CREATION OF A NOVEL TOOL FOR THE AQUACULTURE INDUSTRY TO DELIVER HEALTHY AND SUSTAINABLE SEAFOOD

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Introduction

The fast-growing contribution of aquaculture to global seafood production in recent years has increased scrutiny of the long-term environmental and socio-economic sustainability of the industry. Environmental and ecological concerns include the sustainability of aquaculture feeds, the management of water quality and benthic impacts, health and welfare challenges, biosecurity and escapees, amongst others. Addressing these has become critical to unlock the development of the industry, both in established segments, such as Atlantic salmon (*Salmo salar*) or blue mussels (*Mytilus* spp.), and novel species, such as sugar kelp (*Saccharina latissima*) farming.

Social acceptance and environmentally sustainable production of Atlantic salmon in Scotland have been aided by effective operational changes, such as the replacement of wild-caught fish in feeds by terrestrial ingredients, as well as trials to explore the potential of integrated multi-trophic aquaculture (IMTA) to reduce the local footprint of fish farms. However, this decrease of wild-caught fish in aquaculture feed has reduced the poly-unsaturated fatty acid (PUFA) content in the final product (Sprague et al. 2016), affecting the key marketable attribute and, thus, the health value of oily fish. Furthermore, though feed composition has been linked to the products' nutritional value, it is unclear how changes in feed composition translate to changes in the farm-level environmental footprint of production, a crucial issue to the sector's regulation and social licence to operate.

In practice, though past trials (i.e. IMTA) aimed to reduce the local footprint of fish farms and real operational changes (i.e. ingredient substitution in feed) target a reduction in the global impacts of fish farming, no study has looked at the health-environmental synergies and conflicts that result from changes in operational choices. Several questions arise from this: How does changing fish feed affect the health value of aquaculture products and the farm-level environmental footprint? How sensitive is the farm-level environment to changes in the fish feed? And, if sensitive, how can negative impacts be minimised? Does this change in monoculture and IMTA contexts?

We propose that the nutritional quality of final products and the local environmental impacts at farm-level should not be assessed in isolation. Here we present a new application for industry to quantify the environmental, economic and nutritional output of aquaculture, in both monoculture and IMTA, given multiple operational changes.

Material and methods

An existing ecosystem model (Ren et al., 2012) was coupled to new models of fatty acid dynamics for Atlantic salmon, blue mussels and sugar kelp. The removal of salmon faeces and uneaten feed by mussels was modelled using a new size-dependent consumption model. A graphical user interface (GUI) allows the user to create a virtual Atlantic salmon monoculture and IMTA (Atlantic salmon, blue mussels, sugar kelp) farm and predict the consequence of operational changes to the local environment and nutritional output.

The user can vary farm location, the abundance of cultured and co-cultured species and the proximate composition of the fish (salmon) feed. Values selected by the user are fed into the underlying coupled ecosystem and PUFA model, driven by temperature and proximate composition of the fish feed. Modelled output is species abundance and fatty acid content, particulate organic carbon and nitrogen, dissolved organic nitrogen, ammonium and nitrate concentrations in the water column, total organic carbon and nitrogen concentrations on the sediment. The concentration of the latter nutrients can be used as a proxy for the farm-level environmental footprint.

Results

We demonstrate the model with results from an IMTA farm given a representative feed. Figure 1 shows an example of how results are viewed in the GUI for salmon fatty acids and daily faecal waste from the salmon stock (the latter is a large contributor to total organic waste of the farm). Further outputs, such as fatty acid content in mussels and seaweed, and nutrient concentrations will be presented in full at the conference.

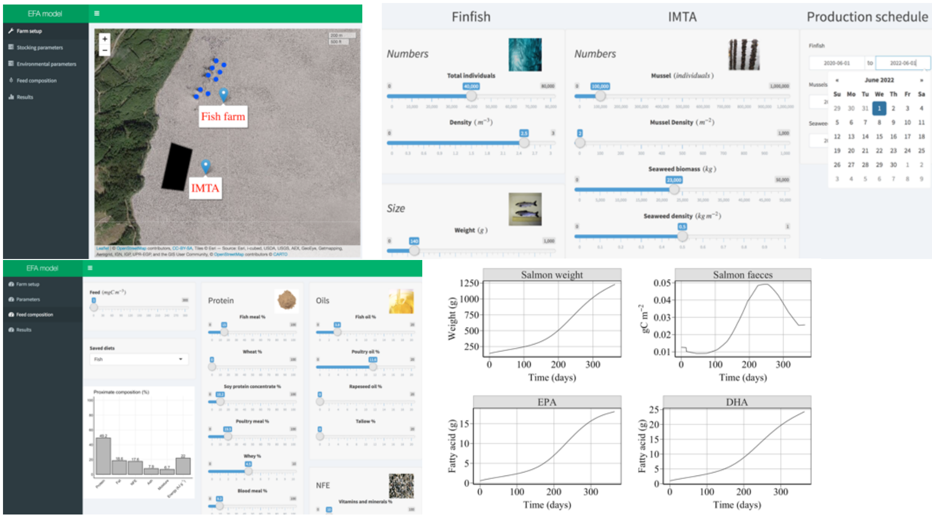

Fig. 1. An example of setting up a farm (upper left), selection of production variables (upper right) and feed ingredients (lower left) and output simulation of changes in salmon weight, total faeces and fatty acid profile (shown for EPA and DHA only) (lower right).

Discussion and conclusion

The FYNE model was designed for business use and allows to hit targets for fatty acid nutritional quality and harvestable weight, while helping to comply with regulatory frameworks on farm discharges and environmental impact. Current work is being done on model validation and parameterisation of the ecosystem component and will be presented at the conference. Future model development will focus on the economics of monoculture and IMTA farms so that, given a choice of farm setup, the user is presented with a timeline of running costs and profit. User testing of the GUI and discussion with businesses will identify features to be improved for commercial use. These additions will ensure the GUI offers a holistic view of a farm to optimise trade-offs between profit, nutritional value of the products and local environmental impacts during grow-out stage.

References

Chang et al. 2019, shiny: Web Application Framework for R, R Package Version 1.4.0. Available at http://CRAN. R-project. org/package= shiny.
Ren et al. 2012. Ecological Modelling, 246, 34-46.
Sawyer et al. 2016. Ecological Modelling, 323, 96-105.
Sprague et al. 2016. 2006–2015. Scientific reports, 6(1), 1-9.