EVALUATION OF CLEARWATER STEELHEAD STOCK PERFORMANCE IN SERIAL

RE-USE RACEWAYS AT HAGERMAN NATIONAL FISH HATCHERY

FINAL REPORT

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August 2006

ABSTRACT

Hagerman National Fish Hatchery rears Clearwater Stock summer steelhead as part of the Lower Snake River Compensation Plan program. Smolts are raised from eyed eggs and released into the upper Salmon and Little Salmon rivers for sport and tribal harvest. During its hatchery life cycle, the Clearwater stock exhibits a late winter/early spring spike in mortality, unlike the other two stocks of summer steelhead being raised at Hagerman NFH. The Hagerman Hatchery Evaluation Team (HET) conducted an evaluation to determine if Clearwater stock mortality is affected by the degree of serial reuse, since the hatchery typically rears the fish in the lower deck of its serial three-pass system of raceways. To evaluate the situation, Clearwater stock was raised in replicate raceways on all three decks for two consecutive years. Mortality, water quality, and fish health were monitored and compared with the same parameters for the Sawtooth stock. The study did not include the evaluation of either downstream migration or adult returns. The results indicate that mortality during the hatchery life cycle of the Clearwater stock is not affected by the degree of water reuse at the hatchery. Recommendations for additional studies are made.

INTRODUCTION

Hagerman National Fish Hatchery (NFH) raises three distinct stocks of summer steelhead as part of the Lower Snake River Compensation Plan (LSRCP) Program. Clearwater Stock originates from the North Fork Clearwater River, currently produced at Dworshak NFH. The other two stocks, Sawtooth and Pashimeroi, originate from the Salmon River. The eggs for these stocks are shipped to Hagerman NFH for incubation where they are hatched and the young reared to smolt size. The smolts are then transferred to several release locations in the Salmon River where they emigrate to the ocean and return as adults for harvest in sport and Tribal fisheries.

Hagerman NFH has reared Clearwater B-Run summer steelhead from Dworshak NFH on several occasions in years past, although the stock was not permanently incorporated into the LSRCP program until 1999. Since 1999, the Clearwater stock has experienced consistent spikes in mortality during the late winter and early spring (**Figure 1**). These periods of elevated mortality have not been observed in the Sawtooth or Pahsimeroi stocks. The Clearwater stock has been characterized with consistent fish health problems and high mortality since the Clearwater stock has been raised at the Hagerman NFH.

Several possible explanations have been hypothesized for the Clearwater stock's performance. Since the program at Hagerman NFH is closely related to that at Magic Valley Hatchery, the Team looked into that situation first. For a number of years, Magic Valley Hatchery has been having similar performance problems with rearing Clearwater stock. In 2002, a coordination meeting was held at Dworshak NFH to examine the problem. The idea was suggested that poor performance could be attributed to egg quality and/or handling at Dworshak NFH. However, after investigation, the claim of reduced egg viability due to egg handling procedures at Dworshak NFH and subsequent fish health problems was not satisfactorily substantiated. Besides, there had been no real differences in handling procedures between those eggs transferred to Magic Valley and those for the Dworshak NFH program, other than the transfer of eggs from Dworshak NFH to Magic Valley Hatchery. If the problem were due to the transfer procedures or methods, it would be reasonable to expect the mortality to occur earlier than late winter or early spring.

Another possible explanation is that the Clearwater stock is adapted to the softer water conditions in the Clearwater River, as opposed to the higher mineral content of waters in the Snake River Aquifer. However, no data have been collected to actually test this hypothesis. A third explanation for the unexplained mortality is that the Clearwater stock receives third-use water in the serial re-use system at Hagerman NFH. Juvenile summer steelhead at Hagerman NFH are reared in three banks (upper, middle, and lower decks) of outside raceways that employ serial water re-use with makeup water in the lower two banks. Since the Clearwater stock was incorporated into the LSRCP program, they have been reared in the lower deck, after the water has already been used in the upper two decks.

Prior to being incorporated into the LSRCP program, the Clearwater stock had been raised on the upper and middle decks (First and second-use water) during brood years 1989-1992. The Clearwater stock also performed poorly during some of those years. Because of the serial re-use

design, poorly performing stocks on the upper or middle decks potentially expose stocks in lower decks to increased pathogen loads. For this and other reasons, the Clearwater stock has been reared on the lower deck since incorporation into the LSRCP program. Since that time, Hagerman NFH experienced several years of Furunculosis and the development of sore-back syndrome in the Clearwater stock raised on the lower deck. Therefore, in 2004, the production staff at Hagerman NFH undertook a formal evaluation of rearing performance between the three decks of raceways, considering the lower water quality in the lower deck as a potential cause for consistently higher mortality rates and poorer fish health for several months prior to the Clearwater stock being transferred off station for release. The evaluation was conducted for two years that included BY2004 and BY2005. The goal of the study was to determine if the Clearwater stock performed differently in each of the three decks of raceways. Performance was measured by mortality and fish health parameters which were compared to the water quality parameters of each raceway deck. For general comparison, performance of the Clearwater stock was also compared to Sawtooth stock control groups in each raceway deck.

EXPERIMENTAL DESIGN AND OBJECTVES

The experimental design and objectives were basically the same both years, with the exception that in the first year, experimental raceways were located at the ends of the decks and only one raceway of Sawtooth stock was used for comparisons in each deck (**Table 1**). In the second year, the experimental raceways were moved from the end of the decks towards the middle of the decks to avoid potential effects from pedestrian traffic that could cause stress from fright response. Also, three raceways of Sawtooth stock were included in each raceway deck for comparison purposes (**Table 2**).

Fish were ponded into raceways as they were transferred out of the nursery.

Table 1. Experimental set up for the raceway/stock evaluation, 2004-2005.

Deck	Stock	Raceways	Raceway for Water Quality Sampling
Upper	Clearwater	55 - 58	55
	Sawtooth	54	54
Middle	Clearwater	78 - 80	78
	Sawtooth	77	77
Lower	Clearwater	99 -102	99
	Sawtooth	98	98

Table 2. Experimental set up for the raceway/stock evaluation in 2005-2006.

Deck	Stock	Raceways	Raceway for Water Quality Sampling
Upper	Clearwater	51 – 53	51
	Sawtooth	48 - 50	50
Middle	Clearwater	73 – 75	73
	Sawtooth	70 – 72	72
Lower	Clearwater	95 -97	95
	Sawtooth	92 - 94	94

The objectives for the study were:

1. To determine if meaningful differences in mortality of Clearwater and Sawtooth stocks occurred between the upper, middle, and lower banks of raceways.

2. To determine if meaningful differences in water quality occurred between the upper, middle, and lower banks of raceways.

3. To determine if meaningful differences in the fish health of Clearwater and Sawtooth stocks occurred between the upper, middle, and lower banks of raceways.

METHODS

Mortality

Mortalities in each experimental raceway were collected daily and expressed as percent monthly mortality. The total mortality rates were transformed for analysis using the Freeman Tukey (1950) angular transformation for small proportions. The data were statistically examined using multiple one-way ANOVA to compare stocks within decks and to compare the mortalities of the Clearwater stock across all three decks.

Fish Health

Ten fish were collected monthly out of one Sawtooth stock raceway and one Clearwater stock raceway from each deck (60 fish total) and were examined to determine fish health 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, 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).

Water Quality

During the first year, water temperature, dissolved oxygen, pH, and ammonia were monitored monthly from November through March. During the second year, monitoring occurred from October through March. The raceways sampled are listed in **Table 1 and Table 2** for the first and second years, respectively. Samples were taken from the quiescent zone of each raceway at 14:30 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 were 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.

RESULTS

Mortality

Monthly and total mortalities for BY04 and BY05 of both stocks during the evaluation are listed in **Tables 3 and 4,** respectively. The Clearwater Stock exhibited the same pattern of increasing mortality during late spring in all three decks of raceways, similar to the previous brood years (**Figures 2 and 3**).

For BY04, the total percent mortality for the Clearwater stock ranged from 6.0% in upper deck raceways to 9.4% in the lower deck raceways. However, there was no significant difference ($P \leq 0.05$) in Clearwater stock mortalities between decks. Total percent mortality for the Sawtooth stock ranged from 0.2% – 0.6%, with no significant differences between decks. Statistical comparisons of the total mortality during the study showed that the Clearwater stock had significantly ($P \leq 0.01$) higher mortality than the Sawtooth stock in all three decks.

For BY05, the total percent mortality for the Clearwater Stock ranged from 3.03% in the lower deck, to 8.89% in the upper deck, exhibiting the opposite pattern of mortality observed in brood year 2004. Unlike BY04, there was significant difference .($P<0.05$) in the total mortality of the Clearwater Stock between the upper and lower decks. Total percent mortality for the Sawtooth stock ranged from 0.29% in the upper deck to 0.62% in the lower deck. However, the increase did not manifest itself to any great extent until March 22. Similar to BY04, mortalities for the Clearwater Stock were significantly higher ($P<0.05$) than for the Sawtooth Stock in all three decks.

Fish Health

For BY04, neither stock had problems with parasites or diseases on the gills. Internal examinations indicated that the fish were in good health, with only a few fish from both stocks showing signs of swollen internal organs just before release, primarily during March 2005. External examinations indicated that the primary fish health issue was dorsal fin erosion. Light to moderate erosion was first observed in November 2004 in both stocks, primarily in the lower deck, although some was observed in the upper deck. From December 2004 through March 2005, moderate to severe dorsal fin erosion was observed in both stocks in all three decks, although the most severe and extensive erosion was seen in the Clearwater stock. The difference in dorsal fin erosion between the two stocks was not quantified.

The bacterial cultures showed growth of *A. hydrophila* in only one culture during the entire study. No other bacteria were observed in cultures from either stock taken out of any deck (**Table 5)**.

Polymerase Chain Reaction (PCR) provided only qualitative results for analyzing the occurrence of *Nucleospora salmonis*. No cold water disease or Furunculosis was observed (**Table 6)**. Results from November indicated that *N. salmonis* was not present. However, the infection was still assumed to be present, but the amount of DNA was too small to indicate a positive result. Results from December and January indicated a hihger incidence of *N. salmonis,* with the

majority being the Clearwater stock raceways on all decks. The Sawtooth stock samples were also positive. The results for February indicated a higher number of positive samples for the Clearwater stock and Sawtooth stock. The results for March indicated wide spread positive samples for *N. salmonis*, with the only negatives (4) being from the Sawtooth stock samples. The pattern of occurrence of *N. salmonis* was almost random, but there seemed to be a higher level of presence in the lower deck. In general, the Clearwater stock appeared to have a slightly higher level of occurrence than the Sawtooth stock.

For BY05, neither stock had problems with parasites or diseases on the gills. Internal examinations indicated that the fish were in good health at the pre-release exam in March 2006.. External examinations indicated that the primary fish health issue, for fish that apparently appeared healthy, was dorsal fin erosion. Light to moderate erosion was first observed in October 2005 in both stocks, occurring in all three decks. From November 2005 through March 2006, moderate to severe dorsal fin erosion was observed in both stocks in all three decks. Pectoral fin erosion was seen in the last two months, primarily in both stocks on the upper deck. The difference in dorsal fin erosion between the two stocks was not quantified.

The bacterial cultures showed growth of *A. hydrophila* in only one culture during the entire study. No other bacteria were observed in cultures from either stock from any deck (**Table 7)**. However, during the last part of March and into April, several raceways of Sawtooth stock were experiencing mortality due to Bacterial Cold Water Disease.

The PCR assay indicated the presence of *Nucleospora salmonis* in the both stocks. No cold water disease or Furunculosis was observed (**Table 8)**. The PCR results from October indicated one *N. salmonis* positive sample in the Clearwater stock from the lower deck. In November, all samples from both stocks, in all three decks, were positive for *N. salmonis*.. The results for December were not available. From January until release, all samples were negative for *N. salmonis* in healthy fish of both stocks. However, *N. salmonis* was observed in moribund Clearwater stock fish in all three decks using both PCR and kidney imprints.

Water Quality

Water quality data for 2004-2005 and 2005-2006 are listed in **Tables 9** and **10**, respectively, The results for both years were almost identical and are combined for simplicity. Several slight trends were observed, but overall, water quality was excellent during both years and never reached levels that would be considered limiting to production or fish health. Water temperature varied between 14.5 to 15.3 degrees C during the study period. The variability in water temperature occurred over time, decreasing slightly from October/November through March. There was little variability between raceways within months. The pH ranged from a high of 8.5 to a low of 7.8, with no discernable trends between raceways, decks, or over time. Dissolved Oxygen (DO) ranged from 9.1 mg/l in the upper deck in November, 2004, to a low of 6.8 mg/l in the lower deck in March, 2005. DO was mostly observed to range from 7.5 to 8.5 and showed a slightly decreasing trend over time, never reaching a level where it ever became limiting to production. Ammonia levels increased slightly from the upper deck to the lower deck every month, with overall levels increasing steadily from October through March.

DISCUSSION

The seasonal pattern of increased mortality in the Clearwater stock of summer steelhead during late winter and spring was expressed both years of the study, similar to the previous three years of production of that stock at Hagerman NFH. The consistent pattern of mortality during the last few months of rearing prior to the fish being transported to the upper Salmon River for release is a clear indication that the phenomenon is not a casual or random occurrence and can be expected to continue. At the same time, the mortality is clearly not strongly related to factors that we monitored during the two years of evaluations. The fact that neither the Sawtooth nor Pahsimeroi stocks exhibited similar mortality trends indicates that the phenomenon is more directly connected to factors intrinsically related to the Clearwater stock rather that to fish cultural protocols or rearing conditions.

Overall, the mortality of the Sawtooth stock was significantly lower, and almost negligible in comparison to the Clearwater stock. The Sawtooth stock exhibited increasing mortality in both years from the upper to the lower decks of raceways. However, the differences between decks were not very meaningful or statistically significant. These results provides additional support that the Clearwater stock mortality is not due to fish culture or rearing conditions.

The only significant fish health issue that may be related to rearing Clearwater stock at Hagerman NFH is the occurrence of *N. salmonis,* which appears to be widespread among all groups. Since testing with PCR at this point does not give quantitative data on the level of infection of *N. salmonis,* we can't make any direct relationship between the occurrence of the organism and the mortality in the Clearwater stock. It is possible that a causal relationship exists between the presence of *N. salmonis,* dorsal fin erosion, and the increased mortality during spring.

Nucleospora salmonis was found in samples of Pebble snails with and without shells which were collected from several of the hatchery's springs during the project. It appears that the Pebble snail may be a potential reservoir of *N. salmonis* infection for fish raised at Hagerman NFH. The occurrence of *N. salmonis* in the Clearwater River has not been documented. The fact that the Sawtooth stock appeared to be relatively unaffected by the presence of the organism is quite interesting. However, it may be that the Sawtooth stock has developed some natural immunity to the organism which the Clearwater stock has not developed since its origin is out of basin.

While water quality was observed to decrease as a result of serial re-use, all parameters remained well within established guidelines and limits for fish culture practices. Therefore, it appears unlikely that water quality had any significant impact on the observed pattern of fish mortality.

Based on two years of evaluation, the Team is convinced that the spring pattern of increased mortality expressed by the Clearwater stock at Hagerman NFH is not related to being reared in the lower deck of raceways and the lower quality of water resulting from serial re-use. Although there may be fish cultural variables that may be influencing the mortality of the Clearwater stock, the Team is convinced that the phenomenon is due to factors associated with the stock having

been transferred from outside the basin and is not adapted for the conditions in the Hagerman Valley. It is interesting to note that both the Sawtooth and Pahsimeroi stocks are not similarly affected and appear to be much more suitable for rearing at Hagerman NFH.

Without more detailed evaluations and data collection, it is not possible to pinpoint precisely the exact causes for the Clearwater stock's poorer performance during the period of smoltification prior to release. The level of mortality occurring at the hatchery is not significant in itself but does point to the fact that the stock may be being released in a compromised condition, resulting in poor emigration to the ocean and poor adult returns. Unfortunately, it is not possible to evaluate past emigration performance or adult returns of the Clearwater stock at Hagerman NFH, since the stock has never been included in the PIT-tagging or coded-wire tagging programs at Hagerman NFH.

RECOMMENDATIONS

The Team has several alternative recommendations to forward to the Project Leaders and Program Managers:

1) First, the Team recommends that the program of rearing Clearwater stock at Hagerman NFH be discontinued and replaced with either Sawtooth or Pahsimeroi stock, both of which originate from the Salmon River and demonstrate good performance both in the hatchery and in the fishery. Further, this action would be consistent with the recommendation made by National Marine Fisheries Service in their *Biological Opinion on Artificial Propagation in the Columbia River Basin: incidental take of listed salmon and steelhead from federal and non-federal hatchery programs that collect, rear, and release unlisted fish species* (National Marine Fisheries Service 1999). The recommendation listed in Section IX.A.1 states: **The action agencies should minimize inter-basin stock transfers in any waters that support listed fish**.

2) The Team's alternative recommendation is for the Lower Snake River Compensation Plan Program to provide sufficient money to effectively monitor and evaluate the adult returns of the Clearwater stock program at Hagerman NFH. This would determine if the program is making a significant contribution towards the mitigation goal established for the Hagerman NFH program by the Lower Snake River Compensation Plan (USACE 1980, Herrig 1990). The Team has already developed a plan of action for such an evaluation using PIT tags to evaluate adult returns to Lower Granite Dam. After considerable discussion, the Team concluded that coded-wire tagging would be nearly ineffective for evaluating adult returns since Clearwater stock smolts are released in locations in the Salmon River where recovering tags from returning adults cannot be accomplished except through the sport fish monitoring program.

3) In the case that alternative 2 is selected, the Team recommends that the Clearwater stock be raised only in the lower deck of raceways.

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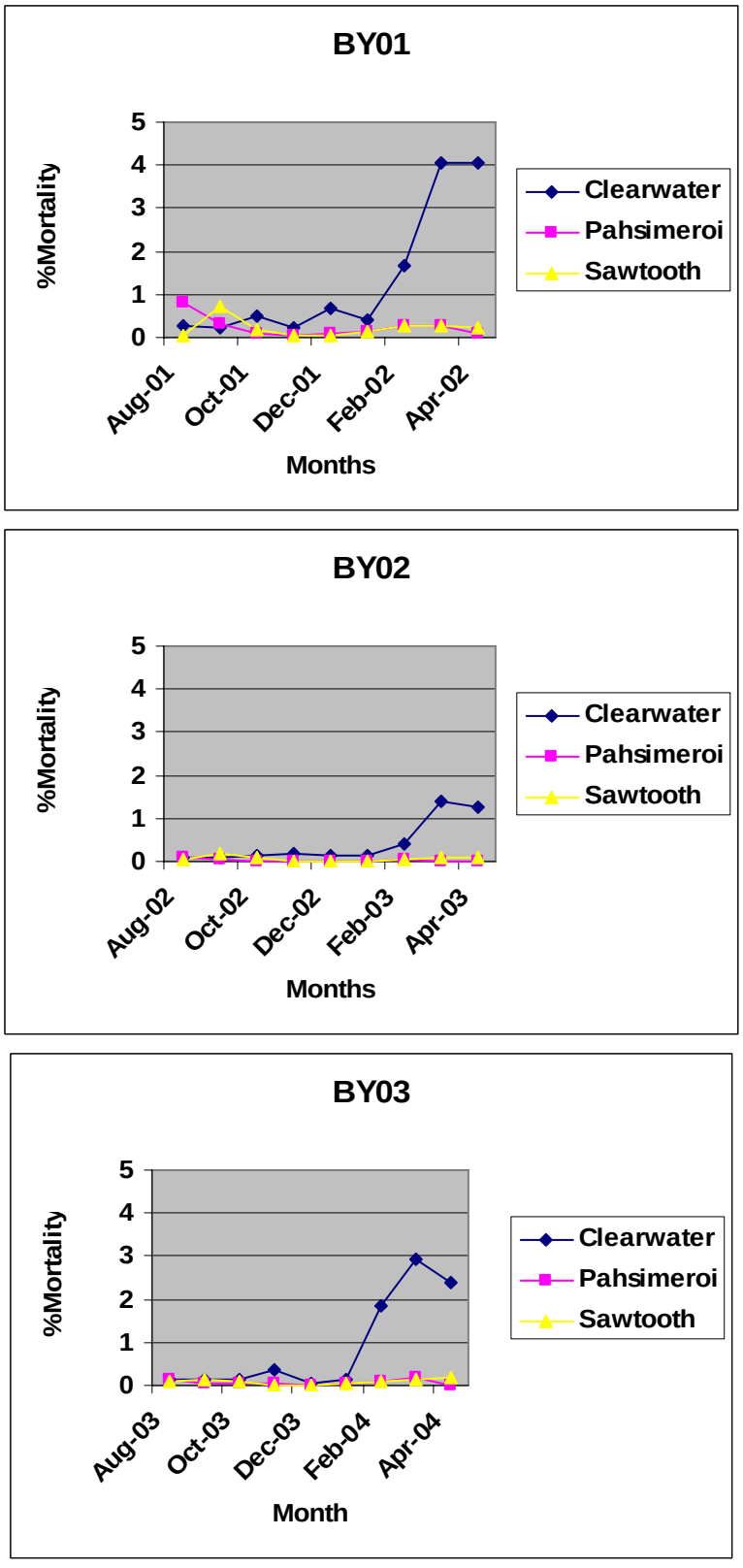

Figure 1. Monthly percent mortalities for three stocks of summer steelhead reared in outside raceways at Hagerman NFH, brood years 2001, 2002, and 2003.

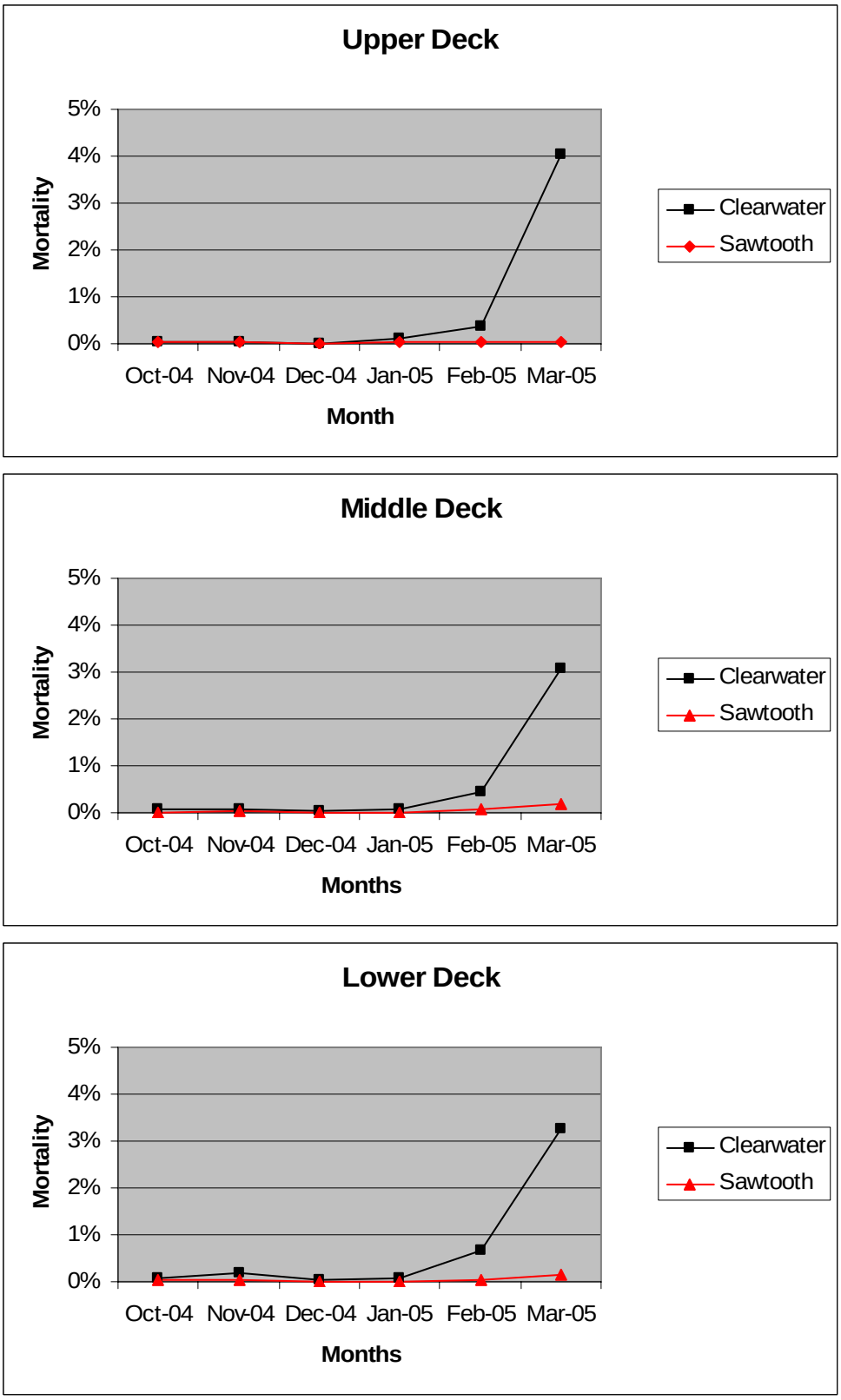

Figure 2. Monthly percent mortalities for the BY04 Clearwater and Sawtooth stocks of summer steelhead in the Upper, Middle, and Lower decks of raceways at Hagerman NFH, 2004-2005.

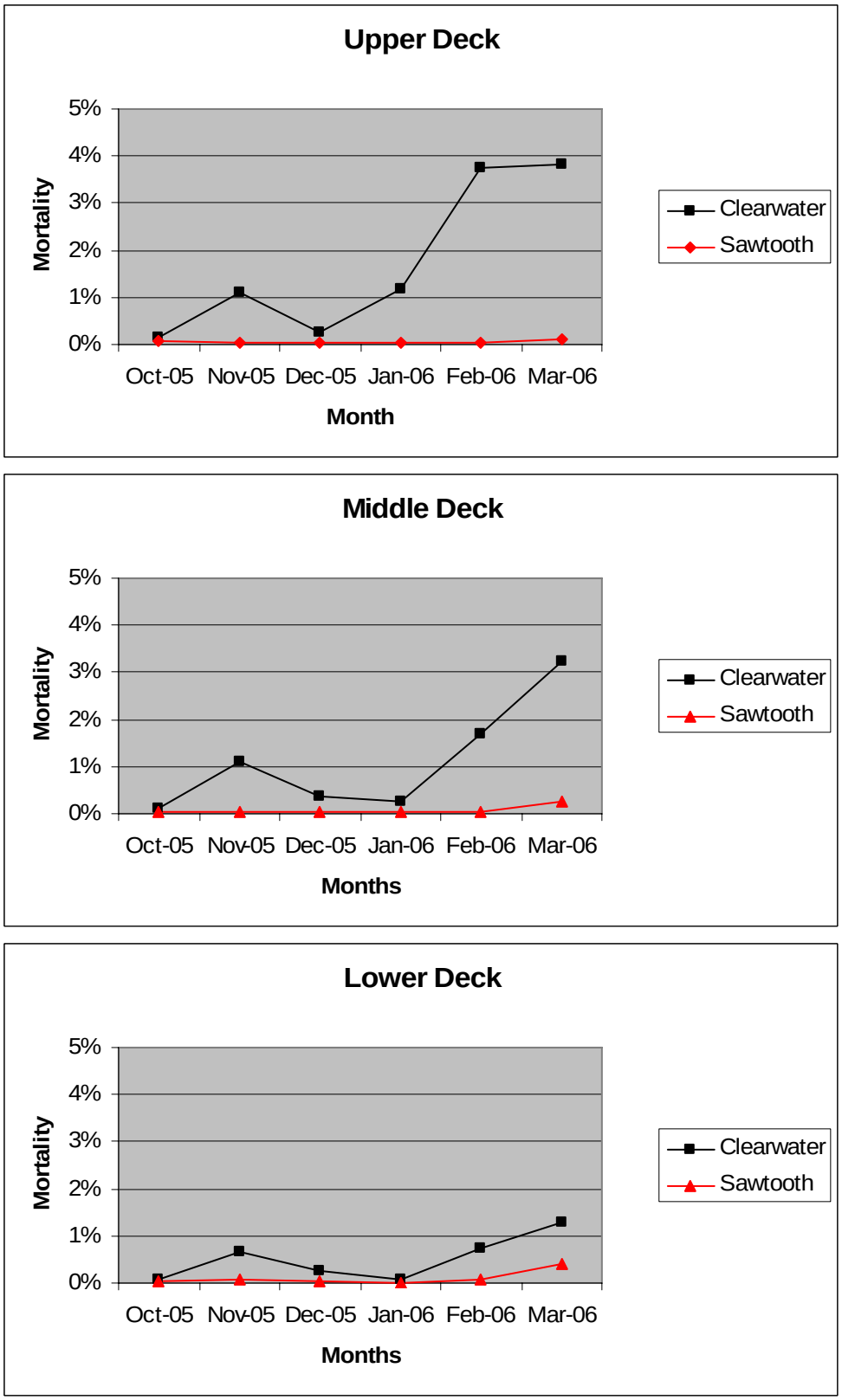

Figure 3. Monthly percent mortalities for the BY05 Clearwater and Sawtooth stocks of summer steelhead in the Upper, Middle, and Lower decks of raceways at Hagerman NFH, 2005-2006.

Table 3. Mortality of BY04 summer steelhead during the Clearwater Stock evaluation study at Hagerman NFH. The total includes mortality until stocking.

Upper Deck

Month	Sawtooth Stock			Clearwater Stock					
	Raceway Mortality	Total Mortality	Percent Mortality	Raceway Mortality				Total Mortality	Percent Mortality
	#54			#55	#56	#57	#58		
October	4	4	0.02	6	7	8	16	37	0.05
November	9	9	0.05	7	5	0	5	17	0.02
December	3	3	0.02	2	2	0	1	5	0.01
January	4	4	0.02	21	6	5	54	86	0.11
February	9	9	0.05	42	7	20	206	275	0.36
March	6	6	0.03	1,069	23	280	1,603	2,975	4.04
Total	**39**	**39**	**0.22**	**1574**	**61**	**447**	**2592**	**4674**	**6.07**

Middle Deck

Month	Sawtooth Stock			Clearwater Stock				
	Raceway Mortality	Total Mortality	Percent Mortality	Raceway Mortality			Total Mortality	Percent Mortality
	#77			#78	#79	#80		
October	2	2	0.01	5	6	23	34	0.06
November	4	4	0.02	3	9	27	39	0.07
December	3	3	0.02	2	8	4	14	0.03
January	3	3	0.02	6	11	29	46	0.08
February	14	14	0.08	56	41	141	238	0.43
March	32	32	0.17	414	315	916	1,645	3.07
Total	**115**	**115**	**0.62**	**599**	**1085**	**1886**	**3570**	**6.42**

Lower Deck

Month	Sawtooth Stock			Clearwater Stock					
	Raceway Mortality	Total Mortality	Percent Mortality	Raceway Mortality				Total Mortality	Percent Mortality
	#98			#99	#100	#101	#102		
October	5	5	0.03	4	7	15	14	40	0.06
November	7	7	0.04	22	24	51	22	119	0.2
December	1	1	0.01	2	3	10	10	25	0.04
January	3	3	0.02	13	6	8	34	61	0.09
February	9	9	0.05	162	46	82	177	467	0.67
March	31	31	0.16	495	421	607	656	2,179	3.24
Total	**126**	**126**	**0.65**	**1811**	**1372**	**1621**	**1760**	**6564**	**9.37**

Table 4. Mortality of BY05 summer steelhead during the Clearwater Stock evaluation study at Hagerman NFH. The total includes mortality until stocking

Upper Deck

Month	Sawtooth Stock					Clearwater Stock				
	Raceway Mortality			Total Mortality	Percent Mortality	Raceway Mortality			Total Mortality	Percent Mortality
	#48	#49	#50			#51	#52	#53		
October	7	10	23	40	0.06	44	35	28	107	0.16
November	8	11	7	26	0.04	250	214	252	716	1.10
December	8	9	11	28	0.05	66	53	48	167	0.26
January	3	4	5	12	0.02	284	232	234	750	1.17
February	4	4	5	13	0.02	1020	765	603	2388	3.76
March	5	24	34	63	0.10	852	709	772	2333	3.81
Total	**35**	**62**	**85**	**182**	**0.29**	**2516**	**2008**	**1937**	**6461**	**9.89**

Middle Deck

Month	Sawtooth Stock					Clearwater Stock				
	Raceway Mortality			Total Mortality	Percent Mortality	Raceway Mortality			Total Mortality	Percent Mortality
	70	71	72			73	74	75		
October	11	6	14	31	0.05	23	22	20	65	0.10
November	7	15	5	27	0.04	372	223	136	731	1.12
December	2	9	13	24	0.04	91	68	70	229	0.36
January	2	7	4	13	0.02	81	41	46	168	0.26
February	7	10	12	29	0.05	435	438	208	1081	1.69
March	41	48	70	159	0.26	904	882	262	2048	3.25
Total	**11**	**6**	**14**	**31**	**0.05**	**23**	**22**	**20**	**65**	**0.10**

Lower Deck

Month	Sawtooth Stock					Clearwater Stock				
	Raceway Mortality			Total Mortality	Percent Mortality	Raceway Mortality			Total Mortality	Percent Mortality
	92	93	94			95	96	97		
October	11	6	4	21	0.03	9	18	19	46	0.07
November	8	7	20	35	0.06	141	145	145	431	0.66
December	3	4	7	14	0.02	70	45	47	162	0.25
January	0	5	5	10	0.02	27	13	6	46	0.07
February	5	9	29	43	0.07	167	102	210	479	0.74
March	65	126	72	263	0.42	153	272	392	817	1.27
Total	**92**	**157**	**137**	**386**	**0.62**	**567**	**595**	**819**	**1981**	**3.03**

Table 5. Results of bacterial cultures for samples taken of BY04 summer steelhead in the Clearwater Stock Evaluation Study at Hagerman NFH, 2004-2005. UT=Upper Deck Treatment, UC=Upper Deck Control, MT=Middle Deck Treatment, MC=Middle Deck Control, LT=Lower Deck Treatment, LC=Lower Deck Control.

Sample	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
UT-1	ng	ng	ng	ng	ng	ng
UT-2	ng	ng	ng	ng	ng	ng
UT-3	ng	ng	ng	ng	ng	ng
UT-4	ng	ng	ng	ng	ng	ng
UT-5	ng	ng	ng	ng	ng	ng
UC-1	ng	ng	ng	ng	ng	ng
UC-2	ng	ng	ng	ng	ng	ng
UC-3	ng	ng	ng	ng	ng	ng
UC-4	ng	ng	ng	ng	ng	ng
UC-5	ng	ng	ng	ng	ng	ng
MT-1	ng	ng	ng	ng	ng	ng
MT-2	ng	ng	ng	ng	ng	ng
MT-3	***A. hydro*.**	ng	ng	ng	ng	ng
MT-4	ng	ng	ng	ng	ng	ng
MT-5	ng	ng	ng	ng	ng	ng
MC-1	ng	ng	ng	ng	ng	ng
MC-2	ng	ng	ng	ng	ng	ng
MC-3	ng	ng	ng	ng	ng	ng
MC-4	ng	ng	ng	ng	ng	ng
MC-5	ng	ng	ng	ng	ng	ng
LT-1	ng	ng	ng	ng	ng	ng
LT-2	ng	ng	ng	ng	ng	ng
LT-3	ng	ng	ng	ng	ng	ng
LT-4	ng	ng	ng	ng	ng	ng
LT-5	ng	ng	ng	ng	ng	ng
LC-1	ng	ng	ng	ng	ng	ng
LC-2	ng	ng	ng	ng	ng	ng
LC-3	ng	ng	ng	ng	ng	ng
LC-4	ng	ng	ng	ng	ng	ng
LC-5	ng	ng	ng	ng	ng	ng

ng= No growth
A. hydro. = *Aeromonas hydrophila*

Table 6. Results of two-fish pool exams using PCR for samples taken of BY04 summer steelhead in the Clearwater Stock Evaluation Study at Hagerman NFH, 2004-2005. UT=Upper Deck Treatment, UC=Upper Deck Control, MT=Middle Deck Treatment, MC=Middle Deck Control, LT=Lower Deck Treatment, LC=Lower Deck Control.

Sample	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
UT-1	***N. sal.***	ng	ng	***N. sal.***	***N. sal.***	***N. sal.***
UT-2	***N. sal.***	ng	ng	ng	***N. sal.***	***N. sal.***
UT-3	ng	ng	ng	ng	ng	***N. sal.***
UT-4	***N. sal.***	ng	ng	***N. sal.***	***N. sal.***	***N. sal.***
UT-5	***N. sal.***	ng	ng	***N. sal.***	ng	***N. sal.***
UC-1	***N. sal.***	ng	***N. sal.***	ng	ng	ng
UC-2	ng	ng	***N. sal.***	***N. sal.***	ng	ng
UC-3	ng	ng	***N. sal.***	***N. sal.***	ng	ng
UC-4	ng	ng	ng	***N. sal.***	***N. sal.***	***N. sal.***
UC-5	***N. sal.***	ng	Ng	***N. sal.***	ng	***N. sal.***
MT-1	***N. sal.***	ng	Ng	ng	ng	***N. sal.***
MT-2	ng	ng	Ng	***N. sal.***	ng	***N. sal.***
MT-3	ng	ng	Ng	ng	***N. sal.***	***N. sal.***
MT-4	***N. sal.***	ng	***N. sal.***	ng	***N. sal.***	***N. sal.***
MT-5	ng	ng	***N. sal.***	ng	***N. sal.***	***N. sal.***
MC-1	***N. sal.***	ng	ng	ng	***N. sal.***	***N. sal.***
MC-2	ng	ng	***N. sal.***	***N. sal.***	ng	***N. sal.***
MC-3	***N. sal.***	ng	Ng	ng	ng	***N. sal.***
MC-4	***N. sal.***	ng	***N. sal.***	ng	***N. sal.***	***N. sal.***
MC-5	***N. sal.***	ng	***N. sal.***	ng	***N. sal.***	***N. sal.***
LT-1	***N. sal.***	ng	***N. sal.***	***N. sal.***	***N. sal.***	***N. sal.***
LT-2	***N. sal.***	ng	ng	ng	***N. sal.***	***N. sal.***
LT-3	***N. sal.***	ng	***N. sal.***	***N. sal.***	ng	ng
LT-4	***N. sal.***	ng	***N. sal.***	***N. sal.***	ng	***N. sal.***
LT-5	***N. sal.***	ng	***N. sal.***	***N. sal.***	***N. sal.***	***N. sal.***
LC-1	***N. sal.***	ng	***N. sal.***	***N. sal.***	ng	***N. sal.***
LC-2	Ng	ng	ng	ng	ng	***N. sal.***
LC-3	***N. sal.***	ng	ng	ng	ng	***N. sal.***
LC-4	***N. sal.***	ng	***N. sal.***	ng	***N. sal.***	***N. sal.***
LC-5	***N. sal.***	ng	ng	ng	ng	***N. sal.***

N. sal.= *Nucleospora salmonis*
ng = No Growth

Table 7. Results of bacterial cultures for samples taken of BY05 summer steelhead in the Clearwater Stock Evaluation Study at Hagerman NFH, 2005-2006. UT=Upper Deck Treatment, UC=Upper Deck Control, MT=Middle Deck Treatment, MC=Middle Deck Control, LT=Lower Deck Treatment, LC=Lower Deck Control.

Sample	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
U-T	ng	***A. hyro***	ng	ng	ng	ng
U-C	ng	ng	ng	ng	ng	ng*
M-T	ng	ng	ng	ng	ng	ng
M-C	ng	ng	ng	ng	ng	ng
L-T	ng	ng	ng	ng	ng	ng
L-C	ng	ng	ng	ng	ng	ng

ng= No growth

A. hydro. = *Aeromonas hydrophila*

* Sawtooth Stock (not in the study) had Bacterial Coldwater Disease in March

Table 8. Results of two-fish exams using PCR for samples taken of BY05 summer steelhead in the Clearwater Stock Evaluation Study at Hagerman NFH, 2005-2006. UT=Upper Deck Treatment, UC=Upper Deck Control, MT=Middle Deck Treatment, MC=Middle Deck Control, LT=Lower Deck Treatment, LC=Lower Deck Control.

Sample	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
UT-1	ng	***N. sal***.	NA	ng	ng*	ng*
UT-2	ng	***N. sal***.	NA	ng	ng	ng
UT-3	ng	***N. sal***.	NA	ng	ng	ng
UT-4	ng	***N. sal***.	NA	ng	ng	ng
UT-5	ng	***N. sal***.	NA	ng	ng	ng
UC-1	ng	***N. sal***.	NA	ng	ng	ng
UC-2	ng	***N. sal***.	NA	ng	ng	ng
UC-3	ng	***N. sal***.	NA	ng	ng	ng
UC-4	ng	***N. sal***.	NA	ng	ng	ng
UC-5	ng	***N. sal***.	NA	ng	ng	ng
MT-1	ng	***N. sal***.	NA	ng	ng	ng
MT-2	ng	***N. sal***.	NA	ng	ng	ng
MT-3	CWD	***N. sal***.	NA	ng	ng	ng
MT-4	ng	***N. sal***.	NA	ng	ng	ng
MT-5	ng	***N. sal***.	NA	ng	ng	ng
MC-1	ng	***N. sal***.	NA	ng	ng	ng
MC-2	ng	***N. sal***.	NA	ng	ng	ng
MC-3	ng	***N. sal***.	NA	ng	ng	ng
MC-4	ng	***N. sal***.	NA	ng	ng	ng
MC-5	ng	***N. sal***.	NA	ng	ng	ng
LT-1	ng	***N. sal***.	NA	ng	ng	ng
LT-2	ng	***N. sal***.	NA	ng	ng	ng
LT-3	ng	***N. sal***.	NA	ng	ng	ng
LT-4	***N. sal***	***N. sal***.	NA	ng	ng	ng
LT-5	ng	***N. sal***.	NA	ng	ng	ng
LC-1	ng	***N. sal***.	NA	ng	ng	ng
LC-2	ng	***N. sal***.	NA	ng	ng	ng
LC-3	ng	***N. sal***.	NA	ng	ng	ng
LC-4	ng	***N. sal***.	NA	ng	ng	ng
LC-5	ng	***N. sal***.	NA	ng	ng	ng

N. sal. = *Nucleospora salmonis*
CWD = Bacterial Cold Water Disease
ng = No Growth
NA – not available due lab mishap
* Moribund Clearwater stock fish were positive for ***N. sal***. by PCR and imprints.

Table 9. Water quality data collected from the Clearwater and Sawtooth stock raceways for the summer steelhead stock evaluation project at Hagerman NFH, 2004-2005.

Month	Raceway	Water Temp.(C)	pH	O2 (mg/l)	Total NH4 (mg/l)	NH3 (mg/l)	Fish Weight (lbs)	Feed Fed (lbs)
November	54	15.1	8.1	9.1	0.034	0.001	1,017	45
	55	15.1	8.1	8.5	0.033	0.001	1,016	62
	77	15.0	8.2	8.8	0.071	0.003	678	48
	78	15.0	8.2	8.6	0.067	0.003	598	54
	98	15.0	8.2	8.5	0.117	0.005	684	50
	99	15.0	8.2	8.5	0.106	0.004	565	41
December	54	14.9	8.5	8.4	0.033	0.003	1,640	55
	55	14.9	8.3	8.2	0.033	0.002	1,638	73
	77	14.8	8.2	8.2	0.074	0.002	1,312	58
	78	14.8	8.2	8.2	0.063	0.002	1,097	67
	98	14.7	8.1	8.0	0.136	0.004	1,219	61
	99	14.7	8.2	8.1	0.115	0.005	1,035	49
January	54	14.7	8.1	8.6	0.036	0.001	1,527	68
	55	14.7	8.1	8.5	0.040	0.001	2,043	91
	77	14.6	8.1	8.3	0.081	0.003	1,628	71
	78	14.6	8.1	8.0	0.076	0.002	1,385	88
	98	14.5	8.1	8.1	0.130	0.004	1,693	75
	99	14.5	8.1	8.2	0.140	0.004	1,308	61
February	54	14.9	8.1	8.2	0.066	0.002	1,976	91
	55	14.9	8.0	8.2	0.073	0.002	2,477	133
	77	14.9	8.0	7.6	0.156	0.004	2,150	94
	78	14.9	8.0	7.5	0.184	0.005	1,765	142
	98	14.9	7.9	7.0	0.242	0.005	2,106	104
	99	14.9	7.9	7.3	0.221	0.005	1,643	84
March	54	14.9	8.0	8.6	0.062	0.002	3,102	121
	55	14.9	8.0	7.7	0.077	0.002	4,315	168
	77	14.9	7.9	7.6	0.167	0.004	3,136	140
	78	14.9	7.9	7.3	0.192	0.004	3,689	224
	98	14.9	7.9	7.6	0.229	0.005	3,441	135
	99	14.9	7.8	6.8	0.221	0.004	3,060	98

Table 10. Water quality data collected from the Sawtooth and Clearwater stock raceways for the summer steelhead stock evaluation project at Hagerman NFH, 2005-2006.

Month	Raceway	Water Temp.(C)	pH	O2 (mg/l)	Total NH4 (mg/l)	NH3 (mg/l)	Fish Weight (lbs)	Feed Fed (lbs)
October	50	15.2	8.2	8.51	0.069	0.003	540	9
	51	15.2	8.1	8.36	0.041	0.001	811	11
	72	15.3	8.2	8.49	0.056	0.002	462	8
	73	15.3	8.2	8.32	0.055	0.002	686	10
	94	15.3	8.3	8.39	0.072	0.004	503	8
	95	15.3	8.3	8.39	0.092	0.005	712	9
November	50	14.7	8.3	8.39	0.064	0.003	976	53
	51	14.7	8.3	8.07	0.048	0.002	1472	64
	72	14.7	8.3	8.07	0.07	0.004	815	44
	73	14.7	8.3	7.99	0.8	0.004	1266	54
	94	14.5	8.3	7.96	0.108	0.005	889	48
	95	14.6	8.3	8.03	0.094	0.005	943	46
December	50	14.9	8	8.48	0.06	0.002	1502	64
	51	14.9	8.2	8.12	0.059	0.002	1673	75
	72	14.9	8.3	8.19	0.084	0.004	1254	54
	73	14.9	8.3	8.1	0.076	0.004	1403	63
	94	14.9	8.3	8.09	0.148	0.008	1350	59
	95	14.9	8.3	8.07	0.126	0.006	1352	54
January	50	14.7	7.9	7.94	0.045	0.001	1988	79
	51	14.7	8	7.74	0.054	0.001	2275	92
	72	14.6	8	7.86	0.092	0.002	1747	64
	73	14.6	8	7.67	0.097	0.002	1906	77
	94	14.5	8	7.67	0.131	0.003	1905	70
	95	14.5	8	7.64	0.125	0.003	1645	67
February	50	14.9	8.1	8.06	0.096	0.003	2951	107
	51	14.9	8.2	8.53	0.033	0.001	3477	116
	72	14.9	8	7.85	0.146	0.004	2463	89
	73	14.9	8.1	7.84	0.155	0.005	2937	98
	94	14.8	8	7.47	0.188	0.005	2685	97
	95	14.8	8.1	8.03	0.145	0.005	2424	92
March	50	15	8.3	8.2	0.065	0.003	3476	110
	51	15	8.2	8.75	0.055	0.002	3079	215
	72	15	8.1	8.03	0.131	0.004	2837	96
	73	15	8.1	7.83	0.109	0.004	2665	186
	94	15	8	7.49	0.141	0.004	3090	104
	95	15	8	7.85	0.139	0.004	2602	108