2002 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 means 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 again develop 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 Evaluation Facility (CJEF, located at Yakima River kilometer 48) from March 12 to June 13, 2002. In total, 899 kelts were collected for reconditioning at Prosser Hatchery. Captive specimens represented 19.8% (899 of 4,525) of the entire 2001-2002 Yakima River wild steelhead population, based on fish ladder counts at Prosser Dam. Kelts were reconditioned in circular tanks and were fed freeze-dried krill, Moore-Clark pellets, altered Moore-Clark pellets (soaked in krill extract and dyed), or a combination of the altered Moore-Clark/unaltered Moore-Clark pellets. Formalin was used 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 then subsequently split into two groups for either 1 or 2-month reconditioning. Surviving specimens were released for natural spawning in two groups, corresponding with reconditioning duration, with releases on May 20/28, 2002. Survival rates for both short-term experiments were high. Long-term reconditioned kelts were subsequently split into three groups that were given three different diet formulations and then released on December 10, 2002. Long-term success indicators include the proportion of fish that survived the reconditioning process and the proportion of surviving fish that successfully remature. A total of 60 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, food preferences, condition, and rearing environments were obtained during this research endeavor. Although survival rates were higher in 2002, even higher survival rates would be desirable; overall the authors were encouraged by the positive results of this innovative project. 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 and successful expression of iteroparity.

ACKNOWLEDGEMENTS

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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, also since 1997[1]. Those 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 the 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 kelt steelhead could be a very cost and biologically effective strategy 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 study to evaluate steelhead kelt reconditioning. Successful expression of iteroparity in steelhead may be limited by post-spawning starvation and downstream passage through the mainstem corridor. Thus, short-term conditioning 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. 4-8 weeks) for kelts to initiate post-spawning feeding, followed by the transportation of kelts around mainstem hydroelectric facilities for release and natural rearing and rematuration in the Pacific Ocean.

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. By this time most surviving fish remature. Based on the past two years' results, long-term feasibility of steelhead reconditioning looks promising. We made substantial progress in 2001 regarding long-term kelt reconditioning, at the time of release we achieved a survival rate of 38% and rematuration of 19.6%. During 2002, we continued to refine and improve the efficiency and success of long-term steelhead reconditioning by repeating the two most successful diet and treatment regimes identified during the 2001 study (krill and Moore-Clark pellets).

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 (river kilometer, (rkm) 48), downstream from Prosser Dam, and adjacent to the Chandler Juvenile Evaluation Facility (CJEF). The Yakima River Basin 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, and the hatchery's primary function is for rearing, acclimation and release of fall chinook salmon *O. tshawytscha*. The facility is also used for coho salmon *O. kisutch* rearing prior to their acclimation in the upper Yakima River Basin.

2.1.1 Kelt Collection and In-Processing

After naturally spawning in tributaries of the Yakima River, a proportion of the steelhead kelts that encounter Prosser Dam facility during emigration are diverted into an irrigation channel that directly connects to the Chandler Juvenile Evaluation Facility. Like other bypass facilities in the Columbia Basin, the CJEF diverts migratory fishes away from the dam to reduce mortality. The CJEF was used to capture kelts, in which we manually collected emigrating kelts that arrived on the separator (a fish separation device initially designed to capture juvenile salmonids). Yakama Nation (YN) staff monitored the Chandler bypass separator 24 hours a day from 11 March to 13 June 2002. All adult steelhead arriving at the CJEF 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).

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

Emigrating steelhead kelt specimens were transferred with a dipnet from the temporary holding tank to a nearby 190-L sampling tank containing fresh river water, where they were 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). Kelt steelhead in poor condition and dark in color were released back in the river, all others were retained for reconditioning. Passive Integrated Transponder (PIT) tags were then implanted in the fish's pelvic girdle for individual fish identification during reconditioning.

2.1.2 Reconditioning Tanks

Upon admission of kelts to the reconditioning program at Prosser Hatchery, all kelts 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.

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 *Salmonicola* in this project's kelt reconditioning experiments during 2000 (Evans and Beaty 2000), Ivermectin^{TM} was again 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^{TM} treatment was assessed based on the prevalence of parasites in test fish relative to non-treated fish at release.

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 recaptured from mortalities and identification numbers were entered into a computer database along with the morphometric 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 in the short-term experiment were weighed prior to release on May 20 and 28, 2002, to ascertain if they were feeding. Fish in the long-term experiment were released on December 10, 2002 to coincide with natural spawning. Morphometric data regarding weight, and presence/absence of parasites – to assess the Ivermectin^{TM} treatments – 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 experimentally 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

Both groups (1 and 2 month) of short-term reconditioned kelts were fed a diet of krill for the duration of their captivity. The following design, employing two tanks was used:

C3 = (1-month experiment) Fish were collected and reconditioned from April 4 to April 20, 2002 and received a diet of freeze-dried krill.

C4 = (2-month experiment) Fish were collected and reconditioned from March 11 to May 28, 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. Preliminary results for truck transportation are presented in this report, but it is likely that fish may reside in the ocean for an additional period of time. Therefore, we expect fish to return from this study in 2003 and possibly 2004.

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 frozen krill, unaltered Moore-Clarke pellets, or Moore-Clarke pellets soaked in krill extract and dyed so as to resemble krill. The following design, employing three tanks was used in the feeding treatment tests:

C1 = Fish were collected for long-term conditioning from April 30 to December 10, 2002 where they received freeze-dried krill for 2.5 months and then a mixed diet of Moore-Clarke pellets soaked in krill extract and dyed pinkish red, along with regular Moore-Clarke pellets.

C2 = Fish were collected for long-term conditioning from April 24 to December 10, 2002 where they received krill for the first 2.5 months and then were given Moore-Clark pellets soaked in krill extract and dyed reddish-pink.

C3 = Fish collected for long-term reconditioning from May 21 to December 10, 2002, after short-term conditioned fish had been released, received krill for the first 2.5 months and then given a combination of regular Moore-Clark pellets and Moore-Clark pellets soaked in krill extract and dyed reddish-pink.

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 reconditioning steelhead kelt were observed with damaged eye(s) at the Prosser Hatchery. The fish's need to avoid negative effects of direct sunlight during periods of hot sun and weather (i.e. seeking shade) has contributed to eye infections negatively affecting the process of reconditioning to an unknown degree. 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 will 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. Approaches included: installing large tank covers to increase overall shading, 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 will crowd 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 19 Lotek Inc. radio tags from the University of Idaho (UI) and used these to observe in-season homing. An additional 40 Lotek Inc. tags were used to observe 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 inserted using the gastric insertion technique.

The 19 fish used for the in-season homing investigation were trucked to the McNary Dam (Rkm 469) pool and released on December 10, 2002. 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.

The 40 long-term reconditioned steelhead used to observe migration routes and spawning grounds selection were released at Prosser Hatchery on December 10, 2002. 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 75.8), 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). Arial flights are planned for the spring of 2003, 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 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 2003. 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 2003.

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. Each tag is unique and identifies an individual fish. Detectors at Bonneville, McNary, and Prosser dams can read the tags as the fish move upstream through the fishways. This 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 899 kelts were kept for reconditioning while 214 were culled due to poor condition or found to be dead on arrival, at Prosser Hatchery from 11 March to 13 June 2002. Collection generally followed in waves with the peak collection day occurring around April 20 (Figure 1). Total kelts used for reconditioning represented 19.8% (899 of 4,525) of the entire Yakima River ESA-listed population, based on fish ladder counts obtained from Prosser Dam for the period July 1, 2001 to June 30, 2002. It is possible that many of the emigrating kelts from the Yakima River were never diverted into the irrigation channel preventing their collection for reconditioning, and may have passed instead over the dam's spillway. A total of 2 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 1.89 kg (range: 0.91 - 3.76 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 and the digestive tract and stomach lining can become severely arthritic.

The overwhelming majority of kelts captured as part of this reconditioning research project were female (Table 1). A consistent finding in our previous steelhead kelt reconditioning work is that the large majority of all kelts available for reconditioning are female (approx. 88% during 2000 and 2001 at Prosser Dam) which may be indicative of the evolutionary advantage of female iteroparity. Based on visual observations, 846 (94.1%) of the kelts were classified as female, whereas only 52 (5.8%) as male in 2002. The gender of 1 steelhead (0.1%) was unknown at the time of collection. Naturally occurring female iteroparity essentially acts in analogous ways as cryopreserving males in iteroparous salmon populations in the Columbia Basin. In addition, the fact that 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, 2002.

Sex	No. Captured	No. Released
Male	54 (6%)	23(4.8%)
Female	844 (93.8%)	444 (93.2%)
Unknown/Unidentified	1 (.1%)	9 (1.8%)
Total	899	476

The majority of kelts collected during 2002 were considered in good or fair overall condition. In terms of gross morphological and physiological condition at the times of release, 468 (97.2%) kelts were classified as good, 13 (2.7%) as fair and 0 (0.0%) as being in poor condition. Regarding fish coloration, we classified 468 (97.2%) as bright, 12 (2.4%) as intermediate, and 1 (0.2%) as dark.

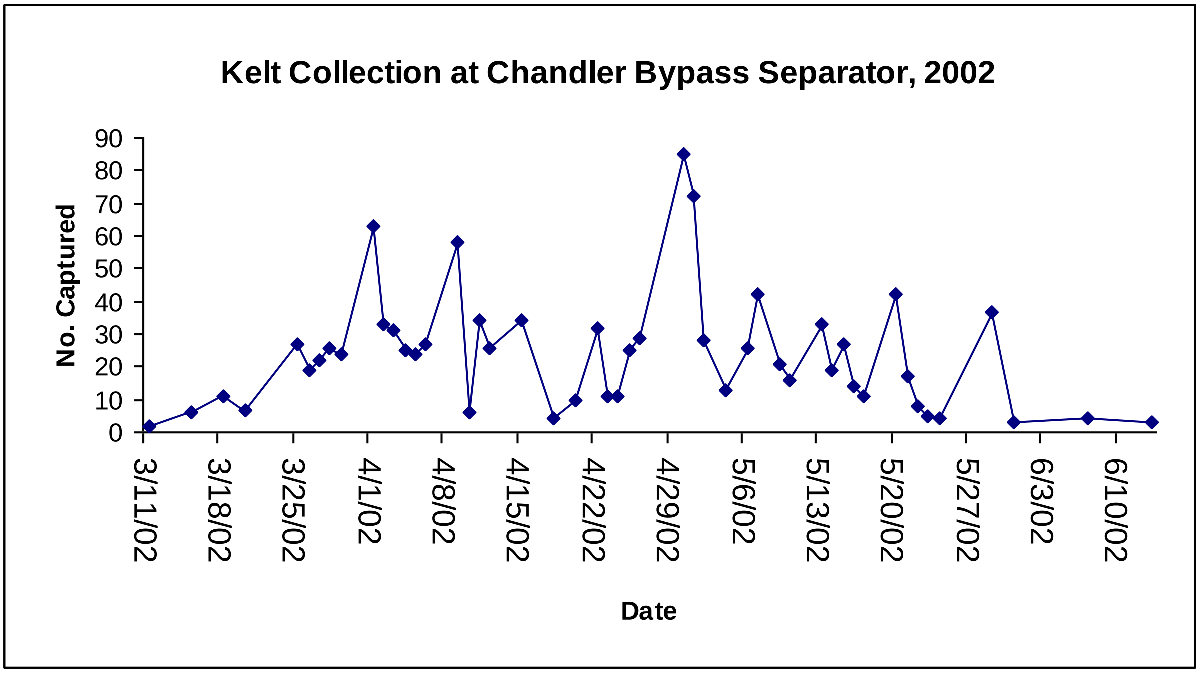

Figure 1. Kelt collection dates and numbers of fish removed from Chandler bypass facility involved in reconditioning procedures at Prosser Hatchery during 2002.

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 1-month reconditioning experiment, kelts were captured during April 4, - April 23, 2002 and released on May 20, 2002. The 2-month reconditioning kelts were captured during March 11- April 4, 2002 and then released on May 28, 2002. Survival rates for both groups were high (60-80%). 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. Based on weight maintained or gained during captivity, we classified surviving specimen as feeders or non-feeders. The percentage of feeders and non-feeders from the 1-month and 2-month experiments differed little.

Table 2: Population statistics for kelts in the short-term reconditioning experiment.		
Tank	C3 (1-month)	C4 (2-months)
No. Collected	259	220
No. (%) Released	163 (63%)	171 (78%)
No. (%) Feeders	39 (23.9%)	43 (25.1%)
Mean In-Weight (kgs.)	1.82	1.92
Mean Out-Weight (kgs.)	1.73	1.82

3.2.2 Mortality Statistics

The majority of mortalities for the 1- and 2-month experiment occurred within the first 10 days of capture (Figure 2). As with past experiments this can be attributed in all likelihood to handling stress, failure to accept starter feed, loss of the ability to convert feed into an appreciable weight gain, or that the fish were near morbid when collected. After the 10-day capture period mortalities drastically decrease. The high survival rates of short-term reconditioned kelts could be misleading due to a high possibility that more mortalities will occur in the wild after release.

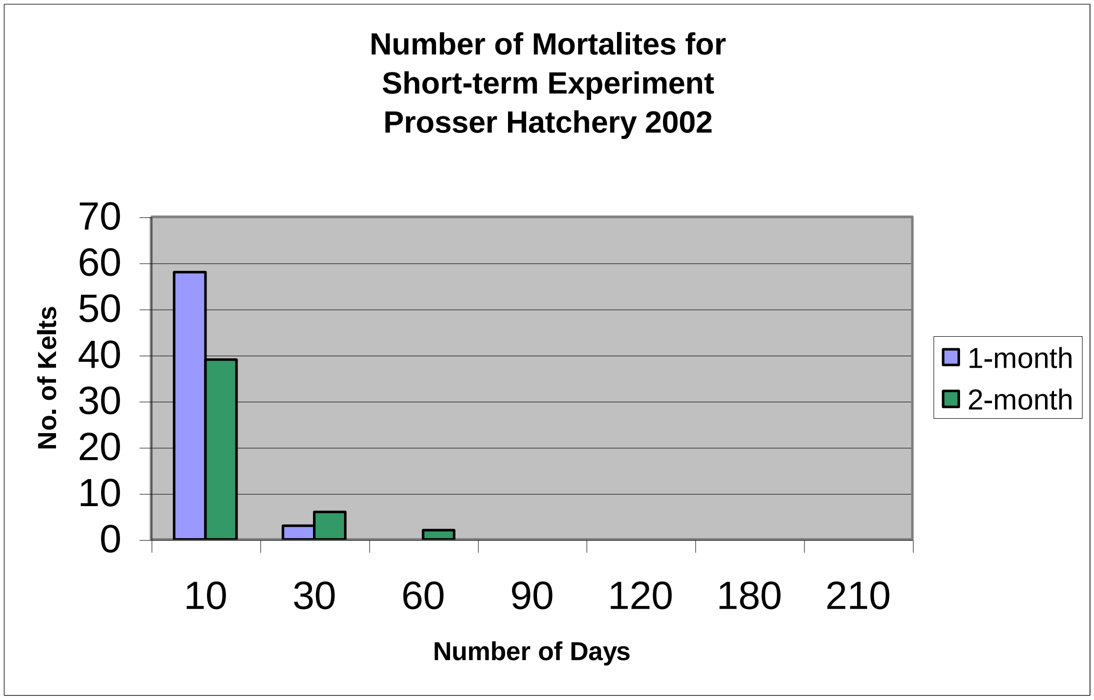

Figure 2: The number of days from capture-to-death of short-term kelts collected for reconditioning at Prosser Hatchery during 2002.

3.2.3 Feeding and Treatment Summary

Short-term kelts (1-month; tank C3 and 2-months; tank C4) received a solitary diet of krill. Part of the rationale for the short-term experiment is to assist the fish in reacquiring a feeding response and the krill diet seemed to be successful at that. It is hypothesized that this regained feeding response will benefit the fish once they are released and have natural prey items available. Although most kelt steelhead in the short-term experiment began feeding on krill, few maintained or gained weight. This may be a function of low nutritional value in the krill only diet or too short of time period to measure weight gain. A large number of the short-term kelts actually lost weight for the duration of this experiment (Figure 3). Both short-term experimental groups had the same diet and one group received an extra months worth of feed yet the percent of feeders differed by approximately 1% between the groups. This indicates that adding a greater nutritional component to the diet may be beneficial in the future. The 1-month reconditioning population had 22.5% gaining weight, 74.3% losing weight, and 3% with no weight change. The 2-month reconditioning experiment had 29.2% of the population gaining weight, 65.4% losing weight, and 5.2% with no weight change. The mean weight change for 1-month short-term reconditioning for immature kelts was –4.97% while the 2-month short-term reconditioning mean weight change for immature kelts was -5.17%. Individual weight gain and loss for both experiments closely mirrored each other with a slightly increased spread for the 1-month experiment. Unfortunately, in the 2-month experiment the additional month had little difference in any appreciable weight gain. As has been noted in last years annual report by CRITFC staff, 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).

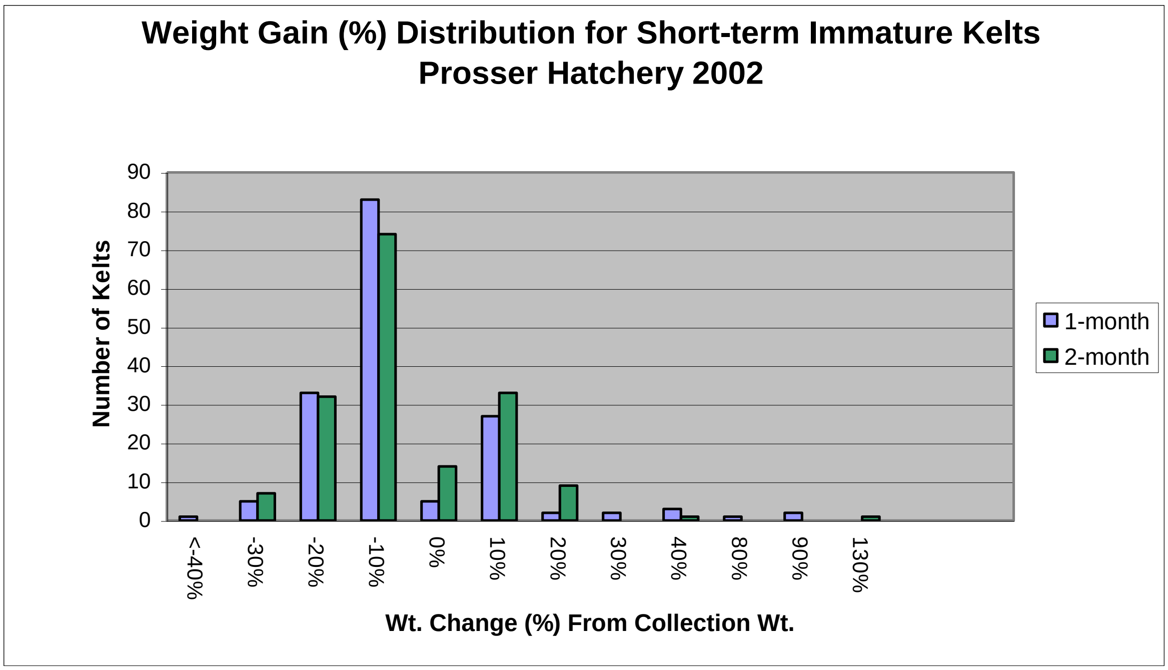

Figure 3: Weight gain distribution (weight gain as a percentage of collection weight) for short-term reconditioned and released kelts at Prosser Hatchery during 2002.

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 10-months and were given different feed types. The three tanks were all started on a krill diet for 2.5 months and then were switched to a maintenance diet of Moore-Clarke pellets for the duration of their stay. Kelts in tank C1 were fed unaltered Moore-Clarke pellets, C2 was fed an altered Moore-Clarke pellet that was soaked in krill extract and dyed pinkish-red so as to resemble krill, and tank C3 was given a mix of the unaltered and altered Moore-Clarke pellets (Table 3). Survival percentage for tanks C2 and C3 closely resembled each other while tank C1 was 20% lower probably due to kelts not quickly accepting unaltered Moore-Clarke pellets. Maturation levels were very high for tank C1 with a 74% rematuring while C2 did well with 50% rematuring. Tank C3 surprisingly did not have a high amount of individuals rematuring possibly due to a late collection date.

Table 3: Fish population statistics by Tank No. for the long-term reconditioning experiments.

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

Tank	C1	C2	C3
No. Collected	192	192	36
No. (%) Released	39 (20%)	84 (44%)	17(47%)
No. (%) Mature	29 (74%)	42 (50%)	5(29%)
In-Weight (kgs.)	1.75	1.99	1.99
Out-Weight (kgs.)	2.39	2.54	2.03
Mature Feeders (%)	26/29 (89%)	39/42 (92%)	3/5 (60%)
Immature Feeders (%)	2/10 (20%)	16/39 (41%)	2/10 (20%)

3.3.2 Mortality Statistics

Once again like experiments during previous years and the two short-term experiments the majority (>50%) of kelt mortalities occurred during the first 10 days of capture (Figure 4). The most probable reason behind the high initial mortality rate is stress from a variety of sources including: in- processing, lack of nourishment, and the extreme conditions of their migration. Many fish probably cannot or will not accept the feed and they may not be able to metabolize food to stabilize necessary vital bodily functions. After the initial 10-days, tank C2 and C3 had relatively low mortalities. Tank C1 averaged 10 mortalities per 30 days, most likely due to unaltered Moore-Clark pellets that steelheads find unpalatable in an unaltered form. Overall, except for tank C1, long-term mortalities declined by nearly 10-20%.

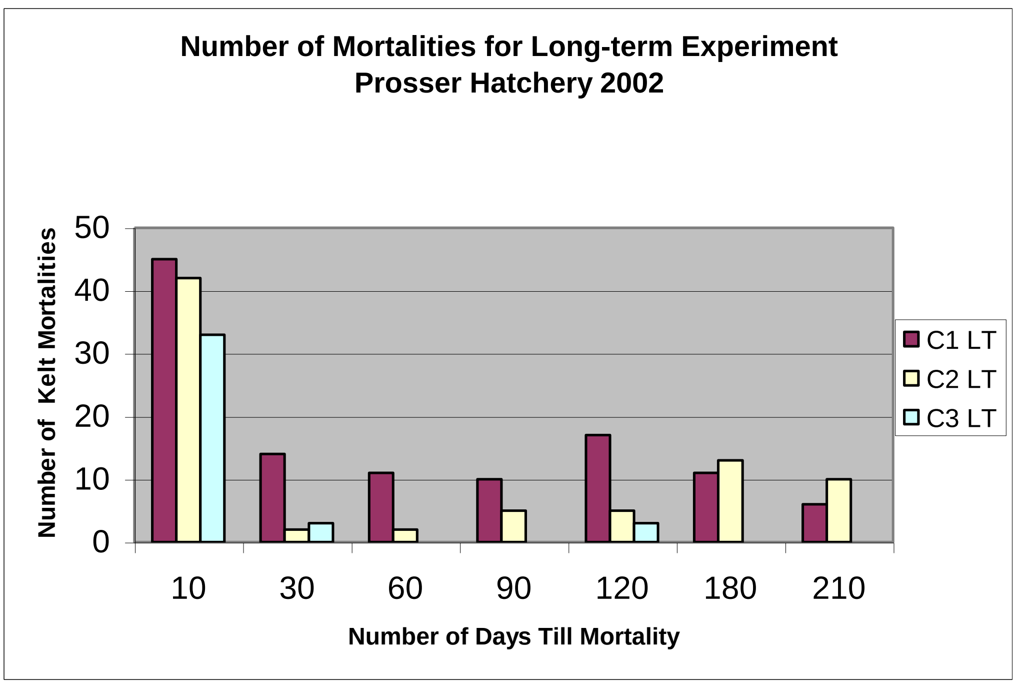

Figure 4: Number of kelt mortalities as a function of time for the long-term reconditioning experiment by tank in 2002.

3.3.3 Feeding and Treatment Summary

For the long-term experiments, kelts in tank C1 were fed krill as a starter diet for 2.5 months and then were given Moore-Clarke pellets. These pellets provided the highest rematuration rate (74%) but they also had the lowest survival rate (20%). In tank C3 kelts were fed the initial krill starter diet then given a mix of regular Moore-Clarke pellets with altered Moore-Clarke pellets that had been soaked in krill extract and dyed pinkish/red to resemble krill. The kelts in tank C3 had the highest survival rating (47%) but they did not mature (29%) like kelts in the other tanks. In the long-term feeding experiments, results indicated that the kelts in tank C2 given the initial krill starter diet, then given altered Moore-Clarke pellets soaked in krill extract and dyed pinkish/red provided the best overall survival (44%) and rematuration (50%) rates in 2002. Interestingly, 45% of the long-term reconditioned kelts that survived in captivity during 2002 did not remature (64 of 140). However, a quarter of the kelts from tank C2 (altered Moore-Clarke pellet diet) exhibited somatic reconditioning, gaining > 0.5 kg in mass (10 of 40). The largest mean weight increase was 36.4% by tank C1, while tank C2 had an increase of 27.2%, and tank C3 with a modest mean weight gain of 2%.

When comparing long-term mature kelts versus immature long-term kelts it is quite apparent that weight gain and the amount of weight gain has an important role to play in the rematuration of steelhead kelts. Nearly 91% (Figure 6) of long-term reconditioned kelts classified as mature gained weight during the reconditioning process while 31% (18/57) of the immature fish examined on this date gained weight (Figure 7). The mean weight change for immature long–term kelts as a percentage of collection weight was –2.5% as compared to 49.4% for mature fish.

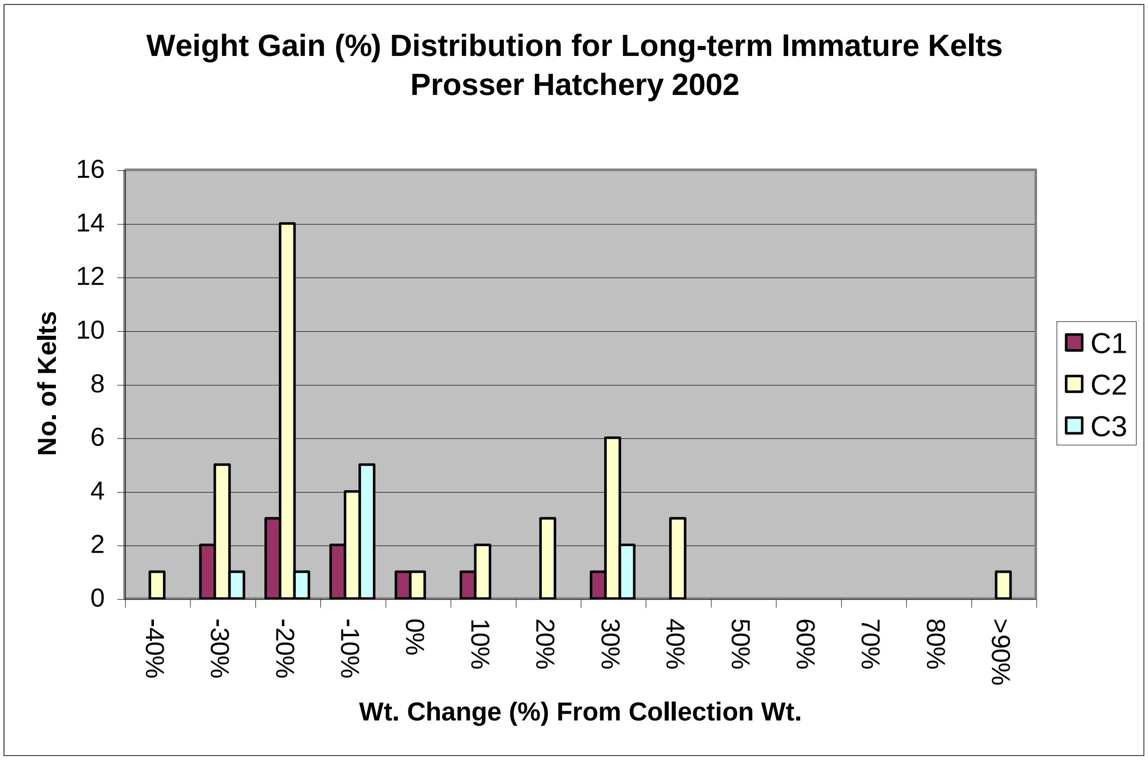

Figure 5: Weight gain (%) distribution for long-term immature kelts by tank number from Prosser Hatchery, WA in 2002.

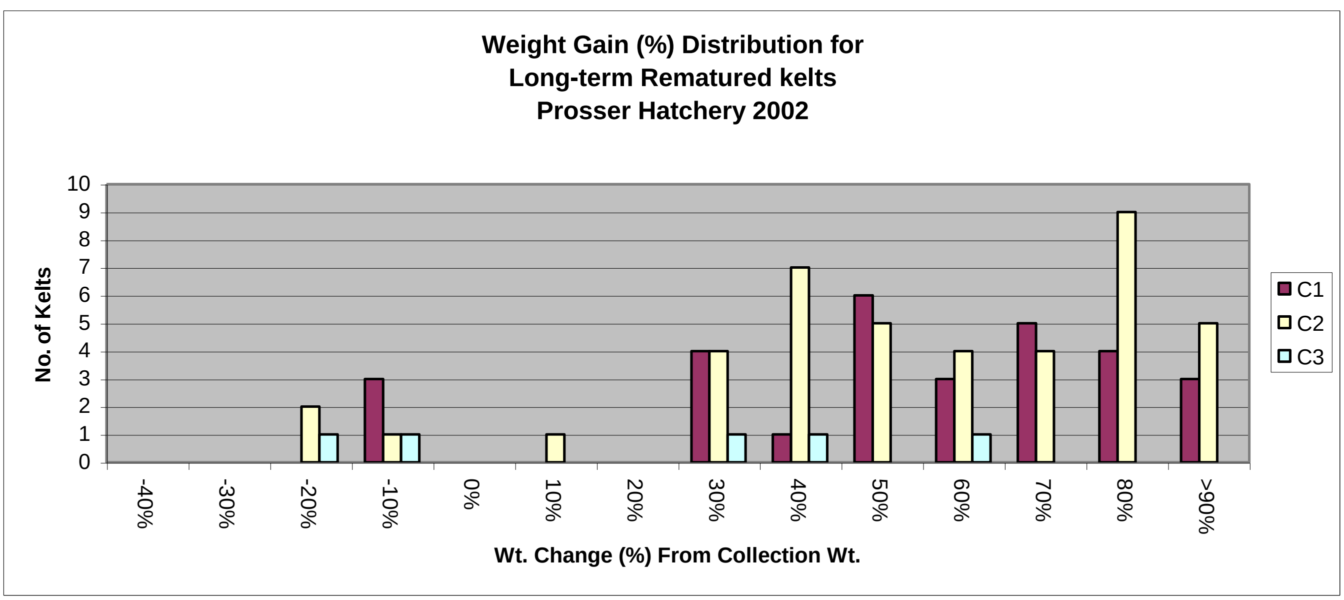

Figure 6: Weight gain (%) distribution for long-term rematured kelts at Prosser Hatchery, WA in 2002.

Krill continued to appear as an important component to reconditioning, compared to previous years when krill was not used. The Moore-Clarke pellets (especially the altered ones) were important in getting kelts to remature. It is apparent from the data that palatability of the Moore-Clarke pellets for kelts comes into question when looking at tank C1 and it's survival rates. The best option so far seems to be the Moore-Clarke pellets soaked in krill extract and dyed red.

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

Yakima Nation technicians installed large tank covers to increase overall shading, painted the bottom of the tanks a blue color but left the tank walls white, and delivered food in different locations around the tank to minimize crowding. The new alterations to the tanks lead 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 albeit that it remained relatively low (Table 5). It appeared that eye damage could have been a contributing factor to mortalities of captive steelhead, which could help to explain the decreased mortality rate in 2002 (Table 5).

Table 4: Comparison of Damaged Eyes 2001 vs. 2002

2001 Mortalities	2001 Release	2002 ST Mortalities	2002 ST Release	2002 LT Mortalities	2002 LT Release
93/347 (26.8%)	41/197 (20.8%)	7/108 (6.4%)	18/334 (5.3%)	11/273 (4.0%)	16/140 (11.4%)

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 possible schemes that can be used to assist post spawn steelhead. The short-term approach has a cost advantage and permits the fish to utilize the therapeutic benefits of saltwater. It also is the less invasive of the two approaches. Long-term reconditioning allows you to release 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-term, 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 –5.07%. An average of 22.9% of the short-term population gained some appreciable weight. Nearly 91% (Figure 7) of long-term reconditioned kelts classified as mature on December 10, 2002 examination gained weight during the reconditioning process while 31% (18/57) 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 –2.5% as compared to 49.4% for mature fish. In both short-term and long-term experiments the majority of mortalities occurred within the first 10-days of capture (Figure 8). Short-term reconditioned fish had a greater survival rate (average of 70.5%) than long-term reconditioned fish (average of 37%). We will not be able to say conclusively that short-term reconditioning produces higher return rates until data is collected in 2003-2004. The preliminary advantage to long-term reconditioning is that kelts show rematuration levels as high as >70% with the only drawback being that survival rates tend to be as low as >20%. Preliminary results show that short-term kelts have about a >15-20% increased survival rate compared to the long-term experiment, but this could also decrease over time. Short-term reconditioning may be a more financially viable answer to increasing kelt rematuration, but results will not be conclusive until several return years can be evaluated.

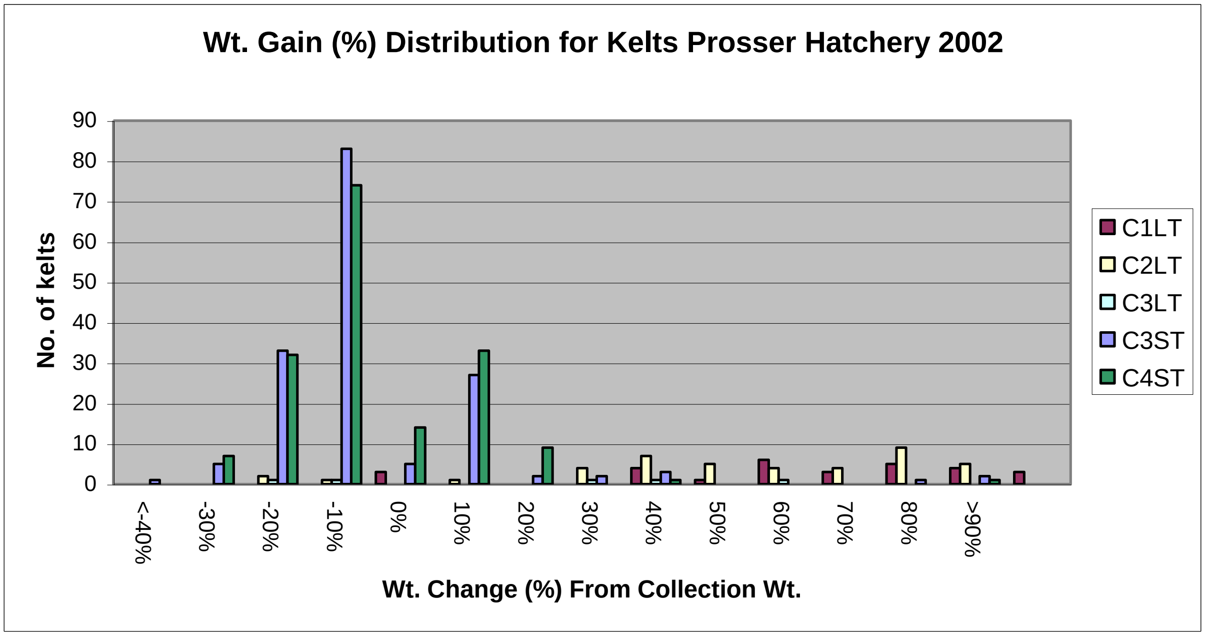

Figure 7: Weight gain (%) distribution for kelts by tank number at Prosser Hatchery, WA in 2002.

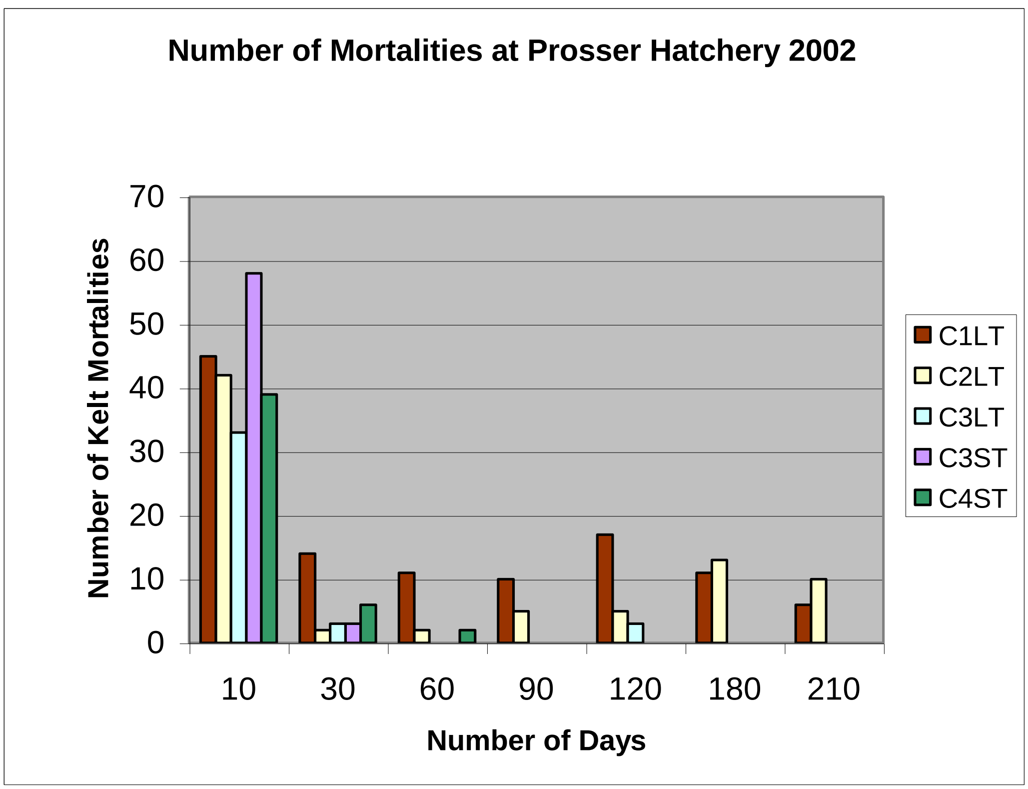

Figure 8: Number of mortalities by tank number at Prosser Hatchery, WA in 2002.

3.5 Biotelemetry

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

3.5.1 Radio Telemetry

During the 2002 season a total of 140 (33.3 %) long-term reconditioned kelts survived reconditioning to be released, with 76 kelts rematuring. A total of 60 kelts of the 76 were radio-tagged with 20 tags from UI and 40 from NMFS then released. Each tag was inserted using the gastric insertion technique.

Radio Telemetry Data Available in 2003

3.5.2 PIT Tag

A total of 331 PIT tags were submitted to the regional PTAGIS database for short-term kelts released below Bonneville Dam on May 20 and May 28, 2002. A query was submitted to the PTAGIS database on June 23, 2003 to allow an assessment of all detection history on these fish since their release. The results of this query are presented in Appendix A.

As of June 23, 2003, a total of 29 (8.8%) of the 331 fish in the release had subsequent upstream detections and one fish was detected downstream at site code "TWX", an abbreviation for a towed detector trawl device in use by NOAA Fisheries to obtain Columbia River estuary PIT tag 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 2002 short-term releases will be presented in subsequent annual reports.

Of the 29 fish with upstream detection history in 2002-03, 10 of these fish (34.5%) have a tag detection history which is consistent with a repeat spawning event (defined as upstream migration detections during the summer and fall of 2002, followed by a 3-6 month period with no detection activity, followed by a downstream detection in late March or early April of 2003). For example, PIT code 3D9.1BF139F373 was released on 20-May-2002, detected at Bonneville on 30-August-2002, detected at McNary (adult ladder) on 25-September-2002, and detected at McNary (juvenile bypass) on 10-April-2003.

A total of 23 of the 29 fish with upstream detection history in 2002-03 (79.3%) were detected at McNary adult fish ladders, and of these 13 were later detected in the Yakima River either at the Prosser adult denil fish ladder in the fall of 2002 or at the Chandler juvenile monitoring facility in the spring of 2003. It should be noted that fish with upstream detections at McNary without subsequent detections in the Yakima is not indicative of straying since only about 8-11% of upstream migrating steelhead in the Yakima pass via the adult denil ladder at Prosser dam and not all downstream migrating kelts are diverted into the Chandler canal and juvenile monitoring facility. Taken together these data provide substantial evidence of homing fidelity in these fish.

Further PIT-tag data will be recorded and published in 2003.

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 Evaluation Facility (CJEF) 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) and 50% (2002). As previously reported by Evans et al. (2001) and Hatch et al. (2002) in this project's previous annual report, 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 warrant additional research, and we are optimistic that kelt reconditioning techniques may ultimately lead to an effective 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's promising approach to increase natural production of wild steelhead is 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 gondal development and successful iteroparous spawning. Kelt reconditioning techniques were initially developed for Atlantic salmon and sea-trout. Evans et al. (2001) provided a comprehensive literature review of kelt reconditioning, and along with past years' success reconditioning wild Yakima River steelhead kelts, continues to support future reconditioning research, as 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.

2002 Short-term Kelt Releases with Post-release Detections

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	5/28/2002	TAG	CHANDL	WJB02148.PRO	AT KL	W
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	5/28/2002	TAG	CHANDL	WJB02148.PRO	AT KL FE	W
	8/31/2002	OBS	BWL			
	10/28/2002	OBS	MC2			
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	4/15/2002	TAG	CHANDL	BDW02091.PRO	AT KL FE	W
	10/1/2002	OBS	B2A			
	10/1/2002	OBS	BWL			
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	4/7/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
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	9/3/2002	OBS	MC2			
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	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	CHANDL	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	

2002 Short-term Kelt Releases with Post-release Detections

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	10/28/2002	OBS	MC2			
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	8/11/2002	OBS	BO2			
	8/27/2002	OBS	MC1			

2002 Short-term Kelt Releases with Post-release Detections

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	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	CHANDL	WJB02140.PRO	AT KL FE	W
	8/27/2002	OBS	BO2			
	10/4/2002	OBS	MC1			
3D9.1BF166BA9C						
	5/20/2002	TAG	CHANDL	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	
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	5/20/2002	TAG	CHANDL	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	
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	9/27/2002	OBS	BWL			
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	3/31/2003	REC	CHANDL	WJB03071.PRO	RE KL FE	
3D9.1BF1692AD1						
	5/28/2002	TAG	CHANDL	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	CHANDL	WJB02148.PRO	AT KL FE	W
	8/22/2002	OBS	BO1			

2002 Short-term Kelt Releases with Post-release Detections

TagId	EventDate	EventType	SiteID[1]	FileId	Flags[1]	RearTyp
3D9.1BF169BC77						
	5/28/2002	TAG	CHANDL	WJB02148.PRO	AT KL FE	W
	9/27/2002	OBS	BWL			
	9/28/2002	OBS	BO1			
3D9.1BF169E65D						
	5/20/2002	TAG	CHANDL	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	

[1]Information about these codes can be found in the PIT Tag Specification Document available on-line at http://www.pittag.org/Software_and_Documentation/index.html