COMPLETED PROJECT CASE STUDY

SAVED: VALIDATING MODELS TO PREDICT AND MEASURE SEA LICE ON SALMON

PARTNERS

University of Strathclyde | Mowi Scotland | Scottish Government's Marine Directorate | The Norwegian Institute of Marine Research | SEPA (Scottish Environment Protection Agency) | Firum (a limited company owned by the Faroese government and formerly known as Fiskaaling) | Scottish Sea Farms (SSF) | Bakkafrost Scotland | The NW Edge

AUTHORS

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BACKGROUND

Understanding sea lice behaviour, dispersion and control is vital for promoting sustainable aquaculture, assessing risk to wild fish populations, and ensuring the long-term robustness and productivity of salmon farming worldwide. There has been a growing push in recent years to collect and use data to support farming operations, including models to predict sea lice levels. The 'Sustainable Aquaculture: Validating Ectoparasite Dispersal (SAVED)' project described in this case study aimed to extend our knowledge of the environmental impact of salmon farming and understand any detrimental impacts on wild fish populations.

The University of Strathclyde acted as the lead academic partner, providing expertise in dynamic systems and sea lice behaviour models while developing comparison and validation models. The lead commercial partner was Mowi Scotland, and other partners include the Scottish Government's Marine Directorate, the Norwegian Institute of Marine Research, the Scottish Environment Protection Agency (SEPA), the Faroe Islands company Firum, Scottish Sea Farms, Bakkafrost, and The NW Edge. The various partners – according to relevance – provided information such environmental data, insight into regulations and the physical aspects of their regions, finfish pen data, insight into sea lice management, and participated by sharing model outputs.

AIMS

The international SAVED project primarily aimed to create a benchmark test tool to validate and compare different sea lice dispersal models developed by industry, academia, and government agencies. These models seek to predict the spread of sea lice in salmon aquaculture environments.

By evaluating the models against empirical data and outputs, the project sought to ensure their accuracy and applicability across key salmon-producing nations, including Scotland, the Faroe Islands, and Norway.

STANDARDISING AND VALIDATING SEA LICE PREDICTIONS

SAVED was undertaken with a structured yet flexible approach, incorporating collaboration, iterative problem-solving, and tool development. The seven-month project was designed to run from January 2024 through July 2024, in four work packages (WP).

WP1: DATA COLLATION AND COMPILATION

During this work package, the team sought to gather existing data on sea lice infestation levels, environmental parameters, and wild fish populations from various salmon farming regions.

WP2: MODEL COMPILATION AND STANDARDISATION OF OUTPUTS

The second work package considered already developed sea lice dispersal models incorporating physical and behavioural aspects. During this stage, the project team also aimed to create a standard for sharing model output and associated metadata and, secondly, to produce a tool for model developers to verify that the model data conforms to this standard.

WP3: MODEL VALIDATION

Using empirical data from sentinel cages, plankton surveys, farm lice counts, and wild fish studies, the SAVED researchers would validate the model developed in WP2.

WP4: TESTBENCH DEVELOPMENT

During the final work package, the SAVED project team aimed to create a user-friendly software platform for running the testbench that allows comparison of sea lice dispersal models.

The testbench workflow involved using the infection pressure model to simulate lice burdens under baseline and model-driven conditions, and comparing model outputs to empirical data using metrics – such as the Kantorovich-Wasserstein distance – to evaluate the accuracy of the dispersion model.

RESULTS

Although the SAVED project did not fully achieve its original aim of developing a validation tool that could be used across salmon-producing regions and farm environments, the team achieved significant milestones, focusing on:

1. Developing a novel model linking sea lice density to expected distributions in fish populations
2. Creating a prototype software tool for data exchange and validation
3. Publishing an ontology for describing datasets, ensuring reusability beyond the project

In the initial planning stages, the project partners encountered challenges with required versus available data, delaying progress. A pragmatic decision to use the Loch Linnhe sentinel cage data provided a starting point. However, this limited the engagement from Faroese and Norwegian partners due to non-uniformity of data with their regions.

The absence of shared data infrastructure posed significant challenges. Attempts to use institutional or cloud-based services were hindered by administrative barriers, leading to reliance on personal and community-supported infrastructure; a suboptimal but necessary workaround.

To validate the data, annotated metadata was required, allowing partners to track information such as where data originated, the units used, and which data corresponded between datasets. Tools like JSON-LD and LinkML were explored for annotating datasets but proved cumbersome and error-prone. The need for a specialised, ergonomic annotation language remains an open problem.

There was no established consensus on connecting time-varying sea lice densities to observed distributions of sea lice on infected fish in sentinel cages. To address this gap, the team developed a novel approach. The method developed models the rate at which fish become infected with sea lice as proportional to the lice density in the water, with variations based on the lice burden on individual fish. Although this problem is typically approached using computationally expensive agent-based models, it was reformulated to produce a much more efficient system of differential equations for the expected distribution. This innovative encoding not only meets the needs of this study but also holds potential for application in other fields.

Training government colleagues on experimental testbench software was impeded by restricted internet access. Despite these issues, the team demonstrated the system's functionality and presented their findings at key forums, including the MASTS Annual Science Meeting and the SLIPd project launch.

IMPACT

Despite a shortened timeline and significant challenges, the SAVED project achieved notable advancements in understanding the environmental impact of sea lice dispersal in salmon farming. The infection pressure model and prototype software offer a foundation for future research and practical applications in aquaculture management.

Key lessons include the importance of robust infrastructure, clear data-sharing protocols, and specialised tools for metadata annotation. Moving forward, the team plans to publish their findings, seek funding for doctoral research on scientific data processing pipelines, and contribute to ongoing initiatives like SLIPd (a SEPA, Marine Directorate, and IMR project).