COMPLETED PROJECT CASE STUDY

# UNDERSTANDING FAILURE RATES IN RAINBOW TROUT POPULATIONS

**PARTNERS**

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**PROJECT LEADS**

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**SUPPORTED BY**

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## BACKGROUND

Failed fish – the term for fish with impaired growth or a significantly slower growth rate than normal – are estimated to make up nearly 10% of salmon populations. This number increases in saltwater Rainbow trout populations, where levels can surpass 30%. Unfortunately, there is limited information about what causes this increase.

As global seafood consumption grows, the Scottish aquaculture sector has diversified, aiming to complement farming of salmon, its top food export. As Rainbow trout aquaculture increases, so does the impact of fish failure and the attempt to understand and prevent this phenomenon. Even a 20% fish failure rate is estimated to cause loss of revenue of more than £12 million per 500,000 fish.

Rainbow trout thrive in colder, oxygen-rich waters, like the North Atlantic. In Scotland, the limited availability of brackish water sites has led to many trout farms being sited in full seawater, which can cause a higher occurrence of fish failure. This project was devised to investigate and further understand the causes of fish failure.

The University of the West of Scotland (UWS) was the lead academic partner, while Kames Fish Farming, a farmer of Rainbow trout for over 50 years, acted as the lead industry partner on this project. UWS was responsible for the overall project management, sample collection, analytical measurements, data interpretation, and report publication. Kames provided failed and normal fish samples, and sorted and isolated failed fish. Kames also performed feeding tests. Finally, DawnFresh provided samples of Rainbow trout from brackish water sites for comparison against the fish reared in seawater.

## AIMS

The primary objective of this study was to identify the cause of failed fish syndrome in Rainbow trout reared in full-strength seawater. The holistic approach undertaken in this study investigated the differences between normal and failed fish through genetics, biochemistry, physiology and husbandry. The project team also investigated the ability of nutrition to overcome this issue.

The majority of the work took place on a fish farm and was divided into two experiments:

1. The first of these experiments involved Passive Integrated Transponder (PIT) tagging 500 randomly chosen smolts before their transfer from freshwater to saltwater. Blood and tissue sampling of individuals before and after seawater transfer also took place to determine fish condition.
2. The second experiment involved randomly selected fish from two separate hatcheries being fed with different types of feed, rich in marine origin protein but enriched with either a Protec component or a second unnamed ingredient. Blood and tissue samples were taken before and after transfer at predetermined intervals.

The ultimate aim of this project was to increase productivity, improve fish health and survivability, and reduce waste in both Rainbow trout and other salmonid aquaculture.

## FAILED FISH IN SEAWATER TRANSFER

Clinical chemistry analysis from the first experiment showed significant differences in alkaline phosphatase (ALP) and ammonia concentration between normal and failed fish after seven weeks at sea. Specifically, this activity recorded that fish in good condition after the seawater transfer saw an increase in ALP and ammonia activity, while failed fish saw a reduction. Reduced levels of ALP, an enzyme essential for metabolic processes found in the liver, indicates liver damage or issues with digestion. In comparison, fish with slowed growth had a higher lactate dehydrogenase (LDH) level, associated with liver disease and muscular dystrophy, and decreased activity of amylase and potassium concentrations.

Histopathological evaluation of the organs of failed fish showed a severe shrinkage of hepatocytes due to disturbance in feeding and metabolism, further indicating liver damage. Additionally, tissue damage to the eye chamber was evident in the form of erosion of the cornea. The project team theorised that difficulties with vision could prevent normal feeding and eventually lead to emaciation and mortality.

## NUTRITION AS A POTENTIAL SOLUTION

The second experiment took place at two hatcheries where fish were given different feeds before being transferred to saltwater. In the Torhouse hatchery, larger fish were given a diet consisting of Horizon and Protec feeds, while smaller fish were fed a High Marine diet. In the Selcoth hatchery, larger fish were fed a High Marine diet, while smaller fish were given a BioMar diet with an undisclosed, unnamed ingredient. Blood and tissue sampling was performed immediately before transfer and 24 hours, four days, and ten days post-transfer.

After the first grading of the fish, which took place seven weeks after the transfer to saltwater, smaller fish were fed a recovery diet enriched with fish oil, green-lipped mussel extract and flour. The fish failure rate was reduced from 42% (Horizon diet) and 39% (High Marine diet) from Torhouse to 17% and 18% at the second grading, while Selcoth's fish failure rate changed from 33% (BioMar diet) and 32% (High Marine diet) to 19% and 13.7%, respectively.

Results from this experiment indicate that initial fish size does not play a role in predisposition to failed fish syndrome. Overall results from the second experiment demonstrate that, although significant differences in biomarker expression existed before transfer between the two sites and between the feed used in the freshwater phase, these differences were generally insignificant four or ten days after saltwater transfer. Although the fish fed the High Marine diet from Selcoth showed the lowest failure rate at 14 weeks post-transfer, this was not significantly reduced from the other feeds that showed similar failure rates between 17-19%.

# IMPACT

Blood biochemistry showed excellent potential to investigate fish health status and was associated with damaged organs and tissue. Moreover, feed trials highlighted the influence of different conditions in hatcheries, fish size and feed type on physiological response in the early stages of acclimatisation after the transfer to seawater.

Interestingly, there was no correlation between size pre-transfer and the likelihood of the fish to fail. Of the biomarkers examined, only chloride showed a significant difference between the normal and small fish in the freshwater phase. As failure is largely understood to be an osmoregulatory issue, biomarkers of osmoregulation, such as chlorine, sodium, and potassium, could be a valuable tool in indicating failure rates.

## FURTHER RESEARCH AND ONGOING WORK

The original project also had a third ambition to incorporate genetic analysis by AquaSearch Ova and proteomic analysis by the University of Glasgow. While these work packages could not be undertaken in time for the conclusion of the project, they may lend themselves well to further investigation.

Failure in Rainbow trout is a complex multifactorial issue that may require the development of different husbandry protocols for fish stocks throughout the year. Although this nine-month study has generated significant amounts of data, which is providing valuable insight into the issue, the results are not conclusive. For this reason, this issue was further investigated in an Innovate UK Knowledge Transfer Partnership (KTP) project between Kames and UWS. Notable achievements from this KTP were as follows:

- Implementation of a new in-house fish health management programme based on the use of non-lethal health monitoring that enabled Kames to identify the causes of their primary health challenge, resulting in the development of a successful breeding programme to overcome this issue;
- Helping the company become more efficient by increasing the percentage of fish that are viable after transfer to sea;
- Direct and significant benefit to the cost of production while also improving the quality of the company's product.

# ADDITIONAL INFORMATION

Knowledge Transfer Partnership: Innovate UK, Kames, UWS