observed during the week of 9 September above the weir and 2 September below the weir (Appendix Table C-3). A total of 49 complete redds was counted above the weir and 13 complete redds were counted below the weir (Appendix Table C- 3). The first live fish were observed in sections 1 and 3 on 16 July with the peaks which occurred on 25 September above the weir and 18 August and 1 September below the weir (Appendix Table C- 3). The first live fish on a redd was observed in section 4 (Unit 3) on 13 August with the peak number of live fish observed on 1 September both above and below the weir (Appendix Table C- 3). Peak carcass recovery was 16 September above the weir and 9 September below the weir (Appendix Table C- 3).

Summaries of fork length, sex, age, and origin from the carcasses recovered during spawning ground surveys and carcasses recovered from the weir are shown in Table 3. The accuracy of the sex assignment at the time of trapping by hatchery personnel of operculum-punched carcasses recovered in the field was checked against the actual sex from internal inspection. There were 16 known tagged (tag or operculum punch) adult chinook salmon carcasses recovered (8 males and 8 females) for which the sex could be positively identified. Fourteen (7 males and 7 females)

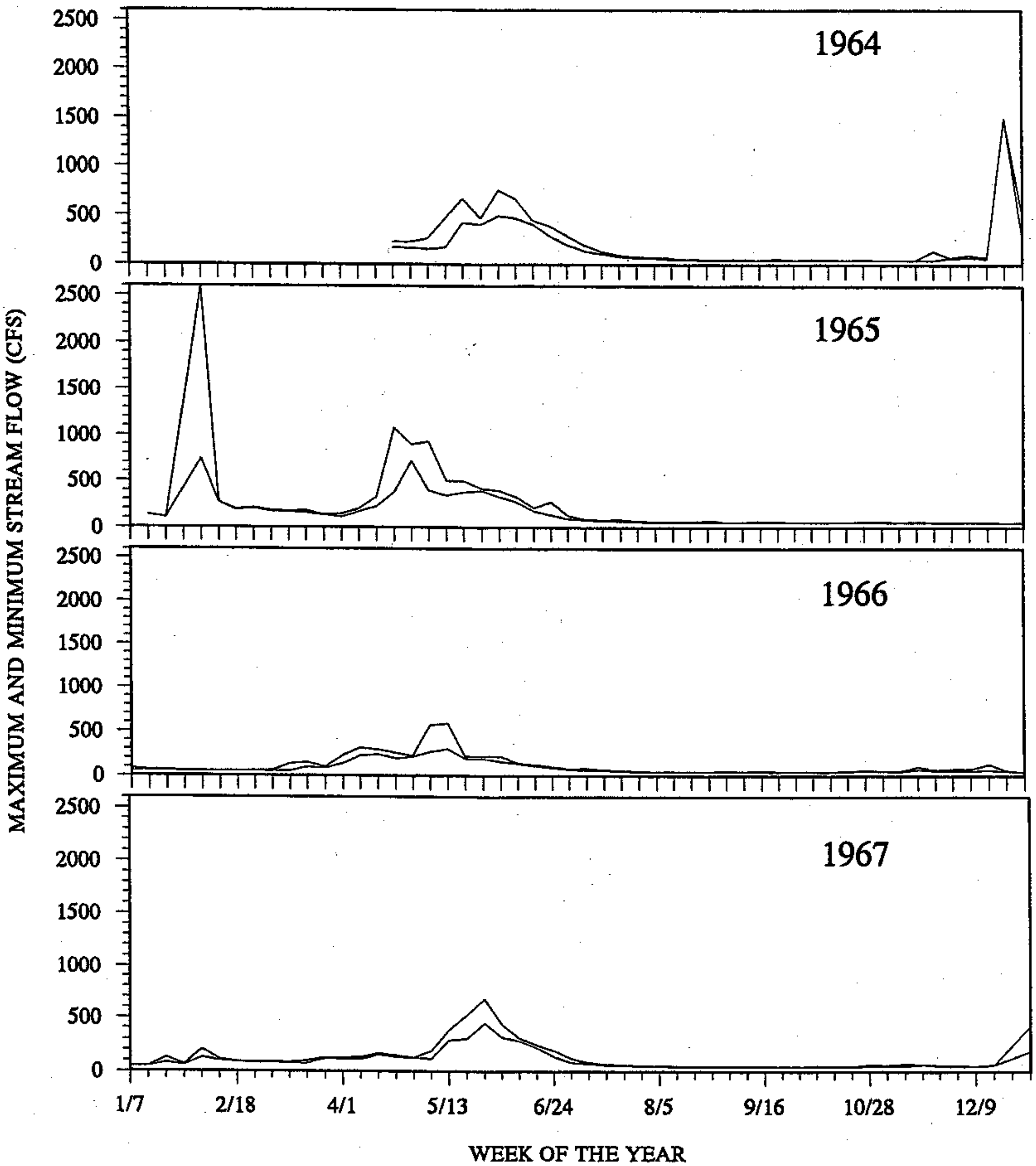

Figure 10. Range of weekly stream flows for Lookingglass Creek from 1964-1967 (Burck 1993). The range of flows are week of the year maximums and minimums of single daily flows measured by methods reported in Burck (1993). The weekly periods end on the date shown.

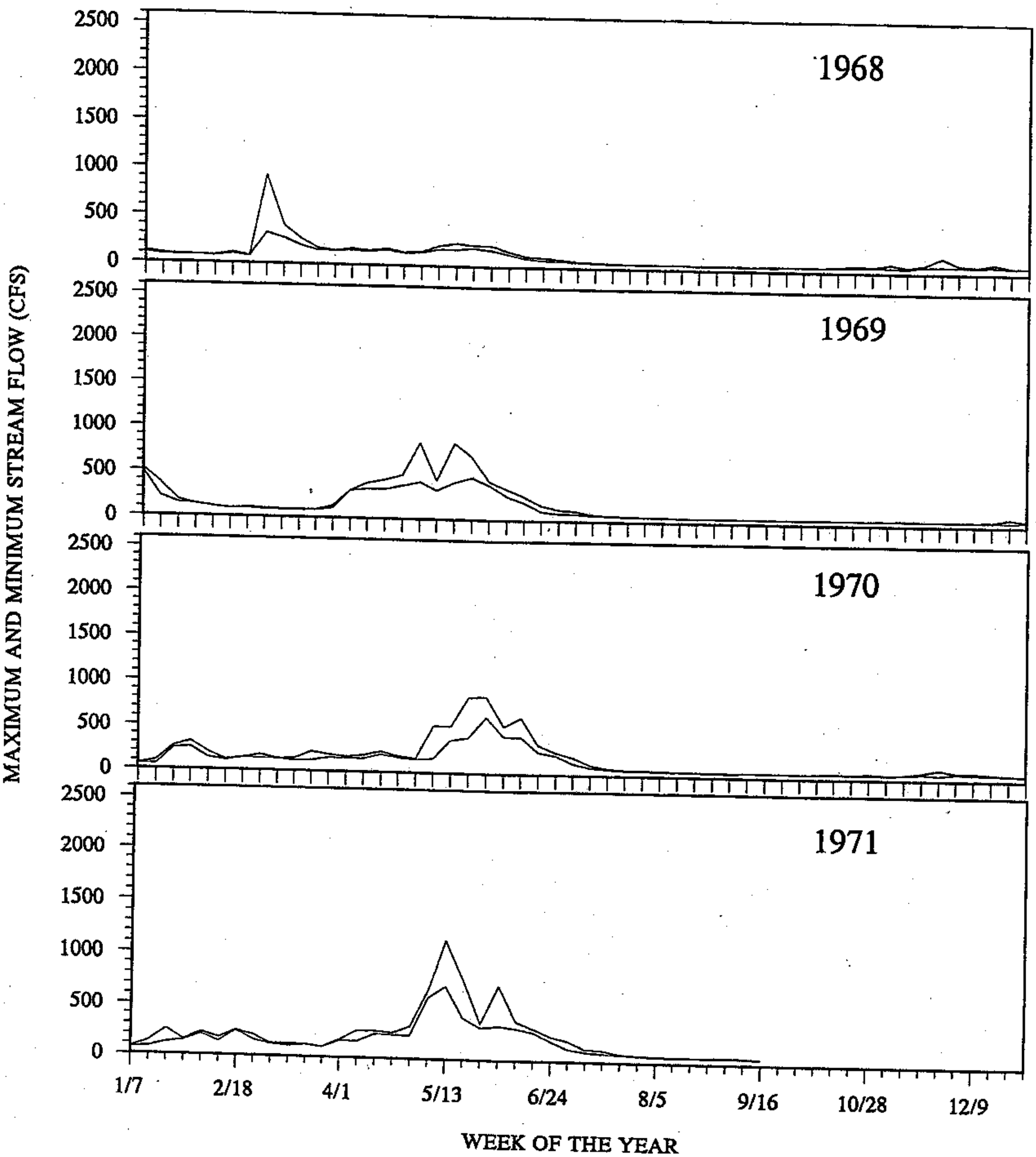

Figure 11. Range of weekly stream flows for Lookingglass Creek from 1968-1971 (Burck 1993). The range of flows are week of the year maximums and minimums of single daily flows measured by methods reported in Burck (1993). The weekly periods end on the date shown.

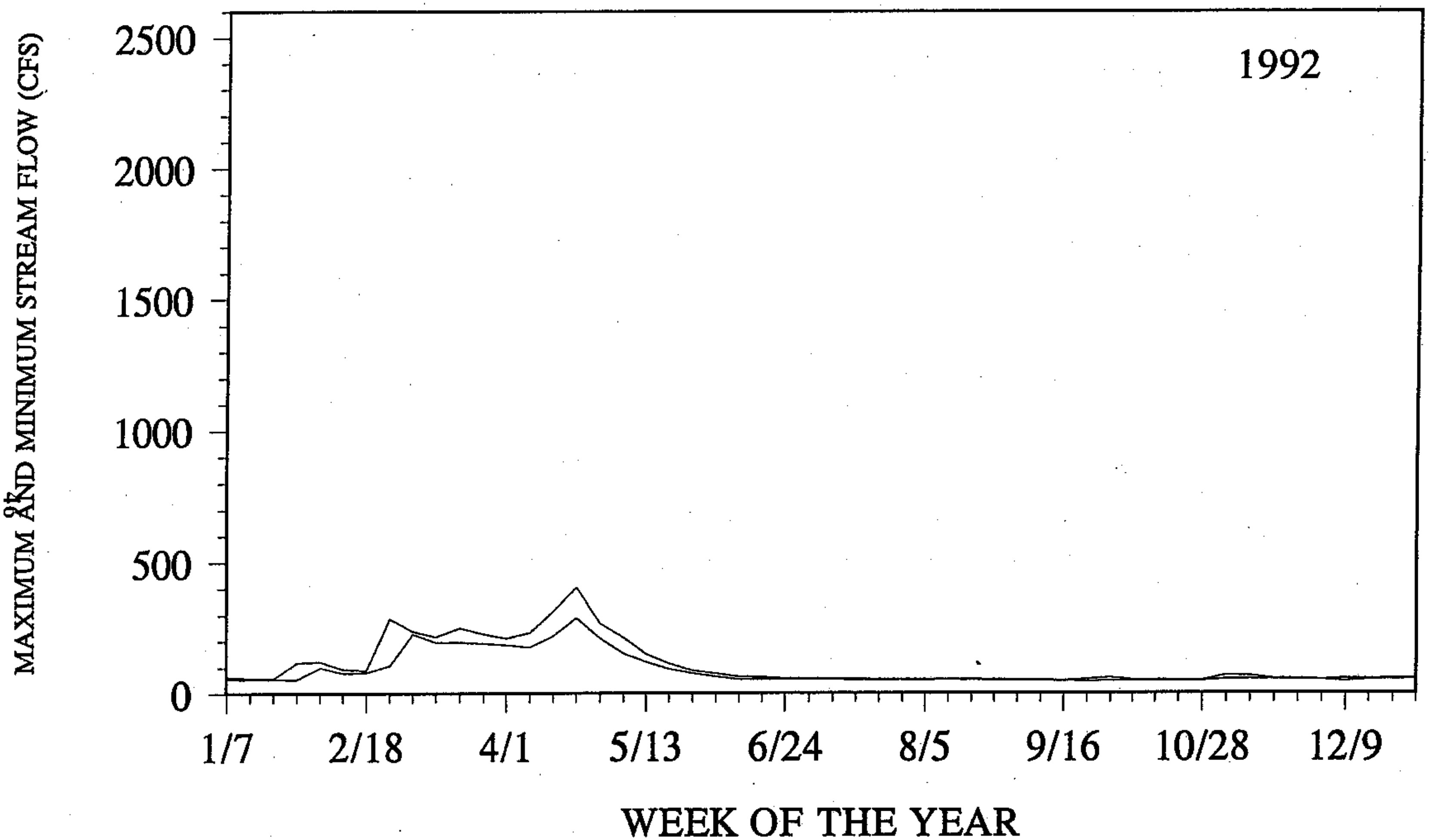

Figure 12. Range of weekly stream flows for Lookingglass Creek from 1992 (Hubbard et al. 1991,1992). The data are a weekly range of 48 daily flows measurements from a stream gaging station on Lookingglass Creek. The weekly periods end on the date shown.

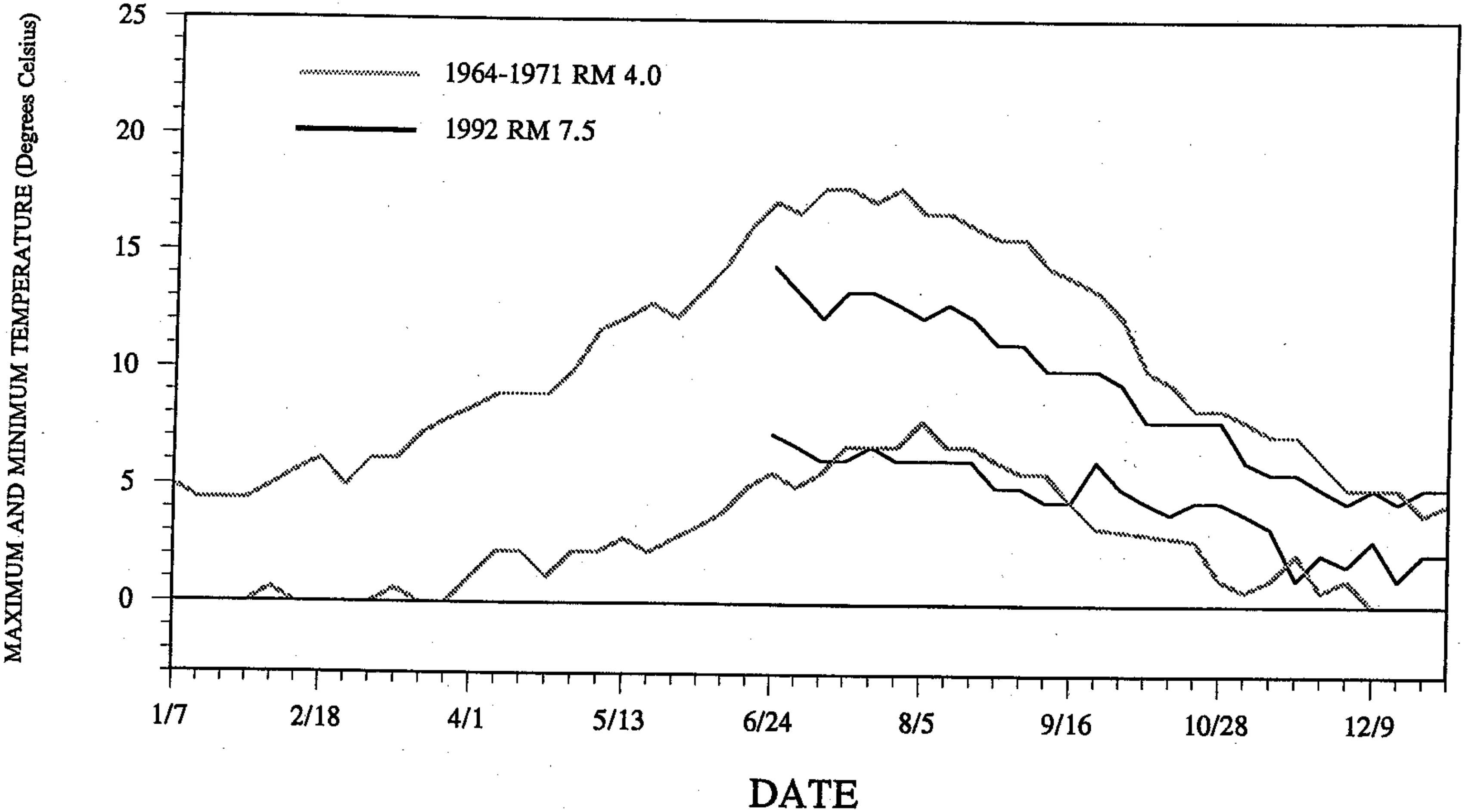

Figure 13. Stream temperatures for Lookingglass Creek from 1964-1971 and in 1992 (Burck 1993; USFS unpublished data). All of the temperature data are weekly ranges summarized from Burck (1993), and the USFS. The weekly periods end on the date shown.

Table 2. Origin, age, assigned sex and fork length from disc-tagged spring chinook salmon released above the weir on Lookingglass Creek in 1992.

			Males[a]							Females[a]					
					Fork Length (mm)							Fork Length (mm)			
Year	Origin[b]	Age	N	(%)[c]	N	Range	Mean	± SD	N	(%)	N	Range	Mean	±SD
1992	Hat.	3	3	(2)	3	450-565	496.7	49.4	---	(--)	---	---	---	---
	Unk.	3	---	(--)	---	---	---	---	1	(1)	1	590	---	---
	Hat.	4	49	(37)	48	600-790	710.8	38.3	51	(38)	51	610-791	704.7	40.0
	Nat.	4	4	(3)	4	700-770	741.1	26.4	1	(1)	1	680	---	---
	Unk.	4	5	(4)	5	673-734	711.3	38.5	4	(3)	4	650-740	709.3	35.4
	Hat.	5	4	(3)	5	735-930	821.0	71.3	7	(5)	7	700-835	763.6	54.1
	Unk.	5	4	(3)	4	775-830	802.5	20.2	---	(--)	---	---	---	---

[a] Sex assigned at the time of tagging by hatchery personnel.
[b] Origin of the fish, Hat. = hatchery, Nat. = natural, Unk. = unknown. The origin was determined using scales from individual fish and applying a discriminant scale model (ODFW unpublished data) for that return year.
[c] The percent of total released.

Table 3. Origin, age, sex at recovery, and fork length from all spring chinook salmon recovered on Lookingglass Creek and Little Lookingglass Creek during spawning ground surveys or taken from of the weir during the spawning season in 1992.

			Males[a]							Females[a]					
					Fork Length (mm)							Fork Length (mm)			
Year	Origin[b]	Age	#	(%)[c]	N	Range	Mean	± SD	#	(%)	N	Range	Mean	±SD
1992	Hat.	3	1	(2)	---	---	---	---	---	(--)	---	---	---	---
	Hat.	4	13	(29)	12	700-780	721.9	41.8	19	(43)	18	670-745	706.2	20.8
	Nat.	4	2	(5)	2	730-757	743.5	19.1	2	(5)	2	670-770	720.0	70.7
	Unk.	4	3	(7)	3	725-760	739.7	14.8	1	(2)	1	732	---	---
	Hat.	5	2	(5)	2	825-930	877.5	52.5	1	(2)	1	835	---	---

[a] Sex was determined by body cavity inspection.
[b] Origin of the fish, Hat. = hatchery, Nat. = natural. The origin was determined using scales from individual fish and applying a discriminant scale model (ODFW unpublished data) for that return year.
[c] The percent of the total recovered that the age and sex could be determined. Nine fish were omitted, 2 with unknown sex, and 7 with unknown age.

were correctly sexed at the time of release for an accuracy of 87% for both sexes (Appendix Table C- 4). There were 2 tagged fish for which the date of tagging (tag-loss, or retained punches) could not be determined that were included in estimation of the accuracy of sex assignment. Because the accuracy for both sexes was equivalent, no correction factor was needed to adjust the estimate of the number of males and females released.

There were 5 tagged chinook salmon that died before spawning from the early group that were recovered above or on the weir (Table 4). Two tagged chinook salmon carcasses from the early group were recovered below the weir and 2 other live tagged chinook salmon were observed below the weir that could be positively placed in the early group. ????Subtracting these fish from the total numbers released above the weir, the number of early fish not observed below the weir was 89. The maximum percentage survival to spawning using the recovered pre-spawning mortality was ((89- 5)/89) * 100 =94%.

The tagged fish in the late group had a higher probability (9/40=22%) of recovery than fish tagged in the early group (13/93=14%) (Appendix Table C- 4). The total number of males above the weir was estimated to be 121, while the total number of females above the weir was estimated to be 81 (Table 5).

There were 49 completed redds counted above the weir, and 13 completed redds counted below the weir (Appendix Table C- 6). There was an estimated 4.12 fish-per-redd and 1.65 females-per-redd estimated above the weir.

Sampling Adult Chinook Salmon for Pathogens

We provided the ODFW Pathology laboratory with 7 chinook salmon carcasses in 1992. Only one chinook salmon sampled had clinical infection levels of *Renibacterium salmoninarum* (bacterial kidney disease, BKD), although the pathogen was present in all of the fish sampled (Table 4). Of the 6 fish sampled for *Ceratomyxa shasta*, one chinook salmon had high levels of infestation, one had negative levels, and the parasite was present at low to moderate levels in the rest (Table 4).

Fecundity Estimates

Fifty-three adult female Rapid River stock spring chinook salmon were sampled for fecundity in 1992 (Appendix Table C-5). The sample contained 13 five-year-old and 40 four-year-old adults (Appendix Table C-5). A regression model of fork length to predict fecundity for 4- and 5-year-old chinook salmon was developed with only data with a sampler variability <5% (N=44) (Figure 14; Appendix Table C-5). The relationship had a positive slope ($P \leq 0.05$ and a r^2=0.33).

Table 4. Results of analyses by ODFW Pathology for pathogens of adult spring chinook salmon recovered in the field above the weir on Lookingglass Creek in 1992.

Date	Recovered Sex	Status[a]	Tag# or Punch	*Renibacterium salmoninarum* ELISA OD[b]	*Renibacterium salmoninarum* Infection Level	*Ceratomyxa shasta* Infestation Level
05/25	Female	PS	1Rop	0.085	Negative	Low
05/25	Male	PS	None	0.086	Negative	Negative
07/14	Male	PS	1Rop	0.141	Low	Moderate
07/15	Male	PS	66	0.121	Very low	---
08/19	Female	PS	02	2.764	Clinical	Moderate
08/25	Female	PS	90	0.102	Very low	Negative
08/27	Male	--	None	0.187	Low	High

a PS = pre-spawning mortality.
b ELISA = Enzyme-linked immunosorbent assay; OD=optical density.

Run Timing

There was variation between years in run timing to Lookingglass Creek from 1967-1974 as well as from 1990-1992 (Figures 15-17). The earliest peak arrival week to the trap from 1967-1974 was 10 June and the latest peak arrival week to the trap was 15 July (Figures 15 and 16). The earliest week that fish entered the trap from 1967-1974 was 13 May, while the latest week was 12 August (Figures 15 and 16). The earliest peak arrival week to the trap from 1990-1992 was 27 May and the latest peak arrival week was 1 July (Figure 17). The earliest week that fish entered the trap from 1990-1992 was 6 May, while the latest week was 9 September (Figure 17). Sixty-three percent of the return in 1992 had arrived at the trap by the week of 27 May, while only 26% of the total released above the weir had been released (Figure 17).

Age Structure

Age composition of the 1971-1974 return years ranged from 4 to 13% age 3, 80 to 87% age 4, and 4 to 9% age 5 chinook salmon (Figure 18). Ranges observed from 1990-1991 were highly variable, ranging from 1 to 13% for age 3, 43 to 94% for age 4, and 5 to 26% for age 5 chinook salmon (Figure 18). Age compositions of the 1992 return and the release group were very similar with 2 and 3% age 3, 87 and 85% age 4, and 11 and 12% age 5 (Figure 18).

Table 5. Population equation variables and estimates for the number of adult spring chinook salmon above the weir on Lookingglass Creek in 1992.

MALE

M_m = # tagged before 10 September - # male carcass and visual recoveries below the weir
$M_m = 49 - 3$
$M_m = 46$

$n_m = 9$

$R_m = 4$

Male recoverability = 9%

$N_m = 46 * 9 / 4$

$$SEM_m = \sqrt{\frac{(46)(9)(46-4)(9-4)}{4^3}} \qquad SEM_m = 37$$

$N_m = 103 + 18$ males from late release that stayed above the weir
$N_m = 121$ total male chinook salmon population above the weir

FEMALE

M_f = # tagged before 10 September - # female carcass and visual recoveries below the weir
$M_f = 44 - 1$
$M_f = 43$

$n_f = 13$

$R_f = 9$

Female recoverability = 21%

$N_f = 43 * 13 / 9$

$$SEM_f = \sqrt{\frac{(43)(13)(43-9)(13-9)}{9^3}} \qquad SEM_f = 10$$

$N_f = 62 + 19$ females from late release that stayed above the weir
$N_f = 81$ total female chinook salmon population above the weir

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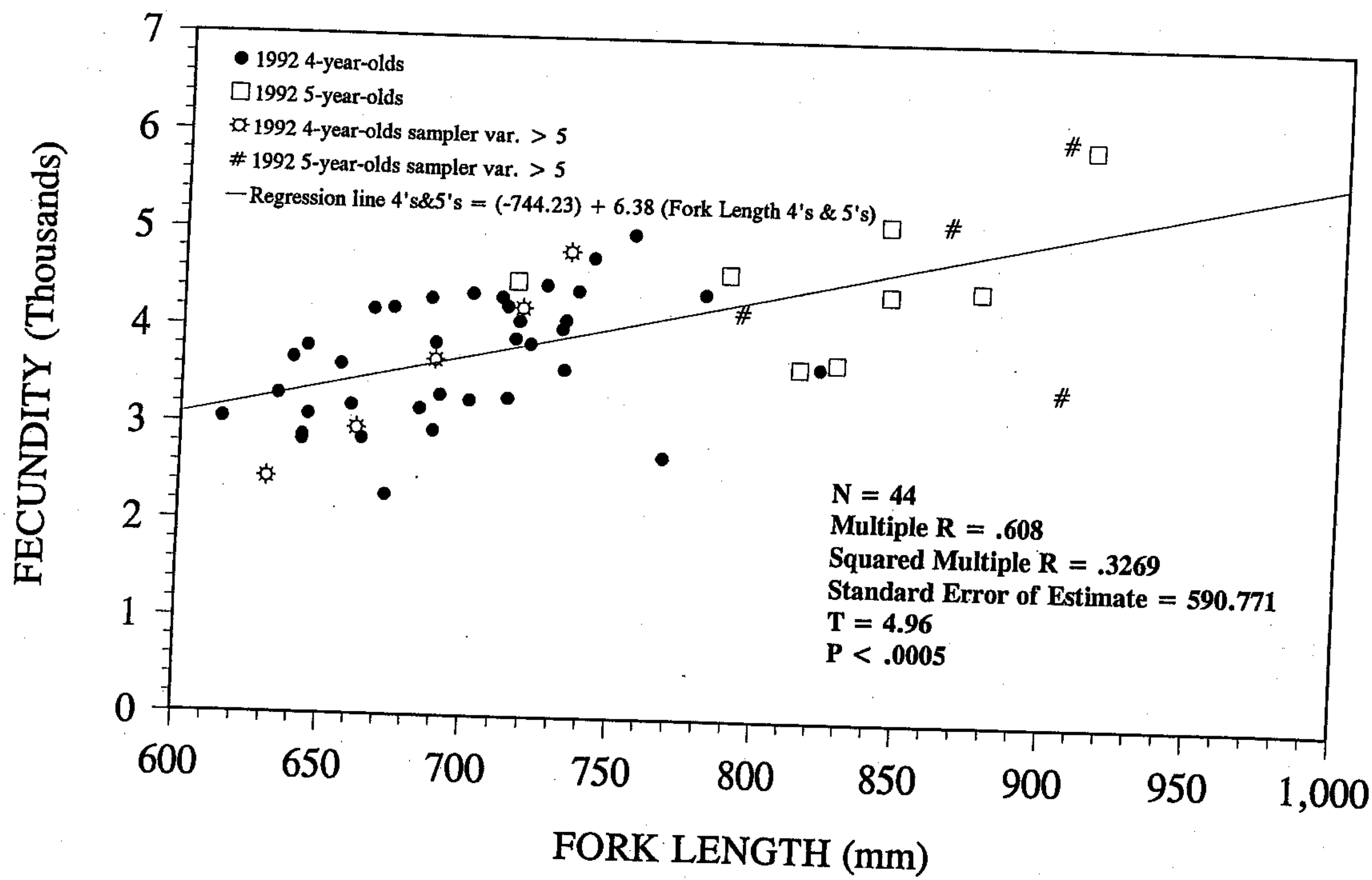

Figure 14. Relationship between fork length and female chinook salmon fecundity estimates in 1992.

Spawning Timing

The highest percentage unoccupied redds observed in 1992 was two weeks later than the latest peak observed from 1966-1970 (Figure 19B). There were two peaks in occupied redds observed in 1992. The first was one week, and the second three weeks, after the latest peak observed from 1966-1970 (Figure 19A). The highest percentages of live and dead fish observed in 1992 were both one week later than the latest peak observed from 1966-1970 (Figure 20).

Redd Distribution and Density

From 1964-1971 0.6 to 6.2% of total redds counted above the weir were in unit 2, 80.5 to 87.9% were in unit 3, and 9.9 to 16.4% were in unit 3 (Figure 21A). In 1992 26.5% of total redds counted above the weir were in unit 2, 61.2% were in unit 3, and 12.2% were in unit 4 (Figure 21A). Densities of redds seen from 1964-1971 ranged from 4.8 to 36.8 redds-per-mile in unit 1, 0.7 to 11.3 in unit 2, 11.7 to 33.3 in unit 3, and 3.0 to 11.2 redds-per-mile in unit 4 (Figure 21B). In 1992 the redds-per-mile in unit 1-4 were 5.2, 8.6, 10.5, and 1.5 respectively (Figure 21B).

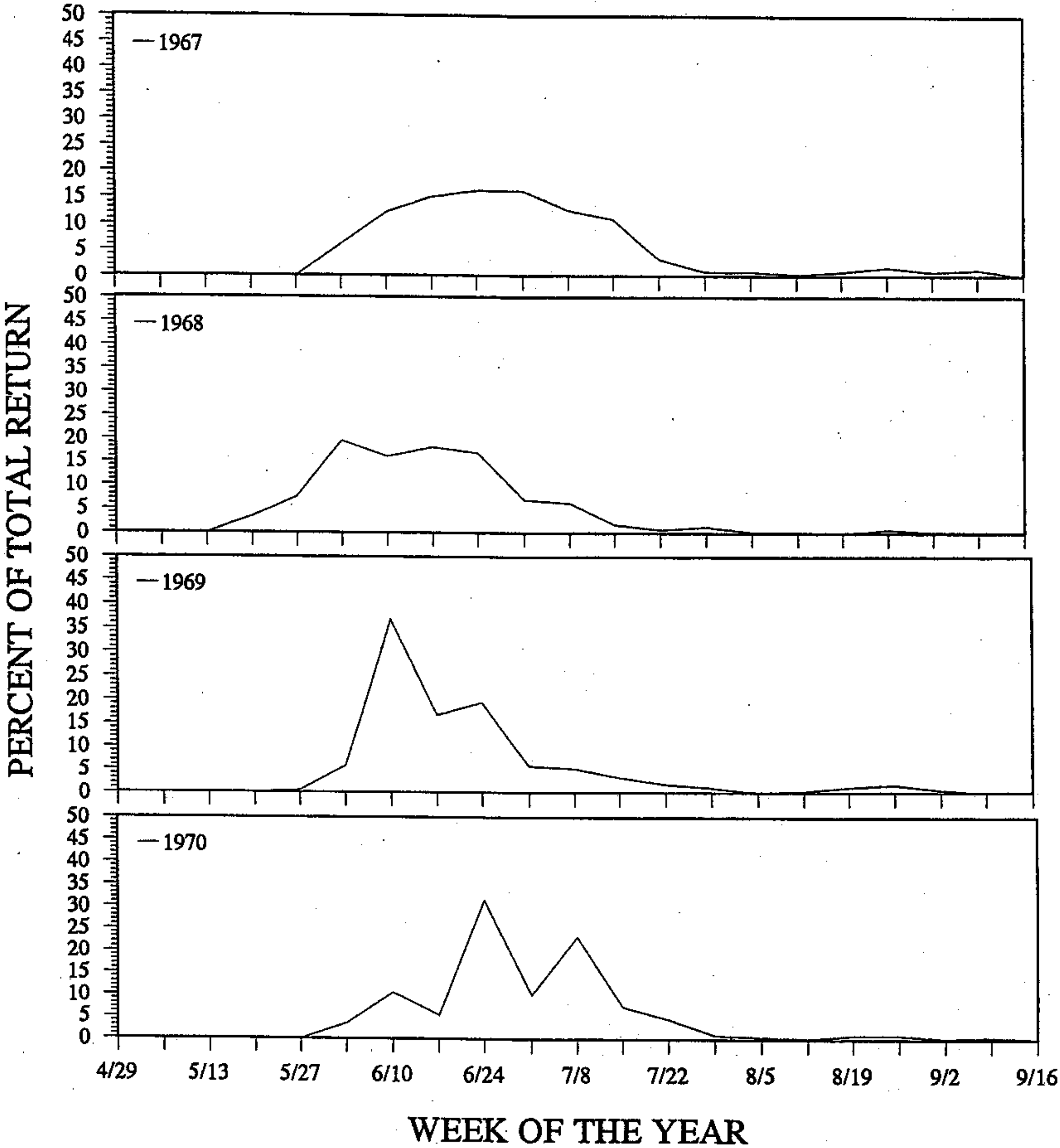

Figure 15. Run timing of chinook salmon to Lookingglass Creek from 1967-1970 (ODFW unpublished data). Week of the year corresponds to a 7-day period which ended with the date shown. Run timing data were from daily trap counts that were summarized by week of the year.

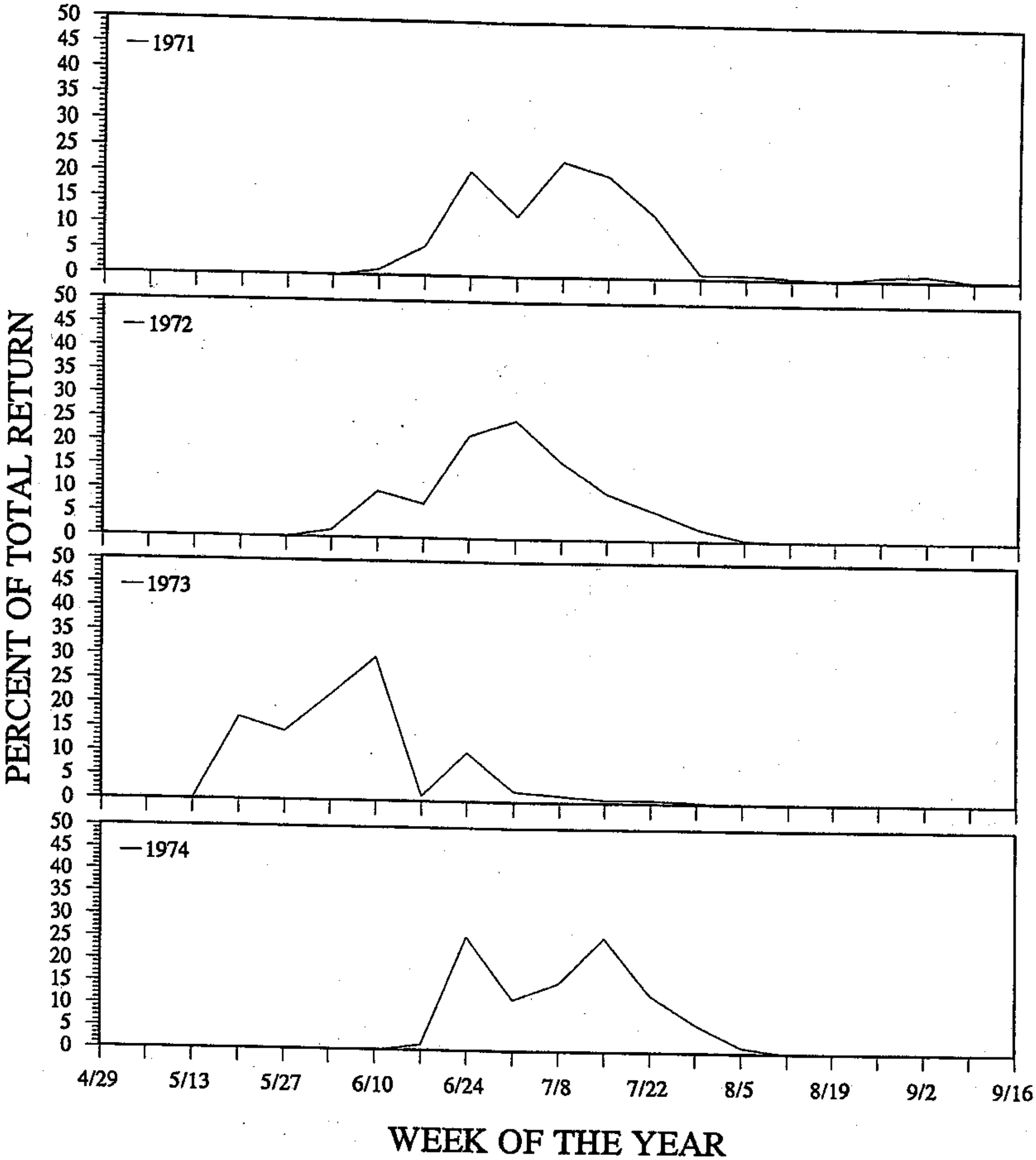

Figure 16. Run timing of chinook salmon to Lookingglass Creek from 1971-1974 (ODFW unpublished data. Week of the year corresponds to a 7-day period which ended with the date shown. Run timing data were from daily trap counts that were summarized by week of the year.

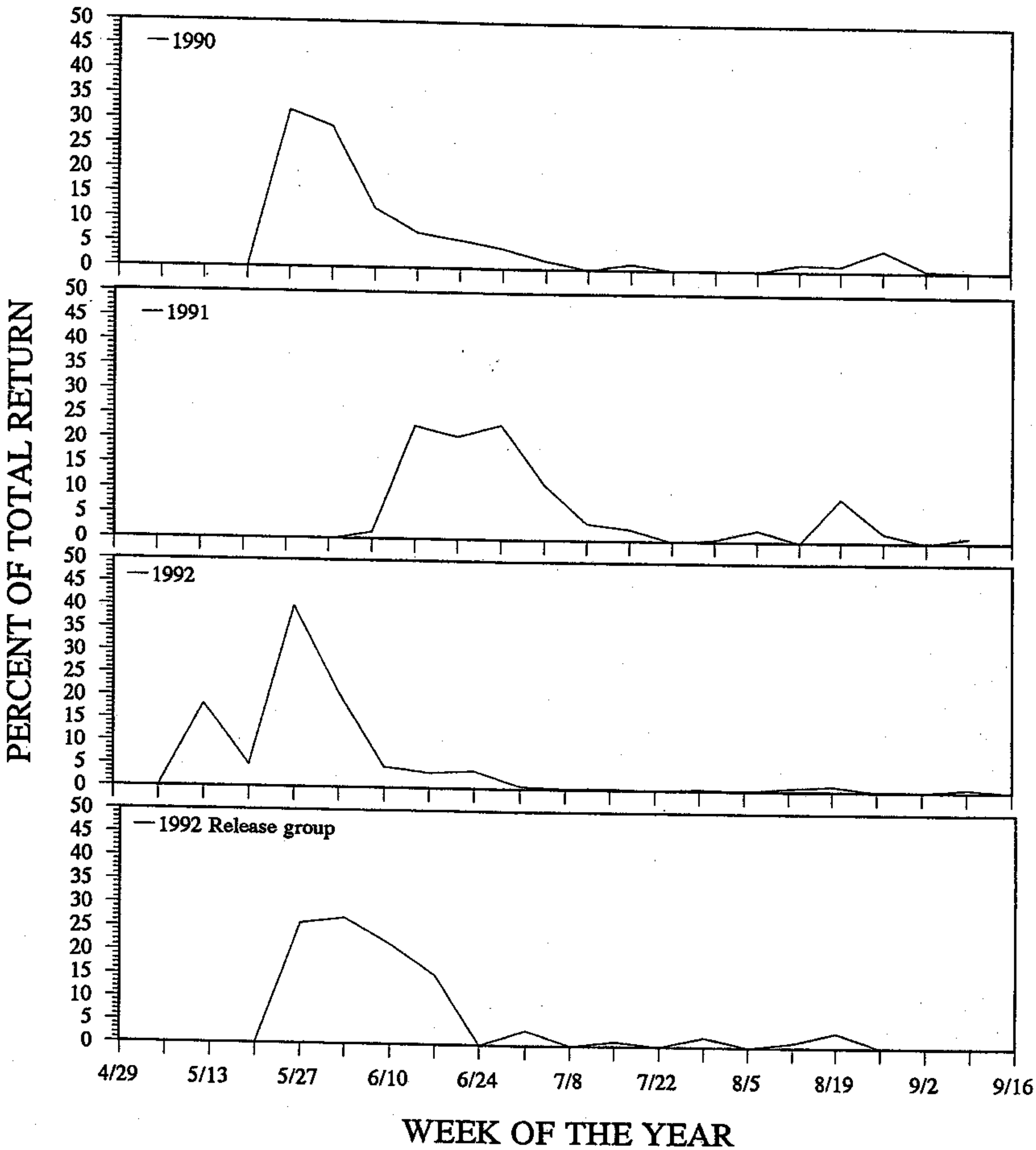

Figure 17. Run timing of chinook salmon to Lookingglass Creek from 1990-1992, and the 1992 release group (Messmer et al. 1992, 1994). Run timing of the release group does not include information from fish released on 10 September. Week of the year corresponds to a 7-day period which ended with the date shown.

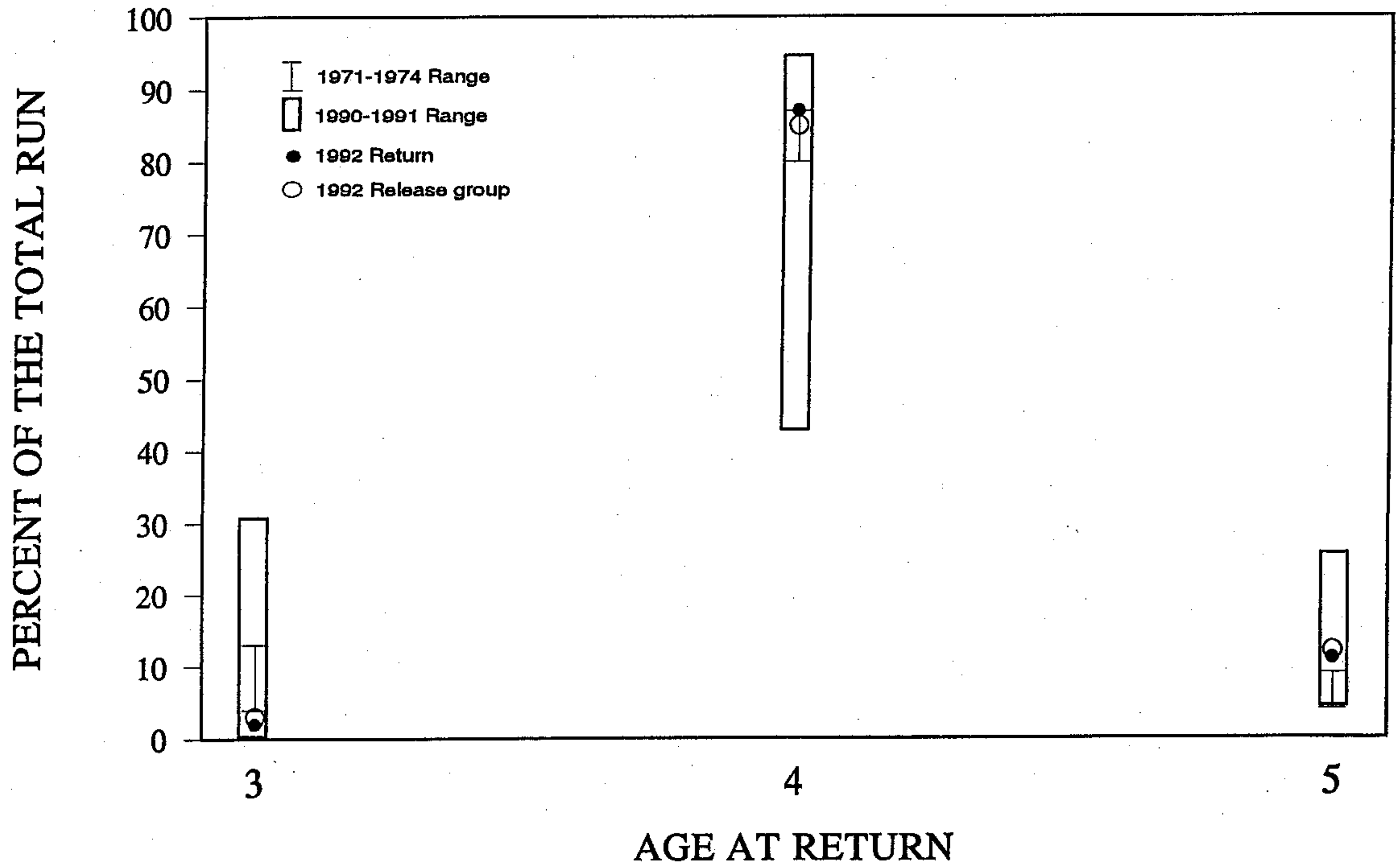

Figure 18. Ranges of age at return to Lookingglass Creek from 1971-1974, 1990-1991, and the total return and release group for 1992 (Burck 1993; Messmer et al. 1992; Messmer et al. 1994).

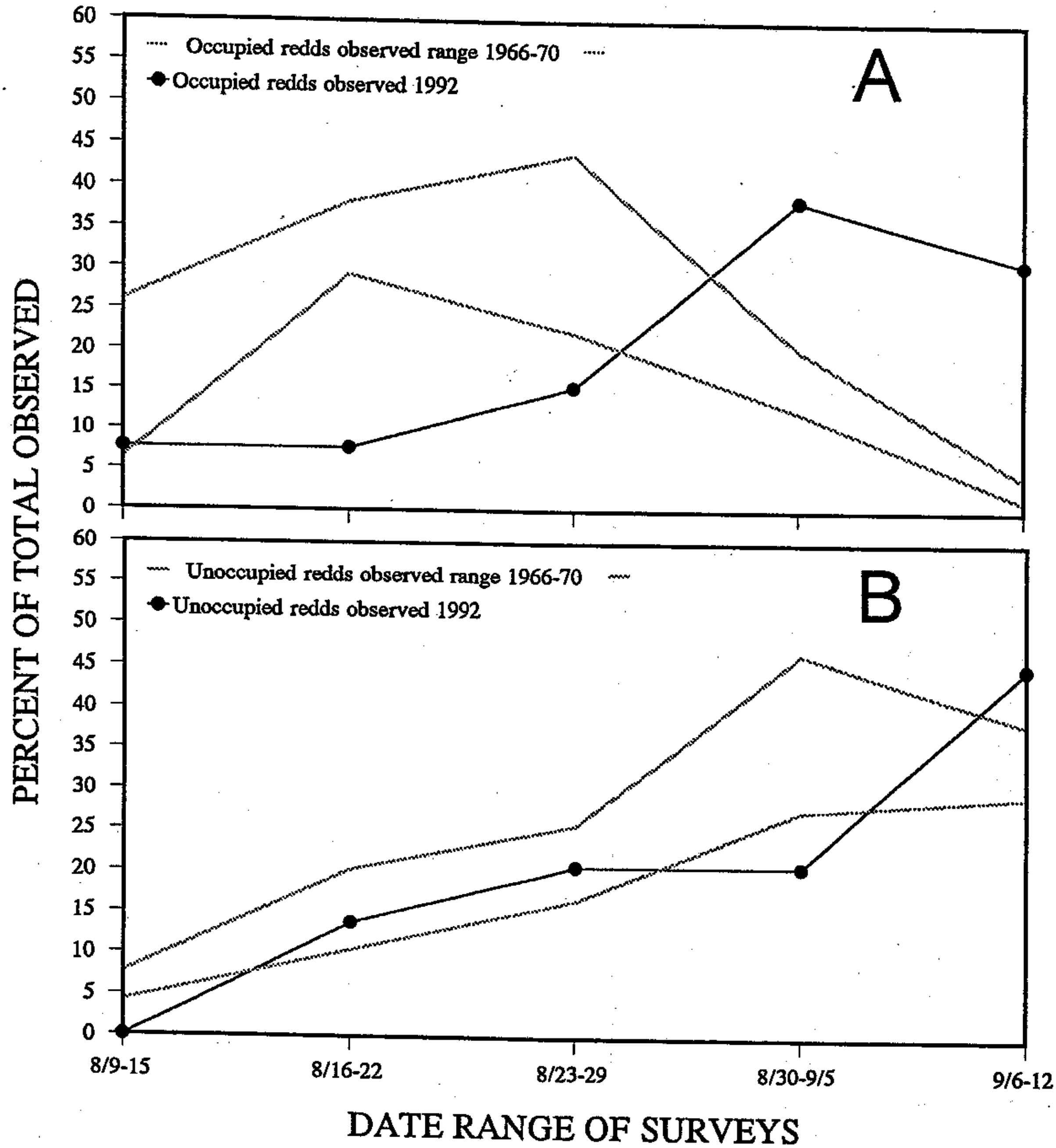

Figure 19. Ranges of percentages of occupied (A) and unoccupied (B) redds for surveys from 1966-1970 and percentages for 1992 (Burck 1967,1968,1969,1970,1971 and current study).

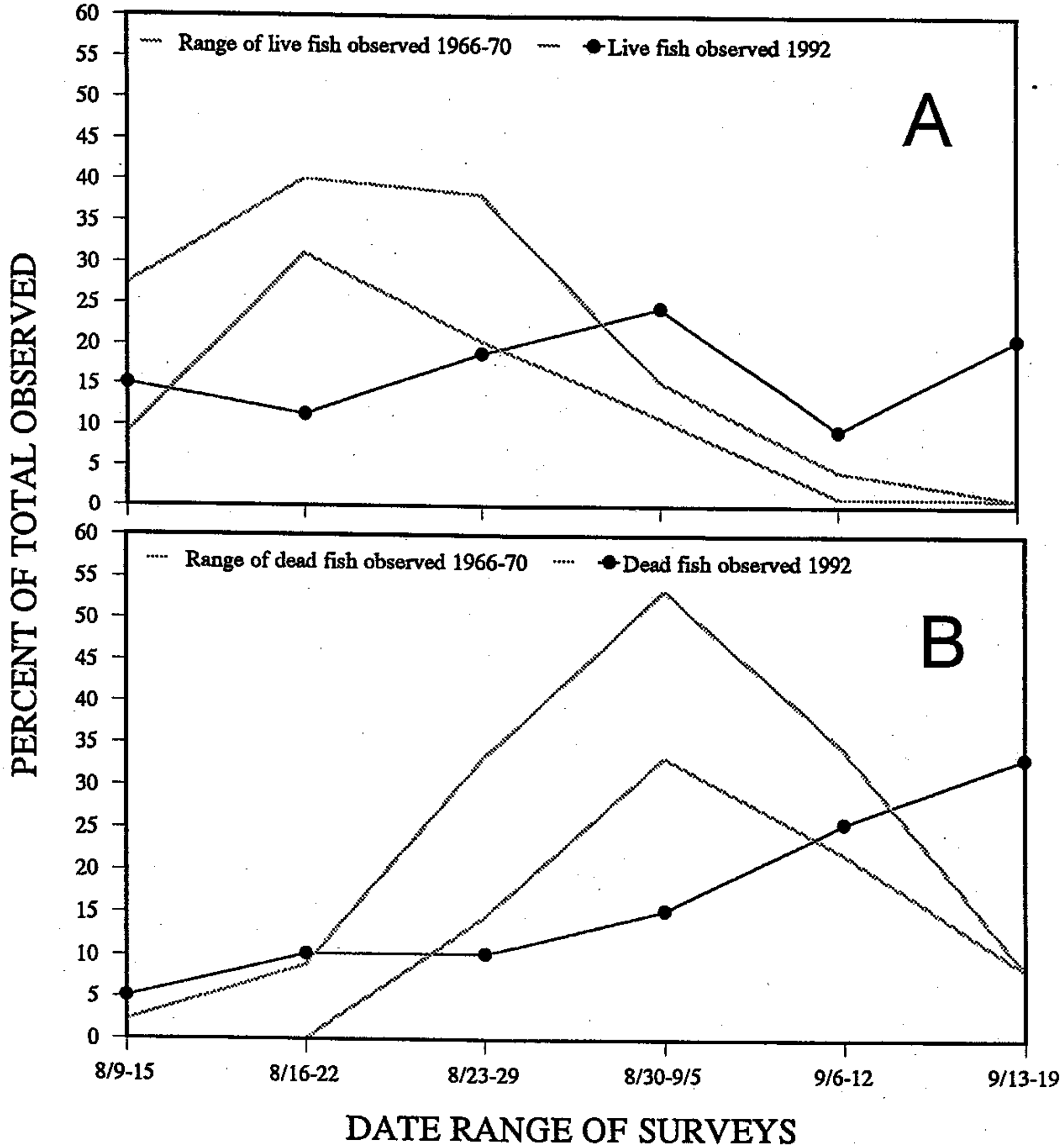

Figure 20. Ranges of percentages of live (A) and dead (B) fish observed for surveys from 1966-1970 and the percentages for 1992 (Burck 1967,1968,1969,1970,1971 and current study).

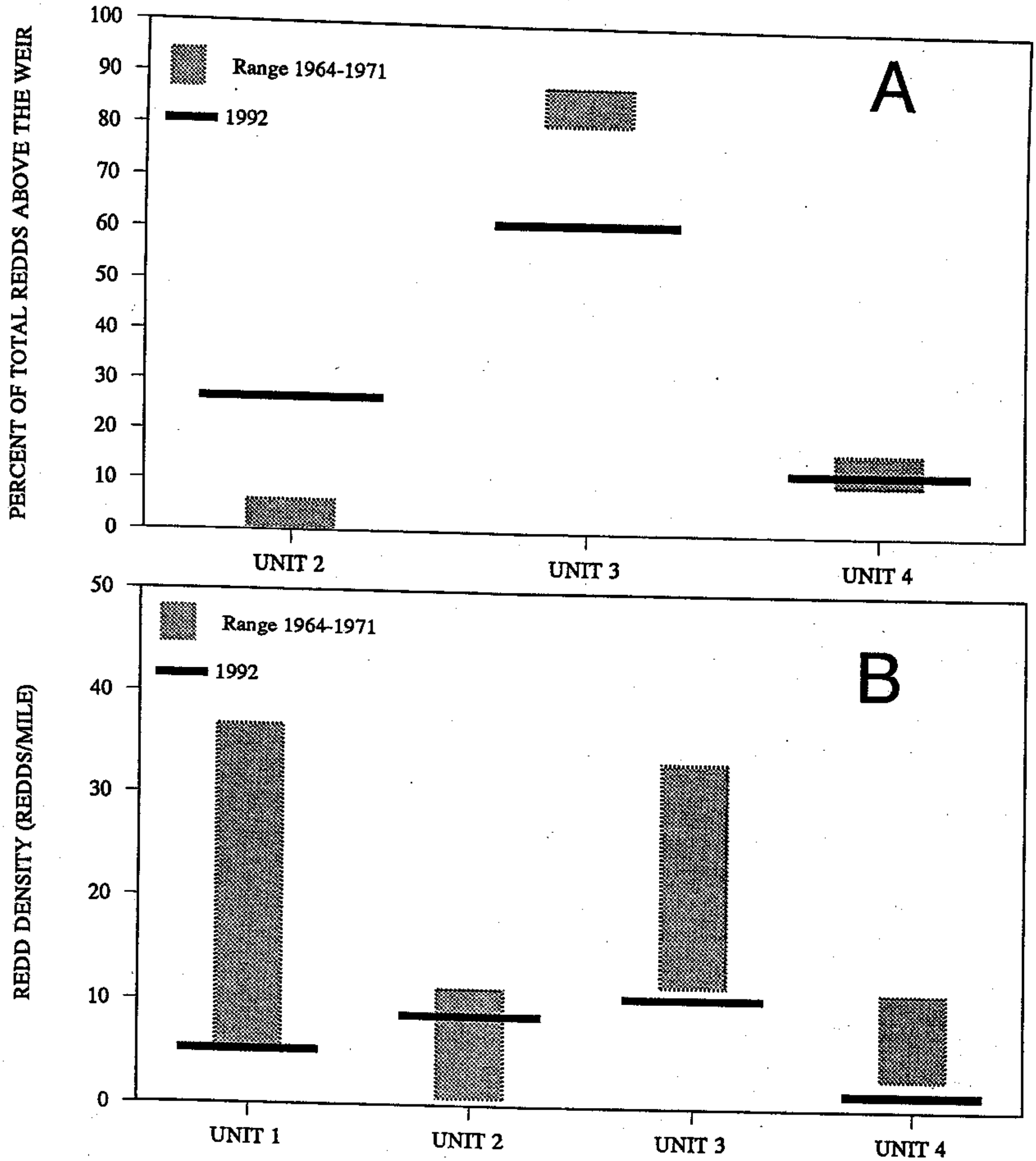

Figure 21. Ranges of percentages of redd distribution (A) and redd densities (B) in Lookingglass Creek for the years 1964-1971 and percentages for 1992 (Burck 1993 and current study).

Discussion

The earlier run timing observed in 1992 compared to that observed in the previous study could have been due to genetic differences between the highly domesticated Rapid River stock (Waples et al. 1993) and the endemic stock. The Rapid River stock may exhibit run timing that is naturally later than that of the endemic stock, or run timing may have been altered through years of natural selection in the hatchery. Alternatively, flows in Lookingglass Creek in 1992 peaked earlier than those observed in the past (1964-1971). Low flows during the upstream migration may have delayed migration of adults in 1992.

Our selection of fish for release without regard to age probably avoided a biased age composition of naturally-spawning fish above the weir. The age composition of the Rapid River stock returns from 1990 to 1992 was much more variable than that which was observed in the endemic stock from 1971-1974. This may have been because of such factors as variability in the number of hatchery juveniles that were produced for each brood year, which would have affected the number of fish returning from each brood. In addition, variability in age composition of different brood years could have also affected the age composition of return years.

The higher percentage of redds observed in unit 2 in 1992 compared to the range observed from 1964-1971 may have been due to a number of factors. These could have included the effects of anaesthetization, homing toward the hatchery, and release of the late group immediately above the unit. Incomplete recovery from anesthetization of the fish in 1992 may have caused some of the fish to drift downstream after release, resulting in the higher redd densities than those which occurred in the previous study. Homing of the release group to the hatchery may have inhibited the migration further upstream of the release site, thereby increasing the number of redds in areas immediately above the hatchery. Lastly, fish released late in the spawning season may tend to spawn in or immediately below the area of release. This would certainly be of consideration for the late group released after the last day of spawning at the hatchery. Many of these fish were ripe. We had to pay particular attention to handling of females, because many of them were shedding eggs. Increases in redds counted in unit 2 and the lower part of unit 3 five days after the 10 September release and the lack of an increase in the number or redds in units 1 and 4 for the same time period suggested that fish from the late group spawned near the site of their release. The overall size of the release explained why the redd densities for 1992 were below the ranges seen from 1964-1974. Because there were fewer fish above the weir in 1992 than any of the years from 1964-1974, the redd production was lower, except in unit 2. Redd densities in unit 1 were also at the low end of the range seen from 1964-1974, which would indicate that the numbers of hatchery fish and fish from natural production that stayed below the hatchery were also probably lower in 1992 than in any year from 1964-1974.

The late release of 40 chinook salmon on 10 September probably contributed to the increases in live and dead fish observed during the last weekly period for 1992. Fish from the late release were ready to spawn, and as a result, did not disperse. This behavior may have made them more likely to be observed during the surveys conducted on 15 September. These fish probably did not migrate much before they attempted to spawn, dying close to the area of release. The short time after spawning before surveys were completed may not have allowed the carcasses to have deteriorated or moved out of the system before the survey was completed and the concentration of fish in a small area may have resulted in increased recoverability.

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SECTION III

ASSISTANCE PROVIDED TO LSRCP COOPERATORS

We provided assistance to Oregon Department of Fish and Wildlife in 1992 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 and summer steelhead 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 the scales of hatchery from naturally-produced spring chinook salmon collected on spawning grounds was 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. Summary of information for juvenile summer steelhead (Little Sheep and Big Canyon Facilities) and spring chinook salmon (Imnaha Facility) that were sampled for stress indices at Northeast Oregon facilities in 1992.

Acclimation facility	Date	Time period[a]	Stressor applied	Acclimated n[b]	Acclimated Time[c], h	Non-acclimated n	Non-acclimated Time, h
Little Sheep	3/22	PT-0	No	20	0833-0857	20	0659-0721
	3/22	PT-1	Yes	19	1114-1131	20	0956-1023
	4/27[b]	-8	No	20	0708-0726	20	0702-0728
	4/27	0	No	20	1807-1822	20	1409-1521
	4/27	1	Yes	20	1850-1905	21	1547-1702
	4/27	4	Yes	20	2240-2300	21	1917-2104
	4/27	12	Yes	20	0515-0531	19	0200-0408
	4/28	24	Yes	20	1700-1718	19	1434-1624
	4/29	48	Yes	19[h]	1610-1628	21	1400-1548
Big Canyon	3/23	PT-0	No	20	0828-0856	21	0701-0730
	3/23	PT-1	Yes	20	1132-1149	20	1001-1026
	4/23[b]	-8	No	20	0716-0734	20	0659-0718
	4/23	0	No	20	1630-1645	20	1237-1336
	4/23	1	Yes	20	1803-1819	20	1343-1449
	4/23	4	Yes	19[f]	2047-2102	20	1652-1743
	4/24	12	Yes	21	0440-0455	20	0037-0129
	4/24	24	Yes	21	1631-1648	22	1234-1338
	4/25	48	Yes	17	1628-1639	20	1235-1324
Imnaha	2/25	PT-0	No	SL	0851-0942	SL	0714-0748
	2/25	PT-1	Yes	SL	1221-1249	SL	1050-1126
	3/30[b]	-8	No	20	0714-0737	20	0710-0736
	3/30	0	No	19	1733-1756	19[f]	1459-1529
	3/30	1	Yes	21[h]	1828-1903	19[d]	1607-1726
	3/30	4	Yes	22	2135-2205	20[e]	1915-1939
	3/31	12	Yes	19[e]	0417-0508	20[f]	0416-0507
	3/31	24	Yes	19[f]	1625-1708	18[g]	1626-1703
	4/ 1	48	Yes	13	1624-1659	19	1623-1657

Appendix Table A-1 (cont.). Summary of information for juvenile summer steelhead (Little Sheep and Big Canyon Facilities) and spring chinook salmon (Imnaha Facility) that were sampled for stress indices at Northeast Oregon facilities in 1992.

Acclimation facility	Date	Time period[a]	Stressor applied	Acclimated		Non-acclimated	
				n[b]	Time[c], h	n	Time, h

[a] Unchallenged groups: PT-0 = pre-transfer; -8 = approximately 8 hours before release; 0 = at release. Stress-challenged groups: PT-1 = pre-transfer, one hour after stress challenge; Times 1 to 48, 1-48 hours after stress challenge.

[b] Sample date was the previous day for the non-acclimated fish.

[c] Sample times cover both trucks which arrived about 50 or 100 minutes apart for summer steelhead. But around the same time for chinook salmon.

[d-i] n = sample sizes reported for plasma cortisol. When plasma chloride sample size differs, notes indicate alternate number: d = 16, e = 17, f = 18, g = 19 and h = 20.

Appendix Table A-2. Summary of information for juvenile summer steelhead (Little Sheep and Big Canyon Facilities) and spring chinook salmon (Imnaha Facility) that were sampled for smoltification indices at Northeast Oregon facilities in 1992.

Acclimation facility	Date	n[a]	Time through acclimation[b]	Treatment	Time, h
Little Sheep	3/22	19[d]	PT	Acclimated	0833-0857
	4/2	20	1/3	Acclimated	1122-1157
	4/13	20	2/3	Acclimated	1130-1158
	4/27	20	RE	Acclimated	0708-0726
	3/22	20	PT	Non-acclimated	0659-0721
	4/3	20	1/3	Non-acclimated	1105-1143
	4/14	20	2/3	Non-acclimated	1129-1208
	4/26	19	RE	Non-acclimated	0702-0728
Big Canyon	3/23	20	PT	Acclimated	0701-0730
	4/2	18[c]	1/3	Acclimated	1000-1036
	4/13	20	2/3	Acclimated	1240-1320
	4/23	18[d]	RE	Acclimated	0659-0718
	3/23	20	PT	Non-acclimated	0828-0856
	4/3	20	1/3	Non-acclimated	1430-1501
	4/14	21[d]	2/3	Non-acclimated	1417-1455
	4/22	20	RE	Non-acclimated	0716-0734
Imnaha	2/25	SL	PT	Acclimated	0851-0942
	3/10	20	1/3	Acclimated	1547-1700
	3/19	19[d]	2/3	Acclimated	1241-1324
	3/30	19[d]	RE	Acclimated	0714-0737
	2/25	SL	PT	Non-acclimated	0714-0748
	3/10	18[d]	1/3	Non-acclimated	1019-1056
	3/18	20	2/3	Non-acclimated	1100-1150
	3/29	20	RE	Non-acclimated	0710-0736

[a] Sample size for both gill ATPase and skin guanine unless otherwise noted. SL = samples lost.

[b] PT = Pretransfer; 1/3 = one third of the way through acclimation; 2/3 = two-thirds of the way through acclimation; RE = within 2 days prior to release.

[c] Guanine sample was 20.

[d] Guanine sample was 19.

Appendix Table A-3. Probability values for results of Mann-Whitney Tests for differences in plasma cortisol and plasma chloride concentrations in summer steelhead between acclimated and non-acclimated treatments for each time for the Little Sheep and Big Canyon facilities in 1992. Significant values are in bold.

Time[a] period	Little Sheep Facility		Big Canyon Facility	
	Cortisol	Chloride	Cortisol	Chloride
PT-0	0.797	0.287	0.018	0.072
PT-1	**0.005**	**0.002**	0.330	0.168
-8	0.379	0.116	**0.000**	**0.010**
0	**0.000**	**0.000**	0.304	**0.000**
1	**0.001**	**0.000**	**0.025**	**0.000**
4	0.348	**0.028**	0.593	**0.000**
12	**0.040**	**0.045**	**0.000**	**0.000**
24	0.633	0.414	0.058	**0.000**
48	0.085	**0.001**	**0.000**	**0.006**

[a] Unchallenged groups: PT-0 = pre-transfer; -8 = approximately 8 hours before release; 0 = at release. Stress-challenged groups: PT-1 = pre-transfer, one hour after challenge; Times 1 to 48, 1 to 48 hours after stress challenge.

Appendix Table A-4. Calculated Z values for Dunn's multiple comparison's test for differences in plasma cortisol concentrations and plasma chloride concentrations between unchallenged baseline samples (Time -8) and post-challenge samples (Times 1-48) within treatments of juvenile summer steelhead in 1992. Significant values ($\alpha \leq 0.30$) are in bold.

			Time[a]					
Index	Facility	Treatment	1	4	12	24	48	Critical Z[b]
Cortisol	Big Canyon	Acclimated	**87.4**	**96.4**	**62.8**	**76.1**	**44.6**	25.9
		Non-acclimated	**88.2**	**81.6**	**90.1**	**73.9**	**80.2**	25.5
	Little Sheep	Acclimated	**62.7**	**58.6**	**56.5**	**60.6**	**65.7**	25.3
		Non-acclimated	**90.7**	**57.2**	**71.1**	**54.8**	**38.9**	25.6
Chloride	Big Canyon	Acclimated	**65.4**	**37.1**	**61.3**	**53.3**	**38.8**	25.9
		Non-acclimated	**87.1**	**56.3**	**54.6**	**45.4**	**36.6**	25.5
	Little Sheep	Acclimated	**37.7**	**63.0**	**60.7**	**77.8**	**84.1**	25.1
		Non-acclimated	**67.1**	**81.3**	**76.7**	**68.0**	**34.8**	25.6

[a] Times 1 to 48 were 1 to 48 hours after the stress challenge.

[b] Critical values differ because of differences in sample size. Values reported were largest critical values among the 5 times within the row.

Appendix Table A-5. Probability values for results of Tukey post-hoc HSD comparisons for differences in mean gill $Na^{+}K^{+}$-ATPase activity and skin guanine concentrations between acclimated and non-acclimated treatments for Little Sheep and Big Canyon (summer steelhead) and Imnaha (spring chinook salmon) facilities in 1992. Significant values are in bold.

Time Period[a]	Little Sheep Facility		Big Canyon Facility		Imnaha Facility	
	ATPase	Guanine	ATPase	Guanine	ATPase	Guanine
PT	1.000	0.560	0.873	1.000	SL[b]	SL
1/3	0.739	0.636	1.000	0.227	1.000	1.000
2/3	0.911	0.378	0.410	0.999	0.997	1.000
RE	**0.005**	0.960	0.999	0.855	0.997	0.998

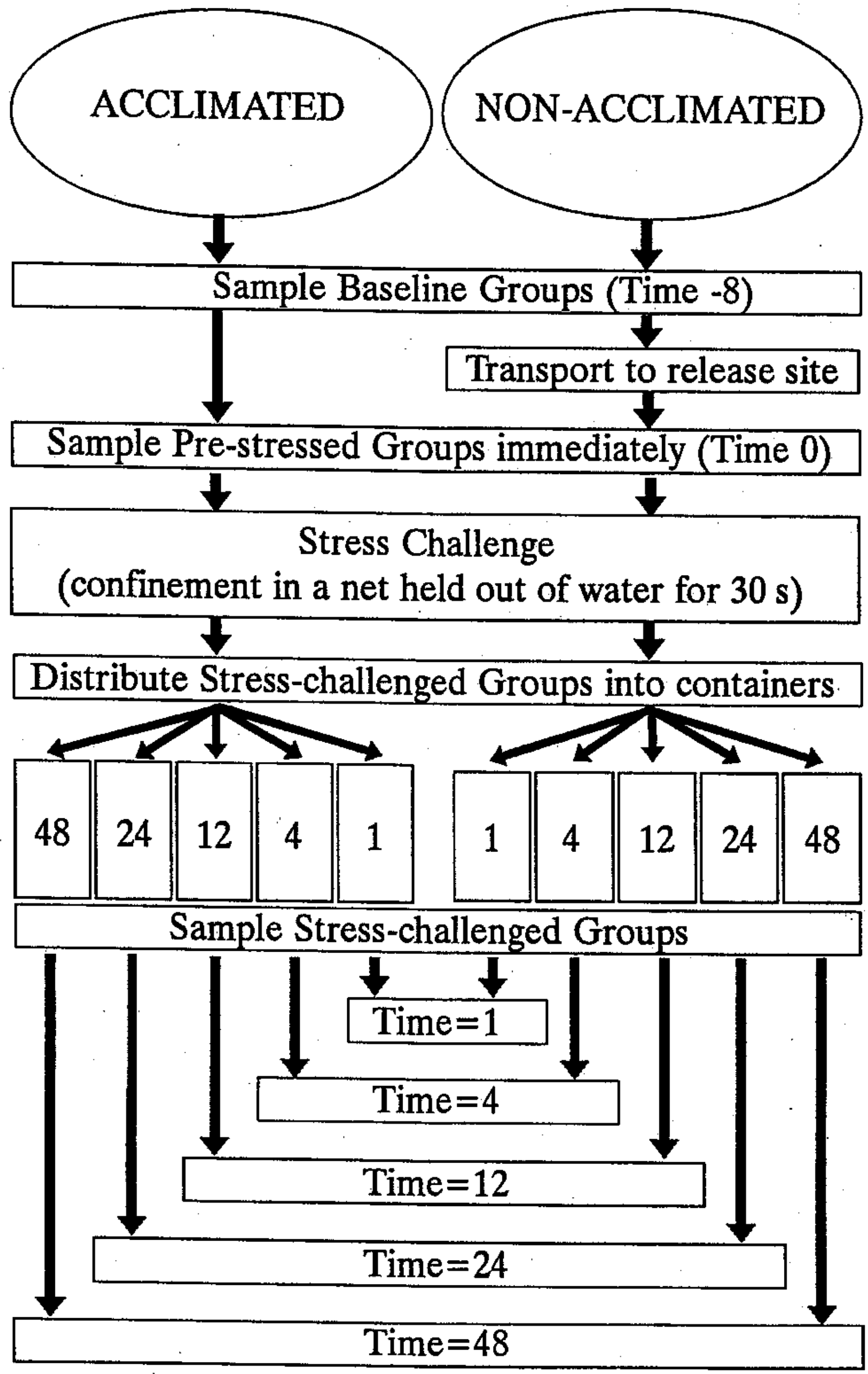
[a] PT = Pre-transfer, 1/3 = one third of the way through acclimation, 2/3 = two-thirds of the way through acclimation and RE = at release.
[b] SL = samples lost.

Appendix Table A-6. Matrix of probability values for the Tukey post-hoc HSD comparison results for differences among sample dates in gill Na^+K^+-ATPase activity and skin guanine concentrations within treatments for Big Canyon, Little Sheep (summer steelhead) and Imnaha (spring chinook salmon) facilities in 1992. Significant values are in bold.

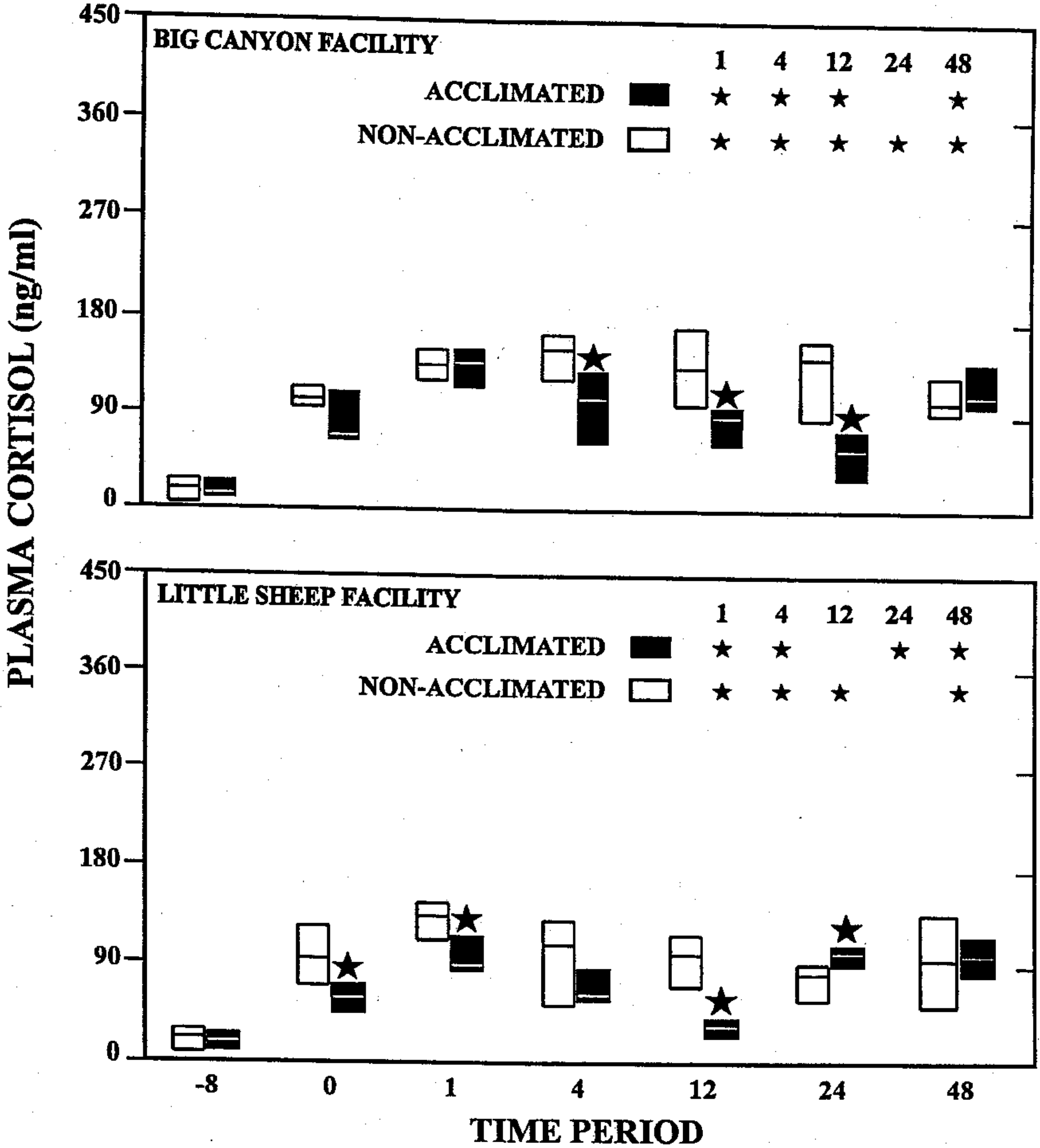
Facility, Treatment	Time period[a]	ATPase			Guanine		
		PT	1/3	2/3	PT	1/3	2/3
Big Canyon, Acclimated	1/3	0.997			0.746		
	2/3	0.899	0.999		0.689	1.000	
	RE	0.930	1.000	0.729	1.000	0.612	0.547
Big Canyon, Non-acclimated	1/3	0.313			0.993		
	2/3	0.999	0.687		0.950	0.530	
	RE	**0.032**	0.985	1.000	0.922	0.459	1.000
Little Sheep, Acclimated	1/3	0.940			0.301		
	2/3	**0.025**	0.409		**0.008**	0.904	
	RE	**0.005**	0.162	0.770	**0.039**	0.992	1.000
Little Sheep, Non-Acclimated	1/3	0.987			0.869		
	2/3	0.770	0.213		1.000	0.986	
	RE	1.000	1.000	0.358	1.000	0.818	0.999
Imnaha , Acclimated	1/3	NA			NA		
	2/3	NA	0.358		NA	0.854	
	RE	NA	0.702	1.000	NA	**0.041**	0.464
Imnaha , Non-acclimated	1/3	NA			NA		
	2/3	NA	0.489		NA	0.703	
	RE	NA	0.265	1.000	NA	0.105	0.853

[a] PT = Pre-transfer; 1/3 = 1/3 of the way through acclimation; 2/3 = 2/3 of the way through acclimation and RE = at release.

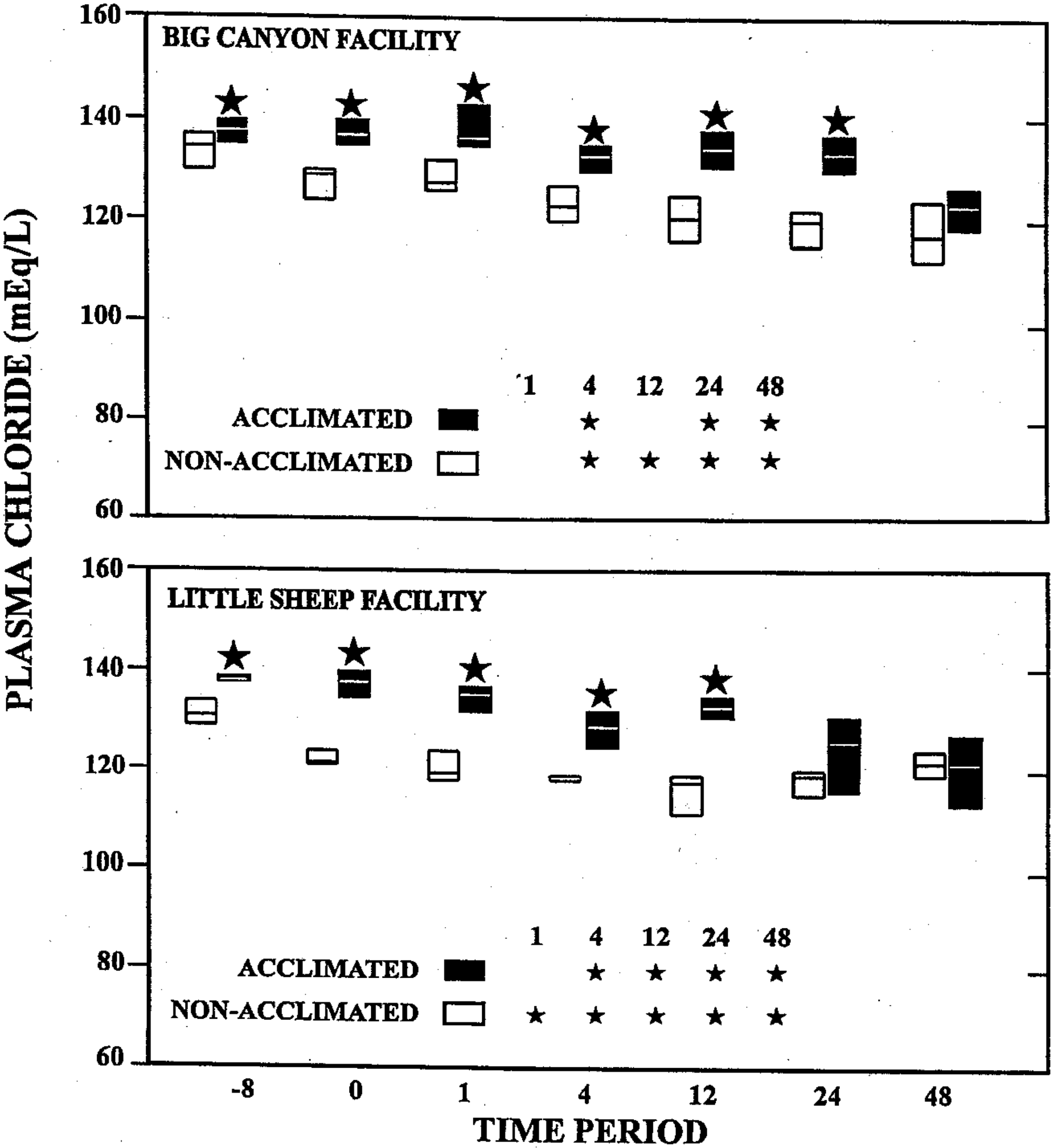
[b] NA = not applicable.



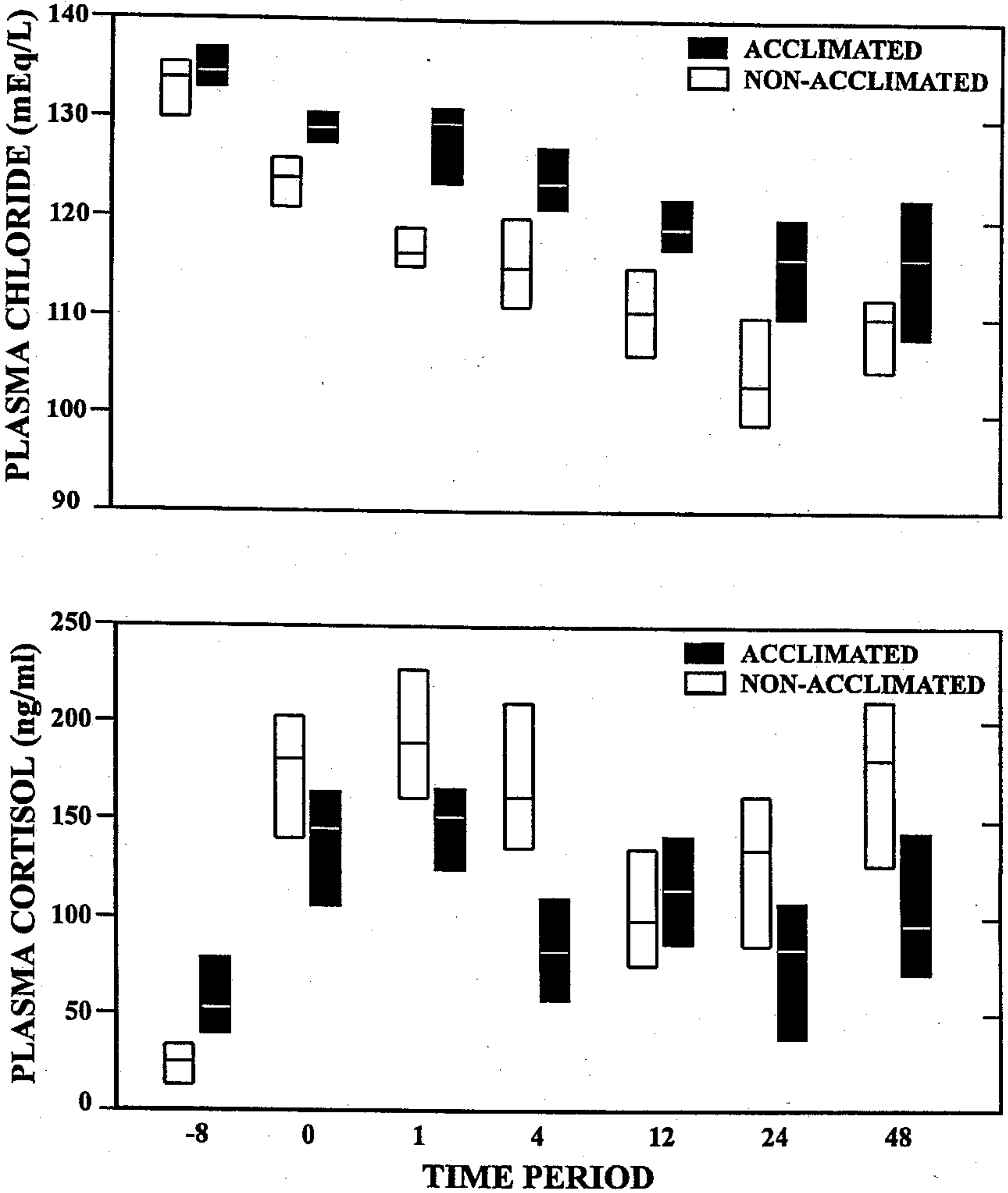
Appendix Figure B-1. Schematic of procedures for sampling fish for stress indices in 1991 and 1992.



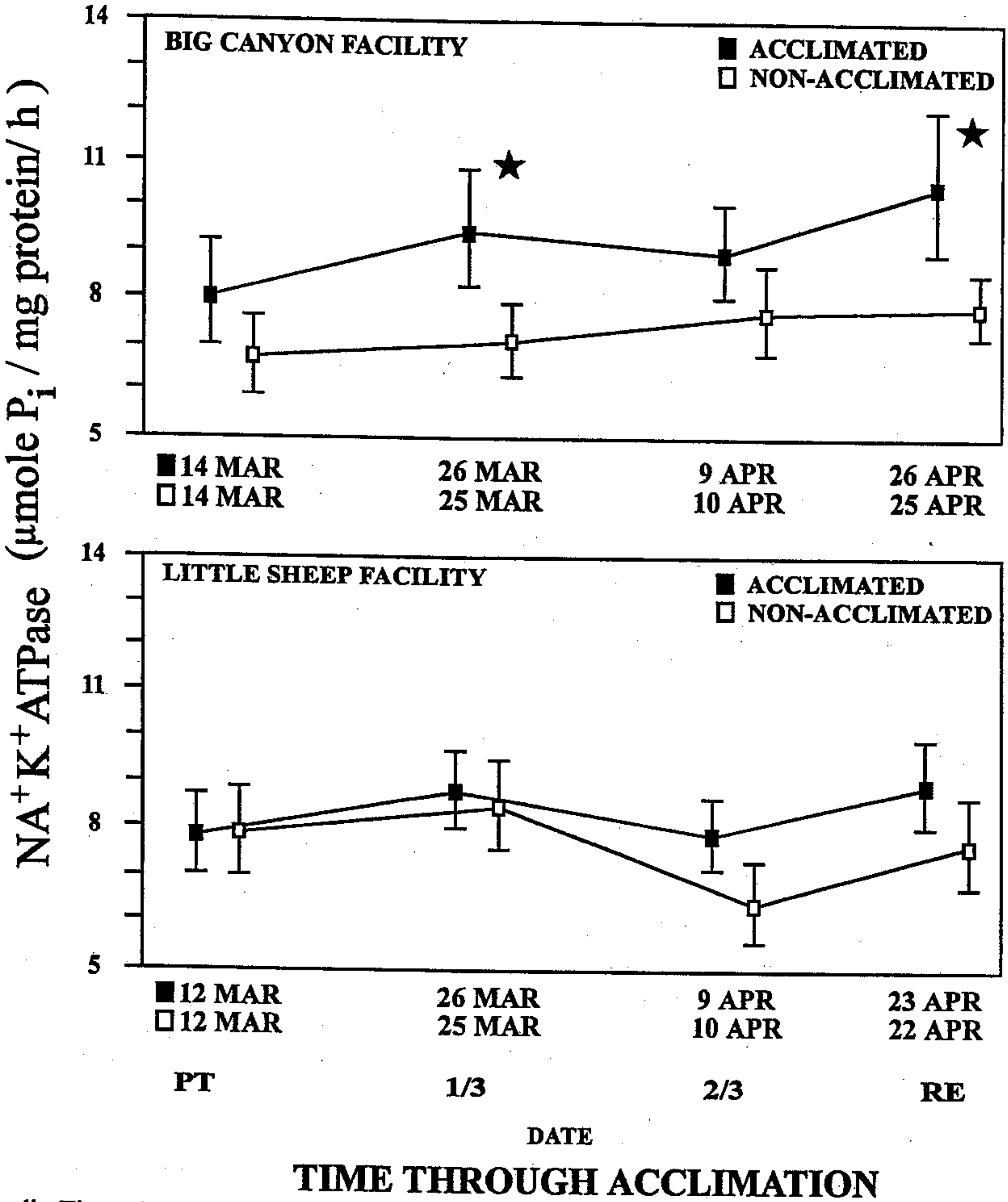
Appendix Figure B-2. Medians and interquartile ranges of plasma cortisol concentrations of acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1991. Stars above medians indicate significant differences between treatments ($\alpha \leq 0.05$) at that time. Stars to the right of the legend indicate significant differences ($\alpha \leq 0.30$) between baseline samples (-8) and each post-challenge time periods within that treatment.



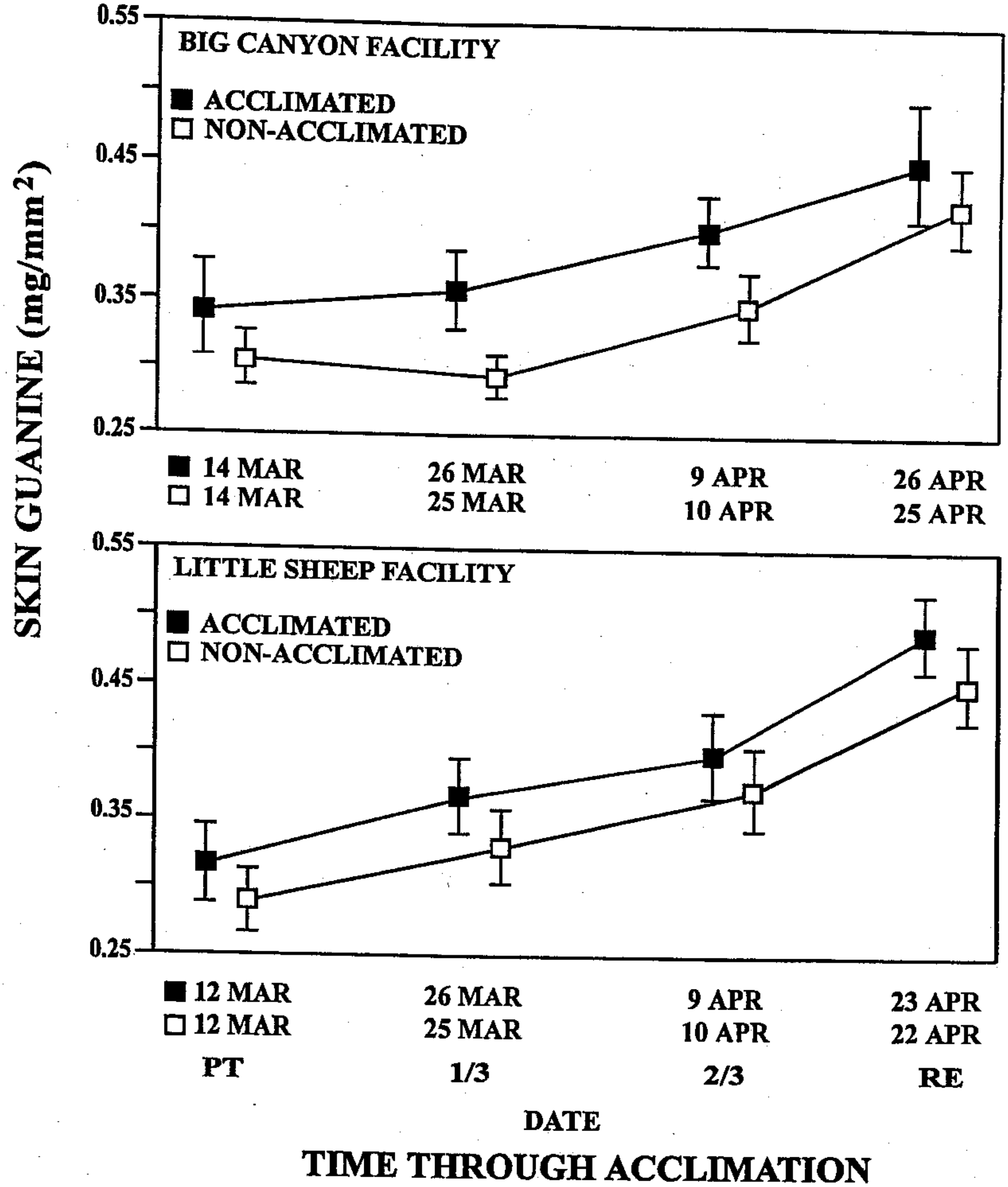
Appendix Figure B-3. Medians and interquartile ranges of plasma chloride concentrations for acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1991. Stars above medians indicate significant differences between treatments ($\alpha \leq 0.05$) at that time. Stars to the right of the legend indicate significant differences ($\alpha \leq 0.30$) between baseline samples (-8) and each post-challenge time period within a treatment.



Appendix Figure B-4. Medians and interquartile ranges of plasma chloride concentrations (A) and plasma cortisol concentrations (B) of acclimated and non-acclimated juvenile spring chinook salmon at the Imnaha Facility and Lookingglass Hatchery in 1992. Statistical tests for the data were not completed.



Appendix Figure B-5. Mean skin guanine concentrations and 95% confidence intervals (bars) for acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1991. Stars above means indicate significant differences ($\alpha \leq 0.05$) at that date between treatments. PT = pre-transfer; ⅓ = after one-third of the acclimation; ⅔ = after two-thirds of the acclimation; RE = within 2 days of release.



Appendix Figure B-6. Mean gill Na^+K^+-ATPase activities and 95% confidence intervals (bars) for acclimated and non-acclimated juvenile summer steelhead at Northeast Oregon acclimation facilities and Irrigon Hatchery in 1991. Stars above means indicate significant differences ($\alpha \leq 0.05$) at that date between treatments. PT = pre-transfer; ⅓ = after one-third of the acclimation; ⅔ = after two-thirds of the acclimation; RE = within 2 days of release.

Appendix Table C-1. Spawning ground survey data collected in 1992.

Start location
End location
Date of survey
Surveyor initials
Start time, temperature, weather
End time, temperature, weather

Live fish (on or off redd)
Redd date, is the date recorded on the flag
Redd number.

Fork Length (mm)
Sex (Male, Female, or Unknown)
Fin Mark (ad, lv, rv, or any combination seen on the fish).
Operculum Punch/Tag Number (number of holes in the operculum, and which side of the operculum was punched: ROP, right; LOP, left).
Snout ID (the 7 digit code used for identifying the snout)
Any other comments

Appendix Table C-2. Adult spring chinook salmon disc-tagged and released above the weir on Lookingglass Creek in 1992.

Date Tagged	Fork Length(mm)	Assigned Sex[a]	Origin[b]	Mark[c]	Tag#	Age	Brood Year
05/21/92	743	F	H	-	1	4	88
05/21/92	725	F	H	-	2	4	88
05/21/92	700	M	H	-	3	4	88
05/21/92	700	F	H	-	4	4	88
05/21/92	705	F	H	-	5	4	88
05/21/92	740	F	H	-	6	4	88
05/21/92	685	M	H	-	7	4	88
05/21/92	835	F	H	-	8	5	87
05/21/92	J 565	M	H	-	9	3	89
05/21/92	715	M	H	-	10	4	88
05/21/92	680	M	H	-	11	4	88
05/21/92	720	M	H	-	12	4	88
05/21/92	730	M	H	-	13	4	88
05/21/92	650	F	H	-	14	4	88
05/21/92	725	M	-	-	15	4	88
05/21/92	695	F	H	-	16	4	88
05/21/92	725	F	H	-	17	4	88
05/21/92	725	F	H	-	18	4	88
05/21/92	650	F	-	-	19	4	88
05/21/92	715	F	-	-	20	4	88
05/21/92	650	F	H	-	21	4	88
05/21/92	725	M	H	-	22	4	88
05/21/92	730	M	-	-	23	4	88
05/21/92	725	M	H	-	24	4	88
05/29/92	700	F	H	-	25	4	88
05/29/92	680	F	H	-	26	4	88
05/29/92	740	M	H	-	27	4	88
05/29/92	765	F	H	-	28	4	88
05/29/92	700	M	H	-	29	4	88
05/29/92	720	F	H	-	30	4	88
05/29/92	660	M	H	-	31	4	88
05/29/92	650	M	H	-	32	4	88

Appendix Table C-2 (cont.). Adult spring chinook salmon disc-tagged and released above the weir on Lookingglass Creek in 1992.

Date Tagged	Fork Length(mm)	Assigned Sex[a]	Origin[b]	Mark[c]	Tag#	Age	Brood Year
05/29/92	740	M	H	-	33	4	88
05/29/92	670	F	H	-	34	4	88
05/29/92	600	M	H	-	35	4	88
05/29/92	760	F	H	-	36	4	88
05/29/92	725	F	H	-	37	4	88
05/29/92	740	M	H	-	38	4	88
05/29/92	730	M	H	-	39	4	88
05/29/92	720	F	H	-	40	4	88
05/29/92	695	M	H	-	41	4	88
05/29/92	740	M	H	-	42	4	88
05/29/92	590	F	-	-	43	3	89
05/29/92	700	F	H	-	44	4	88
06/03/92	680	F	N	-	45	4	88
06/03/92	695	M	H	-	46	4	88
06/03/92	695	F	H	-	47	4	88
06/03/92	760	M	H	-	48	4	88
06/03/92	795	M	-	-	49	5	87
06/10/92	740	F	H	-	50	4	88
06/10/92	730	M	H	-	51	4	88
06/10/92	715	M	H	-	52	4	88
06/10/92	740	F	-	-	53	4	88
06/10/92	870	M	H	-	54	5	87
06/10/92	610	F	H	-	55	4	88
06/10/92	770	M	N	-	56	4	88
06/10/92	720	F	H	-	57	4	88
06/10/92	690	F	H	-	58	4	88
06/10/92	790	M	H	-	59	5	87
06/10/92	750	M	H	-	60	4	88
06/10/92	450	M	H	-	61	3	89
06/10/92	790	F	H	-	62	5	87
06/10/92	775	M	-	-	63	5	87
06/10/92	760	F	H	-	64	5	87

Appendix Table C-2 (cont.). Adult spring chinook salmon disc-tagged and released above the weir on Lookingglass Creek in 1992.

Date Tagged	Fork Length(mm)	Assigned Sex[a]	Origin[b]	Mark[c]	Tag#	Age	Brood Year
06/10/92	810	M	-	-	65	5	87
06/10/92	770	M	H	-	66	4	88
06/10/92	725	M	H	-	67	4	88
06/10/92	735	F	H	-	68	4	88
06/10/92	700	M	N	-	69	4	88
06/17/92	745	F	H	-	70	4	88
06/17/92	755	M	H	-	71	4	88
06/17/92	475	M	H	-	72	3	89
06/17/92	790	M	H	-	73	4	88
06/17/92	725	M	H	-	74	4	88
06/17/92	635	F	H	-	75	4	88
06/17/92	665	F	H	-	76	4	88
06/17/92	700	M	H	-	77	4	88
06/17/92	790	M	H	-	78	5	87
06/17/92	690	F	H	-	79	4	88
06/17/92	780	F	H	-	80	4	88
06/17/92	750	M	H	-	81	4	88
06/17/92	685	F	H	-	82	4	88
06/17/92	710	F	H	-	83	4	88
07/01/92	680	F	H	-	84	4	88
07/01/92	830	M	-	-	85	5	87
07/01/92	750	M	H	-	86	4	88
07/09/92	660	M	H	-	87	4	88
07/28/92	735	F	H	-	88	4	88
07/28/92	695	F	H	-	89	4	88
08/12/92	765	F	H	-	90	4	88
08/19/92	930	M	H	-	91	5	87
08/19/92	680	M	H	-	92	4	88
08/19/92	675	M	H	AD	93	4	88
09/10/92	791	F	H	AD	94	4	88
09/10/92	716	F	H	-	95	4	88
09/10/92	732	F	-	-	96	4	88

Appendix Table C-2 (cont.). Adult spring chinook salmon disc-tagged and released above the weir on Lookingglass Creek in 1992.

Date Tagged	Fork Length(mm)	Assigned Sex[a]	Origin[b]	Mark[c]	Tag#	Age	Brood Year
09/10/92	757	M	N	-	97	4	88
09/10/92	739	M	N	-	98	4	88
09/10/92	750	M	H	-	99	4	88
09/10/92	697	M	H	-	100	4	88
09/10/92	835	F	H	AD	101	5	87
09/10/92	662	F	H	-	102	4	88
09/10/92	638	M	H	-	103	4	88
09/10/92	678	M	H	-	104	4	88
09/10/92	711	F	H	-	105	4	88
09/10/92	652	M	H	-	106	4	88
09/10/92	645	F	H	-	107	4	88
09/10/92	674	M	H	-	108	4	88
09/10/92	694	F	H	AD	109	4	88
09/10/92	734	M	-	-	110	4	88
09/10/92	685	M	H	-	111	4	88
09/10/92	693	F	H	-	112	4	88
09/10/92	701	F	H	-	113	4	88
09/10/92	729	F	H	-	114	4	88
09/10/92	688	M	H	-	115	4	88
09/10/92	673	M	-	-	116	4	88
09/10/92	743	F	H	AD	117	4	88
09/10/92	614	F	H	-	118	4	88
09/10/92	789	M	H	-	119	4	88
09/10/92	649	F	H	-	120	4	88
09/10/92	728	M	H	-	121	4	88
09/10/92	680	F	H	AD	122	4	88
09/10/92	738	M	H	-	123	4	88
09/10/92	682	F	H	-	124	4	88
09/10/92	715	M	H	-	125	4	88
09/10/92	708	M	H	-	126	4	88
09/10/92	744	F	H	AD	127	4	88
09/10/92	703	M	H	-	128	4	88

Appendix Table C-2 (cont.). Adult spring chinook salmon disc-tagged and released above the weir on Lookingglass Creek in 1992.

Date Tagged	Fork Length(mm)	Assigned Sex[a]	Origin[b]	Mark[c]	Tag#	Age	Brood Year
09/10/92	723	F	H	-	129	4	88
09/10/92	734	F	H	-	130	4	88
09/10/92	719	M	H	-	131	4	88
09/10/92	706	M	-	-	132	4	88
09/10/92	680	F	H	-	133	4	88

[a] The sex of the fish was estimated at the time of tagging by hatchery personnel.
[b] Origin of the fish, H = hatchery, N= natural, - unreadable. The origin was determined using scales from individual fish and applying a discriminant scale model (ODFW unpublished data) for that return year.
[c] AD = adipose-fin-clipped

Appendix Table C-3. Spawning ground survey summaries for 1992.

				ALIVE[a]				#Redds[b]		DEAD[c]												Tag-loss[d]		
				On		Off				Tagged				Not-Tagged				Unk.Tagged						
Surv.Type	Wk	Date	Sec.	T	NT	T	NT	O	UO	M	F	J	U	M	F	J	U	M	F	J	U	M	F	U
Pre-Spawn	28	15-Jul-92	1	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	30	23-Jul-92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	32	12-Aug-92	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	33	19-Aug-92	1	1	1	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	34	25-Aug-92	1	1	3	2	5	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Spawn	35	02-Sep-92	1	0	18	1	7	12	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Spawn	36	09-Sep-92	1	0	7	1	3	5	8	1	0	0	0	2	3	0	0	0	0	0	0	0	0	0
Spawn	37	15-Sep-92	1	1	2	3	0	3	10	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0
Spawn	38	23-Sep-92	1	0	4	0	1	2	11	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Spawn	39	01-Oct-92	1	0	0	1	0	0	13	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Pre-Spawn	28	16-Jul-92	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	30	29-Jul-92	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	32	13-Aug-92	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	33	18-Aug-92	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	34	25-Aug-92	2	3	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	35	01-Sep-92	2	1	2	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	36	09-Sep-92	2	1	0	1	0	1	7	1	1	0	1	1	0	0	0	0	0	0	0	1	0	0
Spawn	37	15-Sep-92	2	7	0	1	0	5	8	3	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Spawn	38	23-Sep-92	2	1	0	0	0	1	12	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	28	16-Jul-92	3	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	30	29-Jul-92	3	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	32	13-Aug-92	3	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	33	18-Aug-92	3	1	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	34	25-Aug-92	3	3	1	4	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	35	01-Sep-92	3	6	3	6	6	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	36	09-Sep-92	3	4	2	1	0	6	6	1	1	0	1	0	1	0	0	0	0	0	0	0	1	0
Spawn	37	15-Sep-92	3	12	0	5	0	8	9	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0
Spawn	38	23-Sep-92	3	0	0	2	0	2	17	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table C-3 (cont.). Spawning ground survey summaries for 1992.

				ALIVE[a]						DEAD[c]														
				On		Off		#Redds[b]		Tagged				Not-Tagged				Unk. Tagged				Tag-loss[d]		
Surv. Type	Wk	Date	Sec.	T	NT	T	NT	O	UO	M	F	J	U	M	F	J	U	M	F	J	U	M	F	U
Pre-Spawn	28	16-Jul-92	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	30	29-Jul-92	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	32	13-Aug-92	4	2	1	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	33	18-Aug-92	4	1	2	5	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	34	25-Aug-92	4	0	1	4	3	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	35	01-Sep-92	4	1	4	0	1	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	36	09-Sep-92	4	0	2	1	0	2	7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Spawn	37	15-Sep-92	4	2	0	1	2	2	7	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0
Spawn	38	23-Sep-92	4	1	0	0	0	1	10	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Pre-Spawn	28	16-Jul-92	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	30	29-Jul-92	5	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Spawn	32	13-Aug-92	5	0	0	5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	33	19-Aug-92	5	5	0	2	1	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	34	25-Aug-92	5	2	1	3	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	35	01-Sep-92	5	2	0	1	0	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	36	09-Sep-92	5	1	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	37	16-Sep-92	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spawn	38	23-Sep-92	5	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] Live fish that were tagged (T) or not tagged (NT) observed on redds or off redds.

[b] Number of redds observed that were either occupied (O) or unoccupied (UO) by chinook salmon.

[c] The number of dead fish recovered during the survey that were tagged, not tagged, or unknown of unknown tagging history. Sex categories for carcasses are male (M), female (F), jack (J), and unknown sex (U).

[d] The number and sex of the tagged dead carcasses recovered that had lost their tags as evidenced by an operculum punch. These fish are also included as dead fish in the Dead tagged column for the appropriate sex.

Appendix Table C-4. Adult spring chinook salmon recovered on Lookingglass and Little Lookingglass creeks in 1992.

Date Recov.	Date Tagged	Fork Length(mm)	Rec. Sex[a]	Ass. Sex[b]	Org.[c]	Mark[d]	CWT[e]	Disc Tag#[f]	Age	Brood Year	Rec. Sect.[g]
09/02/92	06/17/92	700	M	M	H	-		77	4	88	1
09/09/92	06/17/92	685	M	F	H	-		82	4	88	1
09/23/92	05/21/92	725	M	M	-	-		15	4	88	1
09/23/92	09/10/92	734	M	M	-	-		110	4	88	1
05/25/92	UNK	710	F	M	H	-		TL	4	88	W
07/14/92	UNK	UNK	M	M	-	-		TL	-	-	W
07/15/92	06/10/92	770	M	M	H	-		66	4	88	W
08/25/92	08/12/92	765	F	F	H	-		90	4	88	W
09/09/92	06/17/92	725	U	M	H	-		74	4	88	2
09/09/92	UNK	UNK	F	F	-	-		TL	-	-	2
09/09/92	06/03/92	695	F	F	H	-		47	4	88	2
09/15/92	UNK	670	F	F	-	-		TL	-	-	2
09/15/92	09/10/92	728	M	M	H	-		121	4	88	2
09/15/92	09/10/92	757	M	M	N	-		97	4	88	2
09/15/92	09/10/92	715	M	M	H	-		125	4	88	2
09/23/92	09/10/92	711	F	F	H	-		105	4	88	2
09/23/92	09/10/92	835	F	F	H	AD	074533	101	5	87	2
09/23/92	09/10/92	680	F	F	H	AD	074739	122	4	88	2
09/09/92	UNK	UNK	F	F	-	-		TL	-	-	3
09/09/92	05/21/92	725	-	M	H	-		24	4	88	3
09/09/92	08/19/92	930	M	M	H	-		91	5	87	3
09/15/92	06/17/92	690	F	F	H	-		79	4	88	3
09/23/92	09/10/92	734	F	F	H	-		130	4	88	3
09/23/92	09/10/92	743	F	F	H	AD	LOST	117	4	88	3
09/23/92	09/10/92	732	F	F	-	-		96	4	88	3
09/15/92	UNK	625	F	F	-	-		TL	-	-	4
08/19/92	05/21/92	725	F	F	H	-		2	4	88	5
09/01/92	06/10/92	720	F	F	H	-		57	4	88	5
08/25/92	-	694	F	-	H	-		NT	4	88	1
09/02/92	-	650	M	-	H	AD	074739	NT	4	88	1
09/02/92	-	730	M	-	N	-		NT	4	88	1
09/09/92	-	825	M	-	H	-		NT	5	87	1

Appendix Table C-4 (cont.). Adult spring chinook salmon recovered on Lookingglass and Little Lookingglass creeks in 1992.

Date Recov.	Date Tagged	Fork Length(mm)	Rec. Sex[a]	Ass. Sex[b]	Org.[c]	Mark[d]	CWT[e]	Disc Tag#[f]	Age	Brood Year	Rec. Sect.[g]
09/09/92	-	780	M	-	H	-		NT	4	88	1
09/09/92	-	710	F	-	H	AD	074745	NT	4	88	1
09/09/92	-	770	F	-	N	AD	LOST	NT	4	88	1
09/09/92	-	745	F	-	H	AD	074745	NT	4	88	1
09/15/92	-	700	F	-	H	AD	LOST	NT	4	88	1
09/15/92	-	770	M	-	H	-		NT	4	88	1
09/15/92	-	760	M	-	-	AD	LOST	NT	4	88	1
09/15/92	-	670	F	-	H	AD	074745	NT	4	88	1
09/27/92	-	780	M	-	H	-		NT	4	88	1
10/01/92	-	690	F	-	H	AD	LOST	NT	4	88	1
05/25/92	-	685	M	-	H	-		NT	4	88	W
08/27/92	-	690	M	-	H	-		NT	4	88	W
09/04/92	-	710	M	-	H	-		NT	4	88	W
09/09/92	-	UNK	M	-	H	-		NT	4	88	2
09/15/92	-	680	F	-	H	AD	074739	NT	4	88	3
09/09/92	-	710	F	-	H	-		NT	4	88	4
09/15/92	-	UNK	M	-	H	AD	LOST	NT	3	89	4
09/23/92	-	705	F	-	H	-		NT	4	88	4
09/23/92	-	670	F	-	N	-		NT	4	88	4
09/15/92	UNK	UNK	M	-	-	-		UNK	-	--	3
09/15/92	UNK	UNK	F	-	-	-		UNK	-	-	3

[a] Sex at recovery was determined by body cavity inspection.
[b] The sex of the fish that was Assigned at the time of disc-tagging by hatchery personnel.
[c] Origin of the fish, H = hatchery, N = natural The origin was determined using scales from individual fish and applying a discriminant scale model (ODFW unpublished data) for that return year.
[d] AD = adipose-fin-clipped (to identify fish with coded wire tag).
[e] The coded-wire-tag number from the tag in the snout that was collected on the spawning ground survey. Some of the snouts did not contain a tag (LOST).
[f] NT = the fish had no punches or tags.
[g] The Unit in which the fish was recovered. W=collected on the weir at the bottom of section 2.

Appendix Table C-5. Fecundity data for Rapid River stock spring chinook salmon spawned at Lookingglass Creek Hatchery in 1992. All weights are in grams unless otherwise noted.

Samp. Date		Age	Fork Length	Ovary Wt.	Sample 1 Tot. Wt.	Sample 1 Cont Wt.	Sample 1 # of Eggs	Sample 1 Eggs/ Gram	Sample 2 Tot. Wt.	Sample 2 Cont. Wt.	Sample 2 # of Eggs	Sample 2 Eggs/ Gram	Eggs not Spawned Good	Eggs not Spawned Bad	Sampler Var.[a]	Mean Fecund. Egg/ Fem	Mean Fecund. Egg/ Gram
08/28	5	845	6.5	1184	28.10	2.30	93	3.6	20.75	2.35	69	3.8	65	118	4.0	4418.4	3.7
08/28	5	793	5.2	1139	24.15	2.15	84	3.8	26.25	2.30	84	3.5	48	87	8.9	4218.0	3.7
08/28	4	716	4.0	830	25.25	2.45	105	4.6	24.30	2.30	106	4.8	185	10	4.6	4096.0	4.7
08/28	5	865	6.4	1175	24.85	2.30	88	3.9	29.00	2.25	123	4.6	169	18	17.8	5162.2	4.3
08/28	5	905	7.4	1547	27.75	2.35	92	3.6	27.15	2.30	103	4.1	24	10	14.4	6030.7	3.9
08/28	4	661	3.0	608	28.40	2.50	138	5.3	27.45	2.35	103	4.1	93	0	29.8	2959.3	4.7
08/28	5	905	6.5	912	27.85	2.45	90	3.5	27.40	2.40	99	4.0	35	25	11.8	3455.4	3.8
09/03	4	642	3.8	572	26.60	2.65	120	5.0	29.10	2.70	132	5.0	20	80	0.2	2880.6	5.0
09/03	4	725	4.2	898	28.90	2.60	130	4.9	28.40	2.55	128	5.0	24	35	0.2	4467.2	4.9
09/03	4	736	4.5	1025	27.50	2.55	105	4.2	27.25	2.75	105	4.3	60	50	1.8	4413.7	4.2
09/03	4	732	4.2	857	25.75	2.55	95	4.1	28.10	2.45	106	4.1	74	26	0.9	3600.6	4.1
09/03	4	633	3.3	744	29.00	2.70	116	4.4	27.15	2.65	109	4.4	7	66	0.9	3302.2	4.4
09/03	4	733	4.1	880	29.95	2.50	144	5.2	28.65	2.65	147	5.7	20	67	7.8	4815.7	5.4
09/03	4	780	5.0	1025	26.15	2.75	99	4.2	29.40	2.55	115	4.3	39	71	1.2	4402.8	4.3
09/03	5	715	4.2	934	27.80	2.65	119	4.7	28.75	2.75	124	4.8	57	0	0.8	4495.7	4.8
09/03	4	720	4.4	898	26.05	2.35	103	4.3	26.40	2.60	101	4.2	2	51	2.4	3859.2	4.3
09/03	5	821	5.4	903	29.45	2.35	109	4.0	28.30	2.65	104	4.1	15	0	0.8	3660.2	4.0
09/03	5	914	7.1	1379	29.60	2.40	116	4.3	27.40	2.40	109	4.4	0	63	2.2	5946.3	4.3
09/03	5	844	6.1	1288	29.20	2.35	107	3.9	27.45	2.35	100	4.0	5	55	0.0	5137.9	4.0
09/03	4	683	3.2	689	29.55	2.50	123	4.5	29.50	2.70	124	4.6	12	89	1.8	3174.5	4.6
09/04	4	717	4.2	907	26.50	2.45	114	4.7	29.55	2.85	120	4.5	38	0	5.5	4226.6	4.6
09/04	4	655	3.1	635	29.55	2.35	152	5.6	27.75	2.60	145	5.8	15	15	3.2	3619.9	5.7
09/04	4	700	3.2	676	28.35	2.55	125	4.8	28.85	2.75	126	4.8	0	0	0.4	3268.5	4.8
09/04	4	700	3.8	798	29.00	2.35	146	5.5	27.85	2.65	137	5.4	13	5	0.8	4369.8	5.5
09/04	4	663	2.8	481	27.00	2.50	135	5.5	25.10	2.65	126	5.6	189	75	1.9	2862.9	5.6
09/04	4	710	3.4	798	29.25	2.45	146	5.4	29.85	2.65	147	5.4	4	0	0.8	4335.7	5.4

Appendix Table C-5 (cont.). Fecundity data for Rapid River stock spring chinook salmon spawned at Lookingglass Creek Hatchery in 1992. All weights are in grams unless otherwise noted.

Samp. Date		Age	Fork Length	Ovary Wt.	Sample 1 Tot. Wt.	Sample 1 Cont Wt.	Sample 1 # of Eggs	Sample 1 Eggs/ Gram	Sample 2 Tot. Wt.	Sample 2 Cont. Wt.	Sample 2 # of Eggs	Sample 2 Eggs/ Gram	Eggs not Spawned Good	Eggs not Spawned Bad	Sampler Var.[a]	Mean Fecund. Egg/ Fem	Mean Fecund. Egg/ Gram
09/04	4	659	2.8	640	28.50	2.45	131	4.9	29.50	2.75	131	4.9	20	4	2.7	3194.1	5.0
09/04	4	666	3.0	689	28.20	2.50	155	6.0	27.05	2.55	147	6.0	46	0	0.5	4193.4	6.0
09/04	4	713	3.7	572	27.60	2.50	140	5.6	29.00	2.50	152	5.7	64	106	2.8	3296.9	5.7
09/04	4	688	3.2	689	28.95	2.30	131	4.9	28.00	2.50	144	5.6	42	0	14.9	3683.2	5.3
09/04	5	876	6.5	1284	26.70	2.35	85	3.5	26.60	2.35	84	3.5	9	2	0.8	4472.7	3.5
09/04	4	688	2.9	621	26.05	2.50	144	6.1	26.75	2.65	150	6.2	24	3	1.8	3857.7	6.2
09/04	5	814	5.3	839	27.75	2.55	108	4.3	28.65	2.45	114	4.4	25	0	1.5	3648.7	4.3
09/04	4	690	3.6	780	28.00	2.30	109	4.2	29.45	2.35	115	4.2	9	17	0.1	3318.8	4.2
09/04	4	614	1.4	503	28.20	2.45	156	6.1	28.95	2.60	160	6.1	0	3	0.2	3053.7	6.1
09/04	4	638	3.0	694	26.95	2.50	130	5.3	29.45	2.60	142	5.3	0	1	0.5	3680.1	5.3
09/04	4	731	3.9	816	27.15	2.35	123	4.9	25.70	2.40	114	4.9	1	3	1.4	4023.0	4.9
09/04	4	644	2.8	599	29.10	2.35	136	5.1	28.35	2.75	134	5.2	7	1	3.0	3096.0	5.2
09/04	4	643	2.7	630	27.95	2.35	155	6.1	26.05	2.55	141	6.0	0	0	0.9	3800.1	6.0
09/04	4	732	3.9	875	25.40	2.25	109	4.7	28.40	2.50	121	4.7	5	1	0.8	4110.8	4.7
09/04	4	741	4.3	1021	29.40	2.40	128	4.7	29.35	2.50	123	4.6	0	7	3.5	4756.7	4.7
09/04	5	788	5.0	975	27.25	2.30	117	4.7	27.70	2.65	119	4.8	4	2	1.3	4606.9	4.7
09/04	4	630	2.3	440	28.80	2.50	141	5.4	27.15	2.55	141	5.7	2	0	6.9	2442.3	5.5
09/04	4	755	4.9	1093	25.10	2.25	103	4.5	28.75	2.45	122	4.6	7	0	2.9	5006.2	4.6
09/10	4	672	3.1	535	26.35	2.60	99	4.2	28.35	2.65	105	4.1	70	4	2.0	2278.9	4.1
09/10	4	688	3.3	608	29.40	2.35	130	4.8	28.05	2.50	120	4.7	68	1	2.3	2955.8	4.8
09/10	4	686	3.4	1025	27.60	2.50	105	4.2	29.40	2.40	114	4.2	4	0	0.9	4312.2	4.2
09/10	4	712	3.7	871	27.70	2.25	124	4.9	28.35	2.30	127	4.9	0	1	0.1	4244.5	4.9
09/10	4	642	2.3	476	27.90	2.45	152	5.9	27.55	2.50	149	5.9	0	4	0.4	2838.7	6.0
09/10	5	827	5.8	993	27.95	2.25	96	3.7	28.70	2.60	97	3.7	8	4	0.5	3709.2	3.7
09/10	4	673	3.3	812	28.85	2.35	136	5.1	28.90	2.50	138	5.2	6	18	1.9	4211.5	5.2

Appendix Table C-5 (cont.). Fecundity data for Rapid River stock spring chinook salmon spawned at Lookingglass Creek Hatchery in 1992. All weights are in grams unless otherwise noted.

Samp. Date	Age		Fork Length	Ovary Wt.	Sample 1 Tot. Wt.	Sample 1 Cont Wt.	Sample 1 # of Eggs	Sample 1 Eggs/ Gram	Sample 2 Tot. Wt.	Sample 2 Cont. Wt.	Sample 2 # of Eggs	Sample 2 Eggs/ Gram	Eggs not Spawned Good	Eggs not Spawned Bad	Sampler Var.[a]	Mean Fecund. Egg/ Fem	Mean Fecund. Egg/ Gram
09/10	4	715	3.9	771	29.80	2.40	139	5.1	25.95	2.45	119	5.1	1	6	0.2	3909.2	5.1
09/10	4	767	3.8	630	26.20	2.50	100	4.2	28.65	2.60	109	4.2	70	8	0.8	2719.2	4.2

[a] A different person counted each sub-sample and Sampler var. is the sampler variability between the 2 people. It is a ratio calculated as the greater eggs/gram divided by the lesser eggs/gram for the two sub-samples, minus 1 multiplied by 100. The greater the ratio the greater the variability between samplers.

Appendix Table C-6. Run timing of chinook salmon that returned to Lookingglass Creek from 1964 to 1974 and 1992.

Run Year	Group[b]	Time Interval (percent of the total return)[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	Endemic	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	Endemic	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	Endemic	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	Endemic	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	244
1968	Endemic	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	Endemic	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	Endemic	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	Endemic	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	Endemic	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	Endemic	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	274
1974	Endemic	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	R.River	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	R.River	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	R.River	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	Release[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[c]

[a] Percent of the total return that arrived at the trap during the 7 day time interval which ended on the date shown.

[b] Endemic stock age structure was summarized from Burck (1972,1973,1974,1975). Rapid River stock age structure was summarized from Messmer (1992,1994). R.River = Rapid River

[c] Does not include late release group (40 fish).

Appendix Table C-7. Age structure of chinook salmon that returned to Lookingglass Creek 1971 to 1974 and 1990 to 1992.

Run Year	Group[a]	Age at Return: Number that Returned 3	4	5	Percent of the Total Return 3	4	5
1971	Endemic	52	327	17	13	83	4
1972	Endemic	30	223	24	11	80	9
1973	Endemic	10	233	23	4	87	9
1974	Endemic	6	64	5	8	85	7
1990	Rapid River	5	491	23	1	94	5
1991	Rapid River	113	154	95	31	43	26
1992	Rapid River	15	801	96	2	87	11
1992	Release	4	113	16	3	85	12

[a] Endemic stock age structure was summarized from Burck (1972,1973,1974,1975). Rapid River stock age structure was summarized from Messmer (1992,1994). Age structure for fish released in 1992 by scale reading.

Appendix Table C-8. Spawning ground survey data from Lookingglass Creek in 1966 to 1970 and 1992[a].

Date Range, Survey date	Fish				Redds			
	Live	(%)	Dead	(%)	Occupied	(%)	Unoccupied	(%)
09-Aug to 15-Aug,								
09-Aug-66	37	4.7	0	0.0	9	2.0	9	1.8
14-Aug-66	60	7.6	4	1.9	28	6.4	49	9.8
09-Aug-67	31	16.9	0	0.0	19	16.8	11	4.2
15-Aug-68	74	24.8	1	1.7	39	23.2	22	5.4
14-Aug-69	54	10.0	2	1.7	19	6.3	39	5.3
11-Aug-70	47	7.2	1	0.8	20	5.0	25	3.7
13-Aug-92	16	15.1	2	5.1	2	7.7	0	0.0
16-Aug to 22-Aug,								
19-Aug-66	170	21.7	1	0.5	87	19.8	76	15.2
17-Aug-67	57	31.2	2	3.3	33	29.2	34	13.1
22-Aug-68	108	36.1	4	6.7	57	33.9	39	9.6
21-Aug-69	136	25.2	0	0.0	82	27.1	65	8.8
20-Aug-70	184	28.3	5	3.8	99	24.8	61	9.0
18-Aug-92	12	11.3	4	10.3	2	7.7	4	13.8
23-Aug to 29-Aug,								
24-Aug-66	223	28.4	7	3.3	136	31.0	88	17.6
29-Aug-66	181	23.1	42	20.1	120	27.3	104	20.8
24-Aug-67	70	38.3	14	23.3	40	35.4	57	22.0
27-Aug-68	55	18.4	15	25.0	33	19.6	65	16.0
25-Aug-69	174	32.2	14	12.0	87	28.8	90	12.2
29-Aug-69	114	21.1	29	24.8	67	22.2	140	19.0
24-Aug-70	198	30.4	13	9.9	113	28.3	84	12.4
28-Aug-70	158	24.3	23	17.6	107	26.8	108	16.0
25-Aug-92	20	18.9	4	10.3	4	15.4	6	20.7
30-Aug to 5-Sep,								
03-Sep-66	81	10.3	69	33.0	59	13.4	174	34.8
31-Aug-67	22	12.0	25	41.7	19	16.8	81	31.3
30-Aug-68	38	12.7	13	21.7	21	12.5	85	20.9
05-Sep-68	21	7.0	17	28.3	16	9.5	90	22.2

Appendix Table C-8 (cont.). Spawning ground survey data from Lookingglass Creek for 1966 to 1970 and 1992[a].

Date Range, Survey date[a]	Fish				Redds			
	Live	(%)	Dead	(%)	Occupied	(%)	Unoccupied	(%)
30-Aug to 5-Sep (cont.),								
04-Sep-69	56	10.4	51	43.6	43	14.2	177	24.0
03-Sep-70	58	8.9	51	38.9	48	12.0	178	26.3
01-Sep-92	26	24.5	6	15.4	10	38.5	6	20.7
06-Sep to 12-Sep,								
08-Sep-66	23	2.9	58	27.8	--	--	--	--
07-Sep-67	3	1.6	19	31.7	2	1.8	76	29.3
12-Sep-68	3	1.0	10	16.7	2	1.2	105	25.9
11-Sep-69	6	1.1	21	18.0	4	1.3	226	30.7
09-Sep-70	12	1.8	38	29.0	12	3.0	221	32.6
09-Sep-92	10	9.4	10	25.6	8	30.8	13	44.8
13-Sep to 19-Sep								
13-Sep-66	8	1.0	18	8.6	--	--	--	--
18-Sep-66	2	0.2	10	4.8	--	--	--	--
15-Sep-92	22	20.8	13	33.3	--	--	--	--

[a] Endemic stock age structure was summarized from Burck (1967,1968,1969,1970,1971).

Appendix Table C-9. Water temperatures (°C) in Lookingglass Creek for 1992, taken at rivermile 7.5 (USFS unpublished data)[a].

Week	Week Ending	Temperature (°C) Max.	Min
25	6/24	14.4	7.2
26	7/1	13.3	6.7
27	7/8	12.2	6.1
28	7/15	13.3	6.1
29	7/22	13.3	6.7
30	7/29	12.8	6.1
31	8/5	12.2	6.1
32	8/12	12.8	6.1
33	8/19	12.2	6.1
34	8/26	11.1	5.0
35	9/21	11.1	5.0
36	9/91	10.0	4.4
37	9/16	10.0	4.4
38	9/23	10.0	6.1
39	9/30	9.4	5.0
40	10/7	7.8	4.4
41	10/14	7.8	3.9
42	10/21	7.8	4.4
43	10/28	9.4	4.4
44	11/4	6.1	3.9
45	11/11	5.6	3.3
46	11/18	5.6	1.1
47	11/25	5.0	2.2
48	12/2	4.4	1.7
49	12/9	5.0	2.8
50	12/16	4.4	1.1
51	12/23	5.0	2.2
52	12/31	5.0	2.2

[a] Temperatures are the maximum and minimum of the 7-day period.