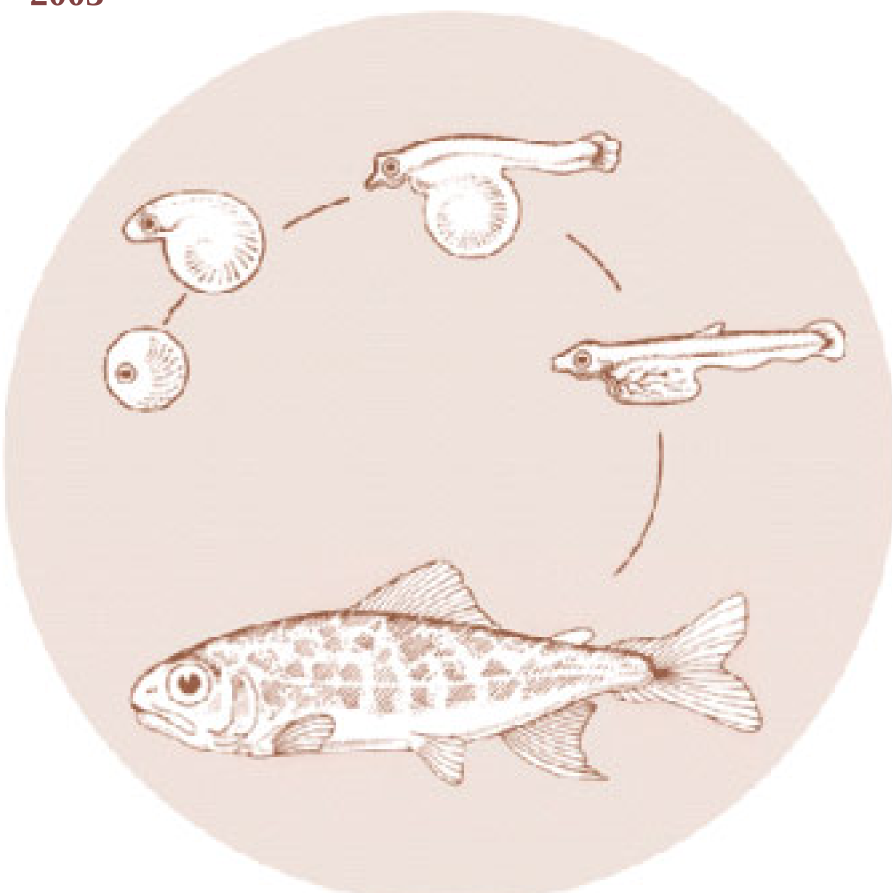
Kelt Reconditioning: A Research Project to Enhance Iteroparity in Columbia Basin Steelhead (Oncorhynchus mykiss)

Annual Report
2003



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2003 Annual Report

Kelt Reconditioning: A Research Project to Enhance Iteroparity in Columbia Basin Steelhead *(Oncorhynchus mykiss)*

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ABSTRACT

Repeat spawning is a life history strategy that is expressed by some species from the family Salmonidae. Rates of repeat spawning for post-development Columbia River steelhead *Oncorhynchus mykiss* populations range from 1.6 to 17%. It is expected that currently observed iteroparity rates for wild steelhead in the Basin are severely depressed due to development and operation of the hydropower system and various additional anthropogenic factors. Increasing the natural expression of historical repeat spawning rates using fish culturing methods could be a viable technique to assist the recovery of depressed steelhead populations. Reconditioning is the process of culturing post-spawned fish (kelts) in a captive environment until they are able to reinitiate feeding, growth, and redevelop mature gonads. Kelt reconditioning techniques were initially developed for Atlantic salmon *Salmo salar* and sea-trout *S. trutta*. The recent Endangered Species Act listing of many Columbia Basin steelhead populations has prompted interest in developing reconditioning methods for wild steelhead populations within the Basin. To test kelt steelhead reconditioning as a potential recovery tool, we captured wild emigrating steelhead kelts from the Yakima River and evaluated reconditioning (short and long-term) success and diet formulations at Prosser Hatchery on the Yakima River.

Steelhead kelts from the Yakima River were collected at the Chandler Juvenile Monitoring Facility (CJMF, located on the Yakima River at river kilometer 75.6) from 12 March to 28 May 2003. In total, 690 kelts were collected for reconditioning at Prosser Hatchery. Captive specimens represented 30.8% (690 of 2,235) of the entire 2002-2003 Yakima River wild steelhead population, based on fish ladder counts at Prosser Dam. All steelhead kelts were reconditioned in circular tanks, fed freeze-dried krill and received hw-wiegandt multi vit dietary supplement; long-term steelhead kelts also received Moore-Clark pellets. Oxytetracycline was administered to reconditioned fish to boost immune system response following the stress of initial capture. Formalin was also administered to prevent outbreaks of fungus and we also intubated the fish that were collected with Ivermectin™ to control internal parasites (e.g., *Salmincola spp.*). Captured kelts were separated into two experimental groups: short-term and long-term reconditioning. Success indicators for the short-term experiment include the proportion of fish that survived the reconditioning process and the proportion of fish that initiated a feeding response. Short-term kelts were reconditioned for 3 to 7 weeks. Surviving specimens were released for natural spawning on June 4, 2003. Survival-to-release was very good for the short-term experiment, with a rate of 89.9%. Long-term steelhead kelts were held for 5-9 months then released on December 8, 2003. Long-term success indicators include the proportion of fish that survived the reconditioning process and the proportion of surviving fish that successfully remature. Survival and rematuration for long-term kelts increased as well with 62.4% surviving to release and 91.7 % rematuring. A total of 47 reconditioned kelts were radio tagged to assess their spawning migration behavior and success following release from Prosser Hatchery and to evaluate in-season homing fidelity.

As in previous years, the kelts reconditioned during this project will substantially bolster the number of repeat spawners in the Yakima River. Valuable knowledge regarding kelt husbandry, condition, and rearing environments were obtained during this research endeavor. The authors were very pleased with the high survival rates. Information collected during this feasibility study has been significantly incorporated into the experimental design for upcoming years of research, and is expected to continue to increase survival of long-term reconditioned fish and successful expression of iteroparity.

ACKNOWLEDGEMENTS

The Bonneville Power Administration, under the direction of the Northwest Power and Conservation Council funded this project. We sincerely appreciate the support, scientific review, and ongoing communication between our project staff and these groups. We appreciate the assistance of Roy Beaty, the project's former Contracting Officer Technical Representative, for his help with the 2003 research endeavor and his successor Tracy Noice the current Contracting Officer Technical Representative for her support of this project. The U.S. Bureau of Reclamation owns the land and the fish facilities, and provided services to Prosser Dam and Prosser Hatchery, and we appreciate their support.

We also thank Michael (Sonny) Fiander, Carrie Skahan, Chuck Carl, Mark Johnston, Bill Fiander and other Yakama Nation Fisheries Program staff for providing fish husbandry and telemetry expertise. This work would not have been possible without their assistance. We thank André Talbot, Phil Roger, John Whiteaker, Bobby Begay, and Jeff Fryer from the Columbia River Inter-Tribal Fish Commission for their assistance in the field, comments on the project, and reviews of the annual report. Lastly, we thank the University of Idaho and the National Marine Fisheries Service for coordination and for donating radio tags to this project.

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1.0 INTRODUCTION

1.1 History

Populations of wild steelhead *Oncorhynchus mykiss* have declined dramatically from historical levels in the Columbia and Snake rivers (Nehlsen et al. 1991; NRC 1996; *US v. Oregon* 1997; ISRP 1999). Since 1997[1] steelhead in the upper Columbia River have been listed as endangered under the Endangered Species Act (ESA). Those in the Snake River have been listed as threatened, since 1997[1]. Stocks originating in the mid-Columbia were listed as threatened in 1999[2]. Causes of the declines are numerous and well known (TRP 1995; NPPC 1986; NRC 1996; ISRP 1999). Regional plans recognize the need to protect and enhance weak upriver steelhead populations while maintaining the genetic integrity of those stocks (NPPC 1995).

Iteroparity rates for *0. mykiss* were estimated to be as high as 79% for 1994-96 in the Utkholok River of Kamchatka (MSU undated; M. Powell UI and R. Williams, ISRP personal communication). Reported iteroparity rates for Columbia basin steelhead are considerably lower, due largely to high mortality of downstream migrating kelts at hydropower dams (Evans and Beaty 2001), and to inherent differences in iteroparity rate based on latitudinal and inland distance effects (Withler 1966; Bell 1980; Fleming 1998). Outmigrating steelhead averaged 58% of annual upstream runs in the Clackamas River from 1956 to 1964 (Gunsolus and Eicher 1970). The highest recent estimates of repeat spawners from the Columbia River Basin were in the Kalama River (tributary of the unimpounded lower Columbia River) have exceeded 17% (NMFS 1996). Farther upstream, 4.6% of the summer run in the Hood River (above only one mainstem dam) are repeat spawners (J. Newton, ODFW, pers. comm.). Iteroparity rates for Klickitat River steelhead were reported at 3.3% from 1979 to 1981 (Howell et al. 1984). Summer steelhead in the South Fork Walla Walla River have expressed 2% to 9% iteroparity rates (J. Gourmand, ODFW, pers. comm.), whereas repeat spawners composed only 1.6% of the Yakima River wild run (from data in Hockersmith et al.

[1] Final Rule 8/18/97: 62 FR 43937-43954.
[2] Final Rule 3/25/99: 64 FR 14517-14528.

1995) and 1.5% of the Columbia River run upstream from Priest Rapids Dam (L. Brown, WDFW, unpubl. data).

1.2 Rationale

Post spawn steelhead represent the portion of the population that successfully survived through an entire life cycle and spawned. These fish have experienced and survived stochastic events and selective forces and have reached a life stage that is less prone to mortality factors than any previous stage. Investing efforts to revitalize the kelt steelhead life history strategy could be a very cost and biologically effective tool for restoration. Kelt reconditioning promotes re-initiation of feeding, thereby enabling kelts to survive and rebuild energy reserves required for gonadal development and iteroparous spawning. Techniques used in kelt reconditioning were initially developed for Atlantic salmon *Salmo salar* and sea-trout *S. trutta.* A review of these studies and those applicable to steelhead kelts are summarized in Evans et al. (2001). Additional reviews of this subject (Hatch et al. 2002) provide strong support of the benefits of kelt reconditioning to address population demographic and genetic issues in steelhead recovery. This project identifies and systematically tests short- and long-term kelt reconditioning approaches.

1.2.1 Short-Term Reconditioning Study

In addition to the long-term reconditioning investigation, short-term reconditioning issues also require evaluation. Successful expression of iteroparity in steelhead may be limited by post-spawning starvation and downstream passage through the mainstem corridor. Thus, short-term reconditioning may augment iteroparity rates by initiating the feeding process and allowing kelts to naturally undergo gonadal recrudescence in the estuary and marine environments. Short-term reconditioning is defined as the period of time needed (approx. 3-9 weeks) for kelts to initiate post-spawning feeding, followed by the transportation of kelts around mainstem hydroelectric facilities for release, natural rearing, and rematuration in the Pacific Ocean. Last year we observed high levels of survival at 89.9% for the short-term reconditioning, with a small amount of “feeders”

(fish maintaining or increasing weight was approximately equal to 6.4%). As expected, there were no re-maturing steelhead kelts during the short-term reconditioning.

1.2.2 Long-term Reconditioning Study

We have defined long-term reconditioning as holding and feeding post-spawn steelhead until approximately the end of the calendar year and then releasing them at Prosser Hatchery, thus allowing them to mingle with the upstream run. By this time most surviving fish remature. Based on the past three years' results, long-term feasibility of steelhead reconditioning looks promising. Survival rates have improved from 19.6% in 2001 to 62.4% in 2003. During 2003, we continued with the most efficient and successful of the long-term steelhead reconditioning regimes by repeating the most successful diet and treatment identified during the 2001 and 2002 studies (krill and Moore-Clark pellets) (Hatch et al. 2001 and Hatch et al. 2002).

1.2.3 Biotelemetry

The ultimate success of kelt reconditioning should be assessed based on the number of individuals that successfully spawn in the wild following reconditioning and release. Although it is difficult to witness individual fish spawning in the wild, and even more difficult to assess the viability and quality of gametes, we have designed future experiments to determine if reconditioned kelts contribute to subsequent generations.

Data collected by Foster and Schom (1989) provided evidence that the ability to home in Atlantic salmon kelts is imprinted during the fish's juvenile life stage and that reconditioning does not alter homing instincts. Because the kelts collected at Prosser Dam are wild fish that could have originated in any of several upstream areas, we cannot know locations of specific spawning grounds for specific individuals. However, use of radio telemetry techniques and Passive Integrated Transponder (PIT) tags can help address such critical uncertainties.

2.0 Tasks and Objectives

2.1 Area and Facilities

Kelt reconditioning research was conducted at the Prosser Fish Hatchery in Prosser, Washington. Prosser Hatchery is located on the Yakima River at river kilometer, (rkm) 75.6, downstream from Prosser Dam, and adjacent to the Chandler Juvenile Monitoring Facility (CJMF). The Yakima River is approximately 344 km in length and enters the Columbia River at rkm 539. Summer steelhead populations primarily spawn upstream from Prosser Dam in Satus Creek, Toppenish Creek, Naches River, and other tributaries of the Yakima River (TRP 1995). The Yakama Nation (YN) operates Prosser Hatchery, with a primary function of rearing, acclimation, and release of fall chinook salmon *O. tshawytscha*. The facility is also used for coho salmon *O. kisutch* rearing prior to acclimation and release in the upper Yakima River Basin.

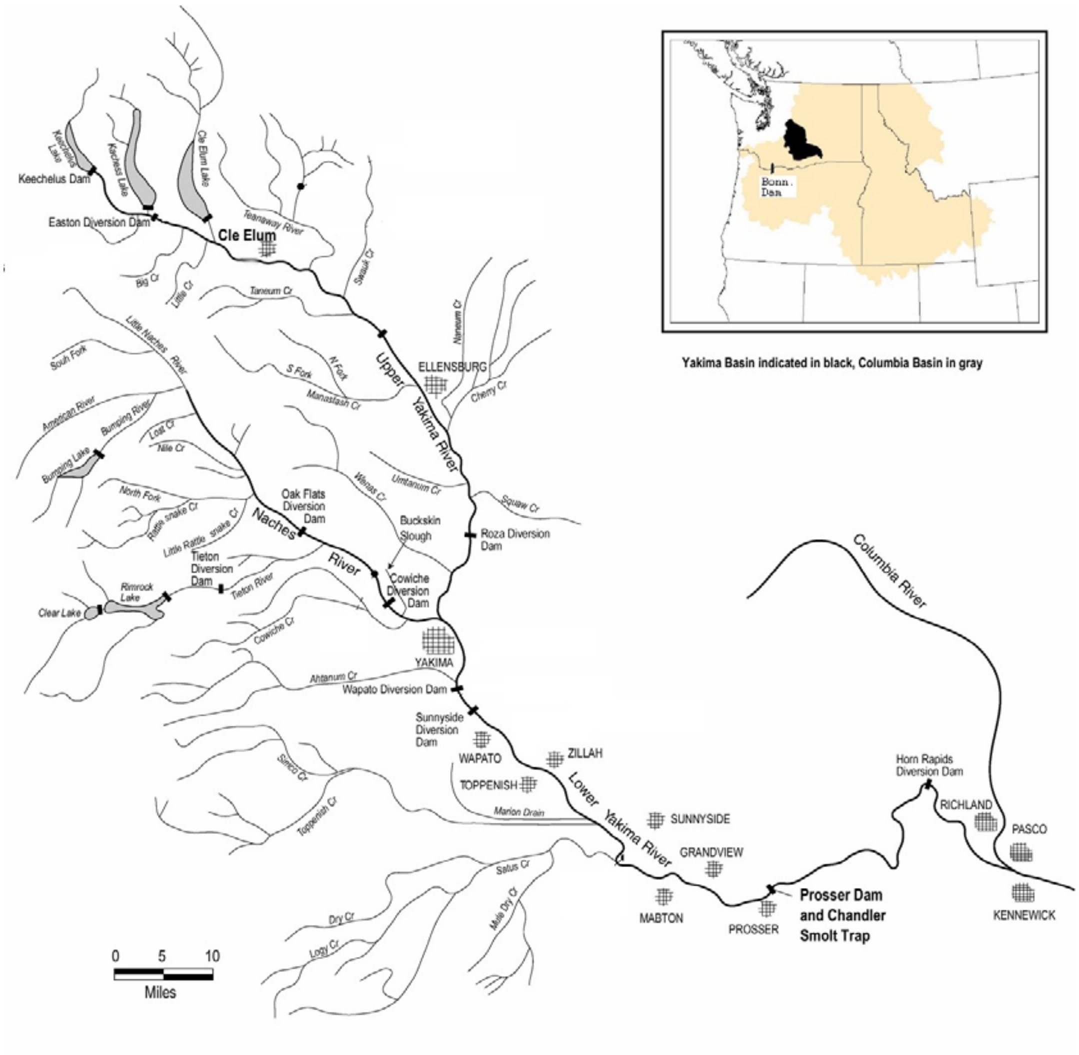

Figure 1: Yakima River Basin.

2.1.1 Kelt Collection and In-Processing

After spawning naturally in tributaries of the Yakima River, a proportion of the steelhead kelts that encounter the Prosser Dam facility during emigration are diverted into an irrigation channel that directly connects to the Chandler Juvenile Monitoring Facility. The CJMF diverts migratory fishes away from the irrigation canal to reduce mortality associated with agriculture. Once diverted into the CJMF, emigrating kelts can be manually collected from a fish separation device (a device which allows smaller juvenile salmonids to “fall through” for processing in the juvenile facility while larger fish can be dipnetted off the separator for processing or release back to the river). Yakama Nation (YN) staff monitored the Chandler bypass separator 24 hours a day from 12 March to

21 June 2003. All adult steelhead arriving at the CJMF separator, regardless of maturation status (kelt or pre-spawn[3]), were dipnetted off the separator and placed into a water-lubricated PVC pipe slide that was directly connected to a temporary holding tank 20' (l) x 6' (w) x 4'(h) containing oxygenated well water (57^{0}F or 13.8^{0}C).

Out-migrating steelhead kelt specimens were transferred with a dipnet from the temporary holding tank to a nearby 190-L sampling tank containing fresh river water, and anesthetized in a buffered solution of tricaine methanesulfonate (MS-222) at 60 ppm.

All specimens visually determined to be prespawn individuals were immediately returned to the Yakima River. Following kelt identification, we collected data on weight (collected in pounds but converted to kg for this report), condition (good- lack of any wounds or descaling, fair- lack of any major wounds and/or descaling, poor- major wounds and/or descaling), coloration (bright, medium, dark), and presence or absence of physical anomalies (e.g., head burn, eye damage). Steelhead kelts in poor condition and dark in color were released back in the river, all others were retained for reconditioning. Passive Integrated Transponder (PIT) tags (if not already present) were then implanted in the fish's abdominal cavity for individual fish identification during reconditioning.

2.1.2 Reconditioning Tanks

Upon admission of kelts to the reconditioning program at Prosser Hatchery, all kelts were retained in one of four 20'(l) x 20'(w) x 4'(h) circular tanks. Individual tank carrying capacity was set at a maximum of 200 fish based on the aquaculture experience of YN hatchery staff, and the project goal of maximizing kelt survival in captivity. Formalin was administered five times weekly at 1:6,000 for 1 hour in all reconditioning tanks to prevent fungal outbreaks.

[3] The term pre-spawner refers to a sexually mature fish that has yet to spawn.

In kelt reconditioning tanks, severe infestation of parasites can be lethal to cultured fishes, steelhead may be especially susceptible to *Salmincola* in such environments. *Salmincola* is a genus of parasitic copepods that can inhibit oxygen uptake and gas exchange at the gill lamellae/water surface interface by attachment to the lamellae. Recent research by Johnson and Heindel (2000), suggested that Ivermectin™ – a treatment often used to control parasites in swine and cattle – increases the survivorship of cultured fish by killing the adult morph of the parasite. Due to its successful use in treating *Salminicola* in this project's kelt reconditioning experiments during 2000 (Evans and Beaty 2000), Ivermectin™ was diluted with saline (1:30) and injected into the posterior end of the fish's esophagus using a small (1cc) plastic syringe. As in previous years, success of Ivermectin™ treatment was assessed based on the prevalence of parasites in test fish relative to non-treated fish at release. Fish received two additional treatments this year with an initial treatment of Oxytetracycline and hw-wiegandt multi vit a dietary supplement. Success was assessed based on increased survival and increases in weight gain.

2.1.3 Kelt Mortality

The following data was collected on all kelts that died during the reconditioning process at Prosser Hatchery. On discovery of a mortality, fish were first subjected to an external examination by hatchery personnel to record the suspected time of death, general condition (good, fair, poor), fish color (bright, intermediate, dark), color of the gill arches (red, pink, white), size of the abdomen (fat, thin), presence of any scars or obvious lesions, and any other anomalies. Once the external exam was completed, an internal examination was conducted to record color of muscle tissue (red, pink, white), type of gonads (ovaries, testes), size of gametes (small, large), and presence of any internal anomalies. PIT tags were also removed from mortalities and identification numbers were entered into a computer database along with the growth measurement data.

2.1.4 Maturation Assessment and Release for Spawning

Upon release all surviving steelhead in the long-term experiment were examined with ultrasound equipment to assess maturation status. Steelhead from the short-term experiment were weighed prior to release on 4 June 2003, to ascertain if they were feeding. Based on weight change during captivity, we classified surviving specimen as feeders or non-feeders. Fish in the long-term experiment were released on 8 December 2003 to coincide with natural spawn timing. Growth measurement data and rematuration status were also recorded on all released individuals. Overall success of the reconditioning process was based on the proportion of fish that survived the reconditioning process and specifically for the long-term experiment the number of fish that successfully rematured (based on ultrasound examinations).

2.2 Objectives

In order to evaluate the feasibility of kelt reconditioning as a potential recovery and restoration strategy for wild steelhead in the Columbia River basin, this project was designed to satisfy the following research objectives:

Objective 1: Implement and evaluate short-term kelt reconditioning, transportation and release downstream from Bonneville Dam.

Objective 2: Continue to refine and improve efficiency and success of long-term steelhead reconditioning at the Prosser Hatchery.

Objective 3: Assess homing fidelity of steelhead kelts following their release from the reconditioning program

2.3 Short-Term Reconditioning

Objective 1: Implement and evaluate short-term kelt reconditioning, transportation and release downstream from Bonneville Dam.

2.3.1 Feeding and Treatment

Short-term reconditioned kelts were fed a diet of krill for the duration (3-7 weeks) of their captivity. The following design, employing one tank was used:

C1 = Fish were collected and reconditioned from 16 April to 4 June 2002 and received a diet of freeze-dried krill.

2.3.2 Truck Transport

All short-term conditioned kelts were transported then released via truck at the Hamilton Island Boat Ramp, below Bonneville Dam. We expect fish to return from this study in 2005 and possibly 2006.

2.4 Long-Term Reconditioning

Objective 2: Continue to refine and improve efficiency and success of long-term steelhead reconditioning at the Prosser Hatchery.

2.4.1 Feeding and Treatment

The long-term conditioned fish were fed a combination of freeze-dried krill for 2.5 months and unaltered Moore-Clarke pellets.

C2 = Fish were collected and reconditioned from April 4 to December 8, 2003.

C3 = Fish were collected and reconditioned from May 12 to December 8, 2003.

C4 = Fish collected and reconditioned from March 12 to December 8, 2003.

2.4.2 Minimize Eye Damage Experienced by Long-Term Reconditioned Steelhead Kelts

During the past two years of the project, relatively high numbers of reconditioned steelhead kelt were observed with damaged eye(s) at the Prosser Hatchery. The fish's behavior to avoid negative effects of direct sunlight (i.e. seeking shade) has contributed to eye infections. The problem is significant enough that it requires attention to reduce the prevalence and severity of eye damage. The general solution is to provide shade to all kelts in the reconditioning tanks at Prosser Hatchery. We anticipated that providing more shade would disperse fish towards the center of the tank, thereby reducing eye damage caused by individual fish rubbing against the tank wall. We identified, tested, and implemented the most practical, cost-effective, and successful approaches to rectify this problem. Last year large tank covers to increase overall shading were installed,

painting the bottom of the tanks a blue color but leaving the tank walls white, and delivering food in different locations around the tank to minimize crowding (e.g., we have observed kelts crowding in the same tank location in anticipation of feeding).

2.5 Biotelemetry

Objective 3: Assess homing fidelity of steelhead kelts following their release from the reconditioning program

2.5.1 Radio Telemetry

We instrumented two lots of fish from the long-term reconditioning release to investigate in-season homing and migration patterns. We obtained 24 Lotek Inc. radio tags from the University of Idaho (UI) and 23 from the Bureau of Reclamation (BOR) to observe in-season homing and migration movements. Each tag had unique bandwidth pulses that provided individual identification codes. The tags used for the in-season homing investigation were programmed to last a minimum of 30 days while the tags used to observe migration routes were programmed to last for at least 155 days. Radio tags were placed using the gastric insertion technique.

The 23 fish used for the in-season homing investigation were trucked to the Wallula Gap near the McNary Dam (Rkm 509) pool and released on December 8, 2003. Assessment of in-season homing will be based on observations of this tagged fish back to the Yakima River Basin and will be included in the next annual report.

A total of 24 long-term reconditioned steelhead used to observe migration routes and spawning ground selection were released at the Mabton boat launch near Prosser Hatchery on December 8, 2003. These fish will be tracked using fixed and mobile tracking systems in conjunction with telemetry work currently being conducted on coho salmon.

Fixed receiver sites are located at Prosser Dam (Rkm 75.6), Slagg Ranch (Rkm 106.2), Sunnyside Dam (Rkm 167.0), Roza Dam (Rkm 205.8), Naches River (Cowiche Dam Rkm 5.8), Toppenish Creek (Rkm 71.1), and Simcoe Creek (Rkm 13.0). Aerial flights

are planned for the spring of 2004, these have proven to be essential in locating fish and investigating the disappearance of kelts. Flights will be conducted in all basins and prioritized by fish movement. Mobile tracking will be done by road and by raft. Mobile tracking allows for actual pinpoint locations and observations of steelhead kelt redd construction and spawning. The mobile and fixed radio-tracking receivers made by Lotek Inc. and National Marine Fisheries Service (NMFS) will be used in 2004-05. We will primarily rely upon upstream movement and visual observations as indicators of live fish. Tags will be recovered from dead fish whenever possible. Results from this aspect of the study will be published in 2004.

2.5.2 PIT Tags

Kelt movement, timing, and survival can be assessed with PIT-tags as the fish move through the hydropower system in the Yakima and Columbia rivers. When caught on their return migration to the ocean, the staple-sized tags are implanted into the abdominal cavity via syringe. All kelts held for reconditioning have a PIT tag implanted (if one is not already present). Each tag is unique and identifies an individual fish. Automatic adult PIT detectors are present in all ladders at Bonneville and McNary Dams. At Prosser Dam, adult migrants passing upstream via the right bank denil fish ladder and trapping facility are bio-sampled and interrogated for PIT tags. These data can be helpful in telling us how many fish survive as they move from one life stage to the next or from one location to the next.

3.0 RESULTS/DISCUSSION

3.1 General Population Characteristics

A total of 690 kelts were kept for reconditioning while 136 were culled due to poor condition or found to be dead on arrival, at Prosser Hatchery from 12 March to 21 June 2003. Collection generally followed migrational waves with the peak collection day occurring around April 14 (Figure 1). The total number of kelts used for reconditioning represented 25.7% (690 of 2,235) of the entire Yakima River ESA-listed population, based on fish ladder counts obtained from Prosser Dam for the period July 1, 2002 to June 30, 2003. It is possible that many of the out-migrating kelts from the Yakima River were never diverted into the irrigation channel and passing via spillway, preventing their collection for reconditioning. A total of two kelts were determined to be of hatchery origin, based on an adipose clip.

Many of the emigrating kelts appeared emaciated upon capture at Chandler bypass. Abdominal surfaces, recorded as “thin” during in processing, were often so gaunt that the specimens had a “snake-like” appearance. The average weight of captured kelts was 2.29 kg (range: 0.61 – 4.60 kg). Research on energy expenditure during migration and spawning, a period when many salmonids are believed to stop feeding, suggested that anadromous fish depleted over 60% of their lipid, protein, and ash reserves during the spawning process (Love 1970). Much of the muscle tissue during this time was converted into water, additionally with some individuals’ digestive tracts and stomach linings becoming severely arthritic.

The overwhelming majority of kelts captured were female (Table 1). This is a consistent finding in previous steelhead kelt reconditioning work, (approximately 88% during 2000 and 2001 at Prosser Dam were female). This may be indicative of the evolutionary advantage of female iteroparity. Based on visual observations, 653 (94.6%) of the kelts were classified as female, whereas only 37 (5.4%) as male in 2003. Naturally occurring female iteroparity essentially is analogous as cryopreservation of males in iteroparous

salmon populations in the Columbia Basin. In addition, since females are naturally able to reproduce with males during different years increases the probability of increased gene flow between and among cohorts or year classes. This has a direct theoretical benefit in the form of increasing the number of breeders (N_b), and the effective population size (N_e) during each spawning season, thus contributing to increased population viability and persistence, crucial to threatened and endangered fish restoration. Rather than a genetic hazard, experimental reconditioning should be viewed as a potential demographic and population genetic enhancement measure, aimed at restoring a recently jeopardized, but naturally occurring evolutionarily stable life history strategy.

Table 1: Sex and survival to release of adult steelhead captured for reconditioning at Prosser Hatchery, 2003.

Sex	No. Captured	No. Released
Male	37 (5.4%)	12 (2.5%)
Female	653 (94.6%)	476 (97.5%)
Total	690	488

The majority of kelts collected for reconditioning during 2003 were considered in good or fair overall condition. In terms of gross morphological and physiological condition at the time of release, 340 (49.3%) kelts were classified as good, 349 (50.6%) as fair and 1 (0.1%) as being in poor condition. Regarding fish coloration, we classified 264 (38.3%) as bright, 395 (57.2%) as intermediate, and 31 (4.5%) as dark.

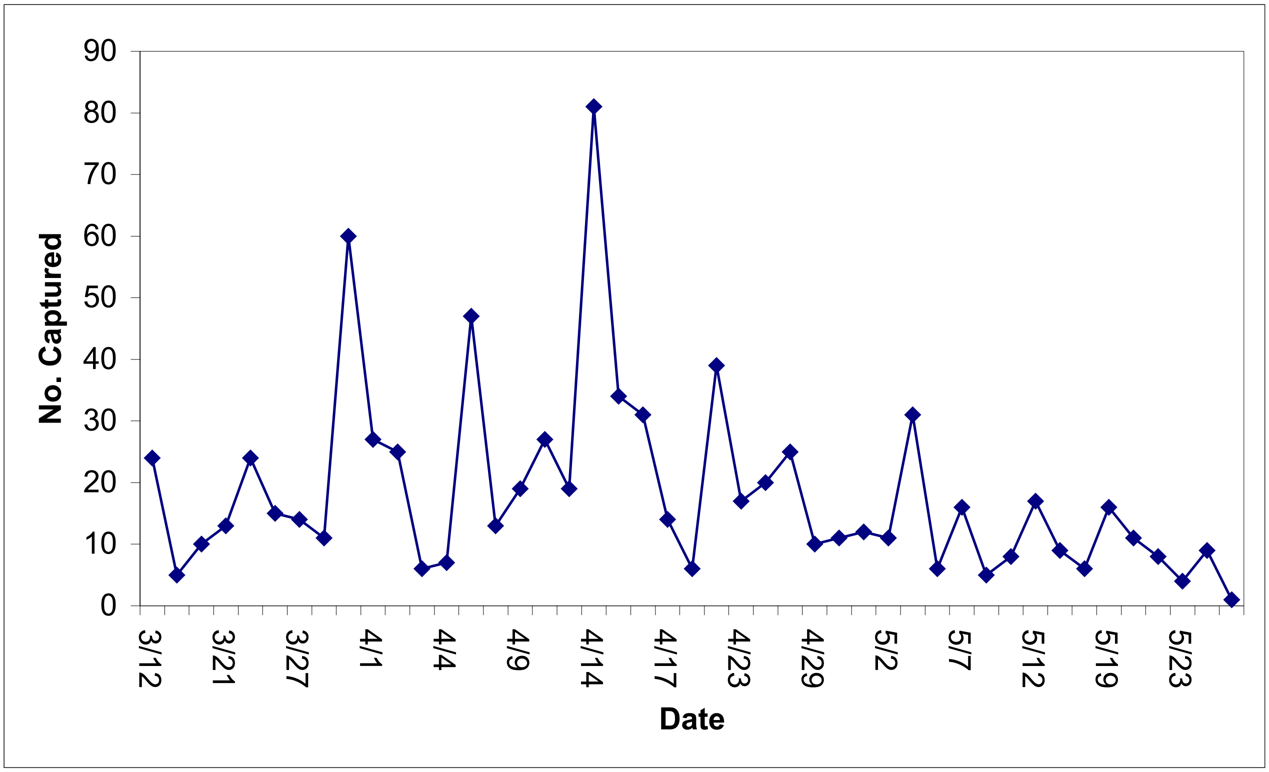

Figure 2. Kelt collection dates and numbers of fish removed from Chandler bypass facility involved in reconditioning procedures at Prosser Hatchery during 2003.

3.2 Short-Term Reconditioning

Objective 1: Implement and evaluate short-term kelt reconditioning, transportation and release downstream from Bonneville Dam.

3.2.1 Kelt Survival and Rematuration

For the short-term reconditioning experiment, kelts were captured through 16 April – 10 May 2003 and released on 4 June 2003. Survivorship in 2003 improved to 89.9% (Table 2), this was a 10% increase versus the most successful short-term reconditioning experiment in 2002. The designers of this experiment expected that kelts would not remature in such a short time span but that the fish would reinitiate feeding behavior and thus increase survival and maturation in the wild.

Table 2: Population statistics for kelts in the short-term reconditioning experiment.	
Tank	C1 (3-7 Weeks)
No. Collected	208
No. (%) Released	187 (89.9%)
No. (%) Feeders	6/187 (2.9%)
Mean In-Weight (kg.)	2.61
Mean Out-Weight (kg.)	2.45

3.2.2 Mortality Statistics

The majority of mortalities for the short-term reconditioning experiment occurred within the first ten days of capture (Figure 2). As observed in past experiments this can be attributed to handling stress, failure to accept starter feed, an inability to convert feed into an appreciable weight gain, or moribund status when collected. After the 10-day capture period mortalities decreased drastically. The high survival rates of short-term reconditioned kelts could be misleading due to the possibility that more mortalities may occur in the wild after release.

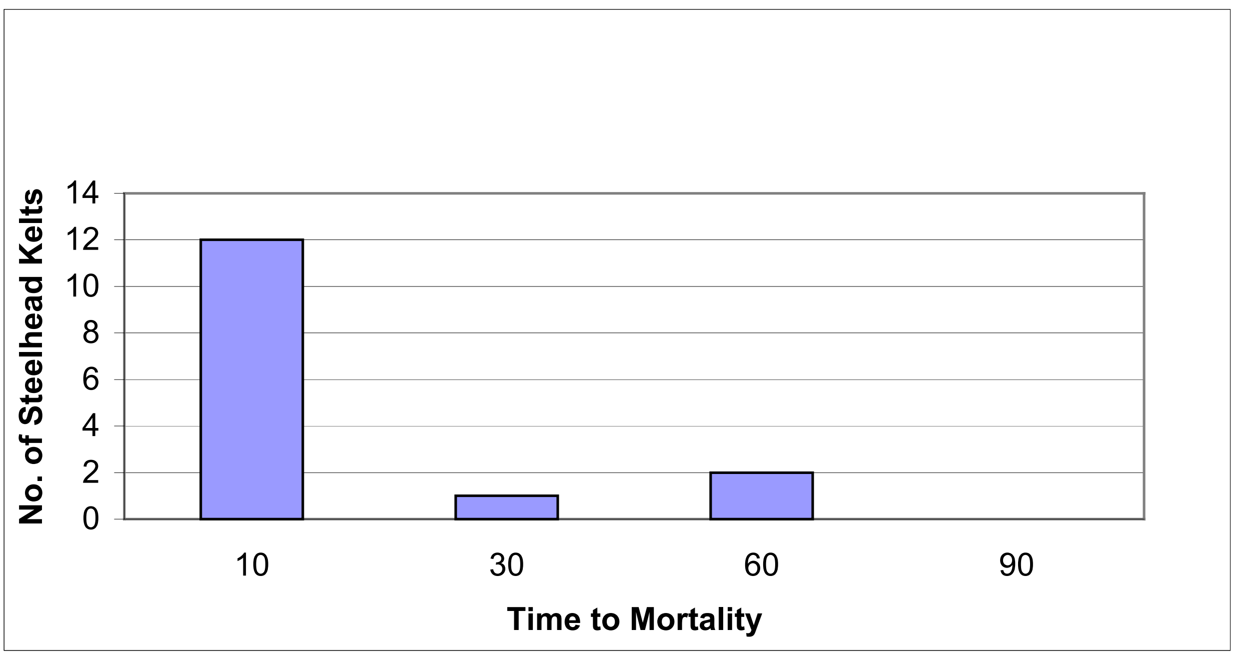

Figure 3: The number of short-term reconditioned kelts from capture-to-death that perished within the time interval at Prosser Hatchery, 2003.

3.2.3 Feeding and Treatment Summary

Short-term reconditioned steelhead kelts received a solitary diet of krill. The objective for the short-term experiment was to assist fish reacquire a feeding response. It is hypothesized that this regained feeding response will benefit the fish once they are released and have natural prey items available. Unfortunately, few kelt steelhead in the short-term experiment fed on krill this year, while very few maintained or gained weight. This may be a function of the low nutritional value in the krill-only diet or due to the relatively short reconditioning time for the addition of any measurable weight gain. Many of the short-term kelts actually lost weight for the duration of this experiment (Figure 3). This suggests that adding a greater nutritional component to the diet may be beneficial in the future. The short-term reconditioning population showed 1.7% gaining weight, 97.1% losing weight, and 1.2% with no weight change. As has been noted in last year's annual report, it appears that krill is an important component of the steelhead diet, but that there is something vital missing from a strictly krill diet for rematuration (Hatch et al. 2002).

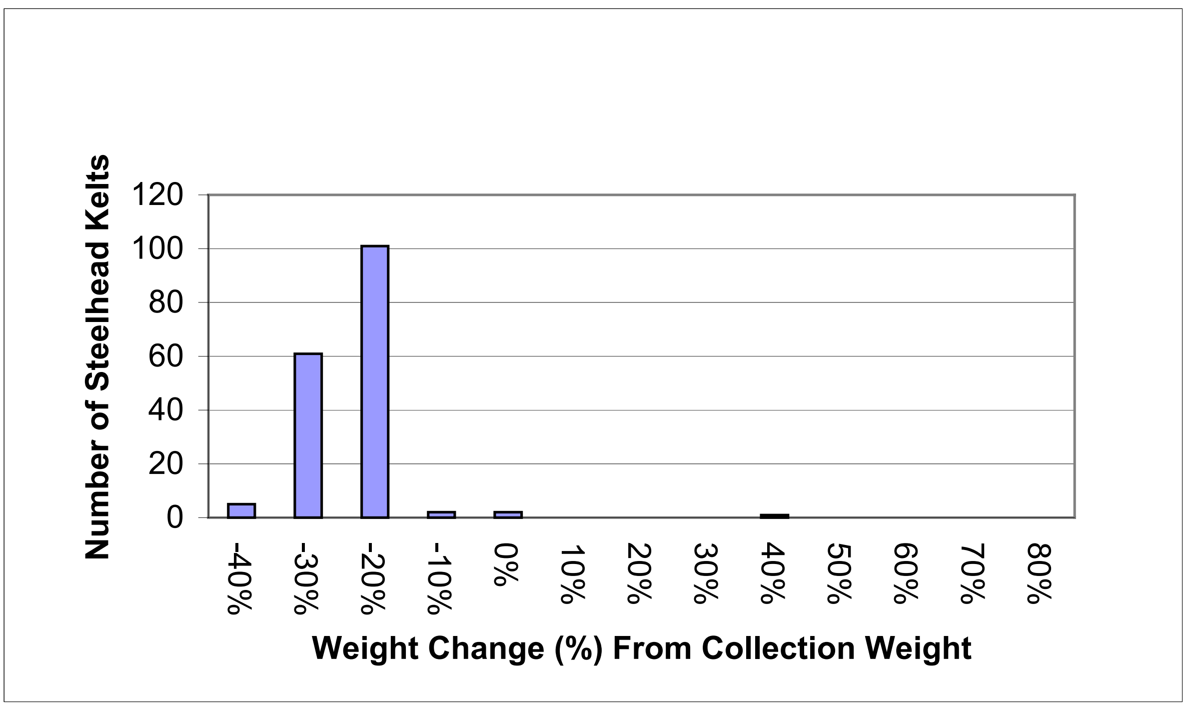

Figure 4: Weight gain distribution (weight gain as a percentage of collection weight) for short-term reconditioned kelts at Prosser Hatchery during 2003.

3.3 Long-Term Reconditioning

Objective 2: Continue to refine and improve efficiency and success of long-term steelhead reconditioning at the Prosser Hatchery.

3.3.1 Kelt Survival and Rematuration

Long-term kelts were held for 5-to-9 months in three different tanks. All of the tanks were started on a krill diet for 2.5 months and then switched to a maintenance diet of Moore-Clarke pellets for the duration of their stay. Survival percentages for all tanks were similar to each other. Maturation levels were very high for tank C3 with a 95.9% rematuring while C2 and C4 did well with approximately 80% rematuring.

Table 3: Population statistics for kelts in the long-term reconditioning experiment.

Tank	C2	C3	C4
No. Collected	205	69	208
No. (%) Released	123 (60.0%)	49 (71.0%)	126(60.6%)
No. (%) Mature	99 (80.5%)	47 (95.9%)	108 (85.7%)
Mean In-Weight (kg.)	2.17	2.39	2.52
Mean Out-Weight (kg.)	2.82	3.70	3.14
Mature Feeders (%)	88/99	44/47	95/109
(Mature feeders/total mature fish)	(88.8%)	(93.6%)	(87.1%)
Immature Feeders (%)	3/11	1/2	1/11
(feeders/immature fish)	(27.3%)	(50%)	(9.1%)

3.3.2 Mortality Statistics

Unlike past experiments, kelt mortalities occurred consistently over the course of the experiment (Figure 4). The mortality rate was much lower than the two previous years where most of the mortalities occurred within the first 10 days. The overall decrease in mortality may be attributable to the addition of new treatments. Overall, long-term mortalities declined from previously observed mortality rates by nearly 10-15%.

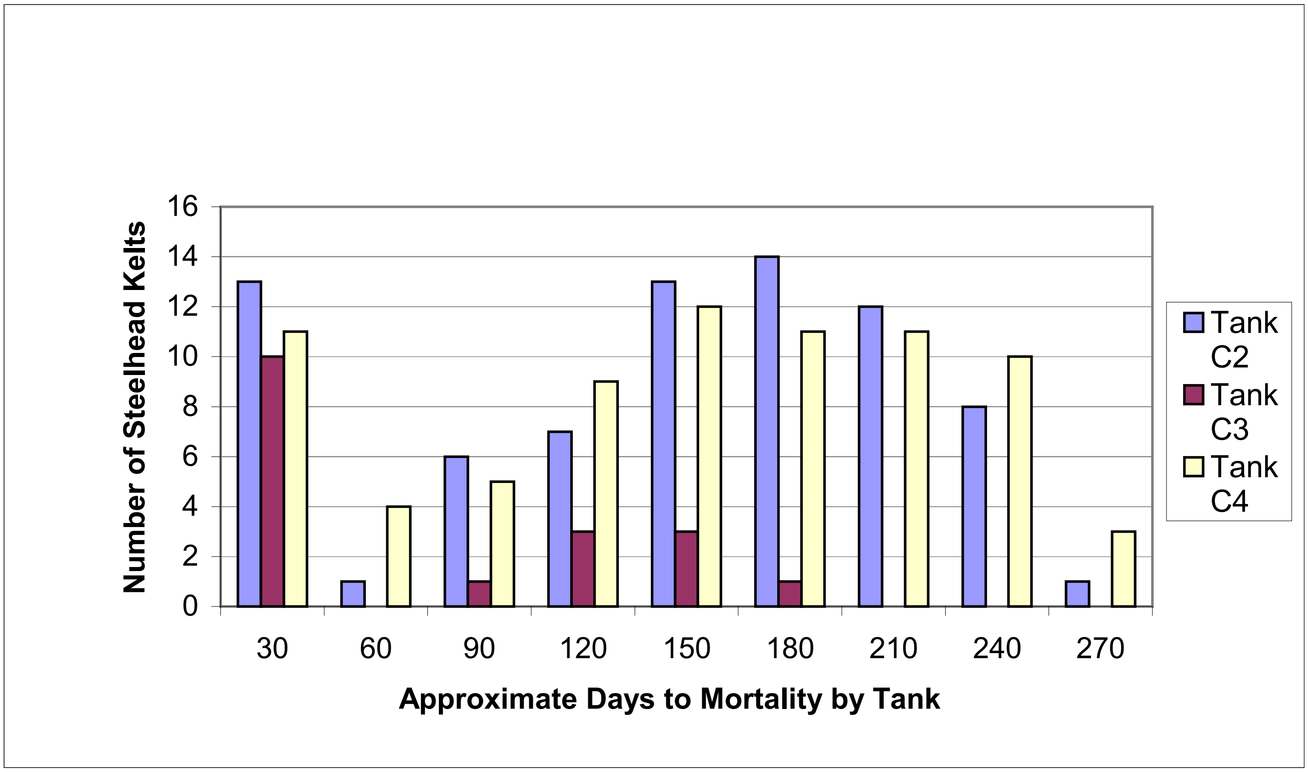

Figure 5: The number of long-term reconditioned kelts from capture-to-death that perished within the time interval at Prosser Hatchery, 2003.

3.3.3 Feeding and Treatment Summary

For all long-term experiments, steelhead kelts were fed krill as a starter diet for 2.5 months and then were given Moore-Clarke pellets based on the exceptional weight gain of the diet used in 2001 and 2002 diet experiments. In 2003 fish were administered approximately 30ml of hw- wiegandt GmbH's multi vit mixed into daily Moore-Clarke pellet feed. The majority of kelts showed appreciable weight gains (>80% of collection weight), with 166 of 278 gaining > 0.5 kg in mass. The largest individual weight increase was 152% of collection weight.   The amount of immature long-term reconditioned kelts at the time of release declined to nearly 8% in 2003. Long-term reconditioning in 2003 improved in every area, with decreases in mortality and immature kelt rates, while increasing maturity rates, individuals experiencing weight gain, and survival rate.

When comparing long-term mature kelts versus immature long-term kelts, it is apparent that the amount of weight gain plays an important role in the rematuration of steelhead kelts. Greater than 85% (Figure 5) of long-term reconditioned kelts classified as mature gained weight during the reconditioning process while 20% (5/24) of the immature fish examined on this date gained weight (Figure 6). The mean weight change for immature long–term kelts as a percentage of collection weight was –13.3% compared to 39.5% for mature fish.

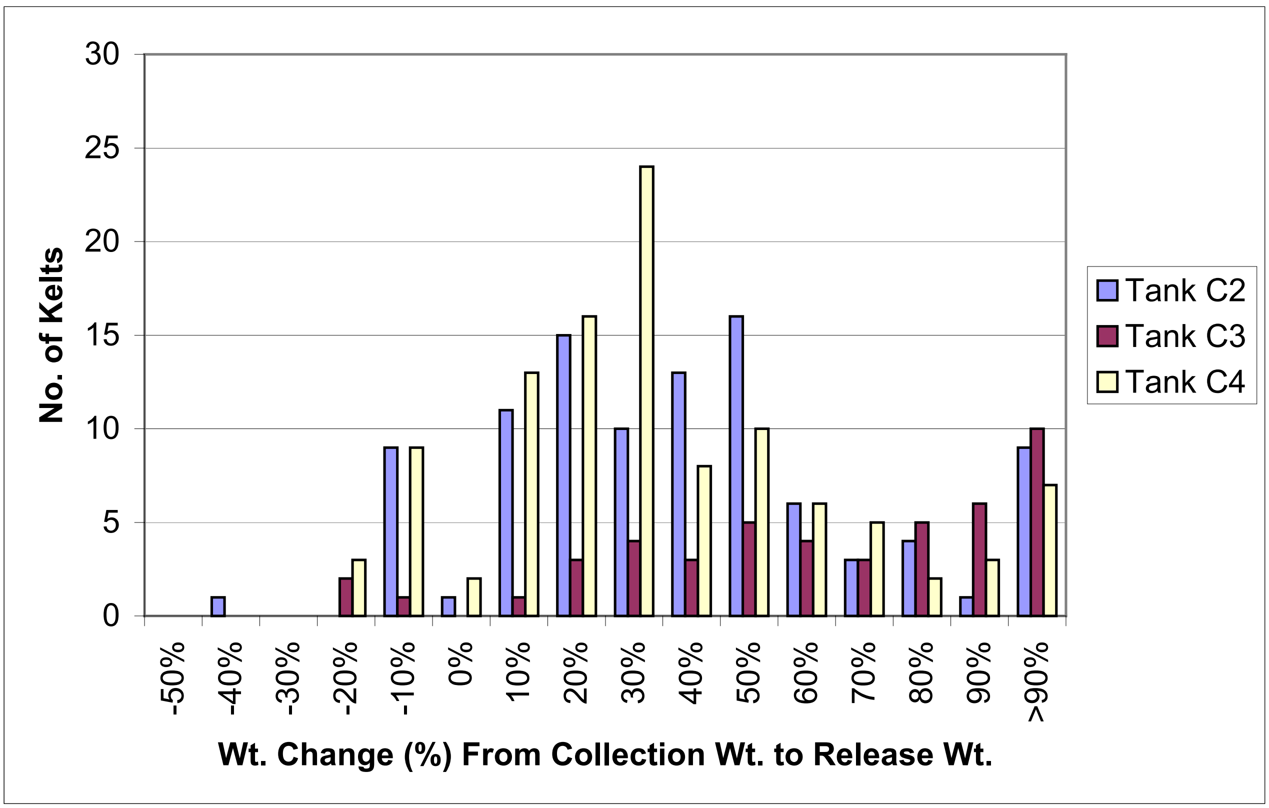

Figure 6: Weight gain (%) distribution for long-term rematured kelts at Prosser Hatchery, WA in 2003.

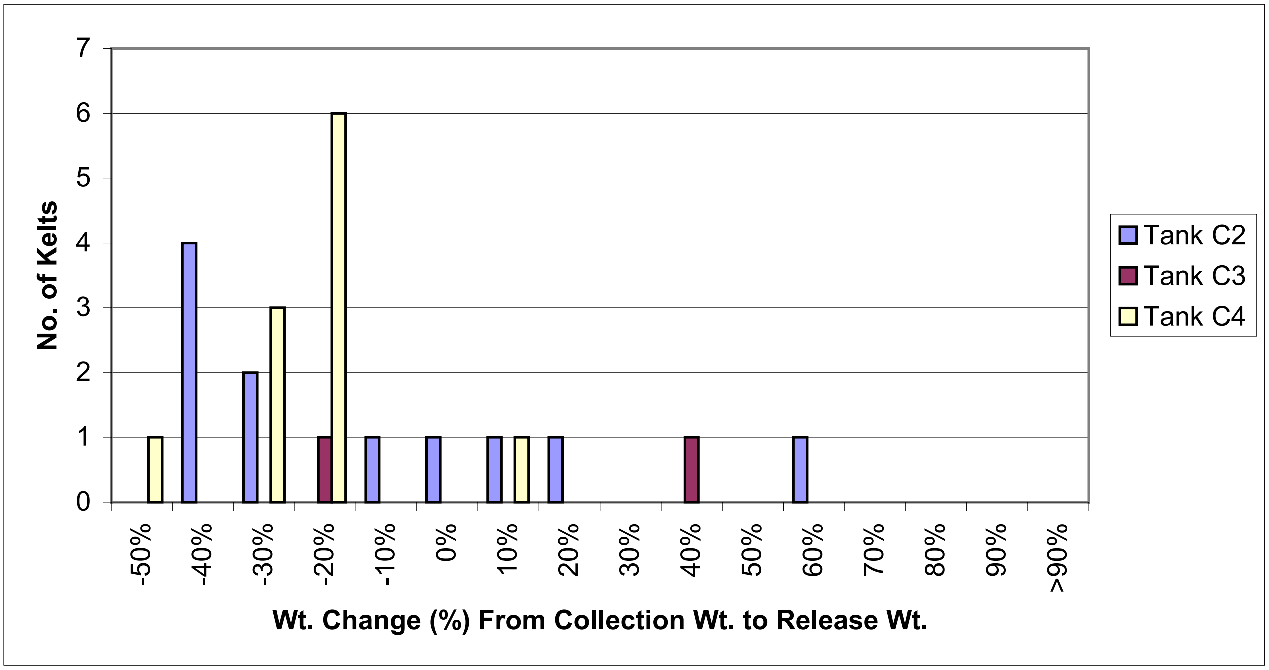

Figure 7: Weight gain (%) distribution for long-term immature kelts by tank number from Prosser Hatchery, WA in 2003.

Krill continued to be an important component for reconditioning. In addition, the continued use of Moore-Clarke pellets and the additional dietary supplement hw-wiegandt multi vit were important factors in long-term reconditioning rematuration rates.

3.3.4 Minimize Eye Damage Experienced by Long-term Reconditioned Steelhead Kelts

In 2001-2002 Yakama Nation technicians installed large tank covers to increase shading, painted the bottom of the tanks a blue color leaving the tank walls white, and dispensed food in different locations in the tank to minimize crowding. The new alterations to the tanks led to very favorable results with an overall decrease in eye damage (Table 5). Comparing short-term release versus long-term release, it appears that the longer kelts are held, the probability increases that they will incur some type of eye damage (Table 5). In 2003 paint on the tanks began to peel off possibly increasing the amount of eye damage observed. In 2004 we plan to use a rubberized coating that will utilize the same color combinations that we used initially in our painting. It appears

that eye damage may be a contributing factor to long-term reconditioned mortalities of captive steelhead while possibly playing a small role in the mortalities of short-term reconditioned kelts (Table 4).

2002 ST Mortalities	2002 ST Release	2002 LT Mortalities	2002 LT Release	2003 ST Mortalities	2003 ST Release	2003 LT Mortalities	2003 LT Release
7/108 (6.4%)	18/334 (5.3%)	11/273 (4.0%)	16/140 (11.4%)	0/15 (0%)	25/192 (13%)	23/163 (14%)	28/301 (9.8)

Table 4: number of kelts with eye damage recorded at time of release /number of kelts with eye condition records at time of release (percent of recorded specimens with damaged eyes at time of release). ST= Short-term; LT= Long-term.

3.4 Long-term vs. Short-term Reconditioning

Short-term and long-term reconditioning scenarios are schemes that can be used to assist post spawn steelhead. The short-term approach is less invasive than long-term reconditioning, is cost beneficial, and also permits the fish to utilize the therapeutic benefits of saltwater. Long-term reconditioning allows the release of rematured fish ready to spawn but it is more expensive and presents more challenges to the fish culturists. In future reports we will compare short and long-term reconditioning scenarios with other approaches such as barging collected fish and allowing kelts to remain in the river.

The mean weight change for short-term immature kelts as a percentage of collection weight was –8.7%. An average of 2.3% of the short-term population gained some appreciable weight. Greater than 85% of long-term reconditioned kelts classified as mature on the December 8, 2003 examination gained weight during the reconditioning process while 20% (5/24) of the immature fish examined on this date gained weight. The mean weight change for immature long–term kelts as a percentage of collection weight was –13.3% compared to 39.5% for mature fish. In the short-term experiments the majority of mortalities occurred within the first ten-days of capture (Figure 8) while mortalities in the long-term experiment remained at a low and fairly steady level. Short-term reconditioned fish had a greater survival rate to release (89.9%) than long-term reconditioned fish (62.4%). While these preliminary results show that short-term kelts

have a significant survival-to-release advantage compared to the long-term kelts, overall survival to return of short-term fish is likely to be significantly less than long-term kelts due to post-release mortality events such as starvation, predation, or overcoming hydrosystem obstacles. We will not be able to assess overall return rates for short-term 2003 releases until these fish return from the ocean in 2005-2006. The primary advantage to long-term reconditioning is that the rematuration levels and survival rates observed in 2003 demonstrate significant potential to provide an immediate boost to the productivity of these ESA-listed fish on the natural spawning grounds. Short-term reconditioning may be a more financially viable answer to increasing kelt rematuration. Results will not be conclusive until several return years can be evaluated.

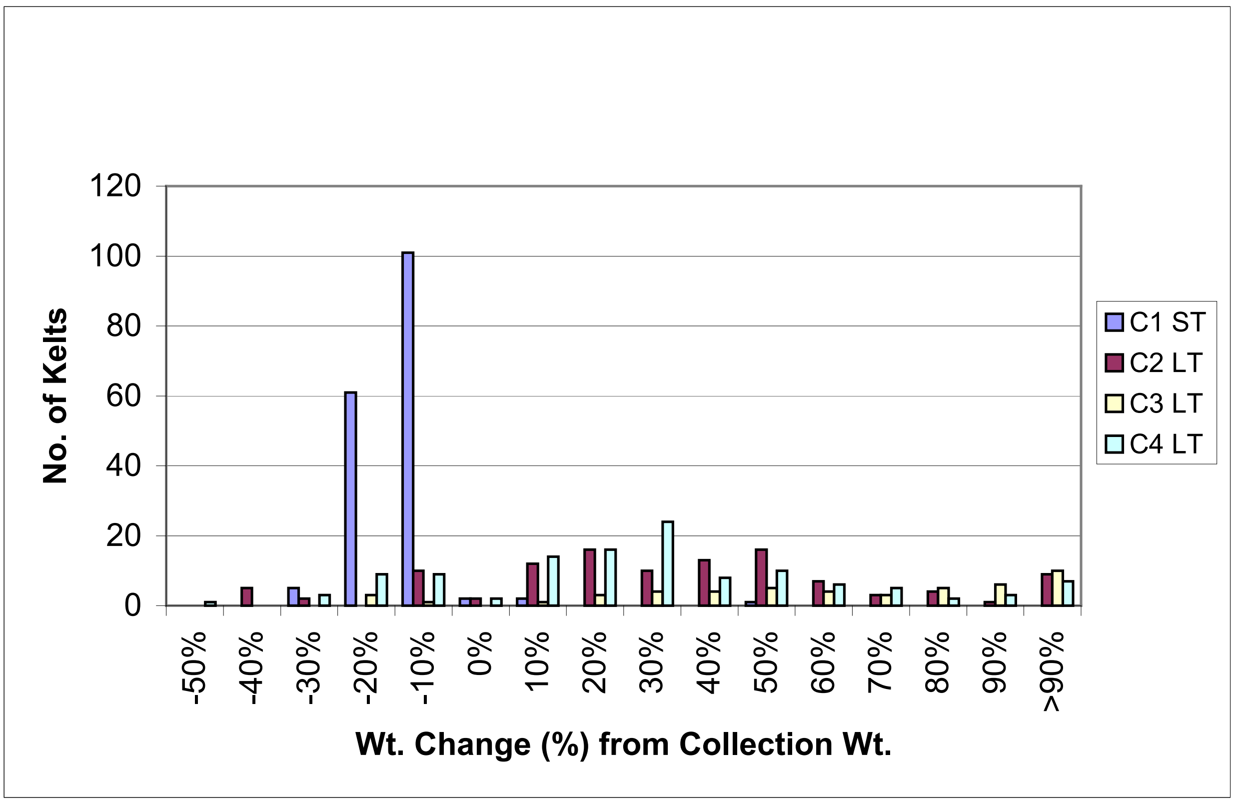

Figure 8: Weight gain (%) distribution for kelts by tank number at Prosser Hatchery, WA in 2003.

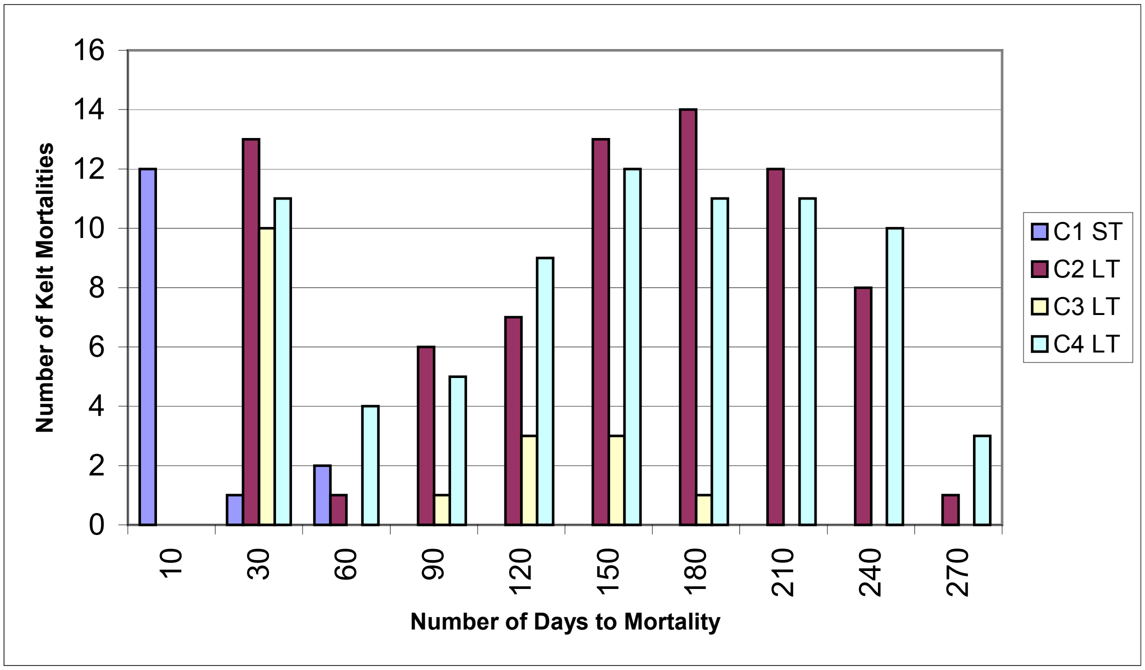

Figure 9: The number of reconditioned kelts from capture-to-death that perished within the time interval at Prosser Hatchery, 2003.

3.5 Biotelemetry

Objective 3: Assess homing fidelity of iteroparous steelhead kelts following their release from the reconditioning program

3.5.1 Radio Telemetry

2002 Experimental Data

During the 2002 season a total of 142 long-term reconditioned kelts (33.8% of all kelts collected and held for long-term reconditioning) survived reconditioning to be released, with 80 of these kelts rematuring. A total of 62 of these kelts were radio-tagged prior to their release on December 10, 2002. Of these, 33 reconditioned kelts with tags from the Yakama Nation Fisheries (channel 10) were released directly into the Yakima River near the town of Mabton (Yakima rkm 96.3) and 29 reconditioned kelts with tags from the University of Idaho (channels 11 and 23) were released into the McNary pool near Wallula Gap (Columbia rkm 509) to obtain data on homing and incidental data on spawning success. Each tag was inserted using the gastric insertion technique. Tagging and observation methods were similar to those described in section 2.5.

Of the 33 reconditioned kelts released into the Yakima River near Mabton, 15 were recaptured as spawned out kelts at Chandler in the spring of 2003 (Table 5, Appendix A). The remaining 18 of these radio tags were all tracked to locations above Prosser Dam (Appendix A). The probable spawning disposition of these fish is summarized in Table 6.

PIT code	Recapture Date	Release Weight	Recap. Weight	Release Maturity	RadioTag Channel	RadioTag Code
3D9.1BF156FFF7	14-Apr-03	7.05	6.15	1		
3D9.1BF13990C1	21-May-03	3.9	3.15	2		
3D9.1BF156F26A	6-May-03	5.1	4	1		
3D9.1BF13AD18D	14-Apr-03	5.65	5	2		
3D9.1BF139ED6E	15-Apr-03	5.95	3.9	1		
3D9.1BF13A6EDD	3-Apr-03	4.3	3.8	1		
3D9.1BF13A6EFF	28-Apr-03	6.15	5.3	1		
3D9.1BF13A4772	23-Apr-03	5.2	4.9	1		
3D9.1BF157054A	15-Apr-03	5.2	3.95	2		
3D9.1BF156A7B7	18-Apr-03	5.5	5.1	1		
3D9.1BF1457A97	24-Mar-03	6	5.7	2		
3D9.1BF13A00D5	14-Apr-03	4.8	4.3	2		
3D9.1BF13ABB86	28-Apr-03	5.05	4.45	2		
3D9.1BF13A7B6C	16-Apr-03	6.7	5.95	2		
3D9.1BF169D26B	25-Apr-03	4.45	4.05	1		
3D9.1BF13A45F4	21-Apr-03	3.95	3.6	1		
3D9.1BF156BAD5	30-Apr-03	11	9.3	1	10	1
3D9.1BF13A6FB4	12-Mar-03	8.8	7	1	10	11
3D9.1BF156ADD8	15-Apr-03	9.85	8.6	1	10	15
3D9.1BF13979AB	5-May-03	9.25	7.85	1	10	21
3D9.1BF1397607	5-May-03	9.45	6.35	1	10	33
3D9.1BF169B809	5-May-03	5.5	4.65	1	10	37
3D9.1BF165F7AF	28-Apr-03	6.45	5.75	1	10	43
3D9.1BF139ECF5	14-Apr-03	6.45	5.65	1	10	47
3D9.1BF1457F6A	16-Apr-03	8.45	7.2	1	10	51
3D9.1BF169B5D9	15-Apr-03	5.2	4.3	1	10	55
3D9.1BF13A6FB5	21-Apr-03	4.95	3.9	1	10	65
3D9.1BF13A00D4	16-Apr-03	8.35	7.4	1	10	83
3D9.1BF13A4988	6-May-03	4.9	3.9	1	10	88
3D9.1BF13A322D	28-Apr-03	9.6	8.4	1	10	91
3D9.1BF13C0579	5-May-03	7.65	6.65	1	10	93
3D9.1BF13A5A32	22-May-03	6.4	4.05	1	23	52

Table 5. Release and recapture data for 32 long-term reconditioned kelt females released on December 10, 2002 and recaptured at Chandler as spawned-out kelts in the spring of 2003. (Weight in pounds; Maturity: 1=mature, 2=immature).

Of the 29 reconditioned kelts released into the Columbia River near Wallula, only 6 had subsequent observations, and only 1 of these (channel 23 code 52) was above Prosser Dam (Appendix A). This fish was tracked to the Naches River (Table 6) and later recaptured on May 22, 2003 at Chandler as a spawned out kelt (Table 5). These radio tags were of a different type than those released in the Yakima River near Mabton. This combined with their release location and our equipment and/or survey techniques may have precluded our ability to subsequently detect these fish after release. We are employing new survey methods to track all 2003 radio-tagged releases and expect better tracking results this season.

The radio telemetry data (Appendix A) for the 34 reconditioned kelts which had subsequent observations above Prosser Dam was analyzed to make determinations about the probable spawning disposition of these fish. Based on these data we believe that: 18 (52.9%) of these fish spawned in Satus, Toppenish, or Ahtanum creeks; 8 (23.5%) of these fish spawned in Sulfur Drain, an irrigation return drain containing upper Yakima River water from the Roza Irrigation District; 5 (14.7%) of these fish spawned in the mainstem Yakima River or had no spawning success; and 3 (8.8%) of these fish spawned in the Naches or Upper Yakima River systems (Table 6).

We had very few radio telemetry “hits” within the main spawning tributaries (Satus, Toppenish, and Ahtanum creeks) themselves (Appendix A). Given the volume, frequency, and timing of radio telemetry detections in the mainstem Yakima River near the mouths of these tributaries, we believe this is probably due to the limitations of our methods and equipment rather than an indication that these fish did not spawn in the tributaries. The Lotek Radio Tags used are 155 day automatic shut off tags. Thus, tags inserted on December 10, would theoretically shut off mid to late April. In addition, many of the tags released in above McNary Pool were University of Idaho tags that were being reused from initial fall chinook tagging at Bonneville Dam. Tag life is relatively uncertain; some tags may last much longer than 155 days or shut off earlier.

The weight loss and timing data from reconditioned kelts that were recaptured at Chandler (Table 5) suggest that spawning success is likely for most, if not all, of these fish.

Chan.	Code	Suggested spawning disposition based on Radio Telemetry data	Satus Topp. Ahtn.	Sulfur Drain	Main-stem	Naches /UY
10	1	Satus Cr. (Yak. rkm 106-114)	1			
10	5	Sulfur Drain (Yak. rkm 98-99)		1		
10	7	Sulfur Drain (Yak. rkm 101-104)		1		
10	11	Toppenish Cr. (Yak. rkm 118-131)	1			
10	13	Satus Cr. (Yak. rkm 106-115)	1			
10	15	Satus/Topp/Ahtanum (Yak. rkm 112-141)	1			
10	17	Mainstem or no success (Yak. rkm 89-93)			1	
10	21	Sulfur Drain (Yak. rkm 94-101)		1		
10	25	Ahtanum Cr. (Yak. rkm 134-141)	1			
10	27	Toppenish Cr. (Yak. rkm 114-119)	1			
10	28	Satus Cr. (Yak. rkm 109-111)	1			
10	31	Mainstem or no success (Yak. rkm 75-76)			1	
10	33	Naches/Cowiche (Yak. rkm 183/Nach. 14-25)				1
10	35	Mainstem or no success (Yak. rkm 89-93)			1	
10	37	Satus or Toppenish Creek (Yak. rkm 113-123)	1			
10	41	Mainstem or no success (Yak. rkm 70-80)			1	
10	43	Satus Cr. (Yak. rkm 102-116)	1			
10	45	Above Roza Dam				1
10	47	Sulfur Drain (Yak. rkm 96-99)		1		
10	51	Satus or Toppenish Creek (Yak. rkm 110-116)	1			
10	53	Ahtanum Cr. (Yak. rkm 125-138)	1			
10	55	Sulfur (Yak. rkm 93)		1		
10	58	Sulfur (Yak. rkm 94-96)		1		
10	61	Satus Cr. (Yak. rkm 106-110)	1			
10	65	Toppenish Cr. (Yak. rkm 124-133)	1			
10	71	Mainstem or no success (Yak. rkm 75-76)			1	
10	78	Sulfur (Yak. rkm 90-94)		1		
10	81	Toppenish Cr. (Yak. rkm 125-133)	1			
10	83	Satus or Toppenish Creek (Yak. rkm 112-128)	1			
10	88	Toppenish or Ahtanum (Yak. rkm 128-139)	1			
10	91	Sulfur or Satus (Yak. rkm 98-107)	1			
10	93	Sulfur Drain (Yak. rkm 88-98)		1		
10	95	Satus Cr. (Yak. rkm 110-114)	1			
23	52	Naches (Yak. rkm 186)				1
		Total by Drainage	18	8	5	3
		Percentage by Drainage	52.9%	23.5%	14.7%	8.8%

Table 6. Summary of assumed spawning disposition based on radio telemetry data (Appendix A) for 34 long-term reconditioned kelt females released on December 10, 2002.

Three of the radio tagged fish released as reconditioned kelts on December 10, 2002 were originally PIT-tagged at Roza Dam in the spring of 2002. The combined sampling data available from subsequent PIT and radio telemetry detections of these fish provides additional information on the effects of the reconditioning process on kelt steelhead (Table 7). Only one of these fish (PIT code 3D9.1BF1456C7D, radio tag channel 10, code 45) was detected migrating above Roza Dam in the spring of 2003, and was eventually detected in Umtanum Creek. The fish was released from Chandler reconditioning on December 10, 2002 (Table 7, Appendix A). One of the other fish (PIT code 3D9.1BF13C0579, radio tag channel 10, code 93) was detected in or near the Sulfur Drain. This may be an indication that the upper Yakima River water returning from this Roza District irrigation return drain is a nuisance, which is providing a false attraction flow. Return data from Yakama Nation coho releases in the upper Yakima River have also highlighted this potential problem (Todd Newsome, YN, personal communication). The remaining fish (PIT code 3D9.1BF1457F6A, radio tag channel 10, code 51) is believed to have spawned in Satus or Toppenish creeks (Table 6, Appendix A). This could be evidence that interbreeding amongst the various Yakima Basin steelhead populations is not uncommon.

PIT Tag Code	Date	Event description	Weight(lbs)	Channel	Code
3D9.1BF1457F6A	4/16/2003	Recaptured Chandler kelt	7.20		
3D9.1BF1457F6A	12/10/2002	Released Chandler kelt	8.45	10	51
3D9.1BF1457F6A	5/15/2002	Recaptured Chandler kelt	4.70		
3D9.1BF1457F6A	3/14/2002	Tagged at Roza	6.61		
3D9.1BF1456C7D	3/7/2003	Recaptured at Roza	7.80		
3D9.1BF1456C7D	12/10/2002	Released Chandler kelt	8.20	10	45
3D9.1BF1456C7D	4/25/2002	Recaptured Chandler kelt	3.75		
3D9.1BF1456C7D	4/2/2002	Tagged at Roza	4.63		
3D9.1BF13C0579	5/5/2003	Recaptured Chandler kelt	6.65		
3D9.1BF13C0579	12/10/2002	Released Chandler kelt	7.65	10	93
3D9.1BF13C0579	5/16/2002	Recaptured Chandler kelt	4.70		
3D9.1BF13C0579	4/19/2002	Tagged at Roza	5.73		

Table 7. Tagging and weight history for 3 fish originally PIT Tagged at Roza Dam in the spring of 2002.

2003 Experimental Data

During the 2003 season a total of 301 (62.4 %) long-term reconditioned kelts survived reconditioning to be released, with 276 kelts rematuring. A total of 47 kelts of the 301 were radio-tagged with 23 tags from UI and 24 from the Bureau of Reclamation then released. Each tag was inserted using the gastric insertion technique.

Radio Telemetry Data Available in 2004

3.5.2 PIT Tag

2002 Experimental Data

Of the 332 short-term reconditioned kelts released in May of 2002, to date we have had a total of 40 (12.0%) of these kelts detected at Bonneville dam. Of these kelts, 29 (72.5%) migrated upriver during September to November of 2002. The rest of the steelhead kelts 11 (27.5%) migrated in July-August of 2003. So far we have detected 6/332 (1.8%) of the short-term reconditioned individuals at the Denil ladder at Prosser, WA (Appendix B). It should be noted however that the Denil ladder is just one of three ladders in operation at the Prosser facility and that there is a good chance that reconditioned kelts are utilizing these other ladders as well. The Yakama Nation is currently seeking funds to add PIT tag detectors at these other ladders. Amazingly enough, we had one of the 2002 long-term releases out-migrate and then return to the Columbia River in 2003 with its last detection at McNary Dam in mid-August.

2003 Experimental Data

A total of 187 PIT tags were submitted to the regional PTAGIS database for short-term kelts released below Bonneville Dam on June 4, 2003. A query was submitted to the PTAGIS database on March 2, 2004 to allow an assessment of all detection history on these fish since their release. The results of this query are presented in Appendix C.

As of March 2, 2004, a total of 4 (2.1%) of the 187 short-term reconditioned fish in the release had subsequent upstream detections. The remaining fish have no subsequent

detections and are most probably still in the ocean, but could also be mortalities. This query will be run prior to producing each year's annual report and new information on subsequent detections of these 2003 short-term releases will be presented in subsequent annual reports.

So far we have not seen the same number of fish return immediately as was the case with short-term kelts released in 2002 (>70% of these releases returned after only 3-4 months in the estuary/ocean). It is possible that the majority of the 2003 short-term release out migrated to the ocean and will be detected in the summer of 2004 possibly due to the change in collection time for short-term reconditioned fish or some other phenomena.

Further PIT-tag data will be recorded and published in 2004.

4.0 CONCLUSIONS

4.1 Kelt Research

- Steelhead kelt reconditioning shows great promise to assist restoration of imperiled wild steelhead populations in the Columbia basin, based on empirical results of this project.

  During 2000, the Yakama Nation collected 512 wild kelts (38% of the subbasin's run that year) at the Chandler Juvenile Monitoring Facility (CJMF) for reconditioning at Prosser Hatchery, producing a first year re-spawner rate of 10% (51/512). Subsequently, kelt rematuration rates in captivity more than doubled from 10% (2000), 21% (2001), 50% (2002), and 85% (2003). As previously reported by Evans et al. (2001) and Hatch et al. (2002) in this project's previous annual reports, kelts reconditioned by this project will substantially bolster the number of repeat spawners in the Yakima River.

- This project is successfully refining techniques, which if further supported by additional, more rigorous future research, appear very applicable to increasing its success, and that of population enhancement efforts at larger geographic scales for wild Columbia Basin steelhead.

- In general, we feel the results of the study still warrant additional research, but feel that we are much closer to devising a management program for ESA-listed steelhead populations in the Columbia River Basin.

- Kelt reconditioning should be viewed at this time as experimental, which has been quite successful, rapidly improving, and very promising. The general approach should also be viewed as one of several available research techniques to guide enhancement of steelhead iteroparity expression. Implementation of best methods should be targeted following several years of rigorous, replicated studies of each approach, including ecological and economic cost/benefit analysis.

4.2 Management Implications of Successful Kelt Reconditioning

Unlike other species of Pacific salmon *(Oncorhynchus spp.)* anadromous steelhead naturally exhibit varying degrees of iteroparity (repeat spawning). Wild steelhead populations have declined dramatically from historical levels in the Columbia and Snake Rivers, for many reasons. Successful steelhead iteroparity involves downstream migration of kelts (post-spawned steelhead) to estuary or ocean environments. Thousands of kelts (i.e., post-spawned fish) of ESA-listed steelhead populations in the Snake R. and mid-Columbia River are incidentally collected each spring (March - June) in the juvenile collection systems throughout the Snake and Columbia rivers. Despite the thousands of kelts that attempt out migration, results from a telemetry study Evans et al. (2001) suggested that only a very small percentile (<5%) successfully navigated the Snake and Columbia River hydropower system. However, resulting data occurred during low and no-spill years. In-river survival rates of emigrating kelts may increase considerably during average and above water years since emigration paths through

open spillways may be available. For this life history expression (iteroparity) to persist in future steelhead runs, successful methods must be developed to augment the current rate of iteroparity among Snake and Columbia River steelhead populations.

CRITFC and Yakama Nation's collaborative effort is a promising approach to increase natural production of wild steelhead to enhance their iteroparous life history strategy with reconditioning techniques. Reconditioning promotes re-initiation of feeding for kelts, enabling them to survive and rebuild energy reserves required for gonadal development and successful iteroparous spawning. Evans et al. (2001) provided a comprehensive literature review of kelt reconditioning which, combined with past years data, suggests that reconditioning is a potentially valuable recovery tool for threatened and endangered steelhead in the Columbia River Basin and elsewhere.

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6.0 Appendix

6.1 Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date			Obs. Date	SiteDescription	Rkm
10	*1*	*12/10/2002*	*W*	*F*			
Recap Kelt Spawned out at Prosser					4/30/2003	Mobile monitoring	75.2
yakima river					4/1/2003	Mobile monitoring	114.2
Yakima River					3/24/2003	Mobile monitoring	107.2
					2/10/2003	Mobile monitoring	108.8
Yakima RiverBelow mouth of Satus Creek					1/16/2003	Mobile monitoring	110.4
Yakima River Mabton Bridge					1/8/2003	Mobile monitoring	0.0
Yakima River					1/7/2003	Mobile monitoring	108.8
Yakima River					12/26/2002	Mobile monitoring	106.4
Yakima River below Granger					12/23/2002	Mobile monitoring	106.4
Yakima River					12/13/2002	Mobile monitoring	106.6
10	*5*	*12/10/2002*	*W*	*F*			
1/4 above sulfur					5/1/2003	Mobile monitoring	98.6
Yakima River					3/19/2003	Mobile monitoring	99.2
Yakima River, 1/2 mile above Mabton Bridge					1/8/2003	Mobile monitoring	0.0
10	*7*	*12/10/2002*	*W*	*F*			
Yakima River					3/31/2003	Mobile monitoring	104.0
Yakima River, just above sulfur drain					1/16/2003	Mobile monitoring	100.8
Yakima River					1/8/2003	Mobile monitoring	0.0
Yakima River					12/26/2002	Mobile monitoring	100.8
10	*11*	*12/10/2002*	*W*	*F*			
Recap Kelt Spawned out at Prosser					3/12/2003	Mobile monitoring	75.2
					2/10/2003	Mobile monitoring	121.6
					1/30/2003	Mobile monitoring	123.2
Yakima River					1/20/2003	Mobile monitoring	131.2
Yakima River, Below Toppenish Creek					1/16/2003	Mobile monitoring	118.4
					1/4/2003	Mobile monitoring	124.8
Yakima River					12/30/2002	Mobile monitoring	118.4
Yakima River					12/26/2002	Mobile monitoring	107.2
Yakima River below Granger					12/23/2002	Mobile monitoring	126.4
Yakima River					12/18/2002	Mobile monitoring	124.8

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date			Obs. Date	SiteDescription	Rkm
10	*13*	*12/10/2002*	W	F			
yakima river					4/1/2003	Mobile monitoring	115.2
Yakima River					3/24/2003	Mobile monitoring	112.0
					2/10/2003	Mobile monitoring	105.6
Yakima RiverBelow mouth of Satus Creek					1/16/2003	Mobile monitoring	107.2
Yakima River					1/3/2003	Mobile monitoring	108.8
Yakima River					12/26/2002	Mobile monitoring	103.2
Yakima River					12/13/2002	Mobile monitoring	102.6
Yakima River @ Mabton Release					12/11/2002	Mobile monitoring	94.4
Yakima River. At Slaggs Ranch					1/3/2002	Mobile monitoring	108.8
10	*15*	*12/10/2002*	W	F			
Recap Kelt Spawned out at Prosser					4/15/2003	Mobile monitoring	75.2
yakima river					4/1/2003	Mobile monitoring	123.2
Yakima River					3/24/2003	Mobile monitoring	140.8
					3/19/2003	Mobile monitoring	140.8
yakima river, teapot dome					3/13/2003	Mobile monitoring	140.8
					2/10/2003	Mobile monitoring	117.6
					1/30/2003	Mobile monitoring	112.8
Yakima River,1 mile above Satus Creek					1/13/2003	Mobile monitoring	112.0
Yakima River					12/30/2002	Mobile monitoring	112.8
Yakima River					12/13/2002	Mobile monitoring	107.2
UI Detection Data NAC					12/9/2002	UI Naches River (Cowiche)	191.3
Naches River Below Cowiche Dam					11/15/2002	Mobile monitoring	4.8
10	*17*	*12/10/2002*	W	F			
yk river euclid bridge					5/1/2003	Mobile monitoring	88.5
Yakima River,above Euclid Road Bridge					1/16/2003	Mobile monitoring	89.6
Yakima River, Mabton Bridge					1/8/2003	Mobile monitoring	0.0
Yakima River					1/3/2003	Mobile monitoring	92.8
Yakima River					12/13/2002	Mobile monitoring	92.6
Yakima River,@ Mabton Release					12/11/2002	Mobile monitoring	93.4
yakima River, 1/2 mile above mabton bridge					1/3/2002	Mobile monitoring	92.8
10	*21*	*12/10/2002*	W	F			
Recap Kelt Spawned out at Prosser					5/5/2003	Mobile monitoring	75.2
2 miles above sulfur					5/1/2003	Mobile monitoring	100.8
Yakima River					3/31/2003	Mobile monitoring	100.8
Yakima River,Below Sulfur Creek					1/16/2003	Mobile monitoring	96.8
Yakima River, 100meters below Sulfer ditch					1/8/2003	Mobile monitoring	0.0
Yakima River					12/13/2002	Mobile monitoring	93.9
Yakima River,@ Mabton Release					12/11/2002	Mobile monitoring	93.1

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date	Obs. Date	SiteDescription	Rkm
10	*25*	*12/10/2002 H F*			
below island			5/1/2003	Mobile monitoring	135.2
yakima river,below island			4/3/2003	Mobile monitoring	136.0
Yakima River			3/24/2003	Mobile monitoring	140.8
yakima river			3/19/2003	Mobile monitoring	138.4
yakima river			3/13/2003	Mobile monitoring	136.0
			2/11/2003	Mobile monitoring	134.4
			1/30/2003	Mobile monitoring	137.6
Yakima River, 1mile up from			1/20/2003	Mobile monitoring	137.6
Yakima River, Side Channel above Granger			1/16/2003	Mobile monitoring	136.0
Yakima River below Granger			12/23/2002	Mobile monitoring	137.6
Yakima River			12/18/2002	Mobile monitoring	119.2
10	*27*	*12/10/2002 W F*			
yakima river			4/1/2003	Mobile monitoring	119.2
Yakima River			3/24/2003	Mobile monitoring	117.6
			1/30/2003	Mobile monitoring	117.6
Yakima River, Below Toppenish Creek			1/16/2003	Mobile monitoring	113.6
Yakima River			12/30/2002	Mobile monitoring	114.9
Yakima River below Granger			12/23/2002	Mobile monitoring	114.4
Yakima River			12/13/2002	Mobile monitoring	96.0
10	*28*	*12/10/2002 W F*			
Yk river just below satus creek			5/1/2003	Mobile monitoring	110.4
yakima river			3/24/2003	Mobile monitoring	110.7
Yakima RiverBelow mouth of Satus Creek			1/16/2003	Mobile monitoring	110.4
Yakima River			12/30/2002	Mobile monitoring	110.4
Yakima River			12/13/2002	Mobile monitoring	108.8
Yakima River @ Mabton Release			12/11/2002	Mobile monitoring	94.4
10	*31*	*12/10/2002 W F*			
yk river just above Prosser Dam			5/1/2003	Mobile monitoring	76.8
UI Detection Data PSR			2/2/2003	UI Prosser Dam	75.2
Above Prosser Dam			1/28/2003	Mobile monitoring	0.0
Yakima River, 1 mile above Prosser Dam			1/16/2003	Mobile monitoring	76.8
Yakima River1/2 mile below Powerlines			1/13/2003	Mobile monitoring	128.0
Yakima River, 1/2 mile above Prosser Dam			1/8/2003	Mobile monitoring	0.0
Yakima River below Prosser			12/21/2002	Mobile monitoring	0.0
Yakima River			12/13/2002	Mobile monitoring	76.1
Yakima River			11/14/2002	Mobile monitoring	98.4

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date	Obs. Date	SiteDescription	Rkm
10	*33*	*12/10/2002* W F			
Recaptured at Prosser as spawned out kelt			5/5/2003	Mobile monitoring	75.2
yk river at Prosser Hatchery			5/1/2003	Mobile monitoring	75.2
naches river,cowiche creek			3/31/2003	Mobile monitoring	14.4
naches river			3/26/2003	Mobile monitoring	22.4
South Fork of Cowiche Creek			3/20/2003	Mobile monitoring	25.6
naches river			3/12/2003	Mobile monitoring	1.9
yakima river, 1/2 mile below mouth of naches river			3/11/2003	Mobile monitoring	183.2
yakima river, 1.5 miles below naches river			3/10/2003	Mobile monitoring	182.4
Yakima River			2/6/2003	Mobile monitoring	148.0
Yakima River, Below Granger Bridge			1/16/2003	Mobile monitoring	129.6
Yakima River above snipes lateral canal intake			12/30/2002	Mobile monitoring	124.8
Yakima River side channel			12/23/2002	Mobile monitoring	125.6
Yakima River			12/18/2002	Mobile monitoring	121.6
Yakima River			12/13/2002	Mobile monitoring	107.8
Yakima River,@ Mabton Release			12/11/2002	Mobile monitoring	97.6
10	*35*	*12/10/2002* W F			
yk river euclid bridge			5/1/2003	Mobile monitoring	88.5
Yakima River,above Euclid Road Bridge			1/16/2003	Mobile monitoring	89.6
Yakima River, 1/2 mile above Sunnyside			1/8/2003	Mobile monitoring	0.0
Yakima River			1/3/2003	Mobile monitoring	92.8
Yakima River			12/13/2002	Mobile monitoring	92.0
10	*37*	*12/10/2002* W F			
Recap Kelt Spawned out at Prosser			5/5/2003	Mobile monitoring	75.2
1 mile above satus			5/1/2003	Mobile monitoring	113.4
Yakima River			4/1/2003	Mobile monitoring	118.4
			2/10/2003	Mobile monitoring	119.2
			1/30/2003	Mobile monitoring	118.4
Yakima River			1/20/2003	Mobile monitoring	123.2
Yakima River, Below Toppenish Creek			1/16/2003	Mobile monitoring	116.8
Yakima River			12/30/2002	Mobile monitoring	115.7
Yakima River below Granger			12/23/2002	Mobile monitoring	123.2
Yakima River			12/13/2002	Mobile monitoring	105.6

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date			Obs. Date	SiteDescription	Rkm
10	*41*	*12/10/2002*	*W*	*F*			
yk river 2 miles above Prosser Dam					5/1/2003	Mobile monitoring	80.0
Yakima River, 1 mile above Prosser Dam					2/4/2003	Mobile monitoring	68.8
Yakima River 1 mile above Prosser Dam					1/20/2003	Mobile monitoring	76.8
Yakima River,2 miles above prosser dam					1/16/2003	Mobile monitoring	78.4
Yakima River, 1 mile above Prosser dam					1/8/2003	Mobile monitoring	0.0
Yakima River					12/26/2002	Mobile monitoring	97.6
Yakima River below Granger					12/23/2002	Mobile monitoring	108.0
10	*43*	*12/10/2002*	*W*	*F*			
recaptured at Chandler as spawned out kelt					4/28/2003	Mobile monitoring	75.2
yakima river					4/1/2003	Mobile monitoring	116.0
Yakima River					3/19/2003	Mobile monitoring	112.8
Yakima River, just above Sulfur					1/16/2003	Mobile monitoring	102.4
Yakima River					1/3/2003	Mobile monitoring	105.6
Yakima River					12/26/2002	Mobile monitoring	102.4
Yakima River					12/13/2002	Mobile monitoring	107.2
10	*45*	*12/10/2002*	*W*	*F*			
UI Detection Data 1RZ					2/18/2003		204.1
Yakima River, 1/2 mile up river from Toppenish Creek					1/20/2003	Mobile monitoring	136.0
UI Detection Data SNY					1/14/2003	UI Sunnyside Dam	165.9
Yakima River below snipes lateral canal intake					12/30/2002	Mobile monitoring	123.2
Yakima River below Granger					12/23/2002	Mobile monitoring	115.2
Yakima River					12/18/2002	Mobile monitoring	116.8
Yakima River					12/13/2002	Mobile monitoring	112.0
10	*47*	*12/10/2002*	*W*	*F*			
Recaptured as spawned out kelt at Chandler					4/14/2003	Mobile monitoring	75.2
yakima river					3/31/2003	Mobile monitoring	98.4
Yakima River					3/19/2003	Mobile monitoring	99.2
Yakima River,Below Sulfur Creek					1/16/2003	Mobile monitoring	96.0
Yakima River					1/8/2003	Mobile monitoring	0.0
Yakima River					12/26/2002	Mobile monitoring	100.0

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date	Obs. Date	SiteDescription	Rkm
10	*51*	*12/10/2002* W	F		
Recap Kelt Spawned out at Prosser			4/16/2003	Mobile monitoring	75.2
Yakima River			3/24/2003	Mobile monitoring	114.4
			2/10/2003	Mobile monitoring	116.0
			1/30/2003	Mobile monitoring	115.2
Yakima River, Below mouth of Satus Creek			1/16/2003	Mobile monitoring	110.4
			1/4/2003	Mobile monitoring	112.0
Yakima River			1/3/2003	Mobile monitoring	110.4
Yakima River			12/26/2002	Mobile monitoring	104.8
Yakima River			12/13/2002	Mobile monitoring	106.7
Yakima River,@ Mabton Release			12/11/2002	Mobile monitoring	93.6
10	*53*	*12/10/2002* W	F		
joe Jays ramp			5/1/2003	Mobile monitoring	152.0
yakima river behind joe jay's			4/3/2003	Mobile monitoring	148.8
yakima river, 2nd opening behind joe jays			3/12/2003	Mobile monitoring	152.0
yakima river, 2 miles below wapato bridge			3/11/2003	Mobile monitoring	156.8
			2/11/2003	Mobile monitoring	136.8
			1/30/2003	Mobile monitoring	138.1
Yakima River			1/28/2003	Mobile monitoring	133.6
			1/23/2003	Mobile monitoring	134.4
Yakima River			1/20/2003	Mobile monitoring	124.8
Yakima River, above granger bridge			1/16/2003	Mobile monitoring	134.4
Yakima River			12/30/2002	Mobile monitoring	113.6
Yakima River below Granger			12/23/2002	Mobile monitoring	113.6
Yakima River			12/13/2002	Mobile monitoring	108.8
Yakima River @ Mabton Release			12/11/2002	Mobile monitoring	93.6
10	*55*	*12/10/2002* W	F		
recaptured as spawned out kelt at Chandler			4/15/2003	Mobile monitoring	75.2
Yakima River,power lines			3/19/2003	Mobile monitoring	92.8
Yakima River, Below Mabton Bridge			1/16/2003	Mobile monitoring	92.8
			1/11/2003	Mobile monitoring	0.0
Yakima River, Powerlines			1/8/2003	Mobile monitoring	0.0
Yakima River			12/13/2002	Mobile monitoring	92.6

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date	Obs. Date	SiteDescription	Rkm
10	*58*	*12/10/2002* *W* *F*			
yk river mabton bridge			5/1/2003	Mobile monitoring	95.8
Yakima River,mabton bridge			3/19/2003	Mobile monitoring	94.4
			1/24/2003	Mobile monitoring	0.0
at Mabton Boat Ramp			1/20/2003	Mobile monitoring	94.4
Yakima River, Mabton Bridge			1/8/2003	Mobile monitoring	0.0
Yakima River			1/3/2003	Mobile monitoring	94.4
Yakima River			12/26/2002	Mobile monitoring	96.0
Yakima River @ Mabton Release			12/11/2002	Mobile monitoring	94.4
10	*61*	*12/10/2002* *W* *F*			
yk river at Prosser Dam			5/1/2003	Mobile monitoring	75.2
yakima river			3/31/2003	Mobile monitoring	107.4
Yakima River			3/19/2003	Mobile monitoring	105.6
			2/10/2003	Mobile monitoring	110.2
Yakima RiverBelow mouth of Satus Creek			1/16/2003	Mobile monitoring	108.8
Yakima River			1/3/2003	Mobile monitoring	108.8
Yakima River			12/26/2002	Mobile monitoring	106.4
Yakima River below Granger			12/23/2002	Mobile monitoring	105.6
Yakima River			12/13/2002	Mobile monitoring	76.0
Yakima River			12/13/2002	Mobile monitoring	107.2
10	*65*	*12/10/2002* *W* *F*			
Recap Kelt Spawned out at Prosser			4/21/2003	Mobile monitoring	75.2
yakima river,below toppenish creek			4/1/2003	Mobile monitoring	126.7
Yakima River			3/24/2003	Mobile monitoring	130.4
			2/10/2003	Mobile monitoring	124.0
			1/30/2003	Mobile monitoring	124.8
Yakima River, 1mile below powerline			1/20/2003	Mobile monitoring	132.8
Yakima River, Near Snipes mt intake			1/16/2003	Mobile monitoring	124.8
Yakima River,1/2 mile below Powerlines			1/13/2003	Mobile monitoring	132.8
Yakima River 3 miles below Granger			1/7/2003	Mobile monitoring	132.0
			1/4/2003	Mobile monitoring	129.6
Yakima River			12/30/2002	Mobile monitoring	120.0
Yakima River below Granger			12/23/2002	Mobile monitoring	121.6
Yakima River			12/13/2002	Mobile monitoring	102.4
Yakima River @ Mabton Release			12/11/2002	Mobile monitoring	94.4

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date	Obs. Date	SiteDescription	Rkm
10	*71*	*12/10/2002* *W* *F*			
UI Detection Data PSR			2/16/2003	UI Prosser Dam	75.2
			1/24/2003	Mobile monitoring	76.0
Yakima River,1 mile above Prosser Dam			1/16/2003	Mobile monitoring	76.8
Yakima River			1/8/2003	Mobile monitoring	0.0
Yakima River			12/13/2002	Mobile monitoring	97.6
Yakima River @ Mabton Release			12/11/2002	Mobile monitoring	93.6
Yakima River			1/3/2002	Mobile monitoring	22.4
10	*78*	*12/10/2002* *W* *F*			
yk river below mabton bridge			5/1/2003	Mobile monitoring	94.1
Yakima River,power lines			3/19/2003	Mobile monitoring	92.8
Yakima River,above Euclid Road Bridge			1/16/2003	Mobile monitoring	89.6
Yakima River, Powerlines			1/8/2003	Mobile monitoring	0.0
Yakima River			1/3/2003	Mobile monitoring	92.8
Yakima River,@ Mabton Release			12/11/2002	Mobile monitoring	91.5
Yakima River, 200 meters below powerlines			1/3/2002	Mobile monitoring	92.8
10	*81*	*12/10/2002* *W* *F*			
just below toppenish creek			5/1/2003	Mobile monitoring	128.0
yakima river,below toppenish creek			4/1/2003	Mobile monitoring	126.6
Yakima River			3/24/2003	Mobile monitoring	130.4
			2/10/2003	Mobile monitoring	123.8
			1/30/2003	Mobile monitoring	124.8
Yakima River, 1mile below powerline			1/20/2003	Mobile monitoring	132.8
Yakima River,			1/16/2003	Mobile monitoring	124.8
Yakima River,1/2 mile below Powerlines			1/13/2003	Mobile monitoring	132.8
Yakima River 3 miles below Granger			1/7/2003	Mobile monitoring	132.0
			1/4/2003	Mobile monitoring	129.6
Yakima River			12/30/2002	Mobile monitoring	121.6
Yakima River below Granger			12/23/2002	Mobile monitoring	128.0
Yakima River			12/18/2002	Mobile monitoring	120.0

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date	Obs. Date	SiteDescription	Rkm
10	*83*	*12/10/2002 W F*			
recaptured as spawned out kelt at Chandler			4/16/2003	Mobile monitoring	75.2
yakima river			4/1/2003	Mobile monitoring	124.8
Yakima River			3/24/2003	Mobile monitoring	128.0
			1/30/2003	Mobile monitoring	117.1
Yakima River			1/20/2003	Mobile monitoring	112.0
Yakima River, 1 mile above Satus Creek			1/16/2003	Mobile monitoring	112.0
Yakima River below Satus Creek			12/30/2002	Mobile monitoring	110.1
Yakima River			12/26/2002	Mobile monitoring	104.0
Yakima River			12/13/2002	Mobile monitoring	94.4
10	*88*	*12/10/2002 W F*			
Recap Kelt Spawned out at Prosser			5/6/2003	Mobile monitoring	75.2
mouth sulfur ditch			5/1/2003	Mobile monitoring	97.6
Yakima River			3/24/2003	Mobile monitoring	133.6
yakima river behind conans house			3/13/2003	Mobile monitoring	139.2
			1/30/2003	Mobile monitoring	124.5
Yakima River			1/20/2003	Mobile monitoring	128.0
Yakima River1/2 mile below Powerlines			1/13/2003	Mobile monitoring	128.0
Yakima River			12/30/2002	Mobile monitoring	118.4
Yakima River below Granger			12/23/2002	Mobile monitoring	120.0
Yakima River			12/18/2002	Mobile monitoring	121.6
10	*91*	*12/10/2002 W F*			
Recap Kelt Spawned out at Prosser			4/28/2003	Mobile monitoring	75.2
yakima river			3/31/2003	Mobile monitoring	107.2
Yakima River			3/19/2003	Mobile monitoring	104.0
Yakima River, above sulfur drain\			1/16/2003	Mobile monitoring	97.6
Yakima River			1/8/2003	Mobile monitoring	0.0
Yakima River			1/3/2003	Mobile monitoring	102.4
Yakima River @ Mabton Release			12/11/2002	Mobile monitoring	93.6
10	*93*	*12/10/2002 W F*			
Recap Kelt Spawned out at Prosser			5/5/2003	Mobile monitoring	75.2
yk river euclid bridge			5/1/2003	Mobile monitoring	88.3
Yakima River,power lines			3/19/2003	Mobile monitoring	92.8
Yakima River,Below sulfur Creek			1/16/2003	Mobile monitoring	97.6
Yakima River, Powerlines			1/8/2003	Mobile monitoring	0.0
Yakima River			12/13/2002	Mobile monitoring	96.3

Appendix A. Observations of radio-tagged kelts released on 10-Dec-2002.

Channel	Code	Tag Date			Obs. Date	SiteDescription	Rkm
10	*95*	*12/10/2002*	*W*	*F*			
yk river just below satus creek					5/1/2003	Mobile monitoring	110.4
yakima river, above satus					4/1/2003	Mobile monitoring	113.8
Yakima River					3/24/2003	Mobile monitoring	110.4
					2/10/2003	Mobile monitoring	113.6
					1/30/2003	Mobile monitoring	112.8
Yakima River, 1 mile above Satus Creek					1/16/2003	Mobile monitoring	112.0
Yakima River below mouth of Satus					1/7/2003	Mobile monitoring	112.0
					1/4/2003	Mobile monitoring	112.0
Yakima River below Granger					12/23/2002	Mobile monitoring	112.0
11	*23*	*12/10/2002*	*W*	*M*			
mouth of Yakima River					5/1/2003	Mobile monitoring	3.2
11	*76*	*12/10/2002*	*W*	*M*			
I240 RR Bridge Richland					5/1/2003	Mobile monitoring	3.4
Yakima River, I-82 Crossing					1/17/2003	Mobile monitoring	8.0
11	*107*	*12/10/2002*	*W*	*F*			
Yakima River, Van Giesen Bridge					1/17/2003	Mobile monitoring	12.8
23	*45*	*12/10/2002*	*W*	*F*			
.5 mile above grain elevator					1/27/2003	Mobile monitoring	0.0
23	*52*	*12/10/2002*	*W*	*F*			
Recap Kelt Spawned out at Prosser					5/22/2003	Mobile monitoring	75.2
mouth of Naches					5/1/2003	Mobile monitoring	186.1
23	*192*	*12/10/2002*	*W*	*F*			
Port Kelly grain elevator					1/27/2003	Mobile monitoring	0.0

6.2 Appendix B. Tag History for 2002 below Bonneville Releases

TagId	EventDate	EventType	SiteID	FileId	Flags	RearTyp
3D9.1BF0EC111B						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL	W
	8/20/2002	OBS	BWL			
3D9.1BF0EE44DC						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/31/2002	OBS	BWL			
	10/28/2002	OBS	MC2			
3D9.1BF11A2739						
	4/15/2002	TAG	CHANDL	BDW02091.PRO	AT KL FE	W
	10/1/2002	OBS	B2A			
	10/1/2002	OBS	BWL			
	10/10/2002	OBS	MC1			
	4/7/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
	12/31/2003	MOR	CHANDL	WJB03365.PRO	M KL FE	
3D9.1BF1310B6C						
	2/25/2002	TAG	ROSAD	BDW02010.ROZ	AT RF FE	W
	4/22/2002	REC	CHANDL	BDW02091.PRO	RE KL FE	
3D9.1BF139784E						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/13/2003	OBS	BO2			
	9/14/2003	OBS	MC1			
3D9.1BF139A2DA						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/25/2002	OBS	BWL			
	9/3/2002	OBS	MC2			
3D9.1BF139A471						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/11/2002	OBS	BO1			
3D9.1BF139E0BD						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/24/2002	OBS	BWL			
	9/3/2002	OBS	MC1			
3D9.1BF139E36C						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	9/9/2002	OBS	B2A			
	9/9/2002	OBS	BWL			
	9/17/2002	OBS	MC1			
	4/14/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
	12/31/2003	MOR	CHANDL	WJB03365.PRO	M KL FE	

Appendix B. Tag History for 2002 below Bonneville Releases

TagId	EventDate	EventType	SiteID	FileId	Flags	RearTyp
3D9.1BF139F373						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/30/2002	OBS	B2A			
	8/30/2002	OBS	BWL			
	9/25/2002	OBS	MC1			
	4/10/2003	OBS	MCJ			
3D9.1BF13A0362						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/27/2002	OBS	B2A			
	8/27/2002	OBS	BWL			
	9/3/2002	OBS	MC1			
	9/27/2002	REC	PROSRD	BDW02244.BOS	RE RF FE	
3D9.1BF13A2BAE						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	5/26/2002	OBS	TWX			
3D9.1BF13A4605						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/25/2002	OBS	B2A			
	8/25/2002	OBS	BWL			
	11/17/2002	OBS	MC1			
3D9.1BF13A4AE1						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	9/16/2002	OBS	BO1			
	10/28/2002	OBS	MC2			
	11/25/2002	REC	PROSRD	BDW02244.BOS	RE RF FE	
	3/31/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
	12/31/2003	MOR	CHANDL	WJB03365.PRO	M KL FE	
3D9.1BF13A50A0						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	7/20/2003	OBS	BO1			
3D9.1BF13A6A96						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/27/2003	OBS	BO3			
	10/7/2003	OBS	MC2			
3D9.1BF13A6CD1						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/14/2002	OBS	BWL			
	10/22/2002	OBS	MC1			
3D9.1BF15639E3						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL MA	W
	8/23/2002	OBS	BWL			
	11/7/2002	OBS	MC1			
	4/14/2003	REC	CHANDL	WJB03071.PRO	RE KL MA	
	12/8/2003	REC	YAKIM1	WJB03342.PRO	RE KL MA	

Appendix B. Tag History for 2002 below Bonneville Releases

TagId	EventDate	EventType	SiteID	FileId	Flags	RearTyp
3D9.1BF156420A						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/19/2002	OBS	B2A			
	8/19/2002	OBS	BWL			
	10/6/2002	OBS	MC1			
3D9.1BF156450C						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	9/4/2002	OBS	B2A			
	9/4/2002	OBS	BWL			
3D9.1BF1564BB6						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/11/2002	OBS	BWL			
	9/17/2002	OBS	MC1			
	9/27/2002	REC	PROSRD	BDW02244.BOS	RE RF FE	
3D9.1BF1565122						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/17/2003	OBS	BO3			
	7/26/2003	OBS	MC2			
3D9.1BF1565423						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/22/2003	OBS	BO1			
	10/6/2003	OBS	MC1			
3D9.1BF1565EFC						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	9/11/2002	OBS	BWL			
3D9.1BF15667AA						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	7/19/2003	OBS	BO1			
	9/18/2003	OBS	MC1			
3D9.1BF156B7FF						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/20/2003	OBS	BO3			
	9/19/2003	OBS	MC1			
3D9.1BF156D39F						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/11/2002	OBS	BO2			
	8/27/2002	OBS	MC1			
3D9.1BF156EA56						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/20/2002	OBS	BWL			
	9/16/2002	OBS	MC1			
	4/1/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
	12/8/2003	REC	YAKIM1	WJB03342.PRO	RE KL FE	

Appendix B. Tag History for 2002 below Bonneville Releases

TagId	EventDate	EventType	SiteID	FileId	Flags	RearTyp
3D9.1BF16698DD						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/25/2002	OBS	BWL			
	9/2/2002	OBS	MC1			
	11/20/2002	REC	PROSRD	BDW02244.BOS	RE RF FE	
3D9.1BF166B8BA						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/27/2002	OBS	BO2			
	10/4/2002	OBS	MC1			
3D9.1BF166BA9C						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/31/2002	OBS	BO1			
	9/29/2002	OBS	MC1			
	10/11/2002	REC	PROSRD	BDW02244.BOS	RE RF	
	4/4/2003	OBS	MCJ			
3D9.1BF166C52A						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/9/2003	OBS	BO3			
	7/18/2003	OBS	MC1			
3D9.1BF1671175						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	8/27/2002	OBS	BO2			
	10/15/2002	OBS	MC2			
	4/9/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
	12/8/2003	REC	YAKIM1	WJB03342.PRO	RE KL FE	
3D9.1BF1675914						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/16/2002	OBS	BWL			
	8/29/2002	OBS	MC1			
3D9.1BF16929C6						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	9/27/2002	OBS	B2A			
	9/27/2002	OBS	BWL			
	10/7/2002	OBS	MC2			
	3/31/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
	12/31/2003	MOR	CHANDL	WJB03365.PRO	M KL FE	
3D9.1BF1692AD1						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/25/2002	OBS	BO1			
	9/28/2002	OBS	MC1			
	10/18/2002	REC	PROSRD	BDW02244.BOS	RE RF FE	
3D9.1BF16934F7						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	8/22/2002	OBS	BO1			

Appendix B. Tag History for 2002 below Bonneville Releases

TagId	EventDate	EventType	SiteID	FileId	Flags	RearTyp
3D9.1BF1699A7B						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/16/2003	OBS	BO2			
	10/25/2003	OBS	MC1			
3D9.1BF169BC77						
	5/28/2002	TAG	COLR3	WJB02148.PRO	AT KL FE	W
	9/27/2002	OBS	BWL			
	9/28/2002	OBS	BO1			
3D9.1BF169D5CD						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/26/2003	OBS	BO1			
3D9.1BF169E3BE						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL FE	W
	7/23/2003	OBS	BO3			
3D9.1BF169E65D						
	5/20/2002	TAG	COLR3	WJB02140.PRO	AT KL MA	W
	9/2/2002	OBS	BWL			
	10/27/2002	OBS	MC2			
	3/28/2003	REC	CHANDL	WJB03071.PRO	RE KL MA	

6.3 Appendix C. Tag History for 2003 below Bonneville Releases

TagId	EventDate	EventType	SiteID	FileId	Flags	RearTyp
3D9.1BF1395C09						
	6/4/2003	TAG	COLR3	WJB03060.PRO	AT KL FE	W
	9/6/2003	OBS	BO3			
	10/28/2003	OBS	MC1			
3D9.1BF168B4D2						
	6/4/2003	TAG	COLR3	WJB03060.PRO	AT KL FE	W
	1/30/2004	OBS	BO2			
3D9.1BF168C000						
	6/4/2003	TAG	COLR3	WJB03060.PRO	AT KL MA	W
	6/6/2003	OBS	BO1			
	6/10/2003	OBS	MC1			
3D9.1BF1690598						
	6/4/2003	TAG	COLR3	WJB03060.PRO	AT KL FE	W
	6/6/2003	OBS	TWX			
3D9.1BF1698462						
	6/4/2003	TAG	COLR3	WJB03060.PRO	AT KL FE	W
	9/13/2003	OBS	BO3			
	9/22/2003	OBS	MC1			