Appendix G: 2015-005: Determining the susceptibility of Australian *Penaeus monodon* and *Penaeus merguiensis* to newly identified enzootic and exotic Yellow head virus genotypes.

Background

The Prawn fisheries support a substantial export industry in northern Australia with (Black Tiger Prawn (*Penaeus mondon*) and Banana Prawn species making the basis of the farming industry. New genotypes of the yellow head disease complex of viruses (YHV) that effects these species was discovered in farmed Australian prawns and overseas.

Until recently, yellow head virus genotype 1 (YHV1) was the only known virus to cause disease. In the early 1990s, YHV1 was the cause of mass mortalities of Black Tiger Prawns and other species in Thailand. YHV1 now has become an established pathogen of the Pacific white prawn in Thailand. Other YHV genotypes such as YHV2, YHV6 and YHV7 are known to occur in Australia and can be pathogenic (DAFF, 2020).

In 2013, a further six genotypes were discovered and more recently, a further four genotypes of YHV were found. While it is understood that YHV1 is exotic to Australia and can cause 100% mortality, YHV9 and YHV10 were recently discovered in imported prawn commodities from China, and YHV7 was detected in diseased Black Tiger Prawns in Queensland (Mohr et al, 2016). The role of these genotypes in causing disease is unknown. Overall, there are still gaps in understanding the pathogenicity of the newly discovered YHV genotypes. This project aimed to address that gap by determining the pathogenicity of YHV 7, 9, and 10 to two commonly farmed prawn species in Australia. Laboratory-based research was conducted at the CSIRO Australian Centre for Disease Preparedness Fish Diseases Laboratory (ACDP AFDL) in Geelong, Victoria. The experiment involved evaluating diagnostic testing methods (RT-qPCR assays) to determine the pathogenicity of three new YHV genotypes.

Description of the project

Table 54 Project summary of project 2015-005

Project code	2015-005
Title	Determining the susceptibility of Australian *Penaeus monodon* and *Penaeus merguiensis* to newly identified enzootic (YHV7) and exotic (YHV8 and YHV10) Yellow head virus (YHV) genotypes
Research organisation	CSIRO – Australian Animal Health Laboratory
Principal investigator	Nicholas J. Moody
FRDC project manager	Carolyn Stewardson
Period of funding	2015-2017
FRDC investment	$159,941
FRDC program allocation	100% Industry

Rationale	To determine the virulence and pathogenicity of YHV7, YHV8 and YHV10 genotypes in commonly farmed Black Tiger Prawns and Banana Prawns using RT-qPCR assay and evaluate the sensitivity and specificity of the assay for monitoring of prawn populations.
Objectives	• Determine the susceptibility of Black Tiger Prawn and Banana Prawn to YHV7. YHV8 and YHV10 • Transfer protocols and controls for diagnostic tests to state diagnostic laboratories
Activities and outputs	• Black Tiger and Banana Prawns were exposed to infectious doses of YHV genotypes and monitored daily for signs of disease and mortality to determine their susceptibility to infection. In trails 1 and 2, prawns were also exposed to YHV1 as a positive infection control and to confirm the pathogenicity to this genotype • Susceptibility of infection was determined by exposing prawns to each genotype • Prawn health was monitored daily for signs of disease and mortality and samples were collected for testing to determine the presence of virus in dead, diseased, and surviving prawns • The experimental setup was sequential with experiment 1 assessing the pathogenicity of different genotypes at 24˚C • Then based on results, experiment 2 investigated pathogenicity by natural routes of infection such as feeding pathways • Experiment 3 repeatedly exposed giant white prawns to YHV7 by injection, co-habitation and feeding at 24˚C to confirm results from prior trials
Outcomes	• Banana Prawns and Black Tiger Prawns are highly susceptible to YHV1 infection causing 100% mortalities in both species 4 to 6 days after exposure • Both species are susceptible to YHV9 infection but refractory to disease • Species are not susceptible to a YHV10 infection • Black Tiger Prawns were infected with YHV7 after injection, co-habitation, and feeding with low levels of pathogenicity as less acute mortalities were recorded
Potential impacts	• Improved understanding of the susceptibility of farmed Australian Black tTger and Banana Prawns to newly discovered YHV7, 9, and 10 genotypes • Empower policymakers, regulators, managers, and producers with information to develop and implement biosecurity measures against YHV complex of disease • Increased biosecurity of imported prawn commodities as well as Australian farmed products • The bioassay protocols developed during this study can be used to assess the pathogenicity of other emerging pathogens • Disease can be screened for in broodstock, entry to farm, in the wild environment and in the case of an outbreak for prioritisation of harvest

Project investment

A breakdown of FRDC investment and contribution by others by financial year is shown in Table 55.

Table 55 Total investment in project 2015-005 from FRDC (nominal dollar terms)

Year ending June 30th	FRDC ($)	Others* ($)
2014/15	$31,882	
2015/16	$34,936	$129,971
2016/17	$77,128	$134,127
2021/22	$15,994	
Total	**$159,941**	**$264,098**

Source: Documents provided by FRDC.

*Contributions to the project cost not sourced from FRDC e.g. in-kind contributions

For the BCA, the cost of managing the FRDC funding was added to the FRDC contribution for the project using a management cost multiplier of 1.157. As per impact assessments in previous years, this multiplier was estimated based on a five-year average of the ratio of total FRDC non-project cash expenditure to project expenditure as reported in FRDC's Cash Flow Statement (FRDC Annual Reports, 2019-2023). No multiplier was applied to the investment by other contributors, as it was assumed that project management and administration were included in the value of funding provided.

In undertaking the impact assessment, all past costs were expressed in 2023/24-dollar terms using the Implicit Price Deflator for GDP.

Summary of impacts

Table 56 below provides a summary of the expected triple bottom-line impacts (economic, environmental, and social) from the project.

Table 56 Triple bottom line impacts, including those valued as part of this evaluation (in bold)

Economic	• **Reduced on-farm occurrence due to screening opportunities. In the event of an occurrence, costs are likely to be lower due to the ability to prioritize harvest** • Potential to inform policy development and implementation of measures against YHV complex
Environmental	• Improved biosecurity across Australia's farmed and wild-caught prawn industries
Social	• Increased research capacity

Public versus private impacts

Benefits are expected to accrue in the majority to private industry, although there are potential benefits in application to wild prawns.

Distribution of private impacts

Private impacts realised from this project will be distributed amongst prawn farmers that increase screening for YHV 7 or need to utilise testing in the case of an outbreak.

Impacts on other Australian industries

No direct impacts to other Australian primary industries were identified.

Impacts overseas

No direct impacts overseas were identified.

Quantification of impacts

For the BCA, the key benefit of a reduction in risk of YHV7 has been quantified. Clarity was provided through consultations with JCU and researchers involved that there has been a significant decrease in the risk, and consequence in the case of, an occurrence of YHV7. Proxy numbers from the White Spot Disease (WSD) outbreak have been used to estimate the consequences associated with a high-consequence outbreak on-farm, although the likelihood of spreading between farms has been said to be much lower for YHV7. The industry has seen a significant increase in value following the WSD outbreak, hence, the quantification is likely conservative in the estimate of benefits.

Estimated benefits

Table 57 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Consequence associated with WSD outbreak in lost prawn crop on-farm, for 6 farms	$23.5M	*Economic impact of 2016 White Spot Disease Outbreak* (Ridge Partners, 2017)
b) Comparable mortality rate for YHV7	80%	Project report indicates that mortality would not be the 100% observed in WSD
c) Consequence for 1 farm	$3.13M	b x (a / 6)
d) Annual risk of crop loss	20%	Per comms, reported 2 outbreaks in last 10 years
e) Annual risk	$626,700	c x d
f) Decrease in risk with project	75%	Analyst assumption, based on comms that the risk would be largely 'avoided'
g) Remaining risk	5%	d x (1-f)
h) Remaining annual risk	$156,600	g x c
i) Marginal savings annually	$470,100	e – h

Adoption costs

Although there are likely to be greater costs associated with greater screening for YHV7, consultations suggested that there would also be a decrease in testing fees for YHV2 as was previously considered important. Hence, this modelling has assumed a net zero change in testing fees.

Counterfactual

The counterfactual is that a similar outcome would have been achieved, but there would have been a significant delay, leading to greater probability of outbreaks and farm mortality events in the short term. This assessment considered this delay to be 10 years, considering the significant costs associated with outbreak events, it is likely that this research would have occurred in the long term.

Attribution

The attribution of benefits from the project - summarised in Table 58 – considers all benefits to be attributable to this project, of which 41% is FRDC and 59% is other parties.

Table 58 Attribution of benefits for project 2015-005

Variable	Assumptions
FRDC costs	41%
Other project party costs	59%
Total	100%

Adoption

Benefits are likely to already be seen in industry, with increased screening already in place. Hence, this assessment considers benefits to be attributed from 2022/23 to 2033/34, over an 11 year period.

Results

Table 59 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24-dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the total investment returning a net present value (NPV) of $4.29 million and a favourable BCR of 8.3. Table 60 shows FRDC investment returning a NPV of $1.75 million and a BCR of 8.3.

Table 59 Investment criteria for total investment in Project 2015-005 ($M)

Year	0	5	10	15	20	25	30
PV Benefits	$1.17	$3.11	$4.57	$4.87	$4.87	$4.87	$4.87
PV Costs	$0.59	$0.59	$0.59	$0.59	$0.59	$0.59	$0.59
NPV	$0.58	$2.52	$3.98	$4.29	$4.29	$4.29	$4.29
BCR	1.99	5.29	7.78	8.30	8.30	8.30	8.30
IRR	14%	24%	25%	26%	26%	26%	26%

MIRR	8%	11%	11%	11%	10%	10%	9%

Table 60 Investment criteria for FRDC investment in Project 2015-005 ($M)

Year	0	5	10	15	20	25	30
PV Benefits	$0.48	$1.27	$1.87	$1.99	$1.99	$1.99	$1.99
PV Costs	$0.24	$0.24	$0.24	$0.24	$0.24	$0.24	$0.24
NPV	$0.24	$1.03	$1.63	$1.75	$1.75	$1.75	$1.75
BCR	1.99	5.29	7.78	8.30	8.30	8.30	8.30
IRR	14%	24%	26%	26%	26%	26%	26%
MIRR	8%	11%	11%	11%	10%	10%	9%

The flow of total undiscounted costs and benefits from the project is presented in Figure 7 below.

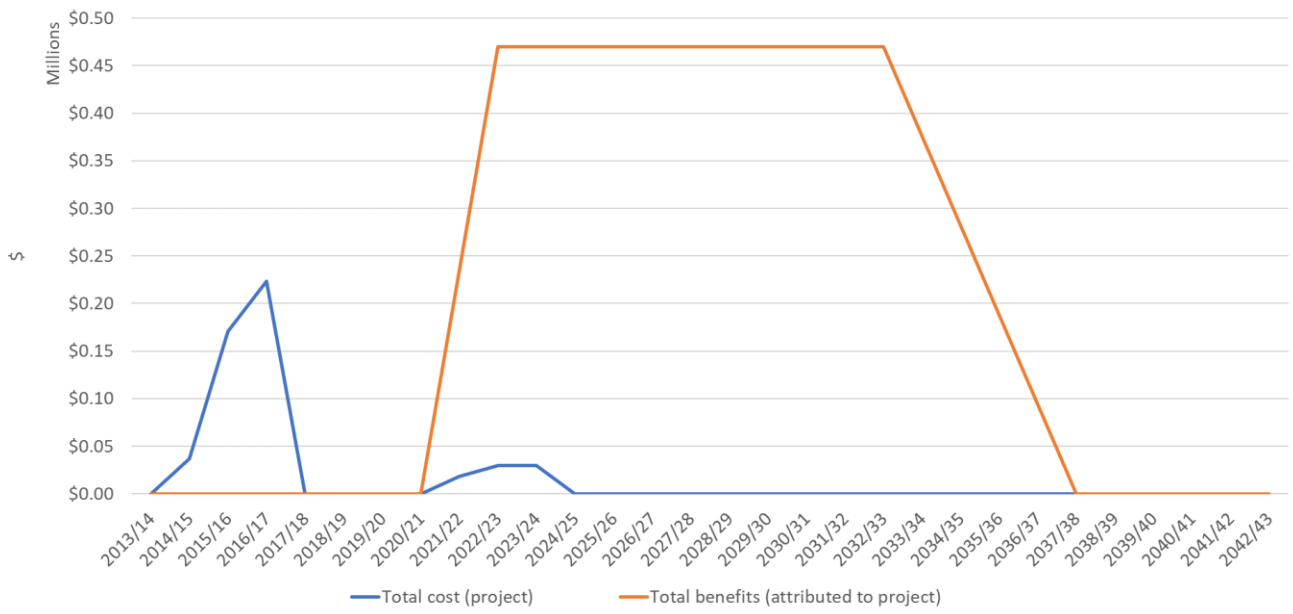

Figure 7 Flow of undiscounted costs and benefits from the project.

Sensitivity Analysis

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 61 below and remain positive under all modelled scenarios.

Table 61 Sensitivity analysis

Changes to key variables	NPV ($M)	BCR	MIRR
Standard assumption	4.29	8.3	9%
Discount rate			
4%	4.35	8.72	8%
6%	4.06	7.92	10%
Decrease in risk attributable to project			
65%	3.64	7.20	9%
85%	4.94	9.41	9%

Confidence ratings

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below in Table 62.

Table 62 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	There is potential for significant benefits still to be realised in the increased understanding of the YHV in the case of a more serious strain's outbreak. Further, other recommendations outlined in the report, such as increased YHV1 biosecurity measures, have not been included considering the lack of clarity in practice changes directly attributable to this project.
Confidence in assumptions	High	Owing to researcher and industry input, the assessment has been conducted on a strong base of assumptions.

Conclusions

Project 2015-005: Determining the Susceptibility of Australian Penaeus mondon and Penaeus merguiensis to Newly Identified Enzootic (YHV7) and Exotic (YHV8 and YHV10) Yellow Head Virus (YHV) Genotypes determined the virulence and pathogenicity of YHV7, YHV8 and YHV10 genotypes in commonly farmed Black Tiger Prawns and Banana Prawns and evaluated the specificity of the assay. It was found Black Tiger Prawns are susceptible to infection and mortalities from YHV7. The key benefit of a reduction in risk of YHV7 was quantified. Based on the adopted assumptions total FRDC investment will return a positive economic return (BCR of 8.3), which remained positive across all modelled scenarios. The delayed timelines arising from changing research priorities at the laboratory inflated the project costs due to conversion to present-day values.

References

DAFF (Department of Agriculture, Fisheries, and Forestry) (2020). *Infection with Yellowhead Virus Genotype 1 (YHV1)*. The Australian Government.
https://www.agriculture.gov.au/sites/default/files/documents/infection-yellowhead-virus-genotype-1.pdf

Mohr PG, Moody NJ, Hoad J, Williams LM, Bowater RO, Cummins DM, Cowley JA, StJ Crane M. (2016). *New yellow head virus genotype (YHV7) in giant tiger shrimp Penaeus monodon indigenous to northern Australia*. *Dis Aquat Organ. 2015 Aug 20;115(3):263-8*. doi: 10.3354/dao02894. Erratum in: Dis Aquat Organ

Moody NJG, Mohr PM and Crane MStJ, CSIRO. (2021). *Aquatic Animal Health and Biosecurity Subprogram: Determining the susceptibility of Australian Penaeus monodon and Penaeus merguiensis to newly identified enzootic (YHV7) and exotic (YHV9 and YHV10) Yellow head virus (YHV)* CSIRO Centre for Disease Preparedness**,** April. CC BY 3.0. Project 2015-005, prepared for FRDC.
https://www.frdc.com.au/project/2015-005

Ridge Partners (2017). Economic impact of 2016 White Spot Disease Outbreak.
https://www.frdc.com.au/sites/default/files/2021-07/2016-267-Project-Summary-Economic-Impact.pdf

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