Low Early Rearing Density of Summer Steelhead (*Onchorynchus mykiss*) at the Hagerman National Fish Hatchery

By the

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Abstract

In June 2009, the U.S. Fish and Wildlife Service Hatchery Review Team issued a report with recommended changes to fish production practices at the Hagerman National Fish Hatchery. Specifically, recommendation HA7 specified reducing rearing densities in indoor nursery tanks to a maximum D.I. of 0.5 by reducing total number of Dworshak B-run fish reared, increasing the number of nursery tanks, and/or marking and tagging the fish after they are transferred to the outside raceways. As a result of this recommendation, the Hagerman Hatchery Evaluation Team compared the performance of steelhead reared at low early rearing densities (0.61 to 0.75 D.I.) to steelhead reared at historic rearing densities (≥ 0.8 D.I.). The low early rearing density group was transferred to the outside steelhead raceways one month prior to ad clipping operations. The historic early rearing density group was kept in the nursery tanks until ad clipping operations started in mid-August 2009. The Hatchery tracked survival, growth, and fish health of the two groups. The Hatchery had several disease epizootics during BY2009. Several of these epizootics started in the low early rearing density groups. As a result, raceway survival was significantly lower for steelhead reared at lower early rearing densities (94.5% vs. 97.3%). The Hatchery hypothesized two reasons for lower survival of the lower early rearing density group including: additional handling stress from two transfers instead of one; and dissolved oxygen and temperature fluctuations in spring ponds during July and August. The Hatchery plans to reduce steelhead production in BY2010. This reduction will help reduce early rearing densities without the additional stress of transferring fish outside before marking and ad-clipping.

Introduction

The Hagerman National Fish Hatchery (Hatchery) annually rears 1.46 million summer steelhead smolts to 4.5 fish per pound (fpp) as part of the Lower Snake River Compensation Plan (LSRCP) Program. The Hatchery receives eyed steelhead eggs from Sawtooth Fish Hatchery in May and June. Eggs are hatched in 60 upwelling incubators and subsequently reared in hatchery rearing tanks (40 tanks – 90 ft^3 and 20 tanks – 85 ft^3) to approximately 100 fish per pound (fpp) or 2.95 inches by mid-August. The steelhead Density Index (Piper 1982) typically peaks at 0.8 in the hatchery rearing tanks. At this time, the steelhead fingerlings are netted into a forklift mounted transfer tank and delivered directly to a Mass Automated Trailer System (MATS) for ad clipping and coded wire tagging. After ad clipping and tagging, the fingerlings are shuttled by 4-inch irrigation pipe to final rearing raceways. The Hatchery utilizes 66 (10-100') Steelhead raceways for rearing steelhead fingerlings to smolts. The Density Index (DI) in the Steelhead raceways typically peaks at 0.2 in mid-April just prior to distribution.

The Hatchery has used the aforementioned method of ponding steelhead fingerlings since 2006 when the Idaho Department of Fish and Game transitioned to the use of the MATS

trailers for steelhead marking. The MATS trailers can effectively mark smaller steelhead (100 fpp) than hand clipping crews. The smaller steelhead appear to heal faster from clipping with less incidence of "deep clips" and "soreback". As another benefit, the Hatchery was able to avoid ponding the steelhead in the raceways before marking which eliminated handling the fingerlings twice; once from the Hatchery to the raceways and then again from the raceways to the marking trailer. Overall, the Hatchery has had excellent survival before and after marking operations. In Brood Year 2008, the steelhead survival rate was 99.5% following the four months after marking (September through December). However, steelhead mortality increased in the final four months of rearing (January to April) to 3.5%.

In 2009, the U.S. Fish and Wildlife Service Hatchery Review Team (HRT) recommended reducing rearing densities in the hatchery rearing tanks (USFWS 2009). Specifically, recommendation HA7 specified reducing rearing densities in indoor nursery tanks to a maximum DI of 0.5 by reducing total number of Dworshak B-run fish reared, increasing the number of nursery tanks, and/or marking and tagging the fish after they are transferred to the outside raceways. The HRT suggested that lower early rearing densities would improve early physiological development and result in better overall fish health and survival through release. The most efficient and economical method of reducing indoor rearing densities while maintaining total smolt production was to transfer fingerlings to outside raceways before marking and tagging. To implement this recommendation, steelhead fingerlings were ponded in early-July at a hatchery tank DI below 0.5. Each raceway contained approximately 100,000 fingerlings for a resulting Density Index of 0.05. In mid-August, the DI would reached 0.10. At this time, the fingerlings were transferred to the MATS for ad clipping and coded wire tagging via a 4-inch Magic Valley Heli-Arc fish pump. After ad clipping and tagging, the fingerlings were shuttled by 4-inch irrigation pipe to final rearing raceways.

In BY2009, the Hagerman Hatchery Evaluation Team (HET) evaluated the benefits of low early rearing density by ponding steelhead into raceways earlier. The HET compared overall survival, fish health, size distribution variance, and fin condition of steelhead reared under historic conditions and at a low early rearing density.

Materials and Methods

Brood Year 2009 Sawtooth stock production was split into two groups: Low early rearing density (DI < 0.8) and historic early rearing density (DI ≥ 0.8). Twelve steelhead tanks (1-4, 10-13, and 18-21) were designated as low early rearing density. Low early rearing density tanks were from Sawtooth Lots 1, 2, 4, and 5. Specific tanks were chosen to represent a sample of each Lot while maintaining: uniformity of fingerling size in the raceways, ponding schedule requirements, water availability, and minimal disruption to normal rearing procedures. Sawtooth Lots were combined at the Hatchery into Lots 1-7 following the Hatchery Standard Operating Procedures (SOP) to increase efficiency of feeding and MATS marking activities. Sawtooth Lots 1 and 2 became Hatchery Lot 1 and Sawtooth Lots 4 and 5 became Hatchery Lot 3.

Brood Year 2009 eyed Sawtooth steelhead eggs received from Sawtooth Fish Hatchery were disinfected upon receipt in 100 ppm Argyntyne (PVP Iodine) solution. Eggs were enumerated using a displacement method following Hatchery SOP's and distributed to incubators in groups of approximately 30,000 in Hatchery Building #1. Each tank had one incubator. Eggs were received between 350-430 Temperature Units (TU's) and hatched at approximately 530 TU's (5 days). After hatching, the fry were kept in the incubator jars for 3-4 days. At that time, the fry were poured into the tank through a minnow grader box to separate and enumerate egg mortality. Fry remained in the tank for another 6-7 days before initial feeding. Salmon Starter #0 was used for initial feeding. Fry were hand fed to satiation daily until MATS marking. Fry were switched to #1 feed at 900 fpp, then #2 at 400 fpp, and #3 or 1.0 mm at 200 fpp. Hatchery tanks were cleaned daily.

In order to allow sufficient UV sterilization between brood years and to finish maintenance projects, the low early rearing density fingerlings were transferred via forklift tank to the steelhead raceways on July 23rd, 2009 at higher than anticipated DI (0.61 to 0.75 D.I.). The fingerlings were ponded at 100,000 fingerlings per raceway at a resulting DI of 0.05. The low density group final rearing raceways were 37-40 for Lot 1 and 41, 42 and 59-64 for Lot 3 (Appendix 1).

The historic density group was ponded during marking and tagging operations, August 19-25, 2009. Historic density raceways were 43-48 and 65-66.

MATS marking for both rearing groups occurred August 19-25, 2009. Low rearing density fingerlings were transferred to the MATS via a 4-inch Magic Valley Heli-Arc fish pump. Historic rearing density fingerlings were transferred to the MATS via a forklift tank. After marking, the both rearing groups were placed on restricted diets using a Hatchery Constant (Piper 1982) method to meet the size at release goal of 4.5 fpp. Fingerlings were switched to 1.5 mm feed at 100 fpp, 2.5 mm at 40 fpp, and 3.5 mm at 20 fpp. Raceways were cleaned weekly until January 2010 and then increased to twice weekly until release in mid-April 2010.

Survival

Survival rates between low and historic early rearing density groups were arcsine transformed and compared using a single factor ANOVA test and were considered significant if $p < 0.05$. Survival rate calculations excluded raceways 40, 47, 48, 60, and 64. These raceways were stocked at lower densities due to discrepancies between inventory estimates and marking numbers (Appendix 1).

Dorsal Fin Index and Size Distribution Variance

Dorsal Fin Indices (DFI) and size distribution variance was conducted on a random sample (n=2) of raceways from each density group. Approximately 30 days prior to release, twenty fish from two lots of lower early rearing density and historic rearing density smolts were randomly grab sampled for right pectoral fin, left pectoral fin, and

dorsal fin measurements to the nearest millimeter with a ruler. Total fork length (millimeters) and weight (grams) was measured by the digitizer (GSE Scale System Model 655). Dorsal fin index was calculated as: (dorsal fin length X 100)/total length. Dorsal fin indices of the two treatments were compared using a single factor ANOVA test and were considered significant if $p < 0.05$. An additional 180 fish were randomly sampled for length and weight to determine size distribution variance. Significant differences ($p < 0.05$) in length variances was determined using a one-tailed, two sample F-test for variances.

Fish Health

Fish health samples were collected several times throughout raceway rearing when mortality rates exceeded 0.1%/day. Fish samples were processed by the Idaho Fish Health Center. Samples of skin mucus and gill filaments were examined for external parasites or the presence of other abnormalities. The fish were opened and examined for visual signs of parasites or other indications of bacterial or viral disorders. Kidney imprints were taken from fish that exhibited signs that varied from 'normal' (swollen and inflamed hindgut, pink fat, anemia, swollen kidney). Imprints, when gram stained, show the presence of N.Salmonis spores and/or bacteria. Kidney samples were collected and then combined into two-fish pools in tissue lysis buffer for Polymerase Chain Reaction (PCR) assays. Individual kidneys were streaked onto Tryptic Soy Agar and Tryptone Yeast Extract plus Salts Agar to isolate bacteria, primarily *Flavobacterium psychrophilum* (causes Coldwater Disease) and *Aeromonas salmonicida* (causes Furunculosis).

Results

Survival

The raceway rearing survival rate for low early rearing density fish was significantly ($p = 0.01$) lower than the historic early rearing density smolts. Low density survival averaged 94.5% compared to 97.3% for historic early rearing density fish.

Dorsal Fin Index and Size Distribution Variance

Steelhead smolts reared at a low early rearing density had a mean DFI of 4.7 compared to a mean of 4.2 for smolts that were reared at a historic early rearing density. There was not a significant difference ($p > 0.05$) between the two groups.

The weight distribution of the two study groups is illustrated in Figure 1. Low early rearing density fish averaged 101 grams compared 90 grams for historic early rearing density fish. Low early rearing density fish had a greater variation in weight distribution than the historic early rearing density fish ($\sigma_2 = 1268$ vs 735).

The length distribution of these two groups is illustrated in Figure 2. Low early rearing density fish had a mean length of 212 mm compared to 204 mm in historic early rearing density fish. There was no significant difference ($p > 0.05$) in variation of the length distribution of the two groups ($\sigma_2 = 538$ vs 564).

Fish Health

The Hatchery experienced multiple disease issues and sporadic elevated mortality levels throughout the raceways in BY2009 (Table 1). Many of these disease episodes and elevated mortality began in raceways that were part of the low early rearing density group and subsequently spread to the historic density group. This is illustrated by examining daily mortality rates for both groups (Figure 3). During disease epizootics, mortality first increased in the low early rearing density group and then increased in the historic early rearing density group one to two weeks later.

Mortality due to disease epizootics was controlled with several treatments throughout the rearing cycle. Furunculosis outbreaks were treated with Aquaflor and Romet in October, December, and February (Table 2). During March and April 2010, several raceways were treated with Chloramine-T and potassium permanganate for gill disease, columnaris, and problems associated with steatitis (Table 3).

Discussion

Lowering the early rearing density in the hatchery nursery tanks by moving steelhead fingerlings to outside rearing raceways prior to marking did not improve overall survival, dorsal fin index, or variance in weight or length distribution. The greater weight variation in low early rearing density fish could be contributed to the greater amount of chemical treatments for disease outbreaks as compared to the historic rearing density fish groups. The additional treatments resulted in more time off feed causing a greater gap between fish at both ends of the size distribution. Contrary to our hypothesis, survival was significantly lower in raceways that were reared at lower early rearing densities. We believe two stress factors may have influenced survival of low early rearing density smolts:

1) When the fingerlings are moved to the raceways from the hatchery building before August, water is supplied to the raceways from Bickle and Riley Spring ponds. During the long, hot days of July an August, these ponds are more susceptible to fluctuations in water temperature and gas saturation than fast flowing springs such as Main spring that supplies the nursery tank water (HHET 2009a). These fluctuations may have increased the stress on the fingerlings during their first month in the steelhead raceways prior to marking.

2) In addition to water quality fluctuations, the low early rearing density fingerlings were subjected to twice the handling stress as historic early rearing density fingerlings. Low

early rearing density fingerlings were transferred from the nursery tanks to the steelhead raceways via a forklift tank on July 23, 2009. They were then subjected to another move via a 4" fish pump starting August 19th, 2009 into the marking and clipping trailers. In comparison, historic rearing density fingerlings were only subjected to one handling episode; transfer from the nursery tanks to the marking and clipping trailer via a forklift tank.

These stress factors may have overshadowed the benefits of lower early rearing densities at the Hatchery. As a result, the fingerlings were more susceptible to disease epizootics which lowered survival. If lower nursery rearing densities are still desired, the Hatchery should consider alternatives to ponding fingerlings in July to accomplish that end.

In BY2010, the Hatchery has cut overall steelhead production by 100,000 smolts to address declining water supplies (HHET 2009b). This reduction will lower early rearing densities by approximately 7%, but will not likely reach the goal of a D.I. < 0.5 recommended by the Hatchery Review Team (Figure 4).

Future Research

The Hatchery will monitor dissolved oxygen and water temperatures during the summer months of 2010 with Campbell Scientific® Dissolved oxygen loggers and HOBO® temperature loggers. The monitoring program will examine the extent of water quality fluctuations during summer weather conditions. The dissolved oxygen and temperature data will then be compared to accepted water quality rearing parameters for salmonid species.

References

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Figures and Tables

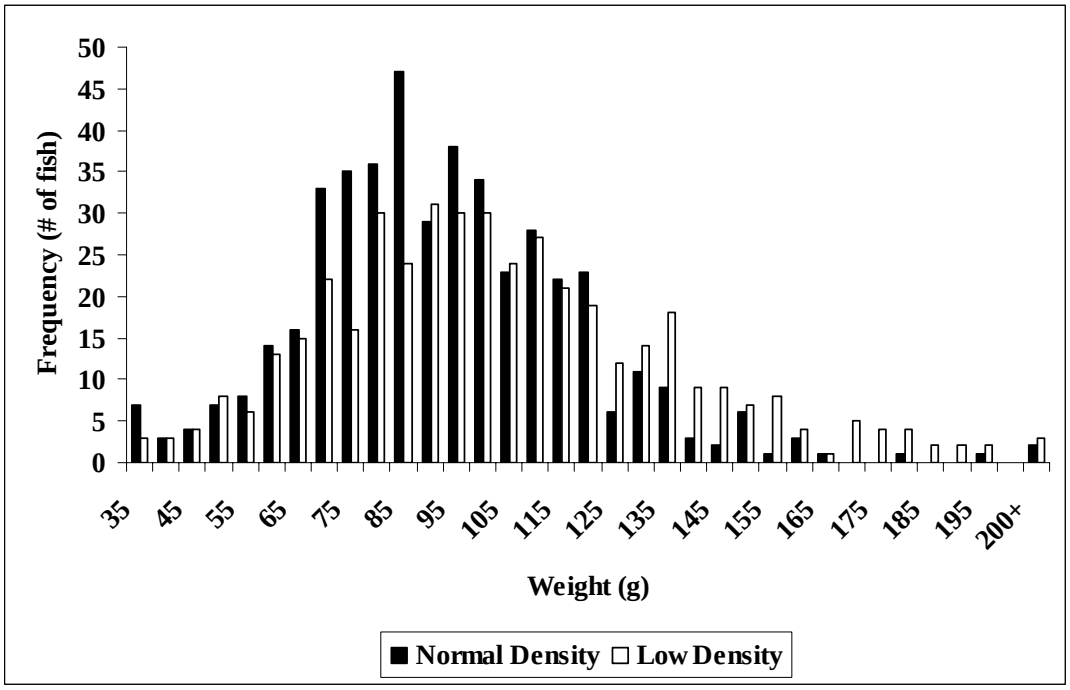

Figure 1. Weight distribution of fish reared at historic hatchery tank density (DI ≥0.8) and low hatchery tank density (DI < 0.8), Hagerman National Fish Hatchery, BY2009.

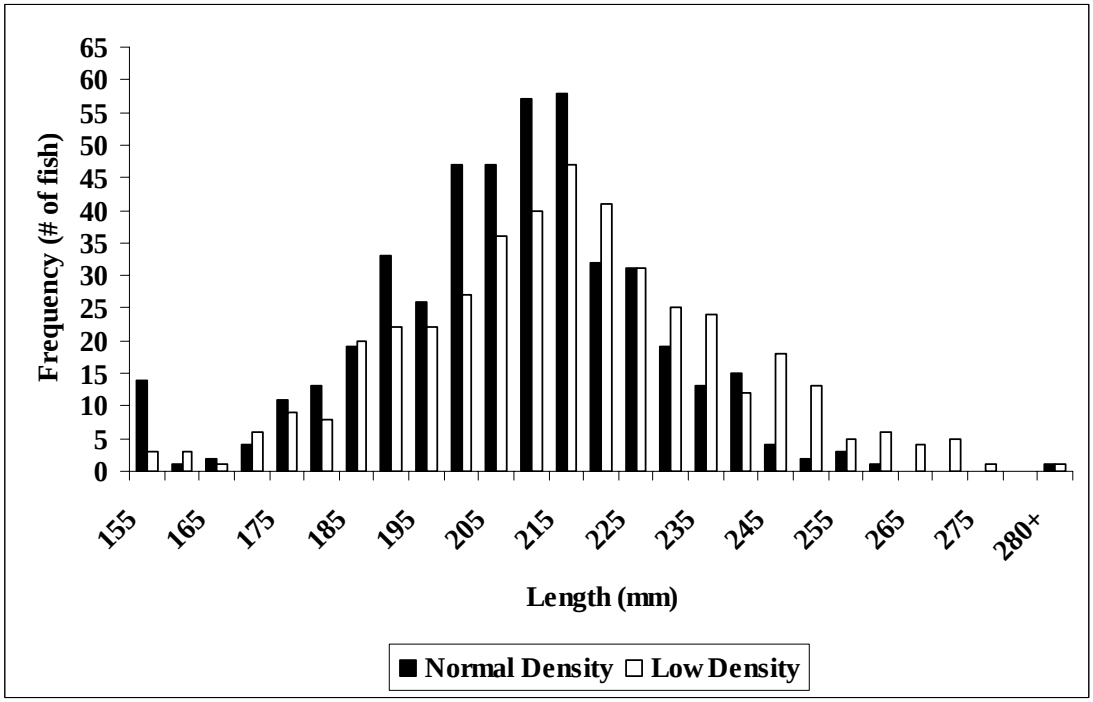

Figure 2. Length distribution of fish reared at historic hatchery tank density (DI ≥0.8) and low hatchery tank density (DI < 0.8), Hagerman National Fish Hatchery, BY2009.

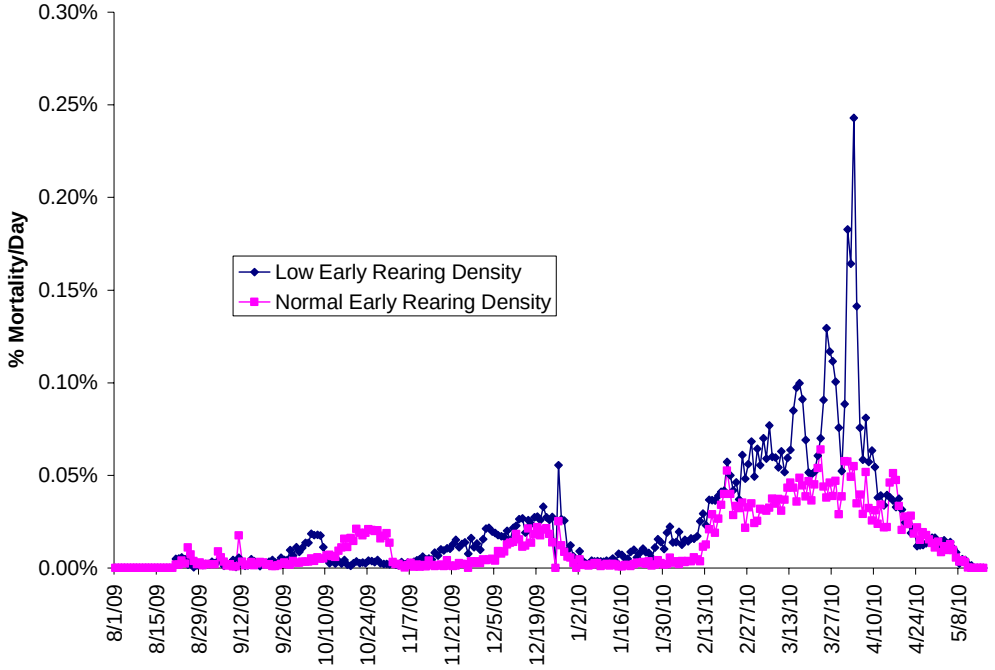

Figure 3. Mortality rates of steelhead reared at historic hatchery tank density (DI ≥0.8) and low hatchery tank density (DI < 0.8), Hagerman National Fish Hatchery, BY2009.

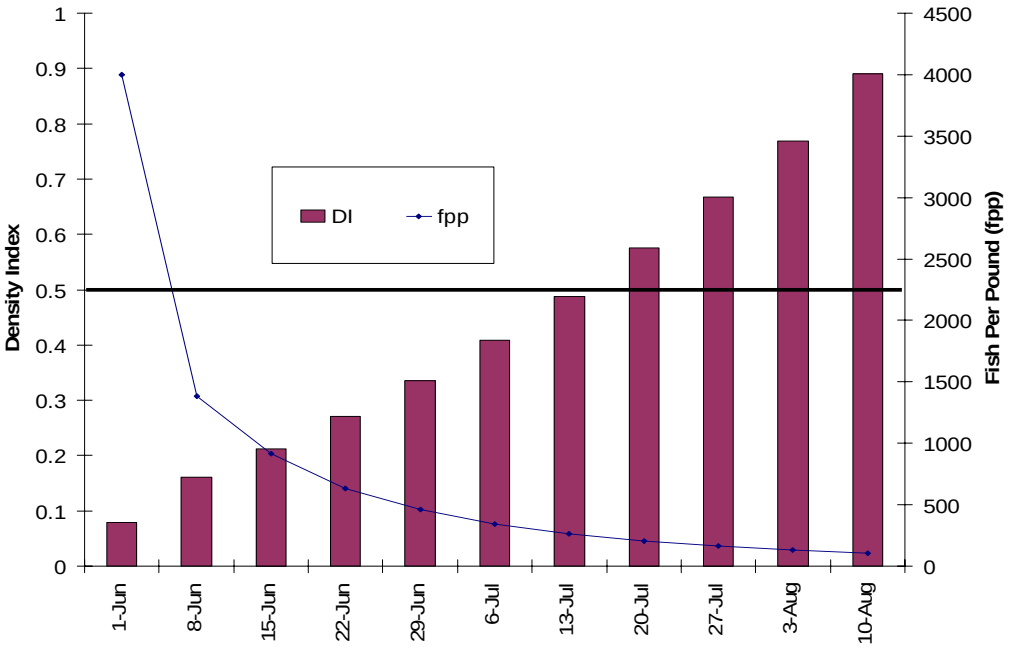

Figure 4. Anticipated nursery rearing steelhead Density Index for brood year 2010, target Density Index of 0.5 with 25,000 fingerlings per nursery tank, Hagerman National Fish Hatchery.

Table 1. Results Fish Health Exams of BY09 summer steelhead from raceways stocked with low or historic early rearing densities, Hagerman NFH.

	17-Dec-09	17-Dec-09	1-Jan-10	17-Feb-10	10-Mar-10
Obs.	Raceway 37,39,41	Raceway 61,62,67	Raceway 37	Raceway 63	Raceway 37,38,39
Density Group	Low	Low (61, 62) Norm (67)	Low	Low	Low
External	Saddle back, fungus eyes	Saddle back	Active dorsal fin erosin, hemoraged pupils,fin fraying	Dorsal lesions, gyrodactylus	Lesions on skin, bad eyes, frayed tails, gyrodactylus
Gills	Pale and anemic	Bad	White, hemoraged	Necrotic gills, mucus, little bacteria	Necrotic gill, small amount of fungus and bacteria
Internal	Swollen kidneys, enlarged spleen, hemoraged intestine and visceral fat	Swollen kidneys, enlarged spleen, hemoraged intestine and visceral fat	Swollen kidneys, enlarged spleen, hemoraged intestine and visercal fat	Swollen kidneys, enlarged spleen, hemoraged intestine and visceral fat	Swollen kidneys, enlarged spleen, hemoraged intestine and visceral fat
Bacterial	Aeromonas salmonicida	Aeromonas salmonicida	Aeromonas salmonicida	Aeromonas hydrophila, Flavobacterium columnare	Flavobacterium columnare, Cold Water Disease
PCR	neg	Nucleospora salmonis	Nucleospora salmonis	Nucleospora salmonis	Nucleospora salmonis

*On 2/24/10 fish were fixed in Davidson's Solution for histology. Results indicated steatitis and N.S. in the intestine.

Table 2. Summary of chemical treatments for Furnculosis (*Aeromonas salmonis)* in raceways stocked with low or historic early rearing densities, Hagerman NFH BY09.

Date Treated	Raceways	Density	Therapeutic Chemical	Duration	Treatment Rate (ppm)
10/5/2009	37-58	Low & Historic	Aquaflor	10 days	10mg/kg fish
10/26/2009	59-102	Low & Historic	Aquaflor	10 days	10mg/kg fish
12/25/2009	37-102	Low & Historic	Romet	5 days	50mg/kg fish
2/5/2009	37-40, 63	Low	Aquaflor	10 days	10mg/kg fish

Table 3. Summary of chemical treatments for gill disease, columnaris, and problems associated with steatitis used in raceways stocked with low or historic early rearing densities, Hagerman NFH BY09.

Raceway	Density	Therapeutic Chemical	Dates Treated*	Treatment Rate (ppm)
37	Low	Chloramine-T	3/6-8/2010	15
39	Low	Chloramine-T	3/6-8/2010	15
40	Low	Chloramine-T	3/9-11/2010	10
42	Low	Chloramine-T	3/9-11/2010	10
38	Low	Potassium Permanganate**	3/14/16/2010	0.5,1.0,2.0
45	Historic	Potassium Permanganate	3/30-4/1/2010	0.5
46	Historic	Potassium Permanganate	3/30-4/1/2010	0.5
47	Historic	Potassium Permanganate**	4/14-16/2010	0.5,1.0,2.0
48	Historic	Potassium Permanganate**	4/14-16/2010	0.5,1.0,2.0

*Treatments consisted of three consecutive days

**Treatments rate was 0.5 ppm (Day 1), 1.0 ppm (Day2), 2.0 ppm (Day3)

Appendix 1.

Low Density versus Historic Density early hatchery rearing ponding plan and raceway survival, BY09 Steelhead, Hagerman National Fish Hatchery

	37	38	39	40	41	42	43	44	45	46	47	48
Stock	S	S	S	S	S	S	S	S	S	S	S	S
Lot	L1	L1	L1	L1	L3	L3	L5	L5	L5	L6	L7	L7
Mark	Ad	Ad	Ad	Ad	Ad	Ad	Ad	Ad	Ad	Ad	Ad	Ad
Tag		PIT	CWT		PIT			PIT		CWT	PIT	
Density	LD	LD	LD		LD	LD	ND	ND	ND	ND		
Survival	91%	94%	92%	96%	97%	98%	98%	99%	98%	98%	97%	94%
D.I.	0.75	0.75	0.75	0.75	0.62	0.62	0.94	0.94	0.94	0.98	0.92	0.92
			DFI							DFI		
Inventory	25000	25000	25000	22212	25000	25000	25012	25001	25002	25007	20324	20357

	59	60	61	62	63	64	65	66	67	68	69	70
Stock	S	S	S	S	S	S	S	S	S	EF	EF	EF
Lot	L3	L3	L3	L3	L3	L3	L4	L4	L4			
Mark	Ad	Ad	Ad	Ad	Ad	Ad	Ad	Ad	Ad	NoAd	NoAd	NoAd
Tag	PIT						PIT		PIT	CWT	C/P	CWT
Density	LD		LD	LD	LD		ND	ND	ND			
Survival	95%	97%	94%	95%	93%	96%	96%	96%	95%	98%	98%	98%
D.I.	0.62	0.62	0.61	0.61	0.61	0.61	1.00	1.00	1.00	0.89	0.51	0.50
			DFI					DFI				
Inventory	24000	20641	24004	24008	24000	20888	24129	24000	24000	19502	19253	16818

S	Sawtooth	PIT	PIT Tagged
EF	East Fork Naturals	Ad	Ad Clip
YF	Yankee Fork	LD	Low Early Rearing Density
CWT	Coded Wire Tagged	ND	Historic Early Rearing Density

Notes:

Survival: Raceway survival from ponding until release
Density Index: Density Index calculated for Hatchery tanks
Inventory: Beginning raceway inventory from ad clipping numbers