End-to-End Supply Chain Optimisation for Barramundi Farming

Background

Mainstream is aiming to change the market for Barramundi, in a similar way that fish farming has done for salmon. This entails: Selective breeding to increase growth rate and improve feed conversion; Developing new markets; Increasing production. To this end it is investing in new production facilities that will give it a 5-fold increase in production.

The farming process consists of 3 stages: (1) Hatchery, where the eggs grow into fingerlings. The fingerlings can be sold to other farms. At this stage, there is an excess of fish and the smaller ones can be culled to create a more even distribution of faster growing fish. Fish are transferred to the next stage every 30 days, at about 1g in weight. (2) Nursery, where the fish grow to about 135g. Further culling is carried out to shape the distribution and every 14 days, the fish that are at or above target weight are transferred to the next stage. (3) Growout, where the fish grow to saleable size, typically 666g. There is currently no culling carried out; slower growing fish are taken out of the main tanks and put into separate ones where they tend to catch up.The growth rates of fish and feed conversion are known as a function of size. Each of these varies among different fish due to genetics and random variation. Growth rate is also affected by other fish, with larger ones eating proportionately more. In each tank, there is a maximum capacity and a maximum feeding capacity.

The normal cycle is 30 days, with the exception of transfer from Nursery to Growout, which is 2 x 14 days. This represents an opportunity to group the larger, faster growing, fish together, leaving the others to catch up. A similar practice is carried out at the end of grow out. This could be done more often, given the negative impact that larger fish have on the feeding of the smaller ones. However, this currently requires extra labour and is believed to have an unsettling effect on the fish, and the slow growing fish ultimately eat more feed.

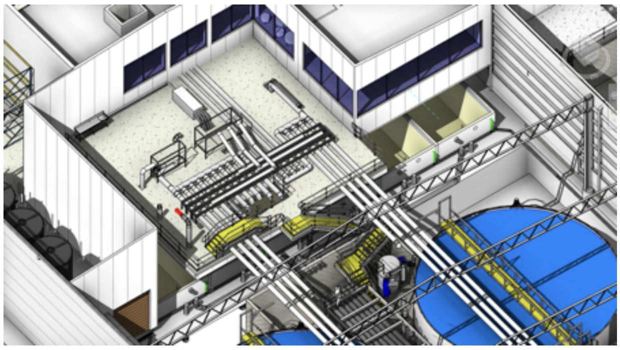

Figure 2: Mainstreams new plant designed with fully automated fish handling equipment. Process optimisation modelling will inform SOP's on fish handling.

Mainstream have a number of products: fingerlings for other producers to grow out, live barramundi, whole small fish around 800g, fillets, and banquet (whole) fish. Apart from live fish and banquet fish, it is assumed that the market is practically unlimited. Live fish and whole fish can be priced differently.

Summary

The aim of the study is to model the production process and design a managing tool that can be used to provide support to decision making in many aspects of production management, including initial stocking size, frequency of grading, percentage of culling and regrouping, and product mix for the current and future fish market.

In order to optimise it is needed to model the process, constraints and economics. Given the growth rate, time to double and feed conversion, some representation of the impact of larger fish on the growth and feeding of the smaller and the tendency of smaller fish to catch up when this impact is removed. The production costs generally can be categorized into fixed and variable costs.

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The Solution

Based on the data provided by MainStream, a data analysis is carried out to fit functions of growth rate and food conversion. Then linear and nonlinear models are developed to model fish growth from the Hatchery stage to the Growout stage and the impact on growth rate from the interaction of bigger and smaller fish in the same group. Causes have been identified for fixed and variable costs. For accuracy and flexibility, partial-fixed cost is introduced as another category. The production cost model constructed is able to accurately calculate the cost for growing fish through every stage, especially the cost per weight unit at each stage. Cases are designed to analyse the performance of growth models, characteristics of costs, and potential improvements in the process, including initial stocking size, frequency of grading, and percentage of culling and regrouping. The following figure shows a prototype of the managing tool.

Results

A program is developed to simulate the process of production at Nursery and Growout stages. In this study, we do not consider the Hatchery stage, which will be left for future work. The growth model and production cost model are implemented, and different stocking sizes are used to empirically analyse the different states of the farming system and find the best stocking size. An analysis on the impact of grading and regrouping is also carried out for the Growout stage.
The simulation results show that the current production process is not optimal in many aspects and a significant improvement can be achieved if optimisation is applied. From the simulations, we find that the initial stocking size in the current process is too large and the culling of more than half fish contributes a large share to the cost.

The capacity at each division is not optimally used; some divisions have capacity wasted and some divisions' capacity is not large enough to let fish grow without intension. The optimisation results provide the optimal durations for each division with different stocking sizes. For the Growout division, the simulation results show the impact of grading frequency and regrouping percentage and their optimal values for different initial stockings.

Potential

The simulation results show that the current operation is not optimal and optimisation can bring a huge potential benefit to the client. Besides the benefit to the current production, the optimisation models can also be used to guide redevelopment of the current farm infrastructure and designing a new infrastructure. The optimisation models and implement experience can become Mainstream's products and services provided to other farms.

Acknowledgments

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