Effects of Fish Cultural Techniques on Size Variation of Summer Steelhead (*Onchorynchus mykiss*) Populations at Dworshak National Fish Hatchery

A Pilot Study

Final Project Report

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BACKGROUND

The Draft Snake River Salmon Recovery Plan (SRSRP) and the Biological Opinion from the National Marine Fisheries Service (NMFS) on Hatchery Operations for 1996-1999 calls for hatchery steelhead *(Onchorynchus mykiss*) to be released between 170-220 mm (TL) in order to minimize residualization of smaller fish and predation by larger fish. Summer steelhead at Dworshak National Fish Hatchery (NFH) often develop relatively wide length frequency distributions by the time they are released in the spring, exceeding the release criteria layed out in the SRSRP. For example, in March of 1995, steelhead released from one particular pond ranged from 80 mm to 240 mm. The Dworshak Hatchery Evaluation Team (HET), comprized of members from the hatchery, the Dworshak Fish Health Center (FHC), and the Idaho Fishery Resource Office (FRO), was given the assignment to discuss the situation and develop recommendations for the Project Leaders and Complex Manager on how best to address the issue.

During meetings in April and May of 1995, team members of the HET identified a number of variables that could have a significant effect on steelhead length frequency distributions including genetics, feeding methods, rearing containers, size at conversion to demand feeders, disease, feed quality, and others. After subsequent discussions, the HET submitted a study plan to the Complex Manager that included three pilot studies designed to evaluate several of these factors. The first study was designed to evaluate the growth potential of smaller sized steelhead after being graded out of the population. A second study was designed to evaluate the effect of converting steelhead to dry feed in demand feeders at a larger size than normal. The last study was designed to evaluate feeding methods and rearing containers. Sampling was initiated in the nursery in June 1995 and was completed in January 1996.

This report summarizes the results of these three pilot studies and provides recommendations for the future.

GROWTH POTENTIAL OF SMALLER SIZED STEELHEAD

Introduction

The objective of this study was to determine if the high proportion of smaller sized steelhead in the hatchery population was a result of genetics or a consequence of fish culture. The study was set up to grade smaller individuals out of the population and rear them separately from any potential influence of larger individuals. Faster growth should be observed compared to controls if smaller size is not genetically controlled.

Methods and Materials

Fish Culture

Broodyear 1995 summer steelhead from egg take 10, were spawned in March 1995 and eyed-up approximately 16 days later in April. The steelhead were kept in incubation trays until May and were then transferred to nursery tanks. Thirteen tanks received about 32,000 fry each. Feeding commercial diet was started on May 11 and the fry were fed an average of 4% of their total weight while in the nursery. In July, each of the 13 tanks were split into 12 additonal tanks (25 tanks total) in order to reduce densities. Water temperature averaged 52.6^{O}F (45 to 58) throughout the nursery rearing period.

About 200,700 steelhead were transfered from 15 nursery tanks to a single outside Burrows pond in August and were allowed to mix for one day to insure that all experimental treatment groups were taken from the same population. Fish were then transfered into separate treatment ponds. Steelhead at that time averaged 92 fish per pound (fpp). Five study ponds were set up to evaluate the growth potential of smaller sized steelhead; two ponds were designated as 'large' fish ponds (BP58 and BP60), one pond was designated as a 'small' fish pond (BP62), and two ponds were set up as controls (BP54 and BP56). Each pond received 26,500 fish.

After being moved to Burrows ponds, fish were hand fed 2.5 mm Biomoist feed the next day. By September 8 fish reached an average of 40 fpp and were switched to Abernathy dry feed in demand feeders. Feed rations were cut in half for 14 days until fish were acclimated to a food size of 6/64 inches. Feed was thrown under the demand feeders and the wires were tapped for nine days to facilitate the transition to the new feeding method. When fish reached 15 fpp, feed size was changed to 8/64 inches. All the fish were adipose fin clipped on 31 October, 1 November, and 2 November, 1995. None of the fish received coded-wire tags.

Grading

On 1 November, all the fish were removed from the 'small' pond and were equally divided between the two 'large' ponds leaving the "small" pond empty. In early January, small fish were graded out of the 'large' ponds and were placed into the empty 'small' pond. To determine the length at which to grade out small fish, the length frequency distributions for fish in the two

‘large’ ponds were examined in January. The lower end of the distribution appeared separate at about 140 mm. The grader separates fish based on fish width. To determine the width at which to set the grader so that only fish 140 mm and less were graded out, 66 fish from BP58 and 147 fish from BP 60 were measured for total length and fish width at the operculum. A simple linear regression of fish length and fish width was calculated and showed a very close ($R^2 = 0.91$) and highly significant ($P<0.01$) relation between length and width. Based on the regression equation, fish 140 mm in total length should have an average width at the operculum of about 0.5 inches.

The grader was set for 0.49 in. for BP60 using a micrometer and fish were crowded into a 10-12 foot section of the pond with the grader at one end. Periodically, someone would get into the pond and physically ‘stir’ the fish up to insure smaller fish could get access to the grates. Because of some mortality in BP60, BP58 was not crowded as tightly, was not ‘stirred up’ as often, and the grader was set at 0.54 inches. The graded fish from the two ‘large’ ponds were placed into the empty ‘small’ pond and were put on 2.5 mm Biomoist feed. The demand feeders were filled with 8/64 inch dry Abernathy feed.

Data Collection and Analysis

In June and July, four nursery tanks were randomly selected each month and a random sample of 150 fish was collected from each tank by sweeping a dip net from the tail to the head and along the bottom of the tank. Fish were anesthesized with MS-222 and measured for total length to the nearest mm.

Starting in August, each treatment and control pond was sampled monthly to determine length frequency distribution. Random samples were collected by crowding fish into a 10-12 foot area of the pond. Fish were randomly dipped from this area and placed into a galvanized tub. A random sample of 150-200 fish was removed from the tub using a quarter net sampler. Fish were anesthesized with MS-222 and measured for total length to the nearest mm. In October, the quarter net sampler was replaced with a half net sampler to accomodate increased fish size.

Length frequency distributions were compared between rearing containers graphically to determine if noticable differences occurred. ANOVA was calculated monthly to detect significant differences in mean lengths between controls and treatments (Wilkinson 1990). A significance level of 0.05 was used to reject the null hypothesis of no significant differences between means. Post-hoc pair-wise differences in means were compared using the Tukey HSD Test (Wilkinson 1990).

Results

Nursery

In June, the length frequency distributions for all four tanks in the nursery were relatively narrow and all were very similar in shape (Figure 1). Mean fish length was 54 mm for all tanks except for Tank 510 which contained fish 53 mm mean length (Table 1). In July, the length frequency distributions had become somewhat wider but were still very similar in shape (Figure 2). However, mean lengths were significantly ($P<0.01$) different. The mean length of fish in Tank 612 was greater than in the other tanks in July (Table 1).

Burrows Ponds Pre-Grading

For August, September, and October 1995, very little difference was observed in the shape of the length frequency distributions between any of the control or treatment ponds on a month to month basis and all were relatively normal in shape (Figures 3, 4, and 5, respectively). Mean lengths were significantly different in both August ($P<0.01$) and September ($P<0.01$). However, October was the only month during that time that no significant ($P<0.22$) differences were observed between mean lengths (Table 2).

In November, some very noticable dissimilarity was observed between the control and treatment ponds (Figure 6) and mean lengths were significantly ($P<0.00$) different. Both of the 'large' ponds began to exhibited bi-modality whereas the controls remained fairly normal.

In January, the length frequency distributions for all four of the pond were again very similar in shape with the two 'large' ponds having returned to a nearly normal distribution (Figure 7). No significant ($P<0.68$) differences in mean lengths for any of the control or treatment ponds were observed in January (Table 2).

Burrows Ponds After-Grading

Grading in 'large' Pond 60 was successful in removing most of the fish less than 140 mm. Less than 5% of the sample measured after grading was less than 140 mm (Figure 8). Grading in 'large' Pond 58 was not as successful. Almost 14% of the sample measured after grading was less than 140 mm (Figure 8). At the same time, grading was not completely effective in preventing fish greater than 140 mm from being removed from the 'large' pond populations; there was a high proportion of fish greater than 140 mm in the 'small' pond population after grading was completed (Figure 8). About 46% of the sample measured from the 'small' pond was greater than 140 mm. The 'small' pond was re-graded in mid-January to remove the larger fish, but the project was terminated shortly after that and further evaluation of length frequency distributions was not conducted.

Discussion

If size at release is genetically controlled, or cannot be manipulated by changing fish cultural practices, then the production program at Dworshak NFH would have to consider incorporating some kind of fish cultural procedure into the production program, such as grading, to insure that size at release conforms to the standards of the Draft SRSRP. PIT-tag interrogation data for steelhead smolts released from Dworshak NFH in 1994-1995 indicate that steelhead smolts less than 170 mm at release have poorer survival than larger smolts (Bigelow et al. 1995). If smaller smolts survive at a lower rate, then their contribution to adult returns and their genetic contribution to the population would be correspondingly lower, ie, the genes for smaller smolts would eventually be eliminated after a few generations of non-contribution. These data provided strong circumstantial evidence that size variation at release was at least partly a result of fish cultural practices.

Unfortunately, the grading procedure we used did not completely segregate a group of smaller sized steelhead from larger steelhead. The grader was not capable of preventing longer fish from going through the grates. Either a number of longer fish forced their way through the grates or some of the longer fish were more slender than average. Because the regression of length and width was so close, the latter alternative is somewhat questionable but not altogether unreasonable. Because Pond 60 was actually crowded more tightly and stirred up more often than Pond 58, the additional pressure and stress during grading may have resulted in larger fish being successful in attempting a forced exit through the grates.

Although our experiment was not completed, information collected during sample counting from February through April indicated that fish in the 'small' pond were growing at a faster rate than fish in the 'large' ponds. On February 1, fish in the 'small' pond averaged about 14.0 fpp while those in the controls and 'large' ponds averaged from 9.0 to 7.0 fpp. By April 1, fish in the 'small' pond averaged 7.2 fpp and those in the control and 'large' ponds averaged from 5.8 to 4.7 fpp. Fish in the 'small' pond experienced nearly 50% increase in growth during that time while those in the control and 'large' ponds averaged only a 34% increase. While the data indicate faster growth in the 'small' pond after grading, the data can not be used to support the contension that smaller sized steelhead actually grew faster in the absence of large fish. It was not possible to collect data on the growth rate of smaller fish in the 'large' ponds independently from the larger fish in those ponds.

At the same time, ancillary data from the Idaho Department of Fish and Game Clearwater Hatchery suggests that fish culture may be a primarily contributing factor to size variation in steelhead at Dworshak NFH. The percentage of steelhead smolts released from that facility in 1995 that were less than 170 mm, was much lower than the percentage released at Dworshak NFH (Brad George, IDFG per. comm). Since the Clearwater Hatchery obtains eggs for their steelhead program from Dworshak NFH, both programs are utilizing the same broodstock, eliminating genetics as the primary explanation for the differences between the facilities.

The Clearwater Hatchery steelhead program differs from the Dworshak NFH program in several ways. First, nursery tanks at Clearwater Hatchery are equipped with baffles and fish are fed

automatically, not by hand. Rearing densities in the Clearwater Hatchery are kept lower than at Dworshak, between .15-.30 lbs/ft^3 whereas Dworshak NFH's densities may reach .70 lbs/ft^3 by the time they are moved outside. Steelhead come out of the nursery at a larger size and later time at Clearwater Hatchery than at Dworshak: 40-60 fpp in October vs 100-120 fpp in August, respectively. Fish are raised in raceways outside at Clearwater Hatchery and are fed mechanically or by hand. At Dworshak NFH, steelhead are raised outside in Burrows ponds equipped with Babbington demand feeders. Finally, Clearwater Hatchery obtains their water from Dworshak Reservoir while Dworshak NFH takes water from the North Fork Clearwater River below the dam. Any or all of these fish cultural differences may account for Clearwater Hatchery's ability to raise steelhead smolts with a smaller percentage less than the targeted release size. At the Clearwater Hatchery, no particular fish cultural procedure or set of environmental conditions could be identified as the major influential variable responsible for maintaining narrow length frequency distributions (Brad George, IDFG per. comm.).

EFFECTS ON SIZE VARIABLILITY AFTER CONVERTING JUVENILE HATCHERY STEELHEAD FROM MOIST TO DRY FEED AT TWO DIFFERENT SIZES

Introduction

Standard hatchery practice at Dworshak NFH is to convert steelhead from hand feeding moist feed to dry feed using demand feeders when the average fish size reaches 40 fpp. The members HET theorized this size might be too small for some fish to make a successful conversion to dry feed in demand feeders resulting in the development of sub-groups of small fish in the population and wide length frequency distributions. By delaying the conversion until fish reach a larger size, a higher percentage of the fish would theoretically make a more successful conversion. The objective of this study was to examine the effect on fish size variability of converting steelhead to dry feed in demand feeders at 20 fpp compared to controls converted at the normal 40 fpp.

Methods and Materials

Fish for this project were taken from the same nursery population that was used for the *Growth Potential of Smaller Size Steelhead* study. The same methods for fish culture, data collection, and data analysis and the same control ponds were used for both studies. One Burrows pond, BP64, received 33,000 fish for this study at the time fish were transfered from the nursery to outside Burrows ponds in August. The fish were hand fed 2.5 mm Biomoist feed until they reached 20 fpp in October at which time they were converted to dry feed in demand feeders.

Results

Length frequency distributions during nursery rearing in June and July were relatively narrow and normal in shape. See the **Results** section of the previous study for details.

Although the distributions for BP64 and the controls were similar at the start of the study, fish in BP64 started growing faster in October and by January had a much narrower length frequency distribution. In August and September 1995, very little difference was observed in the shape of the length frequency distributions between the controls or the treatment pond and all were relatively normal in shape (Figures 9 and 10, respectively). In October, the shapes of the distributions were relatively similar, but the distribution for BP64 had shifted to the right (Figure 11) and the mean length for fish in BP64 was significantly greater ($P < 0.01$) than the control ponds (Table 3).

By November, bi-modality in BP56 and BP64 was beginning to develop with BP64 having a narrower distribution than the control ponds (Figure 12). In January, bi-modality had clearly developed in both BP54 and BP64 and the distribution for BP64 continued to be much narrower than in the control ponds (Figure 13). The mean lengths were significantly different ($P<0.01$) for both November and January (Table 3). Random samples collected the third week in April revealed that fish in BP64 had a relatively normal shaped distribution with only 5% of the

sample less than 170 mm. Unfortunately, about 36% of the sample was greater than 220 mm (Figure 14). Distributions for both control ponds were also relatively normal in shape but were shifted farther to the left. About 20% and 27% of the fish in BP54 and BP56, respectively, were less than 170 mm while less than 4% were greater than 220 mm. While the experiment was successful in reducing the percentage of smaller fish, the percentage of larger fish was increased significantly.

Discussion

One variable that the HET thought might be significant was the size at which steelhead are converted from hand feeding to demand feeders after they are transfered from the nursery to Burrows ponds. Converting fish to demand feeders at a larger size clearly had a significant effect, resulting in a larger average fish size at the time of release. It also resulted in less variability in size. The consistently larger size of fish in BP64 would be expected since they were converted to demand feeders two months later than the controls and received a different diet (Biomoist) in the interim. It would be very difficult to attribute any of the difference solely to the fact that they were converted to demand feeders at a larger size. This conclusion is supported by the results of our other study comparing the effects of feeding methods on length frequency distributions. We had two Burrows ponds and two raceways that were fed by hand throughout the rearing cycle and were never converted to demand feeders. During that time, the fish were fed only Abernathy dry fish food, similar to the other experimental groups and no significant differences were observed between these groups and groups that were converted to demand feeders.

Although the results do not directly address the issue of wide length frequency distributions, it may be significant in terms of developing a strategy to increase the mean size at time of release for later takes of steelhead. The effects of feeding the moist feed on growth, even for a relatively short period of time is quite significant and should be seriously investigated.

EFFECTS OF FEEDING METHODS AND REARING CONTAINERS ON THE GROWTH AND LENGTH FREQUENCY DISTRIBUTIONS OF SUMMER STEELHEAD

Introduction

Summer steelhead at Dworshak NFH are transferred from inside nursery tanks to outside Burrows ponds at a size of about 100 fpp. They are hand fed moist food to a size of about 40 fpp at which time they are converted to dry feed in demand feeders. Two demand feeders are set up on each pond and are kept full so that fish have the opportunity to feed to satiation.

Babbington Response (demand) feeders have been used at Dworshak NFH since 1982 and were identified by the Dworshak HET as one factor that might contribute to the development of wide length frequency distributions in summer steelhead. Rainbow trout are known to be territorial, setting up hierarchies with dominant and subordinate individuals in the population (Abbott and Dill 1989; Abbott et al. 1985; Li and Brocksen 1977; Noakes and Leatherland 1977; Yamagishi 1962). With feeding stations limited to two feeders per pond, dominant individuals could theoretically establish territories around these areas, limiting access by subordinates, and creating the potential for the development of differential growth rates and wide length frequency distributions. The situation would only be exacerbated as feed size is increased to accomodate the increased average size of fish in the population over time. Eventually, food that is available would potentially reach a size too large for the smaller sized fish to handle efficiently, making the situation that much worse.

The objective of this study was to evaluate the effect on length variation in summer steelhead populations by increasing the number of feeding stations per rearing container. Since both raceways and Burrows ponds are used at Dworshak NFH, the study was conducted using both types of containers.

Methods and Materials

The study was designed to evaluate three types of feeding regimes: 1) two feeders per container (control); 2) four feeders per container; and 3) hand feeding. Two replicates were set up for each feeding regime for both raceways and Burrows ponds, giving a total of 12 units in the study, six Burrows ponds and six raceways.

Fish Culture

Broodyear 1995 summer steelhead from take 8 were spawned in March 1995, and the eggs eyed-up approximately 15 days later. Steelhead were transfered from the incubation room to 22 nursery tanks in April. Sixteen tanks received 18,000 fish each and six tanks received 36,000 fish each. The first day of feeding on commercial diet was April 25. Fish were fed an average of 4% of their total weight while in the nursery.
During the first week of May some of the study tanks in the nursery were changed to cooler

water. To try and keep all tanks as similar as possible, the densities in some tanks were increased so that fish could be moved from the cooler water into warmer water. The steelhead which were on warmer (52°F) water ended up receiving only 18 temperature units more than the fish which were moved. Overall densities were higher in four tanks (72,000 fish as compared to 12 tanks at 36,000 fish). These four tanks were split one month later into eight tanks giving all of the tanks similar densities.

A total of 325,000 steelhead were moved from the nursery to outside rearing containers at the end of July. Steelhead at that time averaged 91 fpp. All 325,000 were initially put into one Burrows pond and allowed to mix for one day to insure that all experimental treatment groups were taken from the same population. Six Burrows ponds and six raceways received 32,000 and 21,500 fish each, respectively. Raceway flows were adjusted to 350 gpm to insure that flow indices were similar for all 12 experimental rearing containers.

Fish were hand fed 2.5 mm Biomoist feed starting the day after ponding. During the first week of September, fish reached 40 fpp and were switched to Abernathy dry feed in demand feeders. Feed rations were cut in half for four days until fish were acclimated to dry feed. Feed was increased to 2.5% of body weight for those containers being hand fed. In rearing units with demand feeders, feed was thrown under the demand feeders and the wires were tapped for nine days to facilitate the transition to the new feeding method. Three additional days of tapping and supplemental feeding had to be employed for the raceways because steelhead did not make a rapid transition. At 20 fpp, feed size in demand feeders was increased to a size of 8/64 inches.

Marking began in early October. All steelhead were adipose fin clipped. Most of the fish in two of the raceways were marked with coded wire tags and had the left ventral fin clippped. At that time, some of these fish also received freeze brands. Fish in one of the Burrows ponds were coded wire tagged and had the left ventral fin clipped.

Data Collection and Analysis

In June and July, sampling was conducted in the nursery by sampling four tanks selected randomly. A random sample of about 150 fish was collected from each tank by sweeping a dip net from the tail to the head and along the bottom of the tank. Fish were anesthesized with MS-222 and measured for total length to the nearest mm.

Starting in August, each of the treatment and control ponds were sampled monthly to determine the length frequency distribution. Random samples were collected by crowding the fish into a ten to twelve foot area of the pond. Fish were randomly dipped from this area and placed into a galvanized tub. A random sample of about 150-200 fish was removed from the tub using a quarter net sampler. Fish were anesthesized with MS-222 and measured for total length. In October, sampling was modified by changing from the quarter net sampler to a half net sampler to accomodate increased fish size.
Length frequency distributions were graphed and compared between containers to determine if noticeable differences occurred. A one-way ANOVA (Wilkinson 1990) was used to detect

significant differences in mean lengths between nursery tanks. A two-way ANOVA (Wilkinson 1990) was calculated monthly to detect significant differences in mean lengths between feeding methods, rearing containers and to detect any significant interaction between these two factors. A significance level of 0.05 was used to reject the null hypothesis of no significant differences between means.

Results

Some differences were observed between tanks in the nursery in June and July although the distributions were generally narrow and normal in shape (Figures 15 and 16, respectively). Mean lengths were significantly ($P<0.01$) different between nursery tanks both months (Table 4).

Raceways

In August and September 1995, no noticeable differences in length frequency distributions were observed between feeding methods and all were relatively normal in shape (Figures 17 and 18, respectively). The major change from August to September was the increase in the width of the distributions. In October, the distributions became more irregular in shape and continued to become wider, but were still relatively similar overall (Figure 19). In November, some major differences were observed between the distributions. However, differences appeared to be random. No consistent pattern was detected that could be attributed to a particular treatment. For example, the distributions for the two raceways equipped with two demand feeders were quite dissimilar, while Raceways 11 (hand fed) and 13 (2 demand feeders) were fairly similar (Figure 20). By January, most distributions had become bi-modal and were not completely disimilar from one another (Figure 21). Based on these examinations, feeding methods did not appear to have any significant effect on the shape of the length frequency distributions. There were no significant differences between treatment means for any month examined.

Burrows Ponds

The length frequency distributions for summer steelhead raised in the Burrows ponds exhibited almost the same pattern of growth as those raised in the raceways. Distributions were relatively narrow and normal in shape during August and September (Figures 22 and 23, respectively). In October, the distributions showed more variablility but were not dissimilar (Figure 24). In November, and particularly in January, bi-modality had developed in most ponds (Figures 25 and 26, respectively). Similar to raceways, feeding methods did not appear to have any significant effect on the shape of the length frequency distributions. There were no significant differences between treatment means for any month examined.

One very clear difference between Burrows ponds and raceways was observed. Starting in October, steelhead in Burrows ponds were significantly ($P<0.01$) bigger than those in raceways. One other clear pattern in growth was very evident. Variability around the means and the width of the distributions increased steadily over time (Tables 5 and 6).

Discussion

Of the variables considered, the Team believed that the use of demand feeders on Burrows ponds was the primary reason for the development of wide length frequency distributions. Therefore, the results of this study were somewhat unexpected. However, they are not inconsistent with other similar work. Fuss et al. (1989) compared the effects of two, four, and six demand feeders per container on the growth performance of coho salmon (*O. kitsutch*) at the Humptulips Salmon Hatchery in Washington and found no significant differences in growth performance. Size variation as measured by coefficient of variation didn't vary significantly among groups and it didn't change much between the beginning and end of the experiment.

Rearing container had no observable effect on the shape of the length frequency distribution relative to feeding method. In fact, it is interesting to note that growth was actually poorer in raceways than in Burrows ponds regardless of feeding method. The fish in raceways failed to make a good transition from the nursery to the raceways. Unlike those transfered to Burrows ponds, steelhead in the raceways maintained a portion of their fright/flight response and never fully adjusted to demand feeders or hand feeding during the study. This result should be given very careful consideration during discussions of converting Burrows ponds to raceways.

CONCLUSIONS AND RECOMMENDATIONS

None of the fish culture techniques evaluated in this study appeared to have any significant effects on the size variability of juvenile hatchery steelhead at Dworshak NFH. The number of demand feeders on a rearing container did not have any effect on the size variability of juvenile steelhead and hand feeding did not have any advantage over using demand feeders. Although the average size of juvenile steelhead was larger in Burrows ponds compared to raceways by the time of their release, neither container appeared to have any advantage over the other in terms of reducing size variability.

We found no conclusive evidence that size variability in juvenile hatchery steelhead at Dworshak NFH is a function of genetics. In fact, the Clearwater Anadromous Hatchery has been successful the past several years in rearing and releasing steelhead, that were originally obtained from Dworshak NFH as eggs, that have length frequency distributions that are within 90% of the range recommended by the Draft SRSRP.

We did find that converting juvenile steelhead from moist feed to dry feed at 20 fpp, rather than 40 fpp, resulted in less variability and a larger size at release. However, the result could not be solely attributed to the size at which the fish were converted since the two groups were not feed the same feed during that time period.

We found that steelhead length frequency distributions started increasing in width after fish were transfered from the nursery to outside rearing containers. Several variables are changed by that transfer that could have significant influence. First, the fish are moved from a relatively high density environment in the nursery, reaching a Density Index of 0.7 in some cases, to a very low density environment in the Burrows ponds. Second, fish are moved from a highly protected indoor environment in the nursery to radically different environmental conditions outside. The HET has discussed these points and recommends an evaluation of rearing density on length frequency distributions in two settings: 1) During extended nursery rearing, and 2) Ponding at higher initial densities in Burrows ponds.

By holding several nursery tanks at higher densities for several months longer than normal, it would be possible to observe the effects on length frequency. Clearwater Hatchery holds their steelhead in the nursery until October and moves them outside at about 40-60 fpp. We would design our experiment along those lines. Experiments would be designed so that initial ponding densities would be similar to the nursery.

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Table 1. Statistical summary of fish length data collected for summer steelhead used in the grading and size at conversion studies reared in the nursery during June and July, 1995 at Dworshak NFH, Idaho.

Month	Tank	N	Mean Length[1]	SD	C	Min.	Max.
June	608	150	54	2.8	0.05	44	63
	612	150	54	3.0	0.06	43	63
	510	150	53	3.1	0.06	45	62
	513	150	54	2.8	0.05	46	62
July	107	173	70[A]	5.0	0.07	55	85
	405	177	69[A]	4.5	0.07	51	79
	510	175	70[A]	4.7	0.07	53	84
	612	208	72[B]	4.6	0.06	56	84

[1] Means followed by the same letter are not significantly ($P<0.05$) different based on the Tukey HSD Test (Wilkinson 1990).

Table 2. Statistical summary of fish length data collected for summer steelhead in the grading study reared in outside Burrows ponds from August 1995 through January 1996 at Dworshak NFH, Idaho.

Date	Treatment	Pond	N	Mean[1] Length	SD	C	Min.	Max.
8-95	Control	54	228	82[A]	6.5	0.08	66	103
	Control	56	132	85[B]	6.1	0.07	68	102
	Large BG[2]	58	201	85[B]	6.8	0.08	66	107
	Large BG	60	145	82[A]	6.7	0.08	64	100
	Small BG[3]	62	163	82[A]	6.3	0.08	70	108
9-95	Control	54	193	106[A]	9.8	0.09	67	131
	Control	56	232	107[A]	7.5	0.07	89	125
	Large BG	58	282	109[B]	8.7	0.08	87	137
	Large BG	60	178	108[A,B]	9.0	0.08	78	133
	Small BG	62	237	108[A,B]	8.5	0.08	81	139
10-95	Control	54	241	119[A]	13.2	0.11	80	150
	Control	56	223	120[A]	14.6	0.12	87	174
	Large BG	58	209	122[A]	12.6	0.10	95	159
	Large BG	60	181	119[A]	13.1	0.11	78	150
	Small BG	62	168	121[A]	14.9	0.12	86	205
11-95	Control	54	198	131[A]	17.5	0.13	88	189
	Control	56	87	126[A,B]	18.4	0.15	91	162
	Large BG	58	114	125[B]	18.5	0.15	93	169
	Large BG	60	174	122[B]	19.5	0.16	88	168

Table 2. Continued.

Date	Treatment	Pond	N	Mean[1] Length	SD	C	Min.	Max.
1-96	Control	54	156	161[A]	22.5	0.14	86	199
	Control	56	152	163[A]	22.9	0.14	105	204
	Large BG	58	71	164[A]	23.4	0.14	105	217
	Large BG	60	147	161[A]	23.5	0.16	97	205
	Large AG[4]	58	102	169	26.3	0.15	100	214
	Large AG	60	91	169	19.3	0.11	92	207
	Small AG[5]	62	165	140	19.1	0.14	92	183

[1] Means followed by the same letter are not significantly ($P<0.05$) different based on the Tukey HSD Test (Wilkonson 1990).
[2] Large-graded ponds before grading.
[3] Small-graded pond before grading.
[4] Large-graded ponds after grading.
[5] Small-graded pond after grading.

Table 3. Statistical summary of fish length data collected for summer steelhead in the two control ponds and the size at conversion pond during outside rearing in Burrows ponds from August 1995 through January 1996 at Dworshak NFH, Idaho.

Date	Treatment	Pond	N	Mean[1] Length	SD	C	Min.	Max.
8-95	Control	54	228	82[A]	6.5	0.08	66	103
	Control	56	132	85[B]	6.1	0.07	68	102
	20 FPP	64	163	84[A]	5.6	0.07	66	98
9-95	Control	54	193	106[A]	9.8	0.09	67	131
	Control	56	232	107[A]	7.5	0.07	89	125
	20 FPP	64	175	107[A]	8.7	0.08	86	141
10-95	Control	54	241	119[A]	13.2	0.11	80	150
	Control	56	223	120[A]	14.6	0.12	87	174
	20 FPP	64	129	130[B]	10.4	0.08	104	159
11-95	Control	54	198	131[A]	17.5	0.13	88	189
	Control	56	87	126[B]	18.4	0.15	91	162
	20 FPP	64	132	136[C]	14.7	0.11	100	175
1-96	Control	54	156	161[A]	22.5	0.14	86	199
	Control	56	152	163[A]	22.9	0.14	105	204
	20 FPP	64	125	174[B]	16.4	0.09	122	212

[1] Means followed by the same letter are not significantly ($P<0.05$) different based on the Tukey HSD Test (Wilkinson 1990).

Table 4. Statistical summary of fish length data collected for summer steelhead in the feeding methods/rearing container study during nursery rearing in June and July, 1995 at Dworshak NFH, Idaho.

Month	Tank	N	Mean Length[1]	SD	C	Min.	Max.
June	116	150	61[A]	4.6	0.08	45	70
	216	150	63[B]	3.9	0.06	53	76
	316	155	66[C]	5.0	0.08	48	92
	416	149	66[C]	3.9	0.06	44	73
July	116	186	79[A]	5.4	0.07	65	95
	102	164	77[B]	5.4	0.07	63	95
	201	155	74[C]	4.5	0.06	57	87
	416	167	79[B]	4.8	0.06	64	94

[1] Means followed by the same letter are not significantly ($P<0.05$) different based on the Tukey HSD Test (Wilkinson 1990).

Table 5. Statistical summary of fish length data collected from Take 8 summer steelhead in outside raceways from August 1995 through April 1996 at Dworshak NFH, Idaho.

Date	Treatment	Raceway	N	Mean Length	SD	C	Min.	Max.
8-95	HF[1]	10	203	87	6.9	0.08	69	103
		11	120	87	6.9	0.08	68	113
	2DF[2]	12	203	87	7.3	0.08	62	113
		13	202	85	7.1	0.08	64	104
	4DF[3]	14	230	89	7.3	0.08	71	107
		15	145	88	6.3	0.07	72	108
9-95	HF	10	100	105	9.0	0.09	81	129
		11	182	106	9.1	0.09	85	128
	2DF	12	177	106	9.0	0.09	77	122
		13	195	105	9.8	0.09	81	133
	4DF	14	132	108	9.0	0.08	88	136
		15	128	108	9.8	0.09	80	130
10-95	HF	10	143	119	16.7	0.14	76	164
		11	143	120	15.7	0.13	82	154
	2DF	12	153	117	16.5	0.14	82	161
		13	206	120	17.7	0.15	81	170
	4DF	14	152	121	17.6	0.15	83	164
		15	161	120	16.3	0.14	90	161
11-95	HF	10	79	123	18.9	0.15	80	163
		11	164	123	19.3	0.16	86	183
	2DF	12	188	114	22.5	0.20	69	172
		13	178	130	20.8	0.16	91	187
	4DF	14	110	123	20.9	0.17	83	171
		15	125	128	20.2	0.16	88	177

Table 5. Continued.

Date	Treatment	Raceway	N	Mean Length	SD	C	Min.	Max.
1-96	HF	10	219	146	24.8	0.17	94	201
		11	197	151	23.2	0.15	95	196
	2DF	12	197	136	23.7	0.17	85	195
		13	189	144	26.3	0.18	91	203
	4DF	14	148	150	27.5	0.18	89	214
		15	87	151	25.4	0.17	94	192

[1] Hand Fed.
[2] Two Demand Feeders.
[3] Four Demand Feeders.

Table 6. Statistical summary of fish length data collected for summer steelhead in the feeding methods/rearing containers study during outside rearing in Burrows ponds from August 1995 through January 1996 at Dworshak NFH, Idaho.

Date	Treatment	Burrows Pond	N	Mean Length	SD	C	Min.	Max.
8-95	HF[1]	39	194	87	6.7	0.08	71	106
		41	237	90	6.9	0.08	72	107
	2DF[2]	31	210	87	6.7	0.08	65	108
		33	263	90	7.0	0.08	66	113
	4DF[3]	35	185	88	7.2	0.08	70	107
		37	182	88	7.5	0.09	73	110
9-95	HF	39	227	106	9.1	0.09	85	137
		41	232	109	10.3	0.09	80	148
	2DF	31	242	107	10.0	0.09	84	137
		33	177	109	9.3	0.09	85	137
	4DF	35	213	107	10.7	0.10	69	134
		37	185	110	10.0	0.09	77	139
10-95	HF	39	252	127	15.6	0.12	89	189
		41	238	127	16.2	0.13	88	186
	2DF	31	147	130	19.8	0.15	89	168
		33	206	130	18.5	0.14	84	165
	4DF	35	193	130	21.1	0.16	91	225
		37	208	128	18.4	0.14	86	169
11-95	HF	39	145	138	18.5	0.13	92	169
		41	130	140	20.5	0.15	92	201
	2DF	31	112	149	24.3	0.16	95	191
		33	157	140	23.5	0.17	85	177
	4DF	35	102	139	24.5	0.18	82	178
		37	140	141	22.6	0.16	84	181

Table 6. Continued.

Date	Treatment	Burrows Pond	N	Mean Length	SD	C	Min.	Max.
1-96	HF[1]	39	103	157	25.1	0.16	92	200
		41	178	165	23.8	0.14	101	211
	2DF[2]	31	143	165	27.1	0.16	83	211
		33	158	160	26.6	0.17	97	204
	4DF[3]	35	158	160	26.6	0.17	97	204
		37	92	158	28.2	0.18	91	201

[1] Hand Fed.
[2] Two Demand Feeders.
[3] Four Demand Feeders.