BLUE ECONOMY
COOPERATIVE RESEARCH CENTRE

Australian Government
Department of Industry, Science, Energy and Resources

AusIndustry
Cooperative Research Centres Program

SHORT SUMMARY

4.20.005 Part 1
Jellyfish Mitigation for Offshore Salmon Aquaculture in Australia

KEY POINTS

- Jellyfish can have a severe negative impact on farmed finfish health and contribute to substantial mortalities and higher production costs.
- At present a relatively small number of taxonomically diverse species are recognised as problematic.
- The biological and environmental drivers of jellyfish populations vary for each species, although temperature, food availability, oceanography and weather are key drivers of blooms and dense aggregations.
- There is virtually no quantitative evidence for the efficacy of current jellyfish mitigation strategies.
- Moving farms offshore is unlikely to change or reduce the impact of jellyfish on aquaculture.
- The industry should carry out targeted studies to assess the efficacy of known mitigation strategies.
- In terms of moving offshore, the industry should focus on developing highly automated, remotely operated mitigation strategies, e.g. AI image recognition and early warning systems.
- Knowledge of harmful jellyfish species in Tasmania is limited; this can be addressed by implementing a coherent zooplankton monitoring programme.

THE CHALLENGE

Jellyfish have been a problem for marine finfish aquaculture since the 1950s and have been particularly problematic for the salmon aquaculture industry. The problem has been most prevalent in northern Europe and the impact of harmful jellyfish has been most severe in Ireland and Scotland.

Three taxonomic groups of gelatinous species can impact fish health and cause high mortality rates, harmful jellyfish are from the Phyla Cnidaria, Ctenophora, and Chordata (Order Tunicata). Cnidarian jellyfish possess stinging capsules that harpoon and envenomate salmon, with the delicate gill tissue being particularly vulnerable.

All large bloom forming species are capable of clogging marine pens, reducing water flow and reducing oxygen concentration, leading to hypoxia and asphyxiation of fish.

High mortality events tend to capture the most attention, however, the chronic health impacts due to the constant presence of small hydrozoan jellyfish at relatively low densities may be of greater importance.

These chronic impacts often co-occur with a range of other pathogenic infections and jellyfish, as well as causing the initial injury to fish, are possibly the vector for secondary infections. The mitigation strategies that might prevent these impacts are poorly documented, and it is difficult to assess how current mitigation strategies will work in offshore locations.

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Figure 1. Injuries to farmed Atlantic salmon caused by jellyfish. Images show large areas of necrosis on the skin and gills of the salmon.
Figure courtesy of Hamish Rodger.

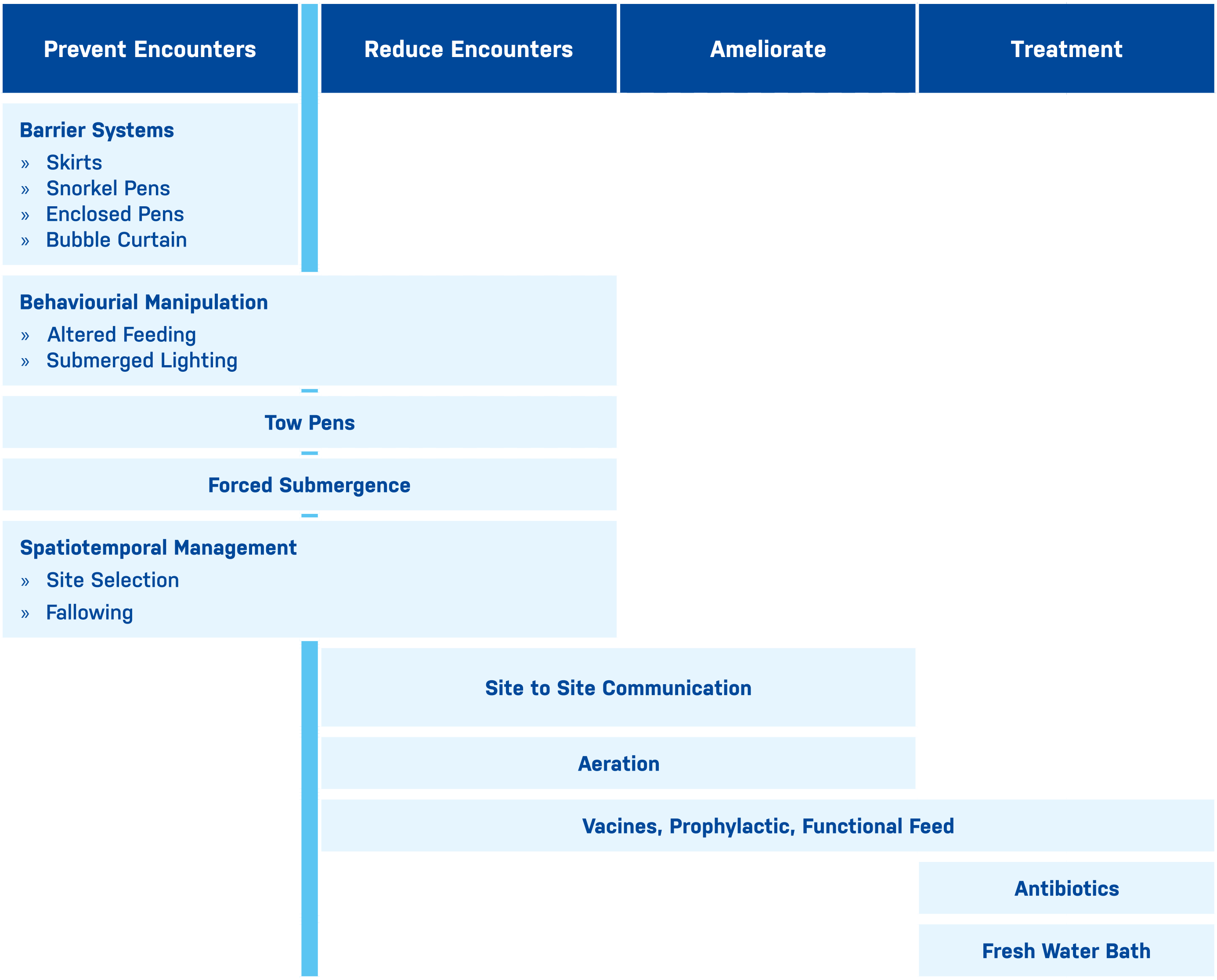

Figure 2. Summary of mitigation strategies used in the management of harmful jellyfish species

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THE OPPORTUNITY

Harmful jellyfish species have a severe negative impact on the health of farmed fish, can cause extremely high mortalities, and cost the global industry hundreds of millions of dollars annually. Developing mitigation strategies with proven efficacy can protect fish, ameliorate the impact of harmful jellyfish, reduce the rate of secondary infections and reduce the need for chemical therapeutics.

These benefits will increase yield and lower costs. Long term ecological monitoring is an important foundation upon which mitigation strategies should be based and can develop the knowledge base and expertise within the industry. Moreover, this knowledge is fundamentally important for collaborative efforts to develop advanced monitoring systems, e.g. AI image recognition and predictive early warning models.

OUR RESEARCH

This report provides a review of the ways in which jellyfish impact finfish aquaculture, a review of current and novel methods for jellyfish mitigation strategies, an assessment of how jellyfish will impact aquaculture as it expands offshore, and an assessment of which mitigation strategies are most useful for offshore aquaculture.

OUTCOMES

Current mitigation strategies for dealing with jellyfish are often the same strategies used to protect against harmful algal blooms and sea lice. Strategies can be broadly separated into three categories,

1. barrier systems to exclude jellyfish from pens,
2. measures to reduce jellyfish – fish encounters once jellyfish have entered pens, and
3. treatment of injuries/infections. Despite some of these strategies being in use for over 40 years, clear and unequivocal quantitative evidence for their efficacy is relatively rare. There is virtually no quantitative evidence for their efficacy as a jellyfish mitigation strategy.

The industry in Australia needs to develop a greater understanding of harmful jellyfish species, however, it has many factors in its favour, and with targeted research that understanding could be developed in a relatively short period.

The industry in Australia is highly automated and collects large amounts of environmental and fish health data which could be used to retrospectively analyse fish health/mortalities against environmental variables. This would be a good place to start, can be started rapidly, and would provide guidance for further research. The industry has multiple research/academia links from this and previous CRC projects, and therefore has access to substantial knowledge and experience in the topics of coastal modelling, Aurelia sp. population dynamics, and salp population dynamics

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NEXT STEPS

Recommendation 1: Implement Consistent zooplankton monitoring across sites using standardised protocols. Sampling must include stratified vertical sampling; this knowledge is crucial in assessing some of the proposed strategies here. A focus on the most exposed, furthest from shore sites and the development of common identification keys across the industry are important.

Recommendation 2: Continue to develop AI image recognition systems as part of an early warning system. In addition, the long-term collection of video data will support ecological modelling and the progress towards predictive modelling tools.

Recommendation 3: Barrier systems could potentially be tested at fallow inshore sites, thereby no risk to fish. Short duration studies during high risk jellyfish periods would be sufficient to form a judgement as to whether these systems deserve further time and effort. It is important to remove as many factors as possible to test these systems initially, therefore, the most sheltered site should be used. Engineering a system for the offshore environment can come later.

Recommendation 4: Conduct a comprehensive audit of existing data held within the industry. Environmental data, fish health data, mortality data, net cleaning records, and meteorological data currently should be assessed for quality and may be used in retrospective analysis of past high mortality events. This can provide valuable insight into how to monitor most effectively, what to monitor, and direct future research efforts.

Recommendation 5: Conduct a review of existing models, ecological and hydrodynamic, that might be repurposed to the study of jellyfish ecology.

Recommendation 6: It would be beneficial to secure ship time on national research vessels to study the offshore distributions and population dynamics of high-risk species. There is high quality research on salps in the Tasman Sea which can be used to plan this type of sampling.

PROJECT TEAM

- Professor Kylie Pitt (Griffith University)
- Professor Bela Stantic (Griffith University)
- Dr Ranju Mandal (Griffith University)
- Dr Tom Doyle (University College Cork, MaREI)
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- Dr Colin Johnston (Tassal)
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- Mr Adam Smark (Huon Aquaculture)

PROJECT REPORTS/PUBLICATIONS

Haberlin D, Doyle T, Pitt KA (2021) Use of image recognition technology to mitigate impacts of marine wildlife on aquaculture. Part 2: Jellyfish Mitigation for Offshore Aquaculture in Australia. 4.20.005. Final Project Report. Blue Economy Cooperative Research Centre

SHORT SUMMARY AUTHOR

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4.20.005 Part 2
Image Recognition of Jellyfish & Testing of the Prototype Network

INTRODUCTION

As aquaculture continues to expand and move offshore, interactions between aquaculture and marine wildlife will continue to increase. New methods, therefore, are needed to detect and manage interactions between aquaculture and problematic marine species.

KEY POINTS

- We reviewed the types of approaches used to automate the detection and identification of marine fauna in underwater videos, with emphasis on jellyfish, which are problematic for finfish aquaculture.
- Proof of concept for a jellyfish image recognition system based on convolution neural networks was established. The prototype network successfully detected two types of jellyfish (moon jellyfish and salps) in video footage collected from feed cameras inside Tasmanian salmon pens.
- Numerous other applications for image recognition technology were identified that could benefit finfish aquaculture as it expands into more remote and less accessible environments.

THE CHALLENGE

Expansion of finfish aquaculture into offshore and energy-intensive environments that are less easily accessed by people, is driving the need for routine monitoring of farms to be automated.

Image recognition technology offers considerable potential for automating observations usually made by people, including detection of wildlife that are problematic for finfish aquaculture, such as jellyfish. Different types of jellyfish cause different problems and require different management responses. For example, stinging jellyfish (cnidarian medusae), which can kill and injure fish, are managed by increasing feeding of fish, which draws fish deeper into pens and away from jellyfish. Non-stinging jellyfish (e.g., comb jellies and salps) affect fish indirectly by occluding nets, restricting water flow and reducing oxygen concentrations inside pens; they are managed by reducing feeding to lower the metabolic demand of fish and activation of aerators.

Jellyfish mitigation strategies need to be enacted quickly, so image recognition systems must accurately detect and identify different types of jellyfish. Detecting jellyfish inside fish pens poses some unique challenges because jellyfish are translucent and may be obscured by fish and infrastructure.

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4.20.005 Part 2 Image Recognition of Jellyfish & Testing of the Prototype Network

THE OPPORTUNITY

Globally, jellyfish cost finfish aquaculture tens to hundreds of millions of dollars annually. Jellyfish pose current problems for the Tasmanian salmon industry and will remain a challenge as farms move further offshore and into more extreme environments, since most of the jellyfish that affect inshore farms also occur offshore. A jellyfish image recognition and alert system will thus immediately benefit the Tasmanian salmon industry but will also be a critical tool for remotely monitoring pens in offshore environments.

The jellyfish alert system could be tailored specifically for the Tasmanian salmon industry but could also be trained to become a globally relevant system if videos containing observations of jellyfish are obtained from fish farms overseas. A jellyfish alert system, therefore, has considerable potential to be developed into a commercial product that would benefit finfish aquaculture globally.

OUR RESEARCH

We reviewed the application of image recognition systems to detect fish, plankton and jellyfish and highlighted specific challenges associated with developing image recognition for jellyfish in aquaculture settings. Proof of concept for a jellyfish recognition system was established by building a prototype convolutional neural network that was developed and tested using video footage of jellyfish taken inside Tasmanian salmon pens. Finally, we explored other ways image recognition technology could be used to benefit finfish aquaculture more generally.

OUTCOMES

The use of image recognition technology to monitor jellyfish is in its infancy. Existing systems have detected relatively large species of jellyfish in clear water and simple visual environments.

We demonstrated that an image recognition system could be developed to detect different types of jellyfish using video footage obtained from feed cameras inside the complex visual environment of a salmon pen. Importantly, our system correctly detected and identified salps, which were considered to pose a particular challenge to detect because they are small and translucent.

Numerous other applications for image recognition technology were identified. These include monitoring of biofouling loads on nets, monitoring the growth, health and behaviour of fish, detecting unwanted wildlife within fish pens and, potentially, recognition of individual fish. Image recognition technology is thus likely to become an integral tool for remote monitoring in the aquaculture industry as it expands into environments where frequent severe weather and sea conditions will reduce access to farms by people.

NEXT STEPS

Our successful prototype jellyfish image detection system demonstrates that a jellyfish alert system could be developed for use by the Tasmanian salmon industry.

We recoommend developing a jellyfish alert system specific to the Tasmanian industry and then expanding the system to become globally relevant by training the network to identify jellyfish in fish pens from other regions of the world.

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PROJECT REPORTS/PUBLICATIONS

Stantic B, Mandal R, Pitt KA (2021) Use of image recognition technology to mitigate impacts of marine wildlife on aquaculture. Part 2: Image recognition of jellyfish and testing of the prototype network. 4.20.005. Final Project Report. Blue Economy Cooperative Research Centre

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