BIM EMFAF Work Programme Project Report 2023

BENEFICIARY: Bord Iascaigh Mhara
PROJECT REFERENCE NUMBER: 23/KGS/STS-BG011-BR109
NAME OF PROJECT: **Marine Challenge**
IMPLEMENTATION PERIOD: 1st January to 31st December 2023

Project Scope

The Marine Challenge Programme included three distinct but interrelated project areas. These were freshwater, barrier systems and resource efficiency. Combined, these work areas were anticipated to result in better husbandry decisions and thus improved fish welfare, achieved via solutions that were sustainable from an economic, environmental, and social perspective.

These work areas are underpinned by a strong reliance on high quality data. Over the last two years BIM has developed a network of real time data sensors in order to collect baseline data on the abundance and frequency of marine challenges to the salmon sector, these broadly fall into two areas, those related to physico-chemical water quality issues and other biological challenges such as those posed by phyto and zooplankton. Having obtained baseline data for multiple years, BIM is now ready to use this real-time data combined with external publicly available data such as rainfall, wind speeds and other meteorological data to enable forecasting of environmental events occurring in the nearshore environment at a resolution that can assist industry members in making good husbandry decisions.

Freshwater

The ability of fish to access freshwater for gill, skin and gut health passively has the potential to improve survival and increase growth rates. At present fish requiring freshwater treatments may be suffering from gill issues that result in reduced gill function leading to respiratory distress. Handling during these times can result in elevated mortality. Feeding rates must also be reduced prior to treatments. Passive systems such as the freshwater snorkel should reduce days at sea and subsequent exposure to harmful environmental events. EMFF and EMFAF funded projects have directly supported significant advancements in this area, with desalination units and freshwater treatments now standard practice for the sector. Based on these projects BIM believed that further improvements could be achieved in a commercial setting and thus undertook work in this area in 2023.

Barrier

Under previous EMFF and EMFAF projects BIM has tested the effectiveness of bubble curtains and ascertained that on sheltered sites we can create a virtual wall that prohibits or significantly reduces the ingress of certain plankton species. We have further ascertained that improvements to the system can be achieved via system amendments, use of oxygen and by testing under different environmental conditions.

In 2023 we sought to mitigate mortalities related to harmful plankton and high plankton abundances via the deployment of a bubble curtain and upwelling devices such as diffusors under varied environmental

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conditions. The reduction of natural stressors in the marine environment improves the resilience in fish and make them less susceptible to co-morbidities. We noted during the 2022 system deployment that air feed line blockages altered the ongoing effectiveness of the bubble curtain. This requires the investigation of alternate air feed lines, so the system is robust and reliable over multiple weeks. Commercial adoption of these systems in Ireland hinge on our ability to demonstrate robustness and effectiveness under varied environmental conditions.

A closed containment system was deployed in conjunction with the Marine Institute at the Lehenagh Pool marine testing site in 2021. Results from that trial indicated that fish health was improved however technical issues (supporting equipment failure) undermined the trial results. Following industry requests for more data and refinement of this system, in 2023 we redeployed a system at Lehenagh Pool to answer these queries. Collaboration with the Marine Institute was key to the success of this project.

Resource efficiency

The farmed Irish salmon sector grows approximately 3.5 million fish per annum with an average weight of 4.5kg. This represents a biomass of 15,000t, based on food conversion ratio of 1:1.3, this means 19,500kg of food is utilised. Food cost is currently at an all-time high with a base cost of €2,300 per tonne, representing a total cost of €45 million per annum. Due to Brexit, it has become increasingly difficult to import food from the UK into Ireland with increased administrative processes required for each consignment. The current Irish feeding strategy is based on operator observation in addition to basic water sampling. It is felt that efficiencies could be made in the feeding process thereby reducing the carbon footprint and improving the competitiveness of the sector by lowering the cost of production. As resource utilisation and competitiveness continues to drive the sector to become more sustainable, we felt it was necessary to look at alternative feeding strategies in order to reduce food waste within the feed system. Newer feeding systems monitor air quality and air-flow rates in the feeding lines to prevent feed loss within the system feed, while variable speed devices also prevent food being split within the lines thus reducing unwanted nutrient input.

BIM custom built a renewable hybrid power plant in 2018 and have been testing this for several years. This unit is capable of storing renewable energy from wind and solar and can supply consistent power as required, backed up by diesel generator. We ascertained that this unit reduced diesel running hours by approximately 80% and reduced fuel consumption by over 50%. In 2023 we initiated a series of commercial trials onboard a feed barge.

Objectives

Freshwater

- To further enhance the efficacy of biological treatment methods.
- Reduce the costs associated with current freshwater treatments, in relation to boats, generators and staff.
- Addressing fish welfare concerns. Passive access to freshwater will lead to a reduction in fish health impacts associated with moving fish by pump.

Barrier

- Via the deployment of a marine cage closed containment system for smolts, improve fish health and welfare over the first summer period for spring smolts.
- Exclude phytoplankton and zooplankton from salmon smolts following sea transfer in spring.
- Have better control of water quality in pen systems used to grow salmon smolts in the spring period.
- Via the deployment of bubble curtains reduce the occurrence of phytoplankton and zooplankton events on trial salmon sites.
- Refinement of the air feed network to enable more consistent operation of the bubble curtain.

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- Collection of salmon specific information in relation to harmful phytoplankton and zooplankton.
- To provide access to phytoplankton and zooplankton expertise to onsite fish biologists and site operatives.
- To evaluate the robustness and efficacy of bubble curtains under varied conditions including stronger tides and increased wave climates.

Resource efficiency

- To improve Feed Conversion Ratios (FCR's) on marine salmon farms.
- To decarbonise marine salmon farms via the use of hybrid technology.
- To trial renewable energy on a commercial salmon farm.

Outcomes

Freshwater

A freshwater snorkel was deployed at a commercial salmon site with multiple control pens. The freshwater feed and sensors were deployed in May along with a 31m circumference snorkel that had a depth of 5m. This contained a theoretical volume of almost 400m^3. The snorkel reinforcement allowed for a prolonged deployment period with no damage to either the snorkel or the pen. The additional weight added to the snorkel also allowed for the cylinder to better maintain its shape under varied tidal conditions. Unfortunately, the trial was unable to establish whether the snorkel could maintain an effective freshwater layer within as the west coast faced a very dry May and June with no appreciable rainfall. Freshwater supply to the snorkel was therefore not available. Given these circumstances it was not possible to test for the fish welfare benefits.

Barrier

The closed containment system (volume 1750m^3) was deployed on a conventional salmon pen at the Marine Institute test site. Additional sub surface flotation was added to the closed containment system prior to deployment. This consisted of closed cell foam contained within an abrasive resistant PVC tarpaulin. It added an additional buoyancy of 750kg.

Equipment failure in previous years resulted in suboptimal filtration and inlet water flow. The inlet drumfilter was removed from the system as this reduced water flow on a continuous basis. This was replaced by passive filtration consisting of a 4m x 4m x 4m polyester screen with a total surface area of 80m^2. Several screen sizes were tested prior to deployment to ensure adequate water flow. The filter volume was based on existing infrastructure at the Marine Institute's test site at Lehenagh Pool. The 25-micron screen did not allow adequate water flow through the filter. It was estimated that a screen area of 200m^2 would be required for an inlet flow rate or 20 litres per second. A 100- and 150-micron screen were also tested with the 100-micron screen deployed for the trial. The uplift pump was replaced by a submersible unit of greater capacity using the redundant power from the unused drumfilter. This kept power consumption low. A new aeration system was also added to the closed bag. The aeration system in conjunction with the increased buoyancy facilitated more effective self-cleaning.

The system was powered by a 24kwh storage hybrid system designed and built in 2019. It can provide three phase and single-phase power. The system consists of two renewable energy inputs, wind and solar and a 30kva genset. Power use to keep the closed containment system powered is 5kwh. This results in 120 units of electricity per day or 840 units per week.

Oxygen sensors were deployed inside the closed pen at two depths, 1m and 5m, to ensure sufficient oxygen was available for fish metabolism at all times. It was noted that oxygen availability at 5m was less than that at 1m by a daily average of 0.56mg/l. At 17.7C this equates to 6% Oxygen saturation. Under average conditions an additional water input of 15l/s was required to sustain oxygen levels within the closed containment system. This additional input would require an additional 2kwh of energy over the growout cycle, raising the energy requirement by 40% on the proposed system.

Furthermore, the oxygen deficit peaked at 2.24mg/l approximately two hours after feeding. It is recommended that once feeding has taken place water flow rates would need to be increased a further 60l/s for a period of three hours. Assuming three feeds per day this is an additional nine hours at 80l/s with an increase in power demand of approximately 9kwh. It is therefore calculated that pumping costs for 3,000 fish within this closed containment system would consume 207kwh per day or 1449kwh per week. This additional pumping was not available at the test site at Lehenagh Pool due to infrastructure requirements and additional filtration needs.

Bubble Curtain

The bubble curtain air feed system was reengineered to work with a grid system as used on Irish salmon farms. The reinforced hosing that was surface mounted in 2022 was replaced with a submerged primary feed pipe 90mm diameter and secondary feed lines of 40mm diameter. The air feed was secured to the grid. Bubble curtain tubing was then hung from the grid and weighted on every cushion float to ensure the bubble curtain did not rise to the surface. Two bubble curtains were deployed in July and August of 2023 to accelerate the learning process with one system deployed (site 1) in a site with significant wave exposure and a second (site 2) on a more tidal site with lower depths.

On site 1, the increased wave exposure required the attachment of additional weight to the hosing to ensure each section of the bubble curtain remained at the correct depth. The adapted air feed line system worked very well under exposed conditions with two replacement joints needed over a three-month period. The bubble curtain was deployed at a depth of 17.5m. This system had a liner curtain length of 840m. The curtain was functioning with two 75kw compressors, but the barrier was more effective when all three compressors were operational. The relative air flow was 1400m3/hr vs 2100m3/hr.

Intensive sampling showed that the bubble curtain was effective on plankton smaller than 1000micron (1mm) with no noticeable difference on larger plankton. The variety and frequency of wind and waves on the site have made it difficult to ascertain a % removal efficiency over the time period but fish health benefits were noted, and survival increased on previous stock generations. Trial results and industry feedback suggest that the bubble curtain can be effective in significant wave and swell conditions with both encountered during the trial period.

On site 2, the depths were much shallower with the curtain deployed at a depth of 11.5m. This site consisted of two grids deployed adjacent to one another. The bubble curtain was deployed on one grid with the second grid acting as a control. With a linear curtain distance of 700m and a depth of 11.5m, two compressors were adequate for running the system. This system was seen to foul more rapidly than the deeper deployed system. It was also noted that as the fouling increased the requirement for the third compressor increased.

The efficacy of the bubble curtain at this site revealed greater consistency with the bubble curtain preventing 30-50% of harmful or target species from crossing into the site. It was also noted that survival increased from 15-30% on a pen specific basis when compared to the unprotected site. The salmon also had a better appetite and subsequently showed increased growth. It was noted on this site that large plankton such as compass jellyfish were very prevalent following deployment. The bubble curtain raises these to the surface, and they become very apparent around the pens. The community structure of these plankton such as bacteria and

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virus carrying potential should be investigated. The direct impact on armoured vs naked phytoplankton species should also be further investigated.
The efficacy of the bubble curtain on this site was surprising given the mixed nature of the water column and its shallow depth. The deployment of the curtain on this site will enable the expansion of the bubble curtain to other shallow sites around the coast.

The use of real time remote sensing equipment was pivotal in the decision-making process regarding the utilisation or stand down of the bubble curtain at both sites. We continued to sample at the sensor locations to build up a profile of the water quality conditions and associated plankton. Tiered alarms have been established on the sensor viewing platform and this can now be used to action an on/off switch on the generator and compressor. The addition of more remote sensing equipment closer to the sites would add further reliability to this resource.

Resource Efficiency
A small feed and camera system were deployed on a test site in order to validate the effectiveness of Artificial Intelligence and machine learning when rationing feed on salmon farms. We established over a five-month period that during normal operation feed efficiency increased by approximately 5% when using the feed and camera system simultaneously. The rates of return on the cost effectiveness of the feeding system are magnified as the fish increased in size. From 100g to 200g for an estimated 100,000 fish, only 5.5kg of food is saved. But when those fish are grown to a predicted harvest weight of 5kg, 27.5 tonnes are saved. This is a saving of €60,000 over a production cycle. The most significant savings were derived from singular events such as rapid drops in water temperature and the system recognises the feeding behaviour of the fish and alerts the operator, the feed can then be switched off. When this occurs at cages with large fish 10t of food can be saved over a two-day period.

The hybrid system was delivered and tested, unfortunately, aging infrastructure on site may have resulted in the loss of the asset so the full hybrid technology trials were postponed to 2024. A powermeter was deployed on the site and it was ascertained that fossil fuel consumption should be reduced by 52% by the addition of the hybrid unit, wind profiles of the site in question indicate that the vertical axis wind turbine should yield an efficiency of 40%, or 96kwh day, this is sufficient to drive the feed system without the use of any fossil fuels, potentially making this the first fossil fuel free feed barge globally.

Summary of Project Spend

Summary of Spend	
Total Approved Costs	€794,000
Total Eligible Expenditure	€793,289
EMFAF Eligible Expenditure	€396,644
Exchequer	€396,644

Project Partners: Marine Institute
Report by: Geoffrey Robinson
Date: February 2024

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