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

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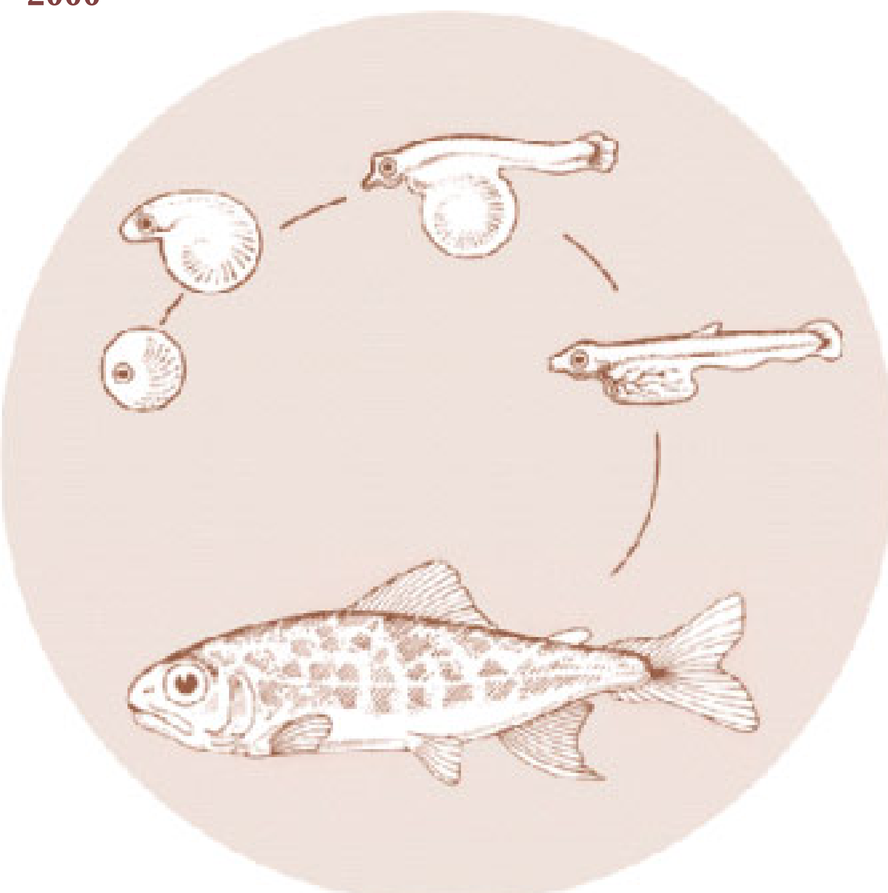

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2000 Annual Report

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. Natural rates of repeat spawning for Columbia River steelhead *Oncorhynchus mykiss* populations range from 1.6 to 17%. Increasing this repeat spawning rate using fish culture techniques could 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 grow and 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 local populations.

The primary purpose of this project in 2000 was to test the general feasibility of collecting, feeding, and treating steelhead kelts in a captive environment. Steelhead kelts were collected from the Yakima River at the Chandler Juvenile Evaluation Facility (Rkm 48) from 12 March to 13 June 2000. Kelts were reconditioned at adjacent Prosser Hatchery in both rectangular and circular tanks and fed a mixed diet of starter paste, adult sized trout pellets, and freeze-dried krill. Formalin was used to control outbreaks of fungus, and we tested the use of ivermectin to control internal parasites (e.g., *Salmincola spp.*). Some the kelts that died during the reconditioning process were analyzed via pathology and gonad histology to ascertain the possible cause of death and to describe their reproductive development at the time of death. All surviving specimens were released for natural spawning on 12 December 2000. Overall success of the reconditioning process was based on the proportion of fish that survived captivity, gained weight, and on the number of fish that successfully underwent gonadal recrudescence. Many of the reconditioned kelts were radio tagged to assess their spawning migration behavior and success following release from Prosser Hatchery.

In total, 512 kelts were collected for reconditioning at Prosser Hatchery. Captive specimens represented 37% (512/1,380) of the entire 1999-2000 Yakima River wild steelhead population, based on fish ladder counts at Prosser Dam. At the conclusion of the experiments (~240 days from capture), 91 fish (18%) had survived and were released to spawn in the wild. Ultrasound examination – to determine sex and reproductive development– determined that 87 (96%) of 91 specimens were female, and we estimated 62 fish (12% of the total collected) had successfully reconditioned. Unfortunately, the majority (82%) of the kelts collected died during the experiment, with the bulk of the moralities occurring during the first 100 days of captivity. Much was learned from the mortalities and modifications were made to the facility to reduce loss for future projects.

Overall, the kelts reconditioned during this project will substantially bolster the number of repeat spawners in the Yakima River. Knowledge regarding kelt husbandry, food type preferences, condition, and rearing environments were obtained during this research endeavor. Although the reconditioning success rate achieved (estimated at 12%) was substantially lower than we initially hoped yet still six times higher than the natural rate of respawning and the authors are encouraged by the results of this innovative project. Information collected during this feasibility study will be incorporated into the experimental design for the upcoming year of research and is expected to increase survival.

ACKNOWLEDGEMENTS

The Bonneville Power Administration, under the Northwest Power Planning Council funded this project. We sincerely appreciate the support, scientific review, and ongoing communication between our project staff and these groups. We sincerely appreciate the assistance of Brad Miller, the project's Contracting Officer Technical Representative, for his help with the 2000 research endeavor. The U.S. Bureau 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 Joe Ravita (Connecticut's Whittemore Salmon Station), Greg Davis (Oregon Department of Fish and Wildlife), and Kent Mayer (Oregon State University) for sharing their knowledge of kelt reconditioning. We thank Michael (Sonny) Fiander, Carrie Skahan, Chuck Carl, Mark Johnston, Jim Dunnigan, and other Yakama Nation staff for providing fish husbandry and telemetry expertise. This work would not have been possible without their assistance. We thank Andre Talbot, Chris Beasley, Phil Roger, and John Whiteaker from the Columbia River Inter-Tribal Fish Commission for their comments on project and reviews of the annual report. Lastly, we thank the Ted Bjornn and his staff from the University of Idaho and the Bureau of Reclamation and the USGS/BRD for their assistance with the radio telemetry portion of this project.

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INTRODUCTION

Many steelhead and salmon populations in the Pacific Northwest are at critically low levels. Thus, many distinct population segments are listed as threatened or endangered under the Endangered Species Act (ESA 1973). Causes of these population declines are numerous and well known (NPPC 1986; TRP 1995), and regional plans uniformly recognize the need to protect and enhance weak upriver steelhead *Oncorhynchus mykiss* populations while maintaining their genetic integrity (NPPC 1995).

One novel approach to effectively increase fecundity of steelhead populations is to capitalize on their inherent iteroparity (ability to spawn multiple times) by artificially reconditioning post-spawners. This concept has been applied to Atlantic salmon *Salmo salar* populations in the U.S. and Canada over the last two decades by maintaining fish in freshwater (Hill 1987; Johnston et al. 1987) and seawater (Ducharme 1972; Gray et al. 1987; Pepper and Parsons 1987). Reconditioning Atlantic salmon has also been attempted in Europe (Dumas et al. 1991) where natural multiple spawners are estimated to be relatively rare (1%). Artificial reconditioning of sea-run brown trout *Salmo trutta* L. has also been undertaken with some success (Poole et al. 1994). We have only located one study that reported artificial reconditioning of steelhead (Wingfield 1976).

Repeat spawners (i.e., surviving kelts) may have significantly augmented early populations of steelhead in the Columbia Basin. For decades, repeat spawners have been documented returning to their natal streams (Long and Griffin 1937, Whitt 1954). Observations of this reproductive life history characteristic within steelhead date back to 1895 (Evermann 1895). Residents in Idaho noticed that steelhead, unlike other salmon in the Snake River, did not die after spawning but appeared to travel back to the ocean (Evermann 1895). Earlier scale analysis of Clearwater River steelhead indicated a repeat spawning rate (equivalent to survival and rematuration rate for kelts) of approximately 2% in 1952 (Whitt 1954), when only two dams impeded their migration. Rates averaging 1.6% have been documented for wild summer steelhead populations in both the Yakima River subbasin (above 4 mainstem dams; Hockersmith et al. 1995) and in the mid/upper Columbia (above 7-9 dams; L. Brown, WDFW, Wenatchee, pers. comm.). Rates ranging annually from 2% to 9% have been estimated for the South Fork Walla Walla River (above 4 dams; J. Germond, ODFW, Pendleton, pers. comm.). Estimates of repeat spawners in tributaries of the lower Columbia River have exceeded 17% (NMFS 1996), with some fish returning to spawn four consecutive times (Leider et al. 1986). Repeat spawning rates for Atlantic salmon in eastern Canada have been observed to vary from 2 to 34% depending on the river system, and some individuals have made six spawning trips (Ducharme 1969).

A suite of questions and associated hypotheses need to be tested prior to implementation of a basin wide kelt utilization scheme. Many of the appropriate questions / hypotheses have been proposed in a five-year plan (Beaty and Evans 2000) but the main issues for the recovery of animals involve feeds and feeding methods, homing, gamete abundance and viability, and management implications and scenarios. Long-term issues relate to the productivity and cost-effectiveness of reconditioning steelhead. We concentrated our efforts this year on locating potential kelt collection facilities, developing kelt identification protocols, investiagating feeds and feeding techniques, and evaluating homing of reconditioned specimens. Specifically, our objectives addressed in this progress report were to:

1) Review literature on kelt reconditioning.
2) Collect and tempt kelts to accept feed for reconditioning.
3) Compare volitional and augmented volitional feeding methods.
4) Evaluate condition and reproductive state of kelts that die during reconditioning.
5) Identify which reconditioned kelts are maturing again.
6) Evaluate the homing ability of the reconditioned kelts.
7) Identify potential locations, upstream of McNary Dam, were wild steelhead kelts might be collectable for future reconditioning work

An understanding of the reconditioning research conducted by others may be critical to the success of this project. Thus, we synthesized those aspects of reconditioning that appear relevant to our project.

LITERATURE REVIEW

The literature on steelhead kelt reconditioning is quite limited. Therefore, in this section we will expand our review to include the more extensive Atlantic salmon kelt reconditioning literature, and complete the section with a summary of the most recent reconditioning programs that have been described to us in personal communications.

Peer Reviewed Manuscripts Relating to Reconditioning: The steelhead kelt reconditioning literature that we were able to locate consists of a single document from the central Oregon coast (Wingfield 1976). In this experiment 24 fish were selected from a group of Siletz River summer steelhead that had been trapped from the river and used as hatchery brood stock in 1973. This selected group was held over with hopes of them spawning the following year. The group consisted of 4 wild fish and 20 marked hatchery-origin fish. The 4 wild fish failed to accept feed and died. All of the hatchery-origin fish accepted food, however 5 fish "were lost to unknown causes" yielding a reconditioning success rate of 63%. Following one year of feeding, the experimental fish were checked for ripeness. Wingfield (1976) discovered that most of the test fish were over-ripe and partly spawned out and that all 11 females had gained weight and produced eggs. Some eggs were salvaged from 4 fish and 3,280 fingerlings were marked and released from this group one year later. Two years later, the return rate for these progeny was calculated at 1.21%. Wingfield (1976) concluded "a supplemental hatchery program can replace and establish new stocks by using adult steelhead that can be fed and spawned the second year."

Studies on artificial reconditioning to enhance repeat spawning have been reported for sea trout (Poole et al. 1994), sockeye salmon *O. nerka* (McBride et al. 1963), arctic char *Salvelinus alpinus* (Boyer and Toever 1993), Atlantic salmon (Ducharme 1972; Hill 1978; Gray et al. 1987; Johnston et al. 1987; Pepper and Parsons 1987; Gauthier et al. 1989; Johnston et al. 1990; Dumas et al. 1991; Eales et al. 1991; Crim et al. 1992; Johnston et al. 1992; Moffett et al. 1996) and precocious chinook salmon *O. tshawytscha* (Bernier et al. 1993).

In Atlantic salmon and sea trout kelt reconditioning studies, introducing feed, preventing mortality, and improving the survivability of offspring have been identified as some of the challenges to address. Food introduction methods have included using devices to place food near the mouth of fish (Johnston et al. 1990; Crim et al. 1992; Moffett et al. 1996); force feeding fish (McBride et al. 1963; Eales et al. 1991; Poole et al. 1994); and, experimenting with various foods including fish (Ducharme 1972; Hill 1978; Gauthier and Desjardins 1989; Johnston et al. 1990; Dumas et al. 1991; Eales et al. 1991; Crim et al. 1992; Johnston et al. 1992; Moffett et al. 1996); maggots (Poole et al. 1994); and, prepared diets (Hill 1978; Gray et al. 1987; Dumas et al. 1991; Crim et al. 1992; Johnston et al. 1992). Increased survivability of offspring has been linked to the nutritional content of the diet given to the kelt parents (Hill 1978; Dumas et al. 1991; Crim et al. 1992). In reconditioning experiments it has been demonstrated that survival chances increase the earlier kelts begin to feed. Using a stick or other device to hold food items near kelts for the purpose of eliciting a feeding response seems to work as well or better than force-feeding fish. This intensive culturing method appears to result in much higher survival and reconditioning rates than simply broadcasting feed in the holding container. However, even with the intense care seldom is 100% survival realized. Using natural foods also seems to improve feeding responses. Pellet type diets are rejected much more often than natural foods during the initial feeding phase of reconditioning. There does seem to be a community response to feeding once a few individuals begin to eat, as others seem to follow. After kelts have been "retrained" to take feed that is broadcast on to the water, it is important to provide a nutritionally balanced diet that meets biological requirements for producing viable progeny. Several studies have documented low viability in offspring and linked this phenomenon with deficient diets (Hill 1978; Dumas et al. 1991; Crim et al. 1992). Generally the nutritionally balanced diet is a semi-moist, pellet-type commercially produced feed. Dyeing the pellets red has shown promise by generating stronger feeding responses.

Preventing mortality and increasing reconditioning rates has led scientists to test the influence of photoperiod (Johnston et al. 1987; Gauthier and Desjardins 1989; Johnston et al. 1990; Eales et al. 1991; Johnston et al. 1992), water temperature (Hill 1978; Johnston et al. 1987; Johnston et al. 1990; Eales et al. 1991; Johnston et al. 1992), and water salinity (Ducharme 1972; Gray et al. 1987; Pepper and Parsons 1987). Manipulating photoperiod has enabled researchers to accelerate the maturation of some Atlantic salmon kelts. In natural photoperiod experiments approximately 40% of the kelts matured after their first year in captivity, while 100% maturation was achieved in kelts that experienced two 6-month compressed light cycles and accompanying water temperature fluctuations. Kelts attempt to feed more, and more tend to stay on feed as the photoperiod increases, provided water temperatures range from 6 to 10 C, or are increasing. Below this temperature range, body metabolism slows down and it is difficult to entice feeding from kelts. Above this temperature range, body metabolism increases dramatically and the fish must begin to feed soon or their condition rapidly deteriorates as they use up energy stores. The majority of Atlantic salmon kelt reconditioning work has been conducted using fresh water but two Canadian studies have used salt water. Gray et al. (1987) demonstrated that successful progeny could be attained from kelts reared at two different salinities of 16% and 28%. The author achieved low maturation rates during the first year, but in subsequent years these rates increased to 80%.

An important difference between Atlantic salmon and steelhead is that Atlantic salmon spawn in the fall, then endure several months of cold before waters warm and they begin feeding. Steelhead spawn in later winter or early spring, when water temperatures are already ascending into feeding range. Because of these ascending water temperatures it is probably more critical for steelhead kelts to begin to feed as soon as possible than it is for Atlantic salmon.

As we stated earlier, the majority of the kelt reconditioning literature involves Atlantic salmon. However, the literature mainly contains independent experiments manipulating a few environmental variables or diet and feeding regimes. Overview descriptions of reconditioning programs are not included in the literature. Therefore, we contacted several scientists that operate Atlantic salmon kelt reconditioning programs and from these discussions put together a brief description of their programs and identified components that are the most challenging. We hope this will provide some guidance for the steelhead programs.

Ongoing Kelt Programs (unpublished)*:* The descriptions that follow are from an Atlantic salmon reconditioning program at Connecticut's Whittemore Salmon Station[1] (1), steelhead kelt reconditioning project conducted by the Oregon Department of Fish and Wildlife (2), a precocious chinook salmon reconditioning experiment conducted by Kent Mayer (Oregon State University graduate student) (3), and a steelhead kelt reconditioning project conducted by the Yakama Nation (4).

(1) The Connecticut River Atlantic Salmon Restoration Program is a cooperative effort between four states, the federal government, and the private sector to restore the extirpated Atlantic salmon to the Connecticut River and selected tributaries. A major problem early in the program was obtaining donor stock to seed the river. A reliable source from year to year was not available, and the number of sea returns didn't approach the number of eggs needed for the program. Looking to some work done in Nova Scotia at the time, the idea of reconditioning spawned out sea-runs, keeping them in captivity to be used for an additional egg source was appealing. The added benefit to the restoration was that the eggs would be coming from "proven" fish: ones that had successfully returned to the Connecticut River.

Post-spawn fish were vaccinated to help prevent outbreaks of furunculosis *Aeromonas salmonicida*, and enteric redmouth *Yersinia ruckeri* and placed in six-foot circular tanks with no more than 4 fish per tank. Fish were then given approximately one week to acclimate prior to feeding.

Training the fish to feed follows a progression from easiest to hardest (least effort by personnel to the most tedious, time consuming). The first attempts at feeding are made by dropping small pieces of the prepared diet in front of the fish. Most of the time this does not elicit a feeding response. However, repeating this a number of times can cause some fish to respond. Usually, it appears the response is not out of hunger but rather anger or irritation for as soon as the piece is inhaled it gets spit back out. For an unknown reason (repetitiveness, palatability, hunger, etc?) fish finally ingest the feed. Once feeding is initiated the amount of feed generally increases until a fish reaches satiation. When fish are feeding aggressively and showing significant weight increase they are moved to larger tanks to continue rearing. Feeding is attempted with each fish

[1] We thank Joe Ravita (Whittemore Salmon Station) for contributing to this section.

two times a day seven days a week, except for one day that is reserved for cleaning. Feeding is only once that day.

Many kelts reject food that is dropped into the tank. For these fish efforts such as pole feeding (placing a small piece of food on the end of a pole) is required. Fish are then enticed to strike at the food. Food is wiggled in front of the fish and even tapped on the fish's snout. Also, food can be slipped into the mouth during the fish's respiration cycle. Again, food is often immediately spit out. Repeated attempts generally result in the fish finally ingesting feed. This can take upwards of a month of daily feeding attempts. Once the fish is feeding well on the pole, it is weaned into eating on the drop and then follows the progression described in the previous paragraph.

Up to 25% of the population requires the most intense, force-feeding regime but this has not met with great success. First, if fish will not feed on the prepared diet after a month or more of trying they'll use raw beef liver or shrimp for food. Again, this is either presented on the pole or dropped depending on the case. If a fish begins to eat using this approach, it is then offered a combination of the prepared diet and either liver or shrimp. It can often take upwards of 4 months for fish to actively feed until satiated. Remarkably, some fish will refuse feed up to 18 months and eventually die of starvation. Once fish are in the large tanks they are fed twice a day to satiation at each feeding (with the exception of tank cleaning days). Feeding continues until early fall with a gradual decline in the amount fed (fish initiated) over the summer months. All feeding is discontinued 3-4 weeks prior to the suspected date of first egg take. The level of success in getting fish on feed varies each year but generally over 80% of the fish eventually feed.

(2) In 1998, the Oregon Department of Fish and Wildlife (ODFW) attempted to recondition 29 Snake River steelhead that had returned to and been spawned at Wallowa Hatchery (M. Edwards, ODFW, pers. comm.). ODFW staff attempted to mimic Atlantic salmon techniques and fish were force-fed beef liver on a stick followed later by a soft krill-based pellet. Kelts were held in 8' shallow cement ponds during the reconditioning effort and formalin was used to treat fungal infections. Only two males of the 29 test fish survived beyond a month, and both were readily taking feed the following fall. The research was continued in 1999 with a similar protocol (e.g., force-feeding) and survival rate improved to 45% (5/11). At the conclusion of the experiment 3 fish (27%) had reached sexual maturity (2 ♀ and 1 ♂) and were spawned at the hatchery. Eggs produced by reconditioned females were viable and milt produce by the reconditioned male successfully fertilized eggs. If reconditioning survival rates can be improved at Wallowa Hatchery, wild kelts could be reconditioned to augment or perhaps even to establish new populations.

(3) Similar to iteroparous species, precocious salmon can also be reconditioned to spawn again (Bernier et al. 1993) and Oregon State University student Kent Mayer attempted to recondition endangered precocious spring chinook – in collaboration with the ODFW under Bonneville Power Administration funding. During this experiment, 38 precocious chinook salmon were held in net-pens (36 cubic feet), fed pellets (2mm) volitionally and force-fed starter paste (saline diluted). At the conclusion of the experiment, four fish had successfully reconditioned and 3 fish (8%) produced viable milt. In the wild, spring chinook are considered

semelparous (producing all offspring at one time, usually these fish die after reproduction) and the practice of reconditioning precocious individuals holds promise for future management applications.

(4) In March - April of 1999, the Yakama Nation (YN) collected 34 wild steelhead kelts at Prosser to test the feasibility of reconditioning. Various feeding methods were attempted to initiate the fish to manufactured feeds. Methods included force-feeding with a syringe down the throat, mixing fry starter paste to saturate the water with the feed and the use of automatic feeders. After 5 months, 17 were living and accepting feed. In February, 7 remaining fish were examined with an ultrasound for presence of reproductive organs, and released to the Yakima River for natural spawning.

Synopsis: From the literature on reconditioning other anadromous fish species, some common threads appear that should be taken into consideration in a steelhead-reconditioning program. First, to successfully recondition kelts it is imperative to get them feeding as soon as possible. This success seems to depend on the makeup of the diet and the presentation to the fish. Natural food items (bait fish, maggots, and krill) are preferred by the kelts over pellet feed. Enticing a feeding response by introducing food items near the kelt's mouth appears to increase food consumption. However, these techniques have added labor costs. Once feeding commences it is important to convert diets from one that elicits a feeding response to one that is nutritionally superior. The consequences of reconditioning kelts on nutritionally deficient diets are ultimately lower survival of progeny. Taking prophylactic measures to address pathogens is important in enhancing kelt survival. Fungus development on kelts can be a problem and must be addressed with treatments (formalin drip) in fresh water or recondition the fish in seawater. Additional treatments such as injecting antibiotics to reduce parasite loads can also improve reconditioning rates.

METHODS

Area and Facilities: Kelt reconditioning research was conducted at the Prosser Fish Hatchery in Prosser, Washington. Prosser Hatchery is located on the Yakima River (Rkm 48), downstream of Prosser Dam, and adjacent to the Chandler Juvenile Evaluation Facility. The Yakima River Basin is approximately 344 km in length and enters the Columbia River at kilometer 539. Summer steelhead populations primarily spawn upstream of Prosser Dam in Satus Creek, Toppenish Creek, Naches River and other subbasins of the Yakima River (TRP 1995). The Yakama Nation operates Prosser Hatchery, and its primary function is for rearing, acclimation and release of juvenile fall chinook salmon. The facility is also used for coho salmon *O. kisutch* rearing prior to the acclimation to the upper Yakima Basin.

Kelt Collection and Processing: After natural 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 (CJEF). The CJEF like other bypass facilities in the Columbia Basin – diverts migratory fishes away from the dam to reduce mortality. We used the CJEF to capture kelts by manually grading specimens that arrived on the separator (a fish separation device intended to capture juvenile salmonids). Yakama Nation staff monitored the Chandler bypass separator 24 hours a day from the period spanning 12 March to 16 June 2000. All adult steelhead, regardless of maturation status (kelt or pre-spawn[2]), arriving at the CJEF separator were dipnetted off the separator and placed into a water-lubricated PVC pipe slide that was directly connected to a temporary 20' (l) x 6' (w) x 4'(h) holding tank containing well water.

Specimens were transferred from the temporary tank via dipnet to a nearby 190-L sampling tank containing well water, where they were anesthetized in a buffered solution of tricaine methanesulfonate (MS-222) at 60 ppm. To ensure that steelhead kelts and not pre-spawn steelhead were retained for reconditioning, we scanned specimens with an ultrasound machine to assess maturation status per methods of Evans and Beaty (2000, 2001). Ultrasound examination ensured that pre-spawn steelheads were not removed from the current spawning population. Ultrasound identification techniques – which allow the gonads of the fish to be examined with acoustic waves – have been developed specifically for maturation assessment among Columbia Basin steelhead (Evans and Beaty 2000). During the ultrasound examination, a linear probe or transducer was placed against the specimen's abdomen and then moved anterior or posterior to view the ovaries or testes. Assessment of maturation status was based on the size, location, and echogenity of the gonads. Visual examinations were also made and estimates were compared with the ultrasound tests to assess the accuracy of the fish culturists' ability to recognize kelts. It was determined that the visual examination was a reliable method. Pre-spawn fish were immediately released into the tailrace of Prosser Dam to resume migration up the Yakima River. All specimens determined to be kelts were collected for reconditioning. Following kelt identification, we collected data on fish length (cm fork length), weight (kg), condition (good, fair, poor), coloration (bright, intermediate, dark), and presence or absence of physical anomalies (e.g., head burn, eye damage). Passive Integrated Transponder (PIT) tags were then implanted in the fish's pelvic girdle for identification during reconditioning.

Reconditioning Tanks: In-processed kelts were initially placed in one of four 25'(l) x 5 '(w) x 4'(h) rectangular tanks containing pathogen-free well water (ca. 14°c) draining at 100 gal.$\cdot$min^{-1}. Individual tank carrying capacity was set a 125 fish based on the aquaculture experience of YN hatchery staff. Formalin was administered five times weekly at 1:6,000 for 1 hour in all reconditioning tanks to help prevent outbreaks of fungus. Kelts were held in the rectangular tanks from 12 March to 16 June 2000. However, we determined that captive fish were being damaged in the rectangular tanks by ramming themselves into the tank walls (causing head and eye damage). Furthermore, water flow through the tanks was at a rate that caused feed to be washed out the tanks rapidly (e.g., within 10-15 seconds). To help reduce future injury and to provide the kelts with more time to accept feed, all kelts were transferred to four 20'(l) x 20'(w) x 4'(h) circular tanks on 16 June 2000. Circular tanks received the same well water and formalin treatments as rectangular tanks.

Feeding and Treatment: In the rectangular tanks, all kelts received Nutra Plus® starter feed made by Moore Clarke to help initiate feeding (Table 1). The starter feed was made into a paste by diluting the feed with water and grinding it into small pieces. We speculated that the scent emanating from the suspended and dissolving paste might help stimulate a feeding response.

[2] The term pre-spawner refers to a sexually mature fish.

Approximately 100g of starter feed were manually spread into the water column three times weekly. On days when starter paste was not administered, an automatic feeder dispensed Moore Clarke adult trout pellets (8.5 mm) at the rate of approximately $80g \cdot fish^{-1} \cdot day^{-1}$(Table 1). Following the 16 June tank transfer, starter paste was no longer placed in the tanks and trout pellets served as the primary kelt diet. However, in an effort to stimulate feeding continually, Argent® freeze-dried krill was administered to the kelts once a day (Table 1) at the rate of approximately $2g\ fish^{-1} \cdot day^{-1}$. Relative to the brown colored trout pellets, we speculated that krill was a more recognizable food source to the wild steelhead and would potentially augment the pellet based diet.

Table 1: Approximate chemical composition of the three food types used to recondition kelts at Prosser Hatchery, 2000.

	Starter feed	Adult pellet	Freeze-dried krill
Protein	53%	46%	66%
Fat	18%	25%	11%
Carbohydrate	12%	13%	9%
Fiber	-	1%	-
Ash	9%	8%	13%
Moisture	7%	7%	1%

Two of the four rectangular tanks – selected at random – also contained a “trainer trout” (rainbow broodstock) that were used to augment volitional feeding. We speculated that trainer trout may help “teach” kelts how to feed or perhaps to elicit a competitive feeding response in kelts. Kelts receiving starter paste (termed volitional control) were compared to fish receiving starter paste with a trainer trout (termed augmented volitional treatment). Comparison was based on the proportion of kelts that survived to tank transfer. We chose to end the comparison following the tank transfer because we suspected many of kelts would already be actively feeding by this time, negating the benefits of a trainer fish.

Upon transfer to the circular tanks, we also tested the use of ivermectin (formulation IVOMEC®) to control outbreaks of *Salmincola* spp., a parasite that can inhibit oxygen uptake in fish by attaching to the gill lamella. Severe infestation of the parasite can result in death, and cultured fish may be especially susceptible to *Salmonicola* because of their enclosed environment. Recent research by Johnson and Heindel (2000), suggests that ivermectin – a medication often used to control parasites in swine and cattle – can increase the survivorship of cultured fish by killing the adult morph of the parasite. To test the use of ivermectin on steelhead kelts, we treated approximately 75% of the kelts with ivermectin. Ivermectin was diluted with saline (1:30) and 3cc were injected into the posterior end of the fish’s esophagus using a small (10cc) plastic syringe. To prevent the lateral transfer of the parasite, treatment fish were maintained in separate tanks. Success of ivermectin treatment was assessed based on the prevalence of parasites in test fish relative to non-treated fish.

***Mortalities*:** Data were collected on most kelts that died during the reconditioning process. On discovery of a mortality, fish were subjected first 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 complete, 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 recovered from mortalities and identification numbers entered into a computer database along with the morphological data.

Pathology and Gonad Histology: To help augment the reconditioning effort, Oregon State University (OSU) provided expertise regarding the pathology and gonad histology of kelt mortalities. The goal of this task was to evaluate samples from steelhead kelt mortalities for evidence of maturation in order to determine which reconditioning treatments were best. In addition, since the cause of death is often uncertain; samples from steelhead kelt mortalities were subjected to pathological examination to determine if preventative/therapeutic measures could be recommended to increase kelt survival.

Based on the criteria that the fish was freshly dead on discovery, some of the mortalities were subjected to more extensive sampling to determine the possible cause of death and to assess their state of reproductive development. At the conclusion of the internal exam, hatchery personnel collected and preserved the following tissues in buffered formalin: a sample of gill arch, kidney, spleen, liver, and gonad. The preserved gonad samples were imbedded in paraffin and cut in thin slices before staining for histological examination. Gill, kidney, and spleen samples were examined for the presence of pathogens, liver samples for evidence of toxicological effects, and gonads for determination of reproductive state. The samples were not randomly selected and no causal connection regarding death during reconditioning can be made from the data.

Samples of gill, kidney, spleen, and liver were sent to the Washington Animal Disease Diagnostic Laboratory in Pullman, WA, where they were examined by Dr. T.J. Baldwin for presence of pathogens in the gill, kidney, and spleen samples and/or of toxic damage in the liver samples. Gonad samples were processed by the Oregon State University School of Veterinary Medicine and then examined microscopically (400x and 65x) by Dr. M.S. Fitzpatrick to determine stage of reproductive development at the time of death.

Maturation Assessment and Release for Spawning: On 12 December 2000, all surviving adult steelhead were released for natural spawning in the Yakima River or transported and released into the McNary pool of the Columbia River. We selected this release time because it coincided with the natural return of many Yakima River steelheads. Prior to release, many of the specimens were examined with ultrasound to assess maturation status. Ultrasound examination allowed us to determine if the fish had successfully developed new gonads and was potentially ready to spawn a second time. Morphometric data regarding fork length, weight, and presence/absence of parasites – to assess the ivermectin treatments – were also recorded on all released individuals. A sample of fin tissue was also removed from each released specimen and place in 15ml vials filled with a lysis buffer for possible future DNA analysis. Overall success of the reconditioning process was based on the proportion of fish that survived captivity, gained weight, and the number of fish that successfully underwent gonadal recrudescence (based on ultrasound appraisal).

RESULTS/DISCUSION

***In-processing Statistics*:** In total, 512 kelts were collected for reconditioning at Prosser Hatchery during the period of 12 March to 13 June 2000. Kelt abundance peaked at Chandler bypass on 3 April (Figure 1). Overall, kelts captured for reconditioning represent 37% (512/1,380) of the entire Yakima River ESA-listed population, based on fish ladder counts obtained from Prosser Dam from September 1999 to March 2000. It is possible that many of the emigrating kelts from the Yakima River were never diverted into the irrigation channel – thus were not collected for reconditioning – and passed instead over the dam's spillway. Thus, a large proportion (at least 37%) of the adult steelhead that successfully reached Prosser Dam during the fall of 1999 and winter of 2000 survived the act of spawning and attempted emigration during the spring as kelts.

In contrast to the abundance of kelts in the CJEF, pre-spawn steelhead were rarely encountered during capture and processing. Only three wild pre-spawn migrants were removed from the Chandler bypass separator from 12 March to 13 June, 2000. We also sampled three hatchery[3] steelhead during the same time period all of which were pre-spawners. Four of the six pre-spawners were collected in early March and the remaining two in April.

Many of the 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 1.7 kg (ranging from 0.54 kg to 4.2 kg). Research on energy expenditure during migration and spawning – a period when many salmonids are believed to stop feeding – suggests that anadromous fish deplete over 60% of their lipid, protein, and ash reserves during the spawning process (Love 1970). Much of the muscle tissue is converted into water and the digestive tract and stomach lining can become severely arthritic. Thus, the emaciated appearance of kelts was not surprising.

The overwhelming majority of kelts captured for reconditioning were female. Based on ultrasound examinations, we classified 452 (88%) of the kelts as female and only 60 (18%) as male. Of the 452 kelts classified as female, 80 individuals had completed spawning (i.e., no eggs were discovered during the ultrasound exam) and sexual dimorphism was used to determine their sex. The majority of kelts collected were considered in good overall condition. In total, 416 (85%) kelts were classified as good, 50 (10%) as fair and 26 (5%) in poor condition. In regards to fish coloration, we classified 317 (64%) as bright, 143 (29%) as intermediate, and 32 (7%) as dark. Complete records regarding both fish condition and coloration were not taken for 20 individuals.

[3] Hatchery origin based on the adipose clip

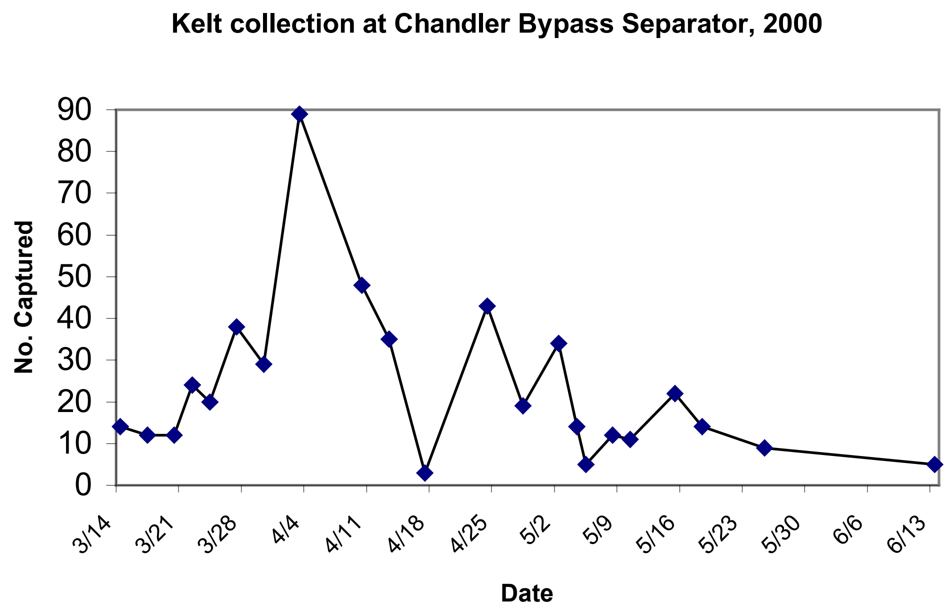

Figure 1: Kelt collection dates and numbers of fish removed from Chandler bypass Facility that were subjected to reconditioning procedures at Prosser Hatchery.

Mortality Statistics: Of the 512 kelts collected for reconditioning, 421(82%) died during the study period, most within 100 days of collection. The early death of captive kelts suggests that they never accepted or were unable to digest feed, and that their remaining energy reserves were not enough to keep them alive beyond 100 days (Figure 2). Surprisingly, 51 (14%) kelts died within the first 10 days of capture. The authors suspect these individuals either died as a result of handling stress or were moribund upon collection. In contrast to the early death of many captive specimens, only 82 (19%) fish died between 100 and 200 days (Figure 2). The proportion of mortalities that were actively feeding prior to death in not known, although an internal examination of body cavity often revealed an empty stomach. The density of fish within each tank prevented us from observing which individuals were and were not feeding, and mortalities were not weighted[4].

Mortality rates were higher in the rectangular tanks relative to circular tanks. In the rectangular tanks, 68% of the kelts died. In contrast, only 32% died while in the circular tanks, despite being held captive for a longer time period. However, we are unable to determine the exact negative effect(s) of the rectangular tanks versus the circular tanks. We speculate that higher mortality in the rectangular tanks was a result of physical damage (caused by ramming into tank walls), higher fish density, and/or because kelts were more vulnerable during the first few weeks of captivity. Regardless of the exact reasons, we recommend kelts be reconditioned in circular tanks to reduce possible physical injury and to allow feed to circulate for longer periods of time.

[4] All mortalities will be weighed during the 2001 study.

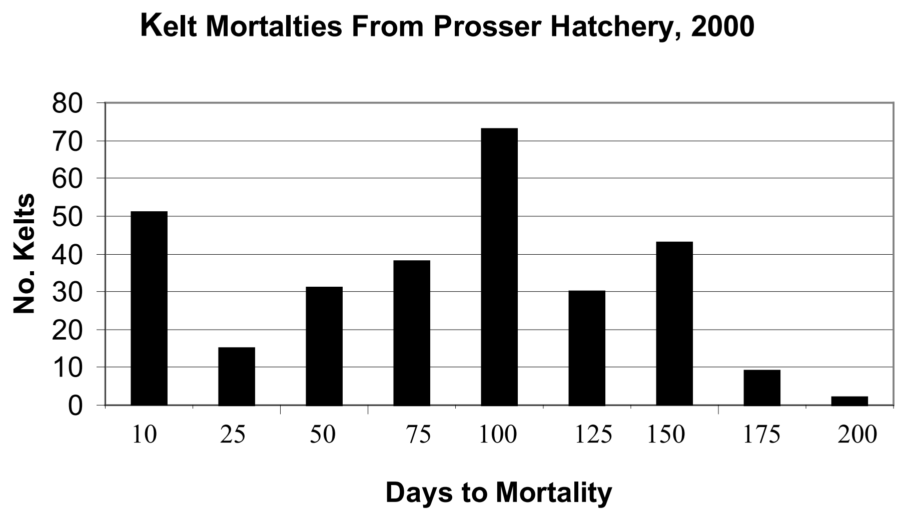

Figure 2: The number of days from capture to death of kelts collected for reconditioning at Prosser Hatchery.

During the night of July 28, 2000, water supply was lost in circular tank 2, resulting in the accidental mortality of 74 kelts (hereafter, referred to as "accidental mortalities"). At the time of the incident, these 74 individuals represented 34% (74/218) of all captive specimens. Of the 74 fish lost, 36 were actively feeding at the time of death and had gained an average 0.68 kg (ranging from 0.2 kg to 1.4 kg). Unfortunately, the authors are not able to determine how many of the fish in circular tank 2 would have successfully reconditioned if this incident had been avoided. We speculate, based on the eventual success rate of kelts in the other three tanks, that an additional 46 specimens from tank 2 would have been alive for the December release. To help prevent future loss and the resulting deadly low levels of oxygen, water aerators were placed in all tanks that operate continuously to reduce risk of loss if water flow stops.

***Pathology and Gonad Histology*:** A total of 22 samples were analyzed from kelts that died between 5 May and 1 September 2000. This included 5 kelts from the “accidental mortality” group. Of the 22 mortalities, records were not complete for one fish in terms of internal examination and 15 fish were missing data regarding some or all-external examination criteria. Of those specimens with complete records, the general condition was characterized as being 'good' for 14 (66.7%), 'fair' for 5 (23.8%), and 'poor' for 2 (9.5%). External coloration was characterized as being bright for 14 (66.7%), intermediate for 5 (23.8%), and dark for 2 (9.5%). All but one of the 'good' condition fish was characterized as having 'bright' external coloration. All 5 of the "accidental mortalities" were characterized as being in good condition with bright exterior coloration. Of those eight fish with complete records regarding abdominal size, 4 (50%) were characterized as having a fat, rounded abdomen and 4 (50%) were characterized as having a thin, emaciated abdomen. Interestingly, all four individuals with fat abdomens were from the “accidental mortality” group and all 4 individuals with thin abdomens were from the “incidental mortality” group. Of the 21 fish subjected to internal examination, 11 (52.4%) had pink muscle color and 10 (47.6%) had white muscle color. The gonads were identified macroscopically as ovaries in 20 (95.2%) of the fish and testes in 1 (4.8%) of the fish. In 2 fish, nematodes were found attached to the pyloric cecae.

Pathology: A total of 13 samples were collected for pathological examination (none of the 5 "accidental mortalities" were included). Of these, 8 were contaminated, 2 were negative for the presence of *Aeromonas salmonicida*, *Yersinia ruckeri*i, *Streptococcus* sp. or *Edwardsiella* sp., and 3 contained *Aeromonas* sp. bacteria. Airborne bacteria and /or fungus had contaminated most of the sample. Therefore, future efforts at collecting samples for pathology will require more rigor. The pathology reports also suggested the possible presence of nematode eggs in the gills of some specimen as well as nematodes present in the mesentery. Some of the pathology reports indicated the presence of pancreatitis, as well as lymphocytic and plasmcytic atrophy. However, none of the pathology reports indicated a likely cause of death.

Gonad Histology: Histological examination of gonadal tissue was performed for 10 fish: the 5 "accidental mortalities" that died on 28 July 2000 and 5 fish ("incidental mortalities") that died between 12 June and 1 September 2000. All 5 of the "accidental mortalities" had gonads that contained yolky oocytes between 0.7 and 1.1 mm in diameter (Figure 3). Samples from the 3 "incidental mortalities" that died before 28 July had atretic oocytes of irregular shape and at various stages of degradation (Figure 3). There was little evidence in these samples of accumulation of new yolk to the oocytes. The 2 "incidental mortalities" that died after 28 July had gonads with small (0.25 mm diameter) oocytes, with one of the fish showing a mixture of atretic and developing eggs.

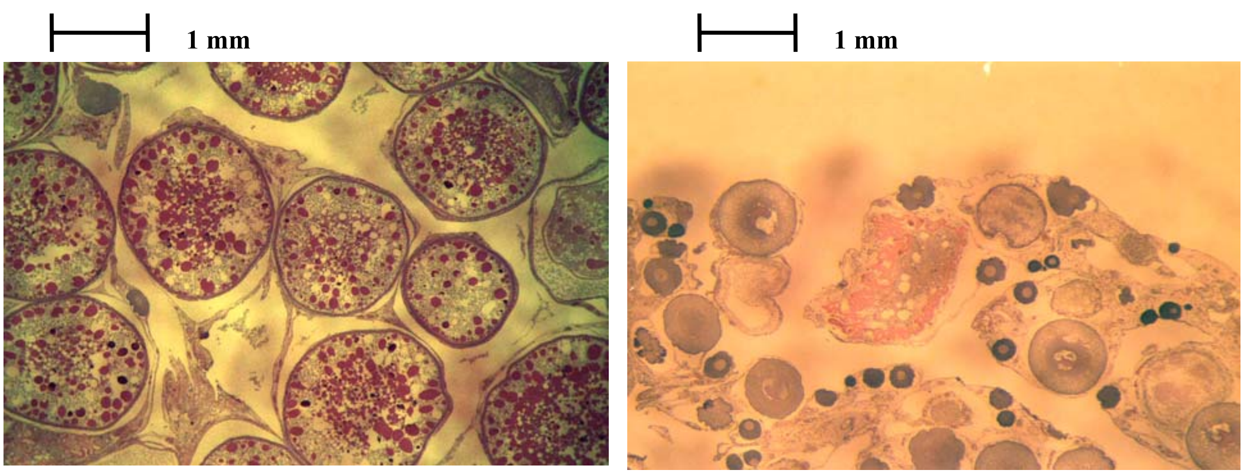

Figure 3. A picture of yolky oocytes (left) and atretic oocytes (rights) from Yakima River adult steelhead being reconditioned at Prosser Hatchery, WA. The fish on the left was actively feeding prior to sampling and appears to be reconditioned, while the fish pictured on the right died during reconditioning efforts and likely never began active feeding.

Reconditioning resulted in successful recrudescence of the ovaries in some of the steelhead kelts. The results of this study indicate that the fish in tank 2 showed the best indications of successful reconditioning. This tank contained the 5 "accidental mortalities" on which histological examination of the gonads revealed the presence of yolky oocytes, indicating that the fish were undergoing vitellogenesis at the time of death. Vitellogenesis, the incorporation by the oocytes of yolk protein that is synthesized in the liver, is an energy-dependent process. Therefore the presence of vitellogenic oocytes suggests that these fish had sufficient energy to begin the process of developing their eggs. In contrast, the fish with atretic eggs showed little indications of reconditioning, as these fish tended to die earlier in the study. The two fish that died late in the study that also had gonad samples examined histologically, showed signs of new oocyte development, although degree of development was well behind that of the 5 "accidental mortalities."

There was some evidence that the external criteria used in characterizing the mortalities could be used for discerning whether gonadal recrudescence was occurring. Those fish classified as possessing a "fat" abdomen – all from the "accidental mortality" group - also had yolky oocytes, according to histological examination. Conversely, those fish classified as being "thin" or emaciated – all from the "incidental mortality" group – had predominately atretic eggs. Aside from abdominal size, other external criteria appeared to have no association with reconditioning success. For example, all 5 "accidental mortalities" were characterized as being bright colored and in good condition, a fish with those attributes was just as likely to yield atretic eggs with no evidence of successful reconditioning.

The pathological examinations were inconclusive for determining the likely cause of death due to contamination resulting from poor sample collection and preparation. Therefore, in order to increase the amount of information gained from pathological samples, more rigorous sample protocols will be implemented. Consultation with State Fish Pathologists from Oregon or Washington will occur prior to the next field season to determine the likelihood that 1) a causative agent for death can be identified and 2) that a treatment protocol would be recommended. It should be noted that in some hatchery operations, a prophylactic injection of antibiotics (e.g. oxytetracycline and erythromycin) to broodstock is routine; therefore, a similar type of treatment may be investigated for the early phases of reconditioning of kelts.

Survival, Maturation, and Growth: On December 12, 2000 most surviving steelhead were examined with ultrasound to assess maturation status and released for natural spawning. In total, 91 (18% of the total collected) adult steelhead were alive at the conclusion of the experiment. However, we speculate that those fish in the "accidental mortality" group would have contributed an additional 46 individuals, making the total percentage 27% (137/512) and not 18% (91/512). Of those fish alive at the conclusion of the experiment (i.e., 91), ultrasound examination determined that 42 individuals had developed a full complement of eggs or sperm, 36 fish were classified as being immature, and 13 fish were released prior to ultrasound examination. Of those 13 individuals released prior to ultrasound examination all but one had gained substantial weight. Of the 36 classified as immature, eight had gained substantial mass while in captivity. In total, we determined that 62 fish (12%) were successfully reconditioned during the course of the study, based on both ultrasound examination and weight gain. Of those fish considered mature, 92% (39/42) were female and the remaining three male. Of those fish immature (36) or not examined for maturity (13), 98% were female and 2% were male, according to the ultrasound exams conducted during capture. In total, 87 (96%) of the surviving steelhead were female.

There is some evidence to suggest that female kelts were more likely to survive to release than male specimens, although only 60 males were collected for reconditioning (Table 2). Only 7% of the males collected for reconditioning survived to the release date, while 19% of the females survived during the same time period. The skewed survival of female kelts relative to male kelts maybe related to their condition upon capture. Of those fish with complete records, 22% (13/59) of the male kelts collected were in poor physical condition. In contrast, only 3% (13/431) of the females collected at Chandler bypass were classified as in poor condition.

Table 2: Sex and survival to release of adult steelhead captured for reconditioning at Prosser Hatchery, 2000.

Sex	No. Captured	No. Surviving	No. Mature[a]
Male	60 (12%)	4 (7%)	3 (0.5%)
Female	452 (88%)	87 (19%)	39 (9%)
Total	**512**	**91**	**42**

[a] 13 fish were released prior to ultrasound exam and information regarding maturity at release is not available.

Our finding that more female kelts were collected at Chandler bypass and that females were more likely to survive the reconditioning process is consistent with data from other iteroparous populations (Withler 1966, Leider 1985, Jonsson et al. 1991, Fleming 1998, and Niemel et al. 2000). A study investigating steelhead populations along the Pacific Coast concluded that females composed 81.5% of all repeat spawners that were examined in eight different coastal rivers (Withler 1966). A review of iteroparous populations conducted by Fleming (1998) compared the sex ratios of repeat spawners within eight Salmoninae species (*Salmo salar, S. trutta, O. mykiss, Salvelinus malma, S. fontinalis, S. alpinus, S. namaycush, and S. huchen*). In all eight species repeat spawners were predominately female. In contrast, the ratio of male to females during the first reproductive episode was approximately equal within each species examined. In the natural environment, the lower ratio of post-spawned males to females may be a result of increased male-male competition on the spawning grounds (Fleming 1998, Niemel et al. 2000), resulting in higher male post-spawner mortality rates (Leider et al. 1986). Although the skewed sex ratios of repeat spawners appears to be a natural occurrence among iteroparous salmonid species, the authors are currently conducting a genetic evaluation to assess the impact of releasing predominately female respawners in the Yakima River Basin. Results of this genetic benefit-risk assessment will be presented in the 2001 annual report.

In order for kelts to stop the senescence process, they must begin feeding and gain weight. There is convincing evidence that weight differs between mature and immature specimen at the time of release (t-value 9.73, $P \leq 0.0001$, d.f. 72.). The mean difference in weight between mature and immature specimens at release is estimated to be 1.59 kg (1.3 kg to 1.9 kg, 95% C.I.). All of those fish classified as mature at release had gained weight during the reconditioning process, and only 25% (9/36) of the immature fish had gained weight (Table 3). Similarly, all mature fish increased in length while many of the immature specimens actually showed a decrease in length

(Table 3). Not surprisingly, those individuals that lost weight were the same individuals that lost length. Thus, it appears clear that kelts must gain substantial mass before they can reach maturity a second time and that food intake is perhaps the most critical aspect of reconditioning.

Table 3: Weight and length statistics from adult steelhead released at Prosser Hatchery, 2000.

	Average weight increase (kg)	Average weight decrease (kg)	Average length increase (cm)	Average length decrease (cm)
Mature	1.68 (n=42)	-	6.13 (n=42)	-
Immature	0.68 (n=9)	0.28 (n=27)	1.91(n=9)	- 3.86 (n=27)
Unknown[a]	1.04 (n=12)	0.02 (n=1)	3.70 (n=12)	- 2.0 (n=1)

[a] 13 fish in the unknown group were released before we could ultrasound them. We suspect many of these had successfully reconditioned because they gained weight over the course of the study.

There is also some evidence that mature fish were in captivity longer than immature fish (t-value=2.45, two sided p=0.0165, d.f.72). The difference in time in captivity to release between mature and immature specimens is estimated to be 9.67 days (between 1.82 to 17.52 days, 95% C.I.). However, the authors question the biological significance of this finding because an additional week or two in captivity would not likely result in successful reconditioning or maturation of immature specimens. As a group, those fish that survived to release were in captivity an average of 241 days (SD=17 days, ranging from 183 to 268 days).

Based on those fish with complete records[5] (n=431), there is no evidence that collection date is associated with survival to release (Table 4). Fish captured in March (~weeks 1-3) were just as likely to survive as those captured in May (~week 8-11) (Table 4). Furthermore, maturation rates – although variable from week-to-week – were consistent through the study period (Table 4). Thus, the data suggests that collecting kelts earlier during emigration does not necessary result in higher reconditioning success. On average, 20% (85/431) of fish collected survived to release and of these, approximately 50% (42/89) were determined via ultrasound examination to be mature.

[5] Data for in-processing date, out-processing date, survival and maturation were available for 431 of the 512 kelts collected. For a record to be included in Table 4 information for all four categories were necessary.

Table 4. Kelt survival and maturation by collection date. Each week (Sunday to Saturday) represents the number of kelts captured from March 12 to June 10, 2000. Survival and maturation data is based on release statistics from December 12, 2000. Only those fish determined to be mature via ultrasound examination are included. Percent maturation is based on number of surviving fish.

Week	No. Collected	No. (%) Survival	No. (%) Mature
1 (3/12 to 3/18)	22	0 (-)	0 (-)
2 (3/19 to 3/25)	49	6 (12%)	2 (33%)
3 (3/26 to 4/1)	61	10 (16%)	6 (60%)
4 (4/2 to 4/8)	76	16 (21%)	6 (38%)
5 (4/9 to 4/15)	71	19 (27%)	15 (79%)
6 (4/16 to 4/22)	3	2 (66%)	1 (50%)
7 (4/23 to 4/29)	48	13 (27%)	7 (54%)
8 (4/30 to 5/6)	35	6 (17%)	2 (33%)
9 (5/7 to 5/13)	24	4 (16%)	2 (50%)
10 (5/14 to 5/20)	32	6 (18%)	1 (17%)
11 (5/21 to 5/27)	7	2 (28%)	0 (-)
12 (5/28 to 6/3)	0	-	-
13 (6/4 to 6/10)	3	1 (33%)	0 (-)
Total	**431**	**85 (20%)**	**42 (49%)**

Feeding and Treatment Summary: The ability of starter paste to elicit a feeding response in kelts cannot be determined from the data collected. Clearly, many of the kelts accepted and were able to digest artificial feed, as evident from the numerous fish that gained weight throughout the study. Furthermore, the use of freeze-dried krill seemed to stimulate the kelts to feed actively. In fact, kelts would aggressively consume krill and many of the very thin fish, perhaps for the first time, started to eat on a regular basis. Unfortunately, krill was not presented to the fish until three weeks after the tank transfer, a period when 68% of the collected kelts were already dead. Overall success of the 2000 project may have been substantially higher if krill were introduced at an earlier date, because feeding behavior seemed to dramatically increase after the introduction of krill. Despite this observation, no casual connection can be made at this time linking krill to higher rates of reconditioning success. For example, the introduction of krill followed the tank transfer (i.e., movement of kelts from the rectangular tanks to the circular tanks) and it is possible that survivorship increased because the kelts were in a more suitable environment and not because the food source was more appealing. However, assessing starter feed types and diet composition was not a primary objective of the 2000 study. Specific studies are currently being conducted at Prosser Hatchery to quantify the response of kelts to various food types and diets. Results of this endeavor will be incorporated in our 2001 annual report.

The benefits of "trainer trout" were also difficult to assess. Recall that trainer trout were put in two of four rectangular tanks in the hopes of "teaching" kelts how to feed. However, there is no evidence to suggest that the presence of a trainer fish increased survival of kelts within a particular tank. Based on those fish with complete records (159 individuals), 80 treatment fish (kelts in tanks with trainer trout) and 79 control fish (kelts in tanks without trainer fish) were alive at tank transfer. This suggests – although a more rigorous test is needed – that kelts can begin feeding without assistance from other "experienced" individuals and/or that the first kelts to start feeding serve as trainer fish.

Ectoparasites: There is overwhelming evidence that gill infestation of *salmincola* differs between those fish receiving ivermectin and those fish without treatment (G-test = 30.08, two side $p \leq 0.001$; where $G_{0.05,\ 1\ d.f.}$). In total, 15 fish were alive at release that did not receive the ivermectin dose. All 15 (100%) had severe (>25% coverage of gills) infestation of s*almincola* on their gills and fins. In contrast, of the 61 fish receiving ivermectin, 43 (70%) had no noticeable signs of infestation on the gill lamella and the other 18 (30%) fish had minor signs (<10% coverage). Unfortunately, data were not collected regarding gill infestation of salmonicola from fish that died during the reconditioning effort, so we cannot speculate if *salmincola* infestation contributed to reconditioning mortality during the course of the study. Given the success of the ivermectin treatment, we recommend all future kelts be treated upon collection.

Spawning After Release: The ultimate success of kelt reconditioning should be assessed based on the number of individuals that successfully spawn in the wild following release. Although it is difficult to witness individual fish spawning in the wild and even more difficult to assess the viability of gametes, data are needed to determine if reconditioned kelts contribute to subsequent generations.

Data collected by Foster and Schom (1989) provide 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 do not and will not know where the natal spawning grounds are. At this time, we have no reason to doubt that mature reconditioned steelhead released from Prosser Hatchery will successfully spawn in the wild, and we hypothesize that the kelts retain the imprint of their natal stream. However, it is possible that reconditioning at Prosser may have blurred the fish's homing imprint or replaced it with an imprint of Prosser Hatchery. To address this possibility, we implanted 62 fish with radio transmitters[6] prior to their release in December of 2000. Twenty of these fish were transported and released above McNary Dam (Columbia Rkm 477) while the remaining 42 fish were released above Prosser Dam at the Mabton bridge boat launch (Yakima Rkm 56). Stationary yagi antennas at McNary Dam (Columbia River), Ice Harbor Dam (Mid-Columbia River), Priest Rapids Dam (Snake River) and Prosser Dam (Yakima River) were programmed to monitor for tagged kelts. Mobile tracking at numerous sites above Prosser Dam provided tracking data for those fish released at Mabton Bridge. We are still analyzing data from this experiment and results will be included in the 2001 annual report. Preliminary results suggest that released fish were returning to the Yakima River.

Conclusions

We arbitrarily set a reconditioning goal of 50% for this research endeavor. The overall success of 18% – with perhaps only 12% reconditioned – obviously falls short of the target goal. Despite

[6] The University of Idaho and the Bureau of Reclaimation - at no cost to this project - graciously donated radio tags.

this, experience gained in 2000 will lead to significantly higher survival rates. Introduction of krill –a more natural food source – appeared to dramatically increase the feeding activity of kelts. The use of circular tanks relative to rectangular tanks appeared to reduce mortality rates following the tank transfer. Furthermore, substantial improvements were made during the 2000 field season to quickly process captured kelts. The initial handling stress may be responsible for the early death of many of the fish, and methods that allow us to expedite initial processing may result in a higher reconditioning success rates. We also noted that fish condition upon capture was associated with survival at release. Those kelts collected in poor overall condition – primarily males – were very unlikely to recondition successfully. Thus, kelts can be selected or culled based on their physical condition at the time of capture, and such methods may save on feed costs and increase overall success rates. In summary, information regarding kelt husbandry, food types, kelt condition, and facility design gained during 2000 research will improve the success of future studies.

Overall, the kelts reconditioned during this project will substantially bolster the number of repeat spawners in the Yakima River. Data collected by Hockersmith et al. (1995) estimated repeat spawn rates of 1.6% for Yakima River steelhead. Assuming those kelts we released as mature fish successfully navigated to their natal streams and spawned, the 2001 Yakima River steelhead run will receive an additional 62 respawners. Although these 62 individuals represent only 3% of the total 2001 Yakima River steelhead run (estimated at 2,120 individuals based on ladder counts at Prosser Dam spanning from September 2000 to June 2001), they will more than double the number of repeat spawners. In addition, increasing repeat spawning will bolster the recruit-per-spawner function, a key element of population viability. In general, we believe the results of the study warrant additional research, and we are optimistic that kelt reconditioning techniques will ultimately lead to an effective management program for ESA-listed steelhead populations in the Columbia River Basin.

Potential Kelt Collection Sites: We speculated that numerous sites throughout the basin have steelhead kelt populations that could benefit from reconditioning. For example, we know that >400 wild kelts can be collected annually at Prosser Dam and that >1,000 wild kelts could be collected each year from the juvenile collector dams on the mainstem Columbia and Snake rivers (Evans and Beaty 2000, Evans and Beaty 2001). In an effort to catalogue these potential kelt collection sites we contacted fishery professionals from around the region. Although this effort is still on-going, we have attached all the information gathered thus far (Appendix 1). We encourage fisheries managers to review this information and ask them to consider the benefits of implementing kelt reconditioning.

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Appendix 1. List of potential kelt collection sites above Bonneville Dam.

Province / Subbasin(s)	Site/Program	Approx. No. of Fish[7]	Contact(s), Source(s)	Notes
Columbia Gorge				
Wind	(none)	–		
White Salmon	(none)	–		
Little White Salmon	(none)	–		
Klickitat				
Hood	Parkdale Fish Facility, Hood R. Production Program	80 W StW 25 W StS	Mick Jennings CTWS, The Dalles 541.296.6866	Spawners are trapped at Powerdale Dam (RM 4), air-spawned at Parkdale when ripe for hatchery production, and released back to the river.
Fifteenmile Creek			Jim Newton or Steve Pribyl ODFW, The Dalles 541.296.4628	
Columbia Plateau				
Deschutes			Jim Newton or Steve Pribyl ODFW, The Dalles 541.296.4628	
John Day	>300 small irrigation diversion screens throughout subbasin.	<12 W StS kelts per year, total.	Tim Unterwegner ODFW, John Day 541.575.1167	
Yakima	Chandler Juvenile Migrant Fish Facility @ Prosser, WA.	514 W StS kelts in 2000.	Joe Blodgett, Manager Yakama Nation Prosser Hatchery 509.945.5899 (cell). This report.	Represents *ca.* 40% of the upstream run, ESA threatened.
Umatilla	West Extension Canal bypass facility (RM 3.0)	64 H&W StS kelts in 1998. 1 W & 1 H StS kelts in 1999. 1 StS kelt in 2000.	Sue Knapp ODFW Hermiston 541.567.5318 Knapp et al. 2000	1998 total includes *ca.* 38 W and 26 H. The total number dropped in 1999 because separator bars were spaced closer to exclude adults from 6" PIT pipe used to detect PIT tags in juveniles.
	Minthorn Springs	80-90 N StS	Gerry Rowan CTUIR 541.276.4109	100-105 pre-spawners collected annually at Threemile Dam Trap (RM 3.0) for holding and spawning at

[7] W = wild origin (non-ad-clipped); H = hatchery origin (ad-clipped); N = natural origin (non-ad-clipped, wild origin progeny of possibly hatchery parents). StS = summer steelhead; StW = winter steelhead.

Province					
	Subbasin(s)	Site/Program	Approx. No. of Fish[7]	Contact(s), Source(s)	Notes
				NMFS 2001	Minthorn springs facility. Target (after pre-spawn mortality) is to spawn 40-41 pairs lethally for maximum egg-take.
		Threemile Dam Trap?		Brian Zimmerman CTUIR 541.278.7613	
		Birch Cr. weir		Tim Bailey ODFW, Pendleton 541.276.2344	
	Walla Walla	Nursery Bridge trap		Jon Germond ODFW, Pendleton 541.276.2344	
		(other?)		Glen Mendel WDFW, Dayton	
		Touchet	20 W StS kelts in 1999/2000.	Mark Schuck, WDFW LSRCP 509.382.1004 OR Butch Harty WDFW Lyons Ferry Hatchery Manager 509.646.3454	Pre-spawners were trapped in fall 1999, then held at Lyons Ferry for live spawning. High morts, but they tried to recondition the kelts. I need to check results (important for review part of report). Kelt recondition is a lower prioritiy for limited space there than the captive ChS broodstock, so reconditioning may not continue.
	Crab Cr.				
	Tucannon	Trap	43 W StS kelts in 1999/2000.	Mark Schuck, WDFW LSRCP 509.382.1004 OR Butch Harty WDFW Lyons Ferry Hatchery Manager 509.646.3454	Pre-spawners were trapped in fall 1999, then held at Lyons Ferry for live spawning. High morts, but they tried to recondition the kelts. I need to check results (important for review part of report). Kelt recondition is a lower prioritiy for limited space there than the captive ChS broodstock, so reconditioning may not continue.
	mainstem Columbia	John Day Dam JBS		Miroslaw Zyndol USACE	
		McNary Dam JBS		Brad Eby USACE Project Biologist 541.922.3211	
	mainstem Snake	Lower Monumental Dam JBS	779 StS in 2000	Bill Spurgeon USACE Project Biologist 509.230.5373 Evans and Beaty 2001	*ca.* 300 W kelts, assuming 50% wild and 90% kelts, with no allowance for kelts that may have been handled previously at upstream dams.
		Little Goose Dam JBS	800 W, 600 H StS	Rex Baxter	Wild kelts removed from the separator in 2000 and not

Province					
	Subbasin(s)	Site/Program	Approx. No. of Fish[7]	Contact(s), Source(s)	Notes
			kelts in 2000.	USACE Project Biologist 509.399.2234x263 (?) Evans and Beaty 2001	previously handled at the Lower Granite separator composed ca. 5%-6% of the upstream wild run.
		Lower Granite Dam JBS	2,200 W, 1,800 H StS kelts in 2000.	Mike Halter USACE Project Biologist 509.843.3364 Evans and Beaty 2001	Wild kelts removed from the separator in 2000 were *ca.* 18% of the upstream wild run, ESA threatened.
Columbia Cascade					
	Wenatchee			Art Viola, District Bio WDFW, Wenatchee 509.664.1227	
	Entiat				
	Lake Chelan				
	Methow				
	Okanogan	Omar and Salmon Creek	40 to 60w	Paul Wagner Golder Associates 509.737.9666	The Colville Tribe is proposing to conduct kelt reconditioning from Okangon wild steelhead captured from Omar and Salmon creeks in 2003.
	mainstem Columbia	Rock Island Dam JBS	6 W, 23 H, 2 unk. StS kelts in 1998. 13 W, 48 H StS kelts in 1999. 11 W, 9 H StS kelts in 2000.	Kris Petersen WDFW, Wenatchee 509.664.3149 Petersen and Tonseth 2000 Praye and Petersen 2001	About 70%-80% of kelts for the three years are female. Some of the ad-clipped (H) kelts may be part of the Upper Columbia ESU (ESA-endangered) outplanted into the Methow and Okanogan subbasins from Wells Hatchery.
		Rocky Reach Dam JBS	26 W, 228 H StS kelts in 1998. 32 W, 105 H StS kelts in 1999. 12 W, 165 H StS in 2000.	Chuck Peven Chelan PUD 509.664.2892x4473	Some of the ad-clipped (H) kelts may be part of the Upper Columbia ESU (ESA-endangered) outplanted into the Methow and Okanogan subbasins from Wells Hatchery.
		Wells Hatchery	376 W StS in 1999/2000	Jerry Moore, Complex Mgr WDFW Wells Hatchery 509.923.2728	Wild, ESA-endangered pre-spawners are trapped at Wells Dam for broodstock and spawned lethally (to obtain pathology samples). Fewer wild fish may be trapped in future
Blue Mountain					
	Grande Ronde	Deer Cr. weir (Wallowa)			
		Upper Grande Ronde	6 StS kelts (H+W)	Steve Boe	

Province Subbasin(s)	Site/Program	Approx. No. of Fish[7]	Contact(s), Source(s)	Notes
	weir, 10 RM above Starkey.	in 2000	CTUIR LaGrande 541.962.3043	
	Catherine Cr. weir, 2 RM above Union.		Steve Boe CTUIR LaGrande 541.962.3043	Weir was blown out for a month in spring of 2000, otherwise would have expected up to 10 kelts.
Asotin				
Imnaha	Little Sheep Cr. weir			
	Imnaha weir			
	Gumboot? Lightning? (NPT)			
Mountain Snake				
Clearwater	Fish Cr. weir (Lochsa)	30-40 StS kelts	Allen Byrne IDFG, Nampa 208.465.8404 OR Robyn Armstrong NPT, McCall 208.634.5290	Weir can collect about half of upstream run as kelts but prone to blowing out in spring floods.
Salmon				