A Review of Literature and Studies Performed and/or Compiled at the Hagerman National Fish Hatchery concerning Soreback and Dorsal Fin Erosion

By the

Hagerman Hatchery Evaluation Team:

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Cooperators

U.S. Fish and Wildlife Service
Hagerman National Fish Hatchery
3059-D National Fish Hatchery Road
Hagerman, Idaho 83332

U.S. Fish and Wildlife Service
Idaho Fishery Resource Office
PO Box 18
Ahsahka, Idaho 83520

U.S. Fish and Wildlife Service
Idaho Fish Health Center
PO Box 272
Orofino, Idaho 83544

Idaho Department of Fish and Game
Nampa Research Office
1414 East Locust Lane
Nampa, Idaho 83688

Hagerman Hatchery Evaluation Team members:

Kathy Clemens, Idaho Fish Health Center
Brian Clifford, Hagerman National Fish Hatchery
Ray Jones, Idaho Fishery Resource Office
Bryan Kenworthy, Hagerman National Fish Hatchery
Adam Leija, Hagerman National Fish Hatchery
Chris Starr, Lower Snake River Compensation Plan
Carl Steifl, Idaho Department of Fish and Game
Jeremy Trimpey, Hagerman National Fish Hatchery
Nathan Wiese, Hagerman National Fish Hatchery
Eric Willet, Hagerman National Fish Hatchery
Steve Yundt, Lower Snake River Compensation Plan

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Abstract

The Hagerman National Fish Hatchery has reported soreback issues since the 1960's. Soreback is as a focal lesion occurring at the anterior base of the dorsal fin and progressing into the underlying muscle. Dorsal fin erosion is the precursor to soreback. There has been considerable research effort in the cause and cures of soreback and dorsal fin erosion. This document summarized this research as well as current (2008) work with soreback. Based on the literature reviewed and observations made on the Hatchery, soreback is induced by aggressive behavior from a restricted diet. Chemotherepeutants and raceway alterations including: shading, baffles, and substrate additions had limited success relieving fin erosion problems. Based on observations made at the Hatchery and past published literature, the most practical option for reducing soreback may be to reduce aggression by increasing feeding rates during the period of the production cycle when soreback is most prevalent.

Introduction

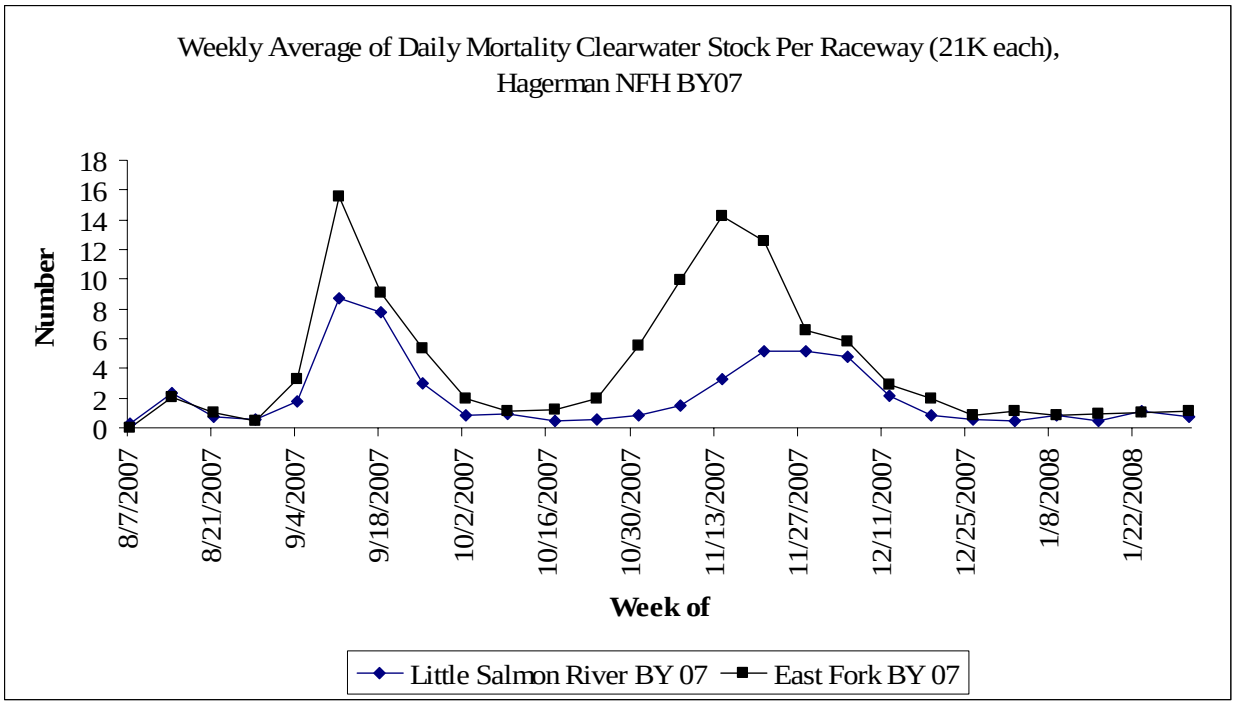
The purpose of this review is to summarize literature and research pertaining to dorsal fin erosion and soreback at the Hagerman National Fish Hatchery (Hatchery).

Soreback has been reported at the Hatchery as far back as 1962 (Pratt, 1962). Soreback is described as a focal lesion occurring in 3 – 9" trout as an ulceration at the anterior base of the dorsal fin that usually progresses into the underlying muscle and other tissues. This lesion is caused by nipping when fish are reared in crowded conditions in concrete raceways and typically found on the largest and most competitive fingerlings in the population. Soreback typically starts as a white patch at the insertion of the dorsal fin, but does not progress any further at water temperatures of 52 - 54ºF or below. Fish with soreback typically congregate at the lower end of a raceway near the surface as a defense mechanism to avoid further nipping. There is no treatment for soreback, but if infected fish are isolated, skin will grow back in 5 – 7 days with pigmentation returning in 30 days, fin regeneration is poor (Warren, 1967).

Warren (1967) noted that the typical occurrence of soreback at the Hatchery was 0.01 – 0.1% (1 – 10 in 10,000), but levels over 10% occurred in overloaded raceways. Ennis National Fish Hatchery had 7% soreback occurrence during the same time period, thought to be caused by excessively high loads of fish. Soreback can affect survival and growth rates of hatchery-reared fish released into the wild. Open sores can lead to infection. Fin loss can affect swimming and mobility and make fish more visible to predators. Infected fish are also a marketing and management problems with satisfaction levels of anglers.

Problem Statement

The Hatchery observed soreback induced mortality in the Clearwater (B-strain) stock during BY2007. The Clearwater soreback mortality (October-November) was significantly ($p<0.05$) greater in the East Fork release group compared to the Little Salmon River release group. To meet size at release goals, the East Fork group was fed at a Hatchery Constant of 5.8 compared to a Hatchery Constant of 6.8 for the Little Salmon River group. The Hatchery hypothesized the East Fork smolts exhibited more aggressive behavior and increased soreback mortality because of lower feeding rates. The soreback in the East Fork and Little Salmon River smolts healed in December 2007. The Hatchery hypothesized the smolts became less aggressive because total biomass increased, dissolved oxygen decreased, and stress from smoltification. The following table illustrates the weekly mortality rate of the Clearwater strain for the Little Salmon River and East Fork release groups:



The Hatchery also observed dorsal fin erosion (the precursor to soreback) differences during the Production Capacity Assessment in Brood Years (BY) 2005-2006 (Hagerman Hatchery Evaluation Team 2007). Sawtooth smolts were reared in experimental tanks (3 replicates) at the same density index (0.2), but higher flow index (2.09) than Sawtooth smolts in the Steelhead raceways (FI = 1.12). The Dorsal Fin Index (Kindschi, 1986) of smolts reared in experimental tanks (DFI = 7.4) was significantly ($p < 0.05$) greater than Sawtooth smolts reared in the Steelhead raceways (DFI = 4.3). The Hatchery hypothesized restricted flows and resulting low dissolved oxygen reduced aggressive nipping behavior and fin erosion in the experimental tanks.

That Hatchery also compared dorsal fin erosion during the intermittent feeding study in BY1996-1999 fish. Six raceways were ponded with 20,000 steelhead fingerlings each and split into two treatments. One group of fish was fed to satiation daily, while the other group was fed a cycle of satiation for 15 days, then fasted for 15 days. At the conclusion of the study, there was no significant difference in dorsal fin erosion between groups fed daily or intermittently.

In addition to recent observations, several studies have been performed with the intention of eliminating or reducing dorsal fin erosion and soreback with chemotherapy treatments, diet modifications, raceway alterations, or a combination of treatments. This paper summarizes literature and research pertaining to the Hatchery and presents recommendations to reduce dorsal fin erosion and soreback at the Hatchery.

Background

Juvenile steelhead have been observed causing dorsal fin injury by nipping. Abbott and Dill (1985) videotaped two groups of juvenile steelhead from the Englishman River, British Columbia that were 24 and 53 days old to observe aggressive behavior. Fish were observed to

pause, orient towards the recipient, and then charge before a nip occurred. Abbott and Dill (1985) observed that aims and nips of reciprocal and nonreciprocal bouts were differently distributed. During reciprocal bouts, aims and nips were concentrated on the dorsal fin and anterior portion of the body. However, during nonreciprocal bouts, aims were mainly directed at the dorsal fin, central part of the body, and caudal fin, but nips were biased towards the caudal fin. This study concluded that the damage observed on the dorsal fin in hatchery-reared salmonids is caused by nipping.

Aggressive behavior has been shown to increase with fish density and then decrease past a certain threshold. However, other studies have had equivocal results. Steelhead aggression was shown to continually increase as rearing density increased by Riley et al. (2005). And fin erosion in steelhead was shown to continually increase as rearing density increased by Winfree et al. (1997). Likewise, Soderberg and Meade (1987) found that density alone did affect fin condition of Atlantic salmon at densities found production hatcheries.

Trout at other hatcheries have also exhibited fin erosion. Trout reared in Utah were shown to have 10 – 50% significantly shorter rayed fins than wild trout (Bosakowski and Wagner 1994). The study sampled 600 trout from all ten state hatcheries and over 100 wild trout, including rainbow, albino rainbow, brown, brook, and cutthroat strains. All trout species were susceptible to fin erosion (no species showed greater susceptibility than another) in hatchery settings and rainbow and brown trout exhibited the most severely eroded dorsal fins.

Fin erosion was found in another study to be less severe in albino steelhead compared to normally pigmented steelhead (Byrne, 1996). Four groups of 250 steelhead at 570 fish per pound were stocked at 24 fish per cubic meter. The four groups were: all normal pigment; all albino; and two mixtures of normal and albino pigment. A month into the experiment, an additional light was installed over the experiment. After eight weeks, dorsal fin erosion was not evident and the fish were crowded to 48 fish per cubic meter. Dorsal fin erosion was immediately evident in the groups with normally pigmented skin. Fin erosion did not occur in the albino steelhead until light levels were enhanced because those fins were not visible at low light intensity. The study concluded fin erosion was caused by sight dependent nipping rather than diet since albinos did not exhibit fin erosion until light levels were increased.

Kindschi and Barrows (2008) performed a similar study to Byrne (1996) to quantify the difference in dorsal fin erosion between normally pigmented and albino trout grown together. Fish were reared as mixed populations of normal pigmentation and albino at 200 fish/tank, separate populations of phenotypes, and individually. Tanks were 122.0 cm long X 35.5 cm wide X 30.5 cm deep with a flow of 3.7 L/min or 2 water exchanges per hour. Trout that were reared individually had complete dorsal fins with a dorsal fin index >11%. Mixed population reared albinos had a greater dorsal fin index of 7.5% compared to 5.6% for normally pigment trout. There was considerable fin erosion in both phenotypes reared in mixed and separate populations. Even though dorsal fin erosion was less prevalent in albinos, this study concluded that fin erosion was not independently affected by phenotype, but other factors such as life stage, feeding rate, nutrition, health, and density are necessary to prevent fin erosion.

Dorsal Fin Index (DFI) was described by Kindschi (1986) at the Hagerman Fish Culture Experiment Station as an equation to quantify relative degrees of dorsal or ventral fin erosion of two or more populations of the same species as: DFI = (fin length X 100)/total length. Kindschi et al. (1989a) described the following DFI between hatchery and wild steelhead trout:

Total Length	Hatchery DFI	Wild DFI
28 – 40 mm	9.7 %	9.3 %
41 – 80	6.9	10.2
81 – 120	1.6	10.9
121 – 160	1.6	10.5
161 – 200	1.3	11.6

The following table illustrates mean dorsal fin indices for the past three brood years in all the steelhead strains raised at the Hatchery.

Brood Year	Strain	Mean DFI	Mean Total Length
2006	PAW	3.4	208
2006	CRW	4.1	201
2006	SAW	4.3	214
2007	PAW	4.1	206
2007	CRW	4.3	204
2007	SAW	4.8	213
2008	CRW	3.2	202
2008	SAW	3.0	197

Chemotherapy Studies

Sawtooth stock steelhead were treated with Romet-B (antibiotic) and Chloramine-T (bactericide) to control dorsal fin erosion at the Tunison Laboratory (Maskill, 1989). Water flow was adjusted to mirror Hatchery conditions with a flow index of 0.60 and a density index of 0.56. Chloramine-T was administered by the drip method for one hour at 7 ppm. Romet-B was added to the feed in a liquid slurry with corn oil and fed at a rate of 51 mg of active ingredient per kilogram of body weight per day. Fish were fed 7 days on, 7 days off. Chloramine-T reduced fin erosion, but the cost of treatment outweighed the benefit. Romet-B reduced fin erosion, but slowed the growth of the fish.

Diet Studies

In the late 1960's, a study tested if fin erosion was caused by hunger-induced nipping at the Lewsiston, Montana state hatchery (Furnish, 1968). The study noted a 90% incidence of fin erosion ranging from minor to complete loss of the dorsal fin in 4" rainbow trout. Three

raceways were stocked with 6,000 trout with fin erosion. One raceway was fed a Silvercup trout feed at standard levels, one raceway was fed a Silvercup trout feed at twice the standard levels, and one raceway was fed a diet similar to the Silvercup feed plus 50% bulk wheat middlings at twice the standard levels. The study lasted 6 weeks. Trout fed the standard Slivercup diet at standard levels had severely eroded fins and some progressed to soreback levels. The fish fed the other two diets returned to normal conditions with very little evidence of the original pre-test fin erosion. The fish fed the wheat middling diet received the same nutritional food value as those fed the Silvercup at the chart value and the same volume as those fed twice the chart value with the Silvercup diet. However, due to a misunderstanding with the feed company, only 25% bulk wheat middling was added, not 50%, so those fish received 1 ½ times the nutritional value as the Silvercup diet.

Feeding behavior and environmental conditions on fin erosion in hatchery-reared rainbow trout was investigated by Larmoyeux and Piper (1969). Five groups of rainbow trout consisting of 10,500, 1.5" individuals were stocked into circular tanks and maintained at a density between 1.4 and 1.5 lb/ft^3. Two of these tanks were fed at a standard feeding ration and the third one was fed 1.8 times the standard ration. The remaining two tanks were maintained at a dissolved oxygen level of 4 ppm. One of the 4 ppm tanks was fed a standard ration, and the second was fed 1.8 times higher. After 280 days, the trout in the low oxygen tank were adjusted to higher dissolved oxygen levels and feeding reduced to standard levels. Fish were also selected from the other groups with severe dorsal fin erosion and set up in replicates. One group was fed at a higher rate in order to correct the erosion, the other fed at the standard level. Fish fed at a high rate in high oxygen were discontinued in the study because fins were in excellent condition. The trout fed 1.8 times standard ration had excellent fins in both oxygen concentrations. Fish that changed from a poor environment to a good environment with a standard feeding rate developed fin erosion. The selected group that had fin erosion and changed to a higher feeding rate showed fin regeneration. Dorsal fin erosion was controlled and corrected by feeding 80% above the standard feeding rate. The aggressive behavior due to hunger appears to be a major factor in fin erosion. When fish were 3 to 4 inches in size, feeding aggression was the highest and declined until fish reached length of 9 inches at the end of the study.

Feeding to satiation reduced and eliminated eroded fins in a study done by Larmoyeux and Piper (1971). Their hypothesis was that trout reared in poor conditions i.e. low in dissolved oxygen or high in ammonia, had less dorsal fin erosion than those reared in more ideal conditions. Trout in poor conditions were less vigorous and not as aggressive during feeding, suggesting feeding behavior played a vital role in fin erosion. The study compared trout reared at less than 5 ppm dissolved oxygen to greater than 5 ppm dissolved oxygen, and feeding rates at established levels and 100% higher than those established levels (double the rate). Trout in low oxygen situations and the trout that were overfed had significantly improved fins. Additional tests found feeding 50% over the established rate increased dorsal fin quality. The study also found that adding 30% of nondigestable bulk to the diet helped satisfy hunger and maintained improved dorsal fin quality.

The prevalence of dorsal skin lesions in steelhead grown at the Hatchery was reduced using feeds supplemented with menhaden or herring oil (Kindschi et al. 1989a). Steelhead fed a standard SilverCup diet supplemented with the menhaden oil had significantly less dorsal fin

erosion than those supplemented with herring oil. However, the study was replicated with SilverCup dry diet compared to SilverCup dry diet supplemented with menhaden oil and found no significant difference in dorsal fin indices. This experiment did not lead to any insight on the cause of dorsal fin erosion. The authors concluded that sunlight, overcrowding, underfeeding, diet and dewatering for cleaning are all variables associated with dorsal fin erosion. They also noted sunburn as a causative agent because as sunlight intensity decreased, dorsal fin erosion decreased during the month of September.

Fin erosion in rainbow trout was reduced by feeding krill/squid meal diets compared to traditional anchovy meal based diets (Barrows and Lellis, 1997). Fish fed the krill/squid meal diet had comparable DFI of wild caught rainbow trout from Bridger Creek in Bozeman, Montana. The krill/squid diet had higher levels of calcium, iron, copper, magnesium, sodium and strontium compared to the anchovy meal diets. The anchovy meal diets had higher levels of potassium and zinc. This study suggests that fish fed a krill/squid meal diet can be grown in normal hatchery tanks, at normal densities, at relatively high temperatures, with normal feeding techniques and still look like wild trout.

Lellis and Barrows (1997) also compared the DFI of fish (from the Hatchery) fed a diet based on krill and fish meals with the addition of testosterone. The DFI of fish fed the krill diets were higher than those of the fish meal diets. Fish on the fish meal diet were observed feeding more aggressively and schooled, where as fish on the krill diet were dispersed among the tank and fed on the feed as is fell through the water column. Adding testosterone to the krill diet decreased the dorsal fin index by week 12, but otherwise did not effect the fin condition.

Raceway Alterations

Bosakowski (Unknown) altered the bottom of traditional concrete raceways in order to improve fin condition of rainbow trout. 1,300 rainbow trout were stocked into two traditional raceways and two cobble-bottomed concrete raceways. The cobble bottom reduced fin erosion by 5-10%. Cobble bottoms were anecdotally attempted at Sawtooth Fish Hatchery, but they had problems with poor raceway sanitation.

The effect of baffles and isolation on steelhead dorsal fin erosion at the Hatchery was evaluated by Kindschi et al. (1989b) and compared to wild steelhead trout. Steelhead were placed into individual compartments that received serial reuse water to determine if sunlight and reused water played a role in fin erosion. Steelhead were also placed into baffled nursery tanks with either 2 exchanges per hour or 4 exchanges per hour and then stocked out in raceways. Steelhead trout were also collected from the Clearwater and Tucannon Rivers to compare fin indexes of wild trout. Isolated fish maintained perfect fins (compared to wild) and had no dorsal fin erosion, indicating sunlight and water reuse did not directly relate to fin erosion. Baffles did not stop the progression of fin erosion and did not ease cleaning of tanks. The eventual loss of the dorsal fin in steelhead grown oat the Hatchery progresses as follows: first; at 35 mm total length, fish exhibit tears between the dorsal fin rays that extend up to half the length of the fin, second; at 40 mm in total length, the fin fringe begins to erode and the white margin disappears, third; at 50 mm total length (30 days after initial feeding) dorsal fin erosion progresses so that only 60% of the fin remains, fourth; at over 50 mm total length, the dorsal fin erodes rapidly and

parasites attach, and fifth; at 70 – 225 mm total length, very few fish had fins longer than 3 mm and dorsal fin is not evident except for eroded epidermal tissue.

Wagner (1993) grew rainbow trout in outdoor concrete raceways either with or without plywood covers over them to compare performance and behavior. Growth, feed conversion, mortality, and fin length measurements were not significantly different at the conclusion of the 215 day study. Negligible differences were observed in behavioral differences of covered and uncovered treatments of fish to seek cover when a stuffed eagle was placed next to the raceways.

Berejikian and Tezak (2005) found that juvenile steelhead raised in enriched tanks had DFI values that were the same as steelhead raised in streams. Six hundred and fifty fish were stocked into each of six tanks with a volume of 1,520 L and a flow rate of 28 L/min at a temperature of 10ºC. Three tanks had tops of commercially grown Douglas-fir for in-water structure, camouflage netting for overhead cover, and an underwater feed delivery system. Three tanks were kept conventional, with no over-head or under-water structure and hand fed. An additional 1,950 fry were stocked into a stream and fed on natural food items. Fish were sampled for DFI at 27, 50, and 64 days after stocking. After 27 days of stocking, dorsal fin index was not significantly different among treatments. However, after 50 and 64 days after stocking, the DFI of the enriched tanks and the fish from the stream were statistically the same and significantly greater than the traditional tanks.

Multiple Variable Studies

Keith Pratt (1962) attempted to test the effect of diet, density, sunlight on the occurrence of soreback in one raceway at the Hatchery. The raceway was split in half vertically than partitioned off into 21 sections. Fish were either stocked at half normal, normal, two times normal, or three times normal density. Fish were either fed the hatchery production diet, Oregon Moist, Purina, meat, or production diet with sulfa. Some sections were provided with shade and others were not. Twenty seven days into the experiment, the following observations were made: the meat diet group showed least recovery; production diet, laboratory control diet, and the laboratory control diet with shade had some fish not healing well; and the Oregon Moist diet and production diet with shade group showed complete healing. However, shortly after sampling some of the test groups were eliminated from the study due to screen failures and no positive conclusions were made.

James Warren, Hatchery Biologist, (1967) in conjunction with the Ennis NFH tried to link population density, diet, and pond shading to the occurrence of soreback. Results indicated that diet alone is probably not the only contributing source to soreback. Pond shading was beneficial to fish up to 3” in size, but detrimental to larger fish. Lower density populations had a lower occurrence of soreback. Typical soreback outbreaks were higher at Ennis (7%) and lower at Hagerman (0.1%) because Ennis has cooler water temperatures leading to higher stocking rates. Jack Larmoyeux (Director if the Hatchery Development Center, Bozeman, Montana), who reviewed the study, remarked that he observed fish in severe stress conditions having better fins than those in optimum conditions. He believed the outbreaks occurred because of aggressive feeding and nipping behavior and feeding to satiation could reduce soreback.

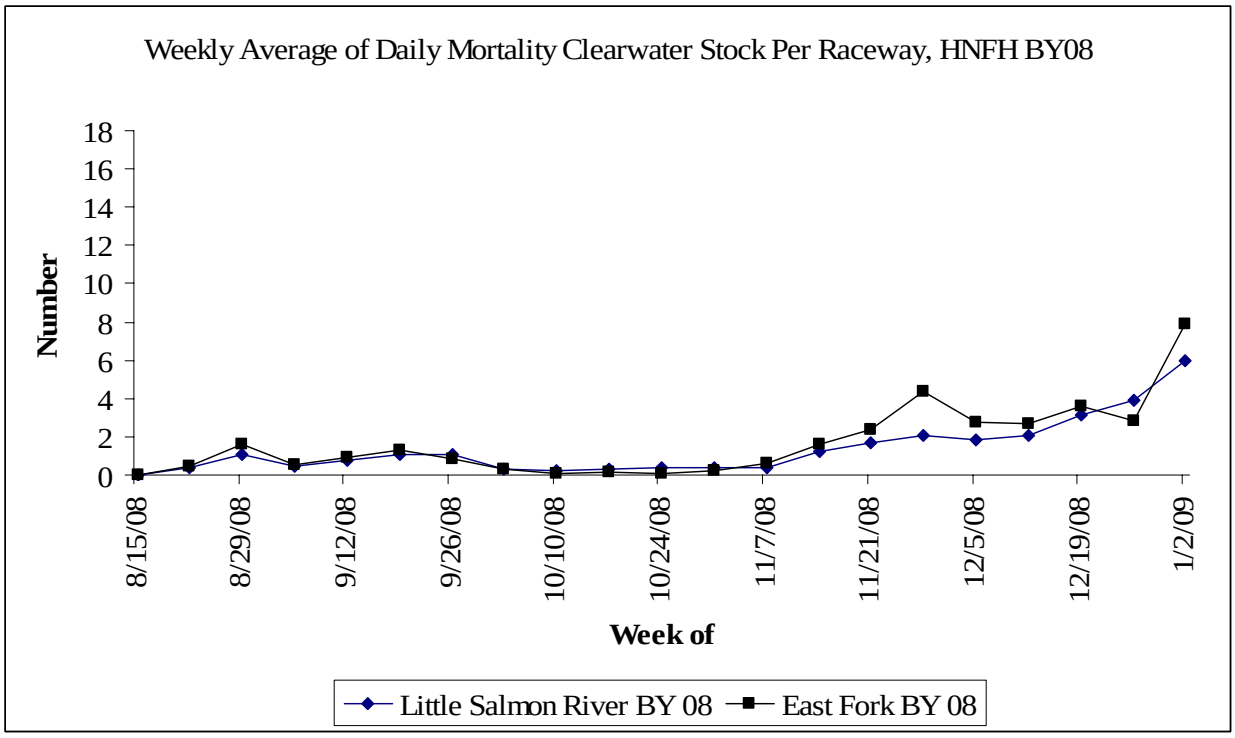
Winfree et al. (1997) tested the effects of water temperature, density, and food deprivation on dorsal fin erosion. Swim-up steelhead fry were stocked into 144-L fiberglass tanks and stocked at a density index of 0, 0.02, 0.1, 0.2, and 0.5. Water temperature was kept at either 10ºC or 15ºC. Fish were fed a standard government-contracted diet daily or fourteen days on and fourteen days off. Water temperature and density had a significant interactive effect on survival, feed conversion, and dorsal fin index. The dorsal fin index was maximized at very low densities in cooler temperatures. Fish fed daily had less dorsal fin erosion than those intermittently fed. DFI was not significantly affected by the interaction of density and food deprivation, but growth, feed conversion, and condition were. Steelhead in this study that were grown individually had perfect fins, but it is not known if it was because of the lack of contact with other fish or if stress was reduced and behavior was altered. This study recommended feeding fish in 15ºC to satiation at reduced stocking rates to keep a favorable DFI.

Conclusions

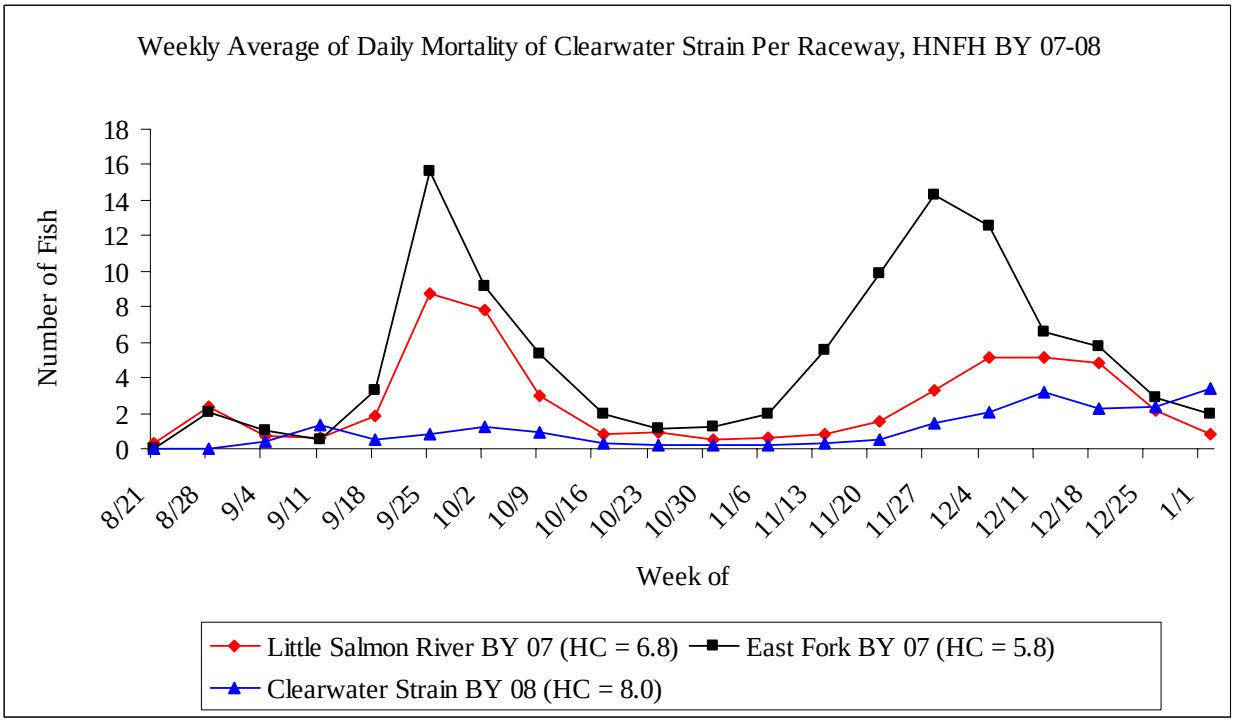
Chemotherepeutants and raceway alterations including shading, baffles, and substrate additions had limited success relieving fin erosion problems. However, rearing fish individually did eliminate fin erosion. In addition, rearing fish in low dissolved oxygen conditions, feeding to satiation, feeding krill/squid diets, and feeding diets with wheat middling fillers reduced fin erosion. Based on the literature reviewed and observations made on the Hatchery, soreback is induced by aggressive behavior from a restricted diet. Feeding a diet that consists of wheat middling bulk could be an option for reducing aggressive behavior by feeding to satiation without increasing growth rates. However, sanitation issues may arise by feeding a highly indigestible diet.

Recommendations

As a result of this review, Brood Year 2008 feeding rates were increased with a double vitamin boost to reduce soreback mortalities in the East Fork release group of the Clearwater Stock. The East Fork release group was also moved to an earlier release date from early May to early April 2009 to match the Little Salmon River releases. Based on the BY07 data, the Clearwater fish destined for the EF release had a significantly larger mortality than the Clearwater fish destined for the LSR. The only difference in the culture of these fish was the feeding rates. Using this observation, the Hatchery maintained Hatchery Constant feeding rates at 8.0 from October until January in the BY2008 Clearwater stock. The Hatchery Constant feeding rate was decreased in February (2 months post-PIT tagging) to 6.8 to meet size for release goals. The following table illustrates the weekly mortality rate of the Clearwater strain for the Little Salmon River and East Fork release groups in BY 08:



During BY08 production, there was no significant difference ($p > 0.05$) in weekly average of daily mortality rates between release groups, unlike observations of BY07 as illustrated below:



Feeding a higher Hatchery Constant at the beginning of the production season did not eliminate soreback, but significantly ($p < 0.05$) reduced the mortality rate associated with it. During BY 07, the EF release group had a high of an average of 14.3 mortalities per day per raceway, compared to the LSR release group which had an average of 5.1. However, in BY 08, the EF release group reached a high of an average of 4.4 mortalities per day per raceway as compared to the LSR release group of 2.1. There was in increased mortality rate observed in late December, but morbid fish did not exhibit soreback conditions.

Feeding at a higher hatchery constant at the beginning of the production season significantly reduced soreback mortalities between the two brood years observed. Additional considerations have to be made to determine if feeding at a higher rate at the beginning of the production season is the overall best management practice.

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