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Hudson Valley Fisheries Velocity Study

I. Introduction

Skeletal deformities in Rainbow Trout (Oncorhynchus mykiss) are becoming an increasingly common issue within Hudson Valley Fish Farm's recirculating aquaculture system. Vertebral deformities are an important welfare indicator in Rainbow Trout (Fjeldal et al., 2025). Various environmental factors within the facility may contribute to the frequency of these deformities. One potential stressor is the velocity at which tank inflow current is set during early rearing. Decreasing current velocity in the early stages of Rainbow Trout development could serve as a solution to reducing skeletal deformities within the facility. Previous studies indicate that increased swimming speed can lead to lactic acid buildup in Rainbow Trout, potentially resulting in mortality and decreased health (Wedemeyer, 1996). This raises the possibility that the facility's current standard velocity is too intense for optimal skeletal development, suggesting that a lower current velocity may be more suitable. To examine the influence of velocity on deformities, a group of Rainbow Trout (cohort 2210R) was selected to test the impact of varying current speeds on early skeletal development. Two study groups were formed from 2210R. The first group remained under normal conditions and was exposed to the farm's standard velocity, while the second group was kept in a low-current environment. The objective of this study is to determine whether the farm's current velocity contributes to the occurrence of skeletal deformities.

II. Materials and Methods

Experimental design

The Rainbow Trout (cohort 2210R) used in this project were received in October 2022 from Riverence Brood LLC, starting with a population of 37,000. Until swim-up, they were kept in the facility's incubation system. From there, they were split into two test groups. Group One remained in a normal current typical of standard farm operations, while Group Two was adjusted at the inflow to maintain low to nearly no current, becoming the low-current group. Both groups were maintained at an incoming flow

rate of 3.5 gallons per minute, measured with an ultrasonic flowmeter. Once cohort 2210R reached an average weight of 0.8 grams, they were moved into five-foot tanks. Accounting for mortalities in both groups, the remaining population was 35,844. When moved into the five-foot tanks, Group Two initially had the sparger/inflow directed completely at the tank wall, resulting in no current. Group One was maintained at a standard current appropriate for the fish's size at that stage. The flow rate for both tanks was set at 20 gallons per minute and increased to 30 gallons per minute when the fish reached five grams. Sixteen days after being ponded into the five-foot tanks, Group Two was transitioned from no current to a light current. As fish size increased, flows in both tanks were set at 30 gallons per minute. Following this, the inflow for Group Two was positioned a quarter of an inch from the tank wall, while the inflow for Group One was positioned three-quarters of an inch away. The inflows were adjusted again, with Group Two moved half an inch from the tank wall and Group One a full inch away. The overarching objective of the experimental design was to maintain a significantly lower velocity in the low-current group compared to the normal-current group while ensuring adequate flow.

Velocity measurements

Once cohort 2210R reached a weight at which both tanks could maintain a measurable current, velocity was measured using the Swoffer Model 3000. Twenty-seven points from each tank were measured (Figure 1). At each point, three readings were taken and recorded. The twenty-seven sampling points were determined based on the tank's diameter and water depth. Using these measurements, six equidistant set points were established for each tank, evenly covering most of the tank's area to obtain a representative average velocity. Three separate measurement trials were conducted throughout the experiment. For the final trial, only statistically significant points were measured (Figure 2). Each recorded data point was measured in meters per second.

Figure one: *Locations of all 27 points sampled in each tank to determine the influence of velocity throughout the area.*

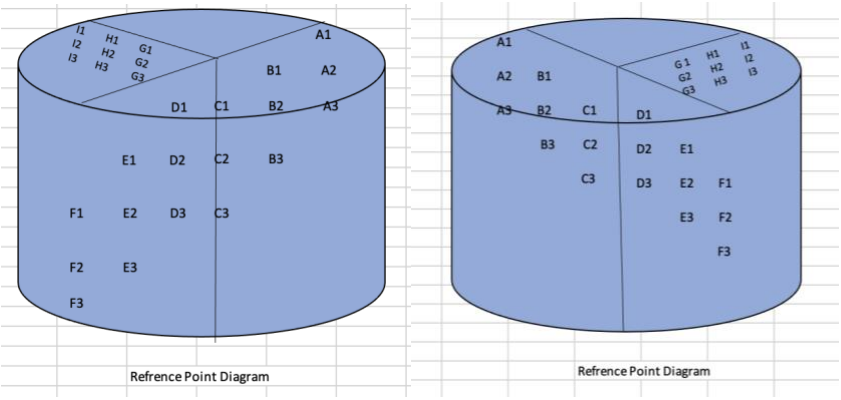
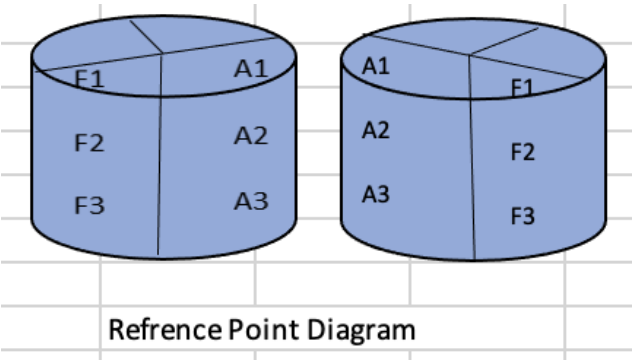


Figure two: *The locations of the statistically significant points measured*



Mineral samples and deformity reports

To monitor weight and length variations between groups, mineral samples were collected on five occasions. Samples were taken when fish reached 1 g, 5 g, 10 g, 20 g, and 30 g. For the 1 g sample, 250 fish were culled from both the normal-flow group (Group One) and the low-flow group (Group Two). For the 5 g through 30 g samples, 50 fish were culled from each group. The length and weight of each fish were recorded. The 1 g and 30 g samples were sent to Midwest Laboratories for mineral testing. The recorded weights and lengths were used to monitor growth. Two deformity assessments were conducted during this study. The first deformity assessment included a sample size of 2,065 fish. Each deformity was recorded and categorized by type. A second deformity assessment was conducted, sampling an

additional 1,471 fish. Sampled fish were individually assessed for head, anterior spine, posterior spine, caudal, and overall spinal deformities.

III. Results

Velocity

Velocity measurements from each trial revealed the consistency and intensity of the current throughout the tanks. After collecting all data points in meters per second, the results were converted into body lengths per second. Each data point, as seen in Figure 1, was measured three times. These three measurements were averaged, producing a single value for each of the 27 data points. These averaged data points were then plotted on a diagram illustrating the average velocity at each location in the tank. Figures 3–5 illustrate the average velocity in body lengths per second for each tank at various stages of the study. Body lengths per second were calculated using the initial velocity (m/s) and the average weight and length of the fish at the time of measurement.

Figure 3. *Velocity readings in body length per second throughout Group one (N11) and Group two (N2). Each point represents an averaged number in body lengths per second from an initial velocity reading in meters per second. Each point is color coded from a scale that combines all readings from every tank. Arrows represent direction of flow in each tank.*

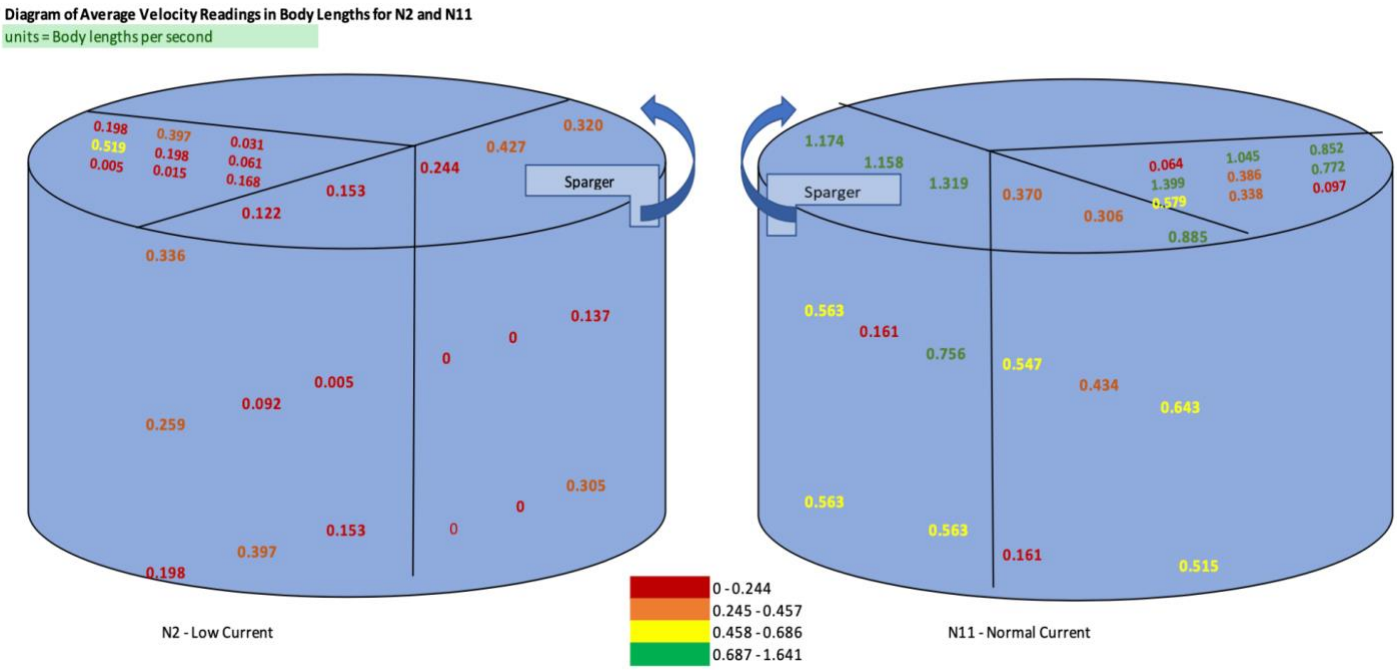


Figure 4. *Velocity readings in body length per second throughout Group one (N12) and Group 2 (N3). Each point represents an averaged number in body lengths per second from an initial velocity reading in meters per second. Each point is color coded from a scale that combines all readings from every tank. Arrows represent direction of flow in each tank.*

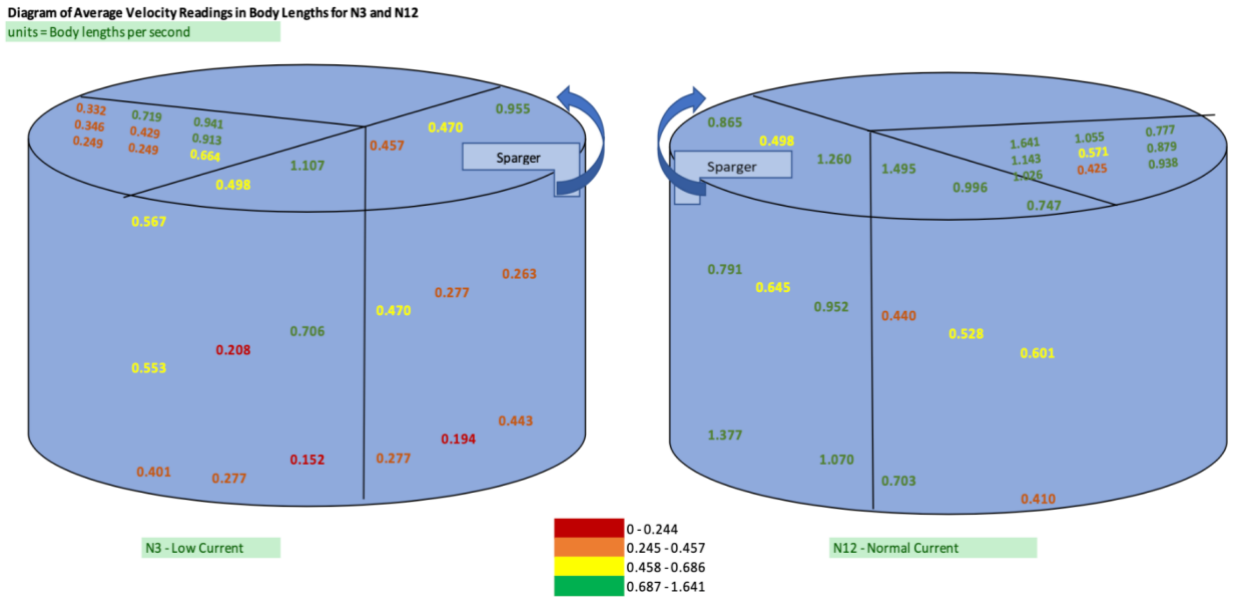
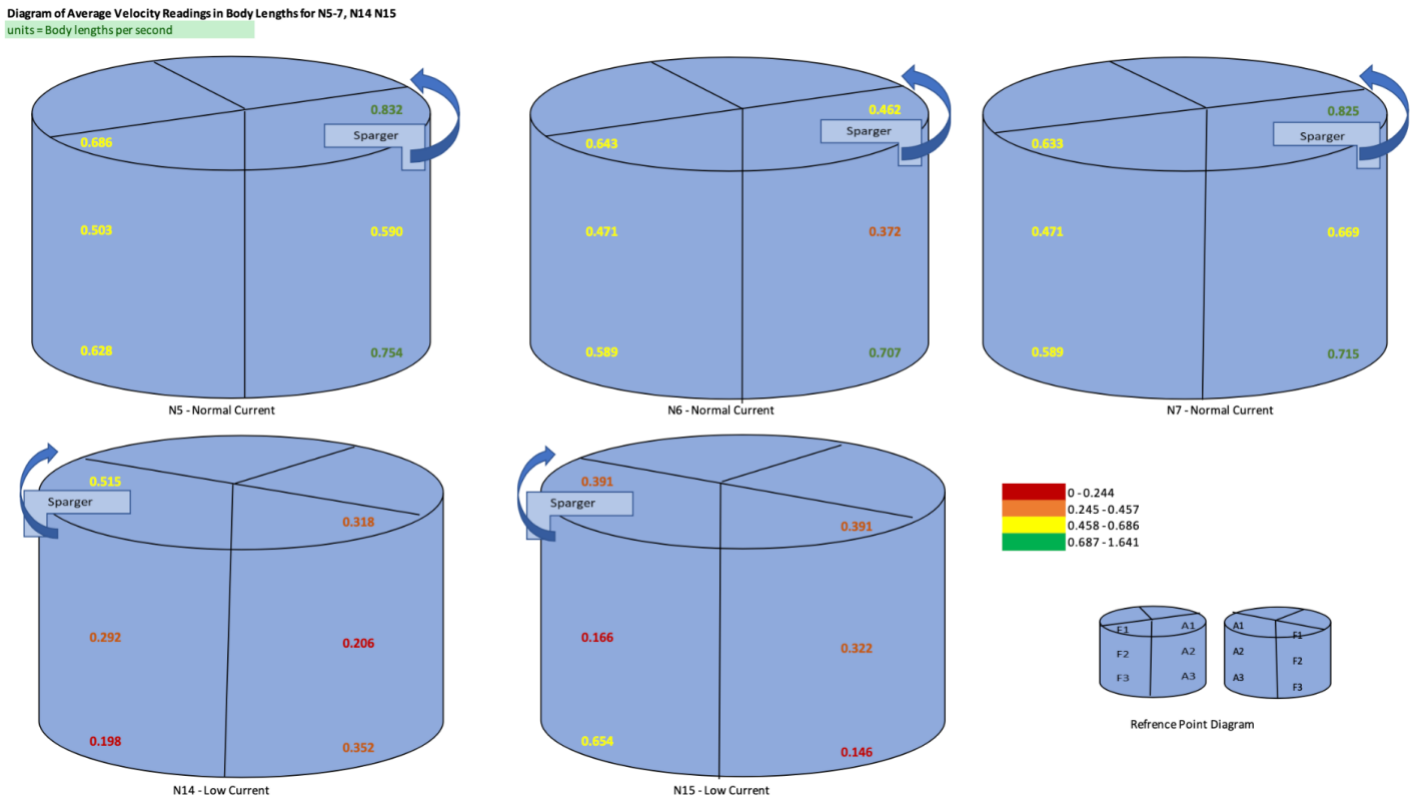


Figure 5. *Velocity readings in body length per second throughout Group One (N5, N6, N7) and Group two(N14, N15). Statistically significant points only were measured color coded from a scale that combines all readings from every tank. Arrows represent direction of flow in each tank.*



Mineral sample and Deformity reports

2210R 1g and 30g samples were sent to Midwest laboratories for mineral analysis. Results for mineral composition for both low current and normal current are displayed in tables 1 and 2.

Table 1. *2210R 1g NF represents the results of the 250 sampled fish from Group One. These fish were exposed to a normal current environment. 2210R 1g LF represents the results of the 250 sampled fish from Group Two. These fish were exposed to a low current environment. Each table provides a mineral breakdown of each group at 1 gram.*

Analysis	Level Found As Received	Units
Sample ID: **2210R 1g NF** Lab Number: **13995216**		
Sulfur (total)	0.16	%
Phosphorus (total)	0.31	%
Potassium (total)	0.27	%
Magnesium (total)	0.02	%
Calcium (total)	0.24	%
Sodium (total)	0.12	%
Iron (total)	16.1	ppm
Manganese (total)	2.6	ppm
Copper (total)	1.6	ppm
Zinc (total)	29.8	ppm

Analysis	Level Found As Received	Units
Sample ID: **2210R 1g LF** Lab Number: **13995217**		
Sulfur (total)	0.16	%
Phosphorus (total)	0.29	%
Potassium (total)	0.27	%
Magnesium (total)	0.02	%
Calcium (total)	0.22	%
Sodium (total)	0.12	%
Iron (total)	17.2	ppm
Manganese (total)	2.5	ppm
Copper (total)	1.5	ppm
Zinc (total)	28.7	ppm

Table 2. *2210R 30g NF represents the results of the 50 sampled fish from Group One. These fish were exposed to a normal current environment. 2210R 30g LF represents the results of the 50 sampled fish from Group Two. These fish were exposed to a low current environment. Each table provides a mineral breakdown of each group at 30 grams.*

Analysis	Level Found As Received	Units
Sample ID: **2210R 30g NF** Lab Number: **13995218**		
Sulfur (total)	0.18	%
Phosphorus (total)	0.41	%
Potassium (total)	0.30	%
Magnesium (total)	0.03	%
Calcium (total)	0.42	%
Sodium (total)	0.09	%
Iron (total)	14.1	ppm
Manganese (total)	2.1	ppm
Copper (total)	2.4	ppm
Zinc (total)	22.8	ppm

Analysis	Level Found As Received	Units
Sample ID: **2210R 30g LF** Lab Number: **13995219**		
Sulfur (total)	0.17	%
Phosphorus (total)	0.36	%
Potassium (total)	0.29	%
Magnesium (total)	0.02	%
Calcium (total)	0.35	%
Sodium (total)	0.09	%
Iron (total)	13.7	ppm
Manganese (total)	1.8	ppm
Copper (total)	2.2	ppm
Zinc (total)	21.1	ppm

In the first deformity assessment, Group One showed that 31.7% of the sampled fish were deformed, with the most prominent deformity being posterior spine, accounting for 41.93% of all deformities. In Group Two, 35.4% of the sampled fish were deformed, with the most prominent deformity being posterior spine, accounting for 44.53% of all deformities.

The second deformity report included 1,471 culled and sampled fish. For this assessment, samples were taken from three tanks in Group One. In Tank N5, 467 fish were sampled. Of those, 47.8% were deformed, with the most prominent deformity being anterior spine, accounting for 65.47% of all deformities. In Tank N6, 241 fish were sampled. Of those, 51.0% were deformed, with the most prominent deformity being anterior spine, accounting for 83.74% of all deformities. In Tank N7, 113 fish were sampled. Of those, 55.4% were deformed, with the most prominent deformity being anterior spine, accounting for 81.42% of all deformities.

For the second deformity report, samples were taken from two tanks in Group Two. In Tank N14, 156 fish were sampled. Of those, 58.3% were deformed, with the most prominent deformity being anterior spine, accounting for 78.02% of all deformities. In Tank N15, 403 fish were sampled. Of those, 58.6% were deformed, with the most prominent deformity being anterior spine, accounting for 74.58% of all deformities.

IV. Discussion

Throughout the early rearing phase of 2210R, velocity in the low-current and normal-current groups was consistently maintained at different rates. Figures 3, 4, and 5 provide a clear distinction between the groups at various stages through the project, as reflected in the average velocity readings. These velocity measurements also offer insight into the consistency of current across different locations evenly spread throughout the tanks. On average, the normal-current tanks exhibited a higher body-lengths-per-second velocity.

The mineral composition between both the low-current and normal-current tanks at 1 gram and 30 grams was very similar. However, in both normal-current samples, mineral composition was higher than in the low-current group. This suggests that the increased swimming velocity in the normal-current group facilitated greater bone formation, leading to a higher mineral composition.

The lower-current tanks, on average, exhibited a slightly higher percentage of deformities in each report. Previous research has also demonstrated a greater number of deformities and higher mortality rates in low-exchange systems, which aligns with the findings of this study (Davidson et al., 2011). Additionally, the increased percentage of deformities in the low-current group may be attributed to lower water quality, as reduced current flow resulted in less self-cleaning within the tanks.

Although the differences were not drastic, the data indicate that the standard-current tanks provided a more favorable environment for Rainbow Trout in a recirculating aquaculture system. The combination of data collected in this study and findings from other research suggests that maintaining an increased velocity is more beneficial than decreasing it. From a system maintenance perspective, keeping tanks at a normal current is also advantageous, primarily due to its role in preserving water quality.

A lack of flow led to a faster and more intense buildup of uneaten feed and waste, resulting in elevated levels of CO_2, suspended solids, ammonia, and other indicators of poor water quality (Noble and Summerfelt, 1996). Throughout the experiment, fish in Group Two were subjected to poor water conditions due to low flow and exhibited stress-related behaviors. Specifically, a visible increase in suspended solids was observed, as reduced flow was insufficient to keep up with feed loads. High levels of suspended solids can create a stressful environment for Rainbow Trout and have been linked to

disease outbreaks, gill damage, and fin rot (Noble and Summerfelt, 1996). Additionally, high turbidity can impact feeding behavior by reducing visibility. As observed in the low-current tanks, schooling behavior increased in response to elevated solid loads and insufficient self-flushing. Since Rainbow Trout are visual predators, reduced visibility can lead to feeding stress and decreased foraging success (Becke et al., 2018). This could explain the lower mineral composition found in the low-current group's body composition samples.

Overall, this research suggests that maintaining a low-velocity current does not aid in prevent skeletal deformities in a recirculating aquaculture system. Instead, the lack of self-cleaning associated with lower flow appears to increase the prevalence of deformities and other health complications in Rainbow Trout. Hudson Valley Fisheries is likely to achieve better production outcomes by maintaining its current velocity levels rather than decreasing them. The primary contributors to the rise in skeletal deformities within the facility should be investigated in other variables such as stocking density, genetics, and diet composition.

References

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