An Evaluation of Continually Declining Water Availability on the Carrying Capacity of Hagerman National Fish Hatchery - A Comparison of Adult Returns Between First-Use and Third-Use Production Water Based on Coded-Wire Tag Return Rates

Annual Report

Brood Year 2008

By the

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Funded by

Lower Snake River Compensation Plan
U.S. Fish and Wildlife Service
Boise, Idaho

July 2009

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Introduction

The water supply for Hagerman National Fish Hatchery (Hatchery) has declined at a rate of nearly 1 cfs per year from 2000 to 2008. In light of these circumstances, and concerns about meeting production goals, the Hatchery assessed the affect of declining water supplies on steelhead smolt production capacity in BY2005 and 2006. This assessment determined that smolts could be experimentally reared to a Flow Index of 1.47 or 12.6 pounds/gpm without detrimental affects on smolt growth (HHET 2007). At the current water decline rate, a Flow Index of 1.47 is predicted in Brood Year 2010 at a production water supply of 58 cfs and a maximum production of 1.46 million smolts at a size of 4.5 fish per pound. Based on these results, the Hatchery Evaluation Team recommended an evaluation of smolt loading in the steelhead raceways on adult steelhead return rates.

The steelhead raceways are designed to pass water serially through three sequential decks of 22 raceways each. Generally, a 3-pass serial use system is considered to be the optimum for water use in a conservation hatchery. However, its overall efficiency in terms of producing quality smolts and subsequent adult survival depends on the water supply remaining constant. As the Hatchery maintains a 1.46 million annual smolt production and water supplies decline, water quality will degrade especially on the third deck. Degraded water quality may eventually manifest itself in poorer on-station performance and reduced survival rates from smolt to adult. The long term goal of this project is to monitor the adult returns from smolts transported from the Hatchery for release at the Sawtooth weir in the Salmon River drainage. Adult returns will be evaluated in relation to gradual changes in water quantity and quality at the Hatchery. The objective of this study is to compare adult returns for summer steelhead reared in the upper deck of raceways at the Hatchery (first-use water) with summer steelhead reared in the lower deck of raceways (third-use water) using coded-wire tags during a five year period (BY2007-2012). This Annual Report summarizes on-station rearing data for Brood Year 2008.

The data from this project will be used to determine optimal steelhead smolt production levels per unit of available water for maximizing adult returns. The Hatchery hypothesizes that declining water supplies will have a detrimental effect on Smolt to Adult Returns (SAR). The Hatchery further hypothesizes that adult return rates will decline in the lower deck of raceways before the upper deck of raceways. By tracking the difference (ΔSAR) between the upper deck and lower deck SAR’s as water supplies decline, the Hatchery will identify a point of diminishing return for smolts released. At this point, the Hatchery should reduce overall smolt production to maximize adult returns. Hence, the Hatchery will quantify a balance between smolt quantity and quality to maximize SAR.

Methods

This study continues efforts to evaluate SAR differences between upper deck and lower deck that started in BY2007. Both efforts used the existing coded-wire tag (cwt) program of 80,000 cwt’s.

Sawtooth Fish Hatchery Lots 1 and 2 eyed steelhead eggs were received on May 24th and June ^{1st}, 2008 at 408 Thermal Units and were combined in Hatchery incubators 1-5. These incubators and associated tanks were designated as Hagerman's Sawtooth stock Lot 1. All eggs hatched within 5 days of receipt and were started on feed on June 16, 2008. Hatchery tanks were fed daily to satiation a minimum of 7 times daily. Tanks were also cleaned daily. Maximum Flow Index was 0.48 and Density Index was 1.17 before ad clipping and coded-wire tag marking on August 19, 2008. During marking, each tank was "skimmed" to lower the Density Index and further mix the original egg Lots 1 and 2 from Sawtooth.

85,076 Hagerman Lot 1 fingerlings were transferred from the hatchery tanks to the marking trailers (Table 1). After coded wire tagging and ad clipping, the fingerlings were directly and evenly (within 10%) distributed into the raceways 47 & 48 (first-use water) and raceways 87 & 88 (third-use water). Raceways 47 & 48 had slightly fewer tags (≈1500 each) because there was less overrun of the cwt wire (Table 1). The cwt wire generally comes in 20,000 fish spools, but an experienced marking crew can squeeze 22,000 cwt tags from a 20,000 fish spool. Experimental raceways were chosen to fit existing ponding schedules based on distribution and rearing requirements. Raceways were hand-fed at a hatchery constant between 6 and 8 depending on sample count size, a target size of 4.5 fish per pound, and a target release date of April 15th, 2009. Sample counts were conducted monthly with fish used for health inspections. Raceways were switched to demand feeders on December 4th. Both treatments were released at the Sawtooth weir on April 16th and April 17th, 2009 at the Sawtooth Fish Hatchery.

Adult Returns

The two treatment groups will be compared based on the numbers of coded-wire tagged adults that return to the weir at Sawtooth Fish Hatchery. Adults will return over a three-year period as I-Ocean, II-Ocean, and III-Ocean adults. The mean number of coded-wire tag returns for each treatment group will be compared with a two-sample T-Test ($P<0.05$).

Using a two sample t-test, we have a 90% chance of detecting significant differences ($p< 0.05$) between the upper deck versus lower deck treatment groups at a return difference of 10 to 40% between groups depending on a pooled sample variance (s2p) of 500 to 20,000 and estimated SAR's between 0.5 and 1.0%.

Fish Health

Ten fish were collected monthly from each raceway (40 fish total) and examined through basic necropsy. 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, showed 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).

Water Quality

Dissolved oxygen, ammonia, pH, and water temperature was monitored from January through March. Carbon dioxide levels were determined using nomographic methods as described by Eaton et. al. (1995) during the same time period. The ten year average from annual water tests from the mixing chamber where used for total alkalinity (135 mg/l) and total dissolved solids (180 mg/l). Dissolved Oxygen was measured twice weekly during March according to Hatchery Standard Operating Procedures. A Dissolved Oxygen logger was installed in raceway 87 to monitor Dissolved Oxygen variation. Water samples were taken from the quiescent zone of each raceway on days that corresponded with fish health samples and feeding. Ammonia concentrations were determined by an independent lab analysis according to the Methods for Chemical Analysis of Water and Waste, U.S. EPA, 1983. Dissolved Oxygen and temperature was measured with a YSI 55 Handheld Dissolved Oxygen meter with an accuracy of ± 0.3 mg/l and ± 0.1 C. The pH was measured with a Hanna Instruments Waterproof pH and Temperature meter model HI98127 with an accuracy of ± 0.1 pH units.

Flow Index

Raceways were sample counted monthly to determine total raceway weight and calculate a Flow Index level. Flow index is a measure of safe carrying capacity based on fish size at a particular water temperature. The Flow Index for the experiment was calculated as outlined in Piper (1982):

$$\text{Flow Index} = \frac{\text{Total Weight}}{(\text{Length x gpm inflow})}$$

The Flow Index was cumulative from upper, middle, and bottom decks i.e. the total weight of the bottom deck included the bottom, middle and upper deck weights. The Flow Index was not increased between decks because no appreciable re-oxygenation occurred.

Fin Quality

Twenty fish from each raceway (47, 48, 87, and 88) were taken from a random grab sample 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) were measured by the digitizer (GSE Scale System Model 655). An additional 180 fish from each raceway were sampled for size distribution. Fin quality was determined by the Dorsal Fin Index which was calculated as described by Kindschi (1986):

$$\text{Dorsal Fin Index} = \frac{(\text{Dorsal Fin Length X 100})}{\text{Total Length of Fish}}$$

Results

Fish Health

There was no significant difference (p=0.05) in survival between treatments. Survival ranged between 96.9% - 98.1% during the study (Table 1). There was no difference in survival between BY 07 and BY 08. Fish Health observations are reported in Table 2.

Water Quality

Daily average outflow dissolved oxygen levels during March 2009 in first-use were higher than third-use (Figure 1). Daily average dissolved oxygen levels ranged from 7.9 mg/l to 6.6 mg/l in first-use as compared to 7.2 mg/l to 6.0 mg/l in third-use. Monthly dissolved oxygen levels as recorded by the DO Logger from raceway 87 had a peak average of 8.6 mg/l in September and sporadically decreased to an average of 7.2 mg/l in April (Figure 2).

Average un-ionized ammonia levels were lower in first-use with a mean value of 0.0028 mg/l (0.0010 mg/l to 0.0028 mg/l) compared to a mean value of 0.0053 mg/l in the third-use (0.0010 mg/l to 0.006 mg/l) (Figure 3). Even though un-ionized ammonia levels were lower in the first use water, there was no significant difference ($p > 0.05$) between the two decks. There was no significant difference in ammonia levels in first-use water between BY 07 and BY 08. However, ammonia levels were significantly higher in BY 07 in third-use water as compared to BY 08.

Average carbon dioxide levels were higher in the third-use (2.9 mg/l) water compared to first-use (1.9 mg/l) water, but not significantly different ($p > 0.05$) Both the first-use and third-use carbon dioxide concentrations were well below the 10 mg/L chronic concentration limit specified in Colt and Tomasso (2001). There was no significant difference between BY 07 and BY 08 in carbon dioxide levels in first-use or third-use water.

Flow Index

The flow index in first-use started at 0.12 in mid-August and gradually increased to 0.61 by the end of April (Figure 4). The flow index in third-use started at 0.33 in mid-August and increased to a peak of 1.24 in the beginning of April, and decreased to 1.01 by the end of April as steelhead distribution progressed.

Fin Quality

There was no significant difference ($p > 0.05$) in The Dorsal Fin Index (DFI) between treatments. The first-use DFI was 3.2 compared to the third-use DFI of 2.8. The DFI of BY 08 was significantly lower than the DFI of BY 07.

Growth

Fish were significantly different ($p < 0.05$) in fork length at distribution (Figure 5) Fish from Raceways 47 and 48 were longer with a mean length of 205.8 mm compared to a mean length of 201.4 mm of fish from Raceways 87 and 88 (Table 1). Both first use and third use water fish were significantly larger in BY 07 as compared to BY 08.

There were also no significant differences ($p > 0.05$) between FCR's with first-use of a mean 1.09 and third-use with a mean of 1.01. There was no difference in FCR between BY 07 and BY 08.

Discussion

Steelhead smolt health and survival remained similar between treatments on station despite lower water quality (not significantly different) in the third-use water treatments. This result was the same as the previous study in BY2007. Smolt size was significantly larger for third-use water smolts compared to first-use water smolts. The size discrepancy can be attributed to feed conversions (Table 1). The smolts on third use water were also slightly larger in BY2007. The instantaneous Flow Index peaked at 1.24 which was similar to Brood Year 2007.

The Hatchery was able to maintain a similar Flow Index by moving the rainbow trout production out of Hatchery 2 and into the Trout Raceways before March. This management strategy provided an additional 1 cfs of water to the Steelhead Raceways. This strategy allowed for more water diversion to the steelhead, even as overall water supply to the Hatchery decreases. The Hagerman Hatchery Evaluation Team recommends continuing this study in Brood Year 2010 following the protocols used in BY2009 and with the following recommendations:

Brood Year 2009 Recommendations

- Reduce overall smolt production by 100,000 smolts for BY 2010

References

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Eaton, Andrew, Lenore Clesceri, and Arnold Greenberg. 1995. Standard Methods for the Examination of Water and Wastewater, 19th Edition. American Public Health Association, Washington, D.C.

HHET 2007. Hagerman Hatchery Evaluation Team. Production Capacity Assessment for Summer Steelhead (*Oncorynchus mykiss*) Produced at the Hagerman National Fish Hatchery. Hagerman National Fish Hatchery, Hagerman, Idaho.

Figures and Tables

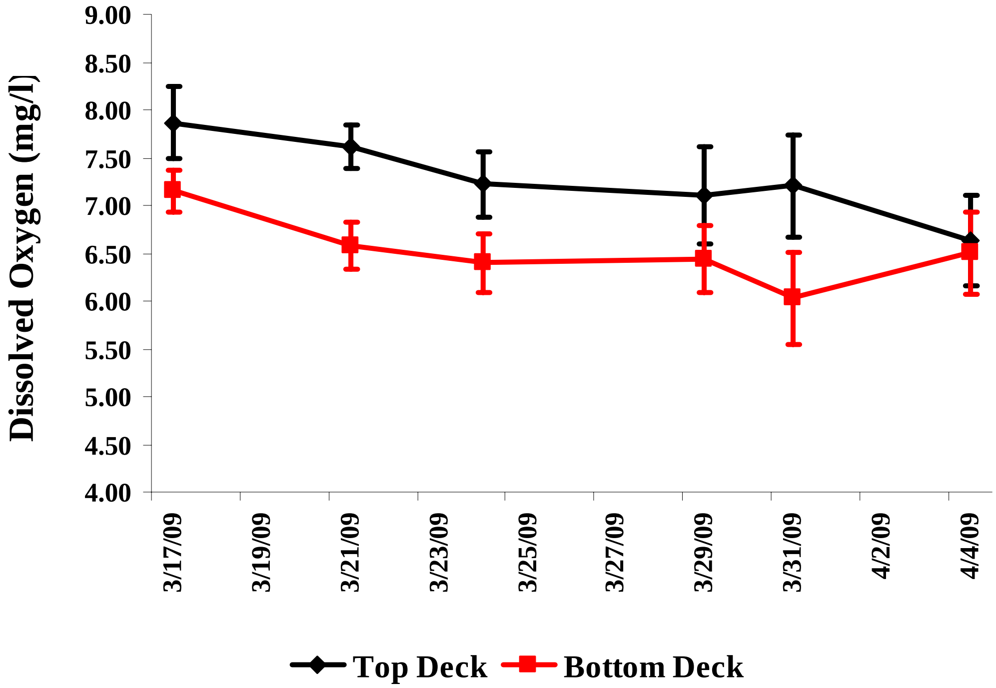

Figure 1. Daily Average Dissolved Oxygen Levels for Outflows of SST Raceways 47 & 48 (Top Deck) and 87 & 88 (Bottom Deck) During A Comparison of Adult Returns Between First-Use and Third-Use Water Based on CWT Return Study, Hagerman NFH BY 2008

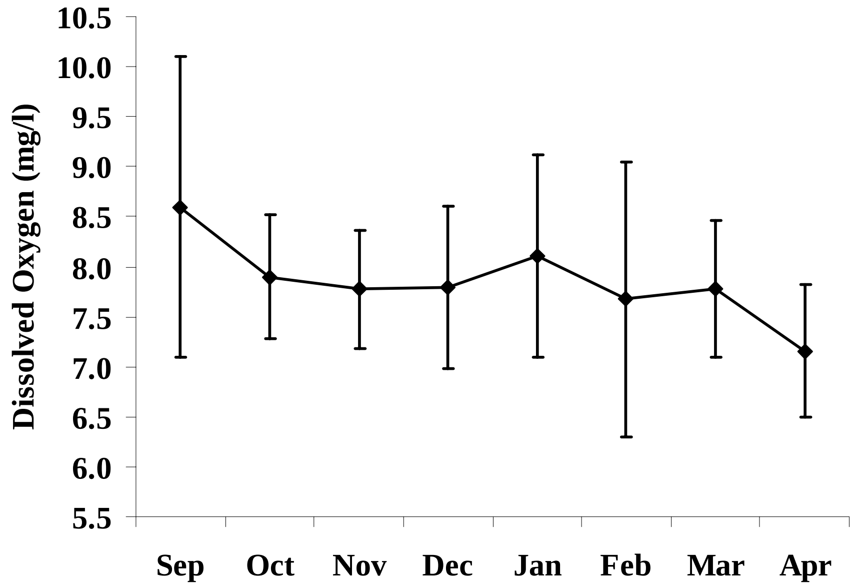

Figure 2. Monthly Average Dissolved Oxygen Levels Recorded from SST Raceway 87, Hagerman NFH BY 2008

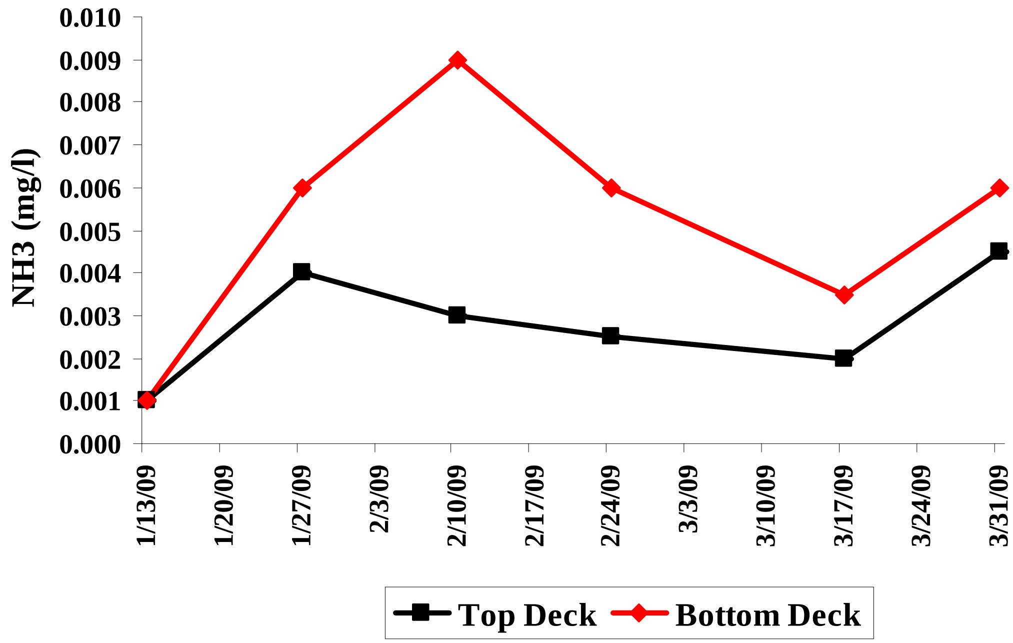

Figure 3. Average Un-Ionized Ammonia Levels for SST Raceways 47 & 48 (Top Deck) and 87 & 88 (Bottom Deck) Outflows During A Comparison of Adult Returns Between First-use and Third-Use Water Based on CWT Return Study, Hagerman NFH BY 2008

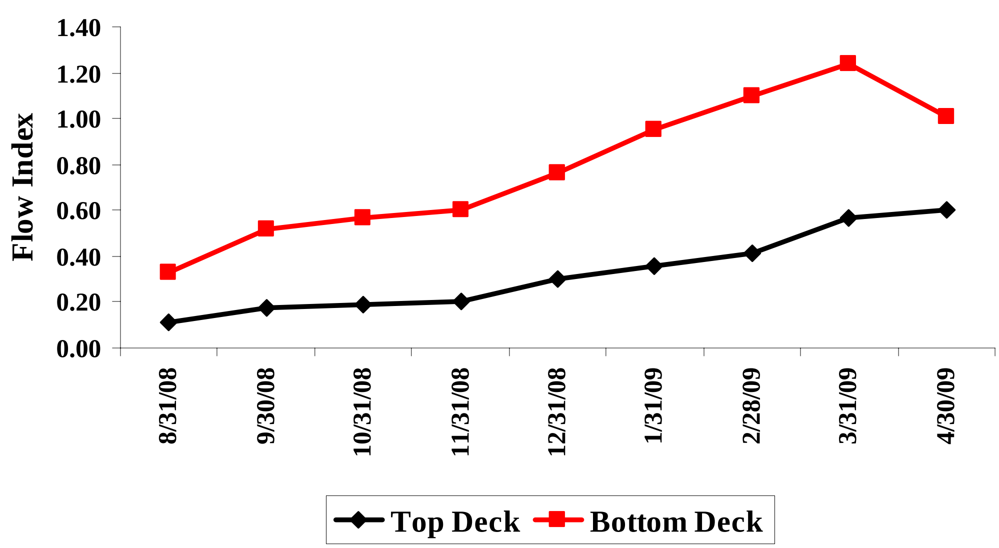

Figure 4. Monthly Flow Index of SST Raceways 47 & 48 (Top Deck) and 87 & 88 (Bottom Deck) During A Comparison of Adult Returns Between First-Use and Third-Use Water Based on CWT Return Study, Hagerman NFH BY 2008

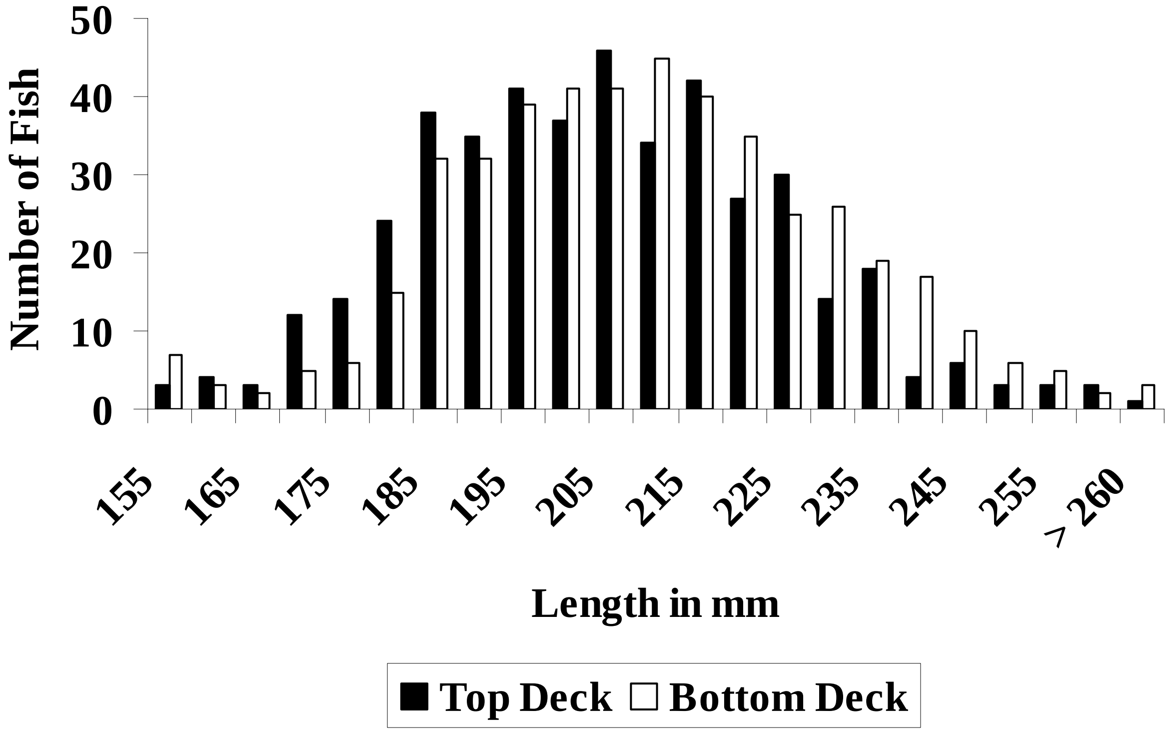

Figure 5. Fork Length Distribution of Fish from SST Raceways 47 & 48 (Top Deck) and 87 & 88 (Bottom Deck) During A Comparison of Adult Returns Between First-Use and Third-Use Water Based on CWT Return Study, Hagerman NFH BY2008

Table 1. Raceways and Tag codes During A Comparison of Adult Returns Between First-Use and Third-Use Water Based on CWT Return Study, Hagerman NFH BY 2008

Tag Code	Raceway	Total CWT (fingerlings)	Size at Marking (in)	Dates Marked	CWT Released (smolts)	Release Date	Survival (Marking to Release)	Release Length (in)	FPP	Total Weight (lbs)	Total Feed (lbs)	FCR
10-86-82	47	20,467	3.35	8/19/2008	19,837	4/16-17/2009	96.9%	8.36	4.63	4280	4689	1.10
10-86-82	48	20,596	3.35	8/19/2008	20,170	4/17/2009	97.9%	8.41	4.54	4440	4771	1.07
10-18-81	87	22,000	3.35	8/20/2008	21,317	4/16/2009	96.9%	8.50	4.40	4850	5060	1.04
10-18-81	88	22,013	3.35	8/21/2008	21,586	4/16-17/2009	98.1%	8.68	4.13	5230	5108	0.98

Table 2. Results Fish Health Exams of BY08 summer steelhead in A Comparison of Adult Returns Between First-Use (Raceways 47&48) and Third-Use Water (Raceways 87&88) Based on CWT Return Study, Hagerman NFH.

	September		October		November		December		January		February		March	
Obs.	47-48	87-88	47-48	87-88	47-48	87-88	47-48	87-88	47-48	87-88	47-48	87-88	47-48	87-88
External	1 Ich Act d.e.	Act d.e.	Act d.e.	Act d.e.	Act d.e.; Gyro	Act d.e.; Gyro	Act d.e.; s.b.; Gyro	Act d.e.; s.b.; Gyro	Act d.e.; Gyro	Act d.e.	Act d.e.	Act d.e.; b.e.; Gyro	b.e.	b.e.; Act d.e.
Gills	Norm	Norm	Norm	Norm	Norm	Norm	Norm	Norm	Norm	Norm	Norm	Norm	Pale	Pale
Internal	Norm	Norm	Norm	Norm	Norm	Norm	Norm	N. sal.	ss	N. sal.	N. sal	N. sal	N. sal	N. sal
Bacterial	n/a	n/a	n/a	n/a	n/g	n/g	n/g	n/g	ah	ah	A. sal CWD	n/a	n/g	n/g
PCR	neg	N. sal.	neg	N. sal	N. sal.	N. sal.	neg	neg	N. sal.	N. sal.	N. sal	N. sal	neg	neg

Abbreviations

N. sal.=	*Nucleospora salmonis*	Act =	Active	CWD=	Coldwater Disease
n/g =	No Growth	d.e. =	Dorsal Fin Erosion	b.e. =	bad eyes
neg =	Negative	p.e. =	Pectoral Fin Erosion	ss =	swollen spleen
Norm =	Normal	A. sal =	Aeromonas salmonicida	s.b. =	soreback
Mod =	Moderate	Gyro =	Gyrodactylus	ah =	A. Hydrophila
n/a	Not available				

* Treated for CWD and Aermonas salmonicida with 1816g/ton Aquaflor at 0.5% daily feeding rate from 3/4-3/13/2009