



Growing a profitable, innovative and collaborative Australian yellowtail kingfish aquaculture industry

Bringing 'white' fish to the market

Fisheries Research and Development Corporation

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This summary is an excerpt from the final report, with minor edits made to ensure it meets departmental style and accessibility requirements. The final report will be made available by the Fisheries Research and Development Corporation in early 2021.

Summary

The project 'Growing a profitable, innovative and collaborative Australian Yellowtail Kingfish aquaculture industry: bringing 'white' fish to the market' was undertaken from 2015 to 2019 as part of the Rural Research and Development for Profit program.

Yellowtail kingfish (YTK) farming was identified by the Fisheries Research and Development Corporation (FRDC) as the greatest opportunity for new aquaculture development in Australia over the next few decades. Substantial increases in farmed area and product, and the use of aqua feeds will result in growth in regional economies and employment.

The key challenge to achieving this growth for YTK was for industry to diversify its focus from supplying only the relatively small volume, high price sashimi market to the larger volume, lower price Australian 'white fish' market. This is to be achieved while enhancing farm productivity and reducing operating costs to maintain profitability and improve sustainability. Feed and feeding strategies comprise 60% of YTK farming operating costs and reducing these costs were the industry's highest common research and development (R&D) priorities.

More specifically, this project was designed to provide new information to assist industry to grow its position by developing more cost effective, sustainable feeds and feeding strategies to enhance YTK health and production.

Benefits to producers

At completion of the project, the independent project impact assessment identified economically quantifiable benefits to the Australian YTK industry in the areas of increased productivity and profitability, which flowed from:

- improvements to YTK specific growth rates and food conversion ratios as a result of improved feed composition and/or adoption of optimal feeding strategies for different water temperatures and YTK size/age classes

- reduced production losses because of improved management of YTK nutritional health (i.e. reduced incidence of disease)
- reduced input costs along the supply chain, particularly for aqua feeds, because of optimised more sustainable feed formulations and use of cheaper sources of protein to replace fish meal.

The unquantified project benefits were identified as increased efficiency and capacity of future YTK R&D and enhanced community wellbeing, which flowed from strengthened Australian YTK R&D networks across regions and between industry participants and greater knowledge of YTK R&D, including methodologies.

Flow-on effects of a more productive, profitable and sustainable YTK aquaculture industry on the social 'fabric' of Australian regional population centres and the environment where improved marine biodiversity and water quality was likely as a result of reduced nutrient loadings through improved feed composition, feeding strategies and feed assimilation.

The independent project impact assessment conservatively estimated that the Australian Government's investment in this project produced, in present value terms, an estimated total benefit of \$126.63 million, net present value of \$119.26 million, benefit-cost ratio of 17.2:1, internal rate of return of 46.5%, and a modified internal rate of return of 16.1%, all based on a medium coverage of benefits and confidence in assumptions.

However, it was also noted that these figures were highly dependent on the underlying YTK aquaculture production data, which included recently announced expected future production from Western Australia and that if these production figures were excluded the benefit to-cost ratio would still be 3:1.

Objectives

The project's focus was on growing the production and profitability of the Australian YTK aquaculture industry.

To achieve this the project had three primary research aims:

- 1) nutrition
- 2) feeding strategies
- 3) nutritional health.

Nutrition

Identify economically sustainable feeds and improved diet formulations to reduce the costs of commercially available YTK feeds by:

- evaluating alternative Australian farm protein and oil sources and the levels that they should be added in YTK diets so as to reduce the necessity for using more costly and potentially less sustainable wild derived fish meal and fish oil
- investigating the potential to reduce the level of protein that is required in YTK feeds by using higher energy and lower protein diets
- developing YTK summer and winter diet formulations that use optimal oil types and levels

- identifying the dietary needs of YTK for select essential dietary nutrients, particularly amino acids and fatty acids
- investigating the costs and benefits of dietary supplements.

Feeding strategies

Develop improved YTK feeding strategies that can improve producers' profits by:

- comparing the effects of optimal feed formulations and feeding strategies developed as a result of this project's R&D with a commercially produced and fed YTK feed
- evaluating the costs and benefits of using high as compared to low energy feeds at warm and cool water temperatures to determine the optimum number of times YTK should be fed
- evaluating the most advantageous combination of diet and feeding frequency for YTK
- evaluating the effect of feeding strategy and diet on the health and capacity of YTK brood stock to be successfully bred and produce juveniles
- developing an improved feeding schedule for YTK based on the incorporation of more information on water oxygen levels and temperature on fish nutrient and energy utilisation.

Nutritional health

Evaluate methods to determine the health of YTK through the analysis of the gut bacteria community (microbiome), immune system and blood chemistry and understand how different diets and feeding strategies can affect fish health and production by:

- developing a method to better evaluate fish health when undertaking nutrition and feeding strategy R&D
- collecting data on the health of the blood and key organs of YTK used in this project's R&D to ensure the nutrition and feeding strategy outcomes are for healthy fish and commercially meaningful
- characterising the type and abundance of the microbiome within the digestive system of YTK so that they might be managed to enhance YTK production in the future
- collecting information to understand how the YTK environment, growth, farm management procedures, disease and parental stock influence the microbiome of the YTK digestive system.

The project also had the aim to:

- enhance the capability, knowledge and networking of project participants and the broader Australian aquaculture industry by
 - disseminating project information through the holding of workshops, provision of presentations at conferences, and the publication of popular and scientific articles
 - training the students engaged in the project so as to develop the next generation of industry R&D providers
 - incorporating the outcomes of the project more broadly so as to allow the extension and translation outputs of this project to other Australian YTK producers, and Australian aquaculturists producing other 'white flesh' fish such as Cobia and Mulloway.

Methods and outputs

The research in this project involved juvenile through to broodstock YTK, primarily held in tanks in the onshore environmentally controlled facilities of the two key research providers, the South Australian Research and Development Institute (SARDI), Adelaide, South Australia and the New South Wales Department of Primary Industries (NSW DPI), Port Stephens, New South Wales.

Nutrition

Nutrition experiments were undertaken using a series of treatments and a control against which they could be compared, typically with 3-4 replicate tanks holding multiple YTK for each experimental treatment. The research demonstrated the relative capacity of YTK to digest nutrients and energy from a wide range of marine and land animal and plant protein and oil sources, and that the use of the optimum ones evaluated can be incorporated into commercial diets to reduce dependence on wild fish meal and oil sources, thereby increasing diversity of choice, reducing costs and enhancing sustainability. The optimum levels of protein, oil and energy, as well as select essential amino acids and dietary supplements to use in feeds were also defined, including in some instances when fed at summer and winter water temperatures.

Feeding strategies

Feed strategy experiments were typically undertaken using a series of treatments and a control, in replicated tanks holding multiple fish, although in two instances they involved using YTK in replicated cages in ponds.

The optimal feeding frequency was defined for two sizes of juvenile YTK under particular environmental conditions (for example summer as compared to winter water temperatures), as was the relationship between dissolved oxygen in the water and the health and performance of YTK. A traditional 'best practice' sardine and squid broodstock feeding strategy was also compared to a more convenient manufactured pellet feed one and the benefits and costs of each determined.

Nutritional health

In general, it was demonstrated from digestive tract histology, blood haematology and biochemistry that the YTK used in the nutrition and feeding strategy experiments were healthy, and the results of these experiments were not impacted by the presence of unhealthy fish. A 'challenge test' was also developed and validated that could be used to characterise the health ('robustness') of YTK used in nutrition and feeding strategy experiments in tanks.

The experiments used to evaluate the microbiome (bacteria community) associated with the digestive system and skin of YTK were either achieved by sampling nutrition and feeding strategy experiments in tanks; sea-cages on a commercial farm where differences existed in various farm management practices, including feed type, disease status and genetic stock; or wild sourced YTK. The project provided the first detailed descriptions of the microbiome in Australian YTK in relation to a wide range of different factors. It was found that in general, an increase in dominance by some bacterial species and a significant reduction in the diversity of other bacterial species occurred as a result of disease, farming and the feeding of a specific diet. However, this was not always clear, suggesting that many interacting factors contribute to the nature of the microbiome in the YTK digestive system.

A novel manipulation experiment undertaken at the end of the project showed that the gut and skin microbiome of YTK can be modified, important if this research is to lead to the development

of proactive techniques to manage YTK health. This experiment also demonstrated that the application of an antibiotic to control a common YTK disease may exacerbate the issue by allowing the proliferation of other bacteria species.

Outcomes

Nutrition

The results of the nutrition research have provided aquafeed manufacturing companies with information to improve YTK feed formulations and the cost effectiveness of commercial feeds. The provision of these improved commercial feeds will increase on-farm productivity, profitability and/or reduced operating costs, as well as enhanced the on-farm environment through improved nutrient utilisation.

Feeding strategies

The results of the feeding strategy research has enabled YTK aquaculturists to optimise the frequency and amount of feed fed on-farm to closer align with the nutritional requirements of YTK and the environment in which they are farmed. This has already reduced on-farm operating costs, increased profitability and enhanced the farm environment.

Nutritional health

Sampling methodologies, such as a challenge test, parasite monitoring and treatment, digestive tract histology, blood haematology and biochemistry, and microbiome assessment, were advanced for determining YTK nutritional health. A large reference data set was also established and early detection markers of changing health status proposed for two on-farm health issues. These advances will lead to increase on-farm productivity and profitability.

Collaboration

As a result of the project, strong relationships were built between researchers from the two research organisations involved, researchers and the four industry participants, and the six supporting universities. The four Honours, two Masters and six PhD students, and three postdoctoral fellows (or equivalent), benefited greatly from the applied research and opportunity for close interaction with industry. Students, researchers and project technical staff, both from research organisations and industry, also participated in a number of training sessions, with the 'YTK Health Training Workshop' the most substantial.

Extension

A wide range of extension activities were undertaken as part of the project, with the annual 'K4P Research Workshop' a highlight. Many workshop and conference presentations (verbal and posters) were given, and a number of popular and scientific publications produced, with more underway. As a final project extension activity a presentation was given as part of the 'Fisheries - making the most from a renewable resource' session at the ABARES Outlook 2019 conference, held in Canberra on the 5th and 6th March 2019.