Appendix N: 2017-203: Risk from diarrhetic shellfish toxins and *Dinophysis* to the Australian Shellfish Industry

Background

Marine biotoxins are chemical compounds produced by certain microalgae. Diarrhetic Shellfish Toxins (DSTs) are marine biotoxins that are produced by species belonging to the genus *Dinophysis* (and less commonly *Prococentrum*) (Ajani et al, 2021). DSTs can bioaccumulate through the food chain and cause Diarrhetic Shellfish Poisoning (DSP) (Ajani et al, 2021). DSP causes gastrointestinal symptoms, and may also promote tumor/cancer formation, although the impact of chronic exposure to DSTs is still not well known (Lee et al, 2016).

In NSW shellfish and aquaculture areas, since 2005 there have been 29 positive test results (<1%) recorded for the presence of DSTs (NSW Food Authority, unpublished data). Nationwide, there have been three serious human DSP poisoning events – in 1997, 1998, and 2000 (Quaine et al, 1997; Madigan et al, 2006; Burgess and Shaw, 2001). A failure to address DST and DSP can lead to an increase in seafood related illnesses, damaged public perceptions of seafood, and direct economic losses for the shellfish industry (Ajani et al, 2021). For example, the damage from one event of Paralytic Shellfish Toxins (PSTs, produced by *Alexandrium catenella*) in 2012/13 was estimated at $23 million (Ajani et al, 2021).

For this reason, the Tasmanian and wider Australian aquaculture/shellfish industries are proactive about monitoring and assessing their products for the presence of marine biotoxins and the microalgae that produce them (Ajani et al, 2021). There are currently three commercially available rapid test kits for the detection of DSTs, and five commercially available for the detection of DSP in shellfish (Ajani et al, 2021). However, there is still no clear identification of the DST toxin profiles present in Australian shellfish, nor an assessment of capabilities to detect these toxins (both in the laboratory and in-the-field rapid test kits). There is also a need to develop a rapid onsite molecular test for the presence of DST producing microalgae (qPCR), so that harvest management can become simpler, faster, and with fewer closures (Ajani et al, 2021).

Australian aquaculture industries are keen to adopt efficient, fast, and cost-effective management tools for biotoxins and the organisms that produce them (Ajani et al, 2021).

Project details

Table 108 Project summary of project 2017-203

Project code	2017-203
Title	Risk from diarrhetic shellfish toxins and *dinophysis* to the Australian Shellfish Industry
Research Organisation	University of Technology Sydney
Principal investigator	Penelope Ajani
FRDC project manager	Adrianne Laird
Period of funding	January 2019-December 2020
FRDC investment	$241,125
FRDC program allocation	10% Communities, 80% Industry, 10% People

Rationale	To generate new knowledge about DSTs in Australian shellfish.
Objectives	• Identify DST profiles present in Australian shellfish and assess laboratory capabilities to detect these toxins • Generate knowledge about commercial DST test kits and rapid molecular techniques (such as qPCR) for DST toxin and species detection • Compare the efficacy of commercially available toxin detecting kits using relevant sample matrices • Develop a quantitative PCR assay for *Dinophysis* species detection for potential onsite farm use • Provide cost versus benefit analysis of improved testing of DSTs in Tasmanian shellfish • Conduct a workshop to train shellfish industry members in the use of the rapid method of qPCR for *Dinophysis* detection in environmental samples and seek their advice and feedback on how to best move forward

Activities and outputs	• Examined DSTs in spiked and naturally contaminated shellfish, including the Sydney Rock Oysters, Pacific Oysters, Blue Mussels, and Pipis, in four laboratories and five rapid test kits. The results did not support the use of any DST rapid test kit as a stand alone quality assurance measure
	• Developed a rapid and quantitative polymerase chain reaction (qPCR) assay to detect species belonging to the genus *Dinophysis* in environmental sample. The qPCR was successful in the early detection of a bloom of *Dinophysis acuminata* in the Manning River on 9/2/2019.
	• Completed a cost-benefit analysis of rapid detection of DSTs using the Pacific Oyster industry in Tasmania as a case study. The analysis considered three hypothetical scenarios for the implementation of DST rapid testing:
	  • (1) Implement Neogen DST rapid kit testing on-farm in Tasmania
	  • (2) Implement Neogen DST rapid kit testing in laboratory in Tasmania
	  • (3) Implement qPCR testing on-farm in Tasmanian
	• Presentation to stakeholders at the Australian Shellfish Quality Assurance Program's Science Day
	• Conducted workshops to train farmers in rapid diagnostic testing
	• Acceptance of a manuscript for publication in *Toxins*

Outcomes	• Provided confidence to the seafood industry that all four tested laboratories offering marine biotoxin analysis can detect all analogues in all shellfish matrices with a reasonable error level • Contributed to knowledge about the use of current commercial available rapid DST test kits finding that they all have unacceptably high levels of incorrect results at the regulatory level and are therefore not suitable as a standalone method for quality assurance • Successful development of a rapid, sensitive and efficiency quantitative real-time qPCR assay, which with further development could be a valuable early warning tool for HAB monitoring
Potential impacts	• Greater knowledge about DSTs, DSP and quality assurance methods • Potential future cost savings in DST testing regimes if rapid tests could be further developed and validated • Potential for further development and validation of a simplified and commercialised qPCR pipeline for the detection of *Dinophysis* spp. for on farm use

Project investment

A breakdown of FRDC investment and contribution by others by financial year is shown in Table 109.

Table 109 Total investment in project 2017-203 from FRDC (nominal dollar terms)

Year ending June 30th	FRDC ($)	Others* ($)
2018/19	$21,796	$83,783
2019/20	$88,192	$6,000
2021/22	$131,137	-
Total	**$241,125**	**$89,783**

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

Table 110 Triple bottom line impacts, including those valued as part of this evaluation (in bold)

Economic	• Potential future cost savings in DST testing regimes if rapid tests could be further developed and validated • Potential for further development and validation of a simplified and commercialised qPCR pipeline for the detection of *Dinophysis* spp. for on farm use
Environmental	
Social	• Greater knowledge about DSTs, DSP and quality assurance methods

Public versus private impacts

The potential impacts identified from the project will accrue to both public and private beneficiaries. Any future efficiencies in the testing regime are likely to be of benefit to farmers and regulators in the respective states.

Distribution of private impacts

Future private impacts if realised would be of benefit to shellfish farmers as a cost saving in their testing regimes and harvest management strategies.

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

While the project contributed to improved knowledge about DSTs, DSP and quality assurance methods, at this stage there are no quantifiable benefits from the investment. The inclusion of rapid diagnostics in testing regimes has the potential to lead to cost savings and improve on farm harvest management in the future, however, this project ultimately found that none of the current commercially available rapid DST test kits are suitable as a standalone method for DST analysis in Australia at this time. Similarly, while the project did successfully develop a qPCR assay for *Dinophysis* species detection, further validation and commercialisation is required such that it is too early to quantify any potential impacts from this novel assay. It is likely that inclusion in a multiplex assay would make this a feasible tool in the future.

The benefit cost analysis completed as part of the project considered if there would be a reduction in commercial loss and economic impact from potentially harmful DST blooms in Tasmania following the introduction of any new diagnostic testing approach. It was concluded that to be implemented under the state's ShellMAP program, any new testing regime would need to be implemented at a frequency and scale that ensures the risk of an infected product leaving a growing area continues to be negligible. Therefore, it is considered that any new testing regime would not have any change to the expected commercial loss or economic impact from potentially harmful DST blooms.

Results

To maintain consistency for reporting and analysing projects, Table 111 below displays the modelled Present Value of Costs (PV Costs). The PV Costs were discounted to 2023/24 using the Implicit Price Deflator for GDP. The PV Cost is displayed for the length of the investment period plus 30 years from the last year of investment (2023/24).

The PV Costs for total investment were $0.44 million. Table 112 shows PV Costs from FRDC investment were $0.33.

Table 111 Investment criteria for total investment in Project 2017-203 ($M)

Year	0	5	10	15	20	25	30
PV Costs	$0.44	$0.44	$0.44	$0.44	$0.44	$0.44	$0.44

Table 112 Investment criteria for FRDC investment in Project 2017-203 ($M)

Year	0	5	10	15	20	25	30
PV Costs	$0.33	$0.33	$0.33	$0.33	$0.33	$0.33	$0.33

The flow of total undiscounted costs from the project is presented in Figure 13 below.

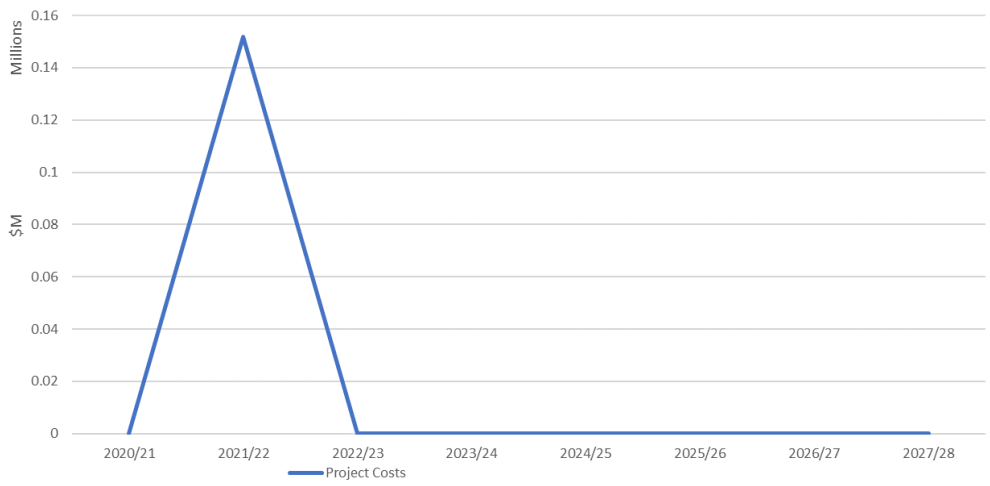

Figure 13 Flow of undiscounted costs and benefits from the project.

Conclusions

Project 2017-203: Risk from Diarrhetic Shellfish Toxins and Dinophysis to the Australian Shellfish Industry aimed to generate new knowledge about DSTs in Australian shellfish and investigate options for future approaches to testing that reduce testing costs and are effective at detection. While the project contributed to improved knowledge about DSTs, DSP, and quality assurance methods, the project ultimately found that none of the current commercially available rapid DST test kits are suitable as standalone method for DST analysis in Australia at this time. If rapid tests could be further developed and validated, there could be potential future cost savings in DST testing regimes, however, this benefit is too uncertain to quantify at this time. Similarly, while the project did successfully develop a qPCR assay for *Dinophysis* species detection, further validation and commercialisation is required such that it is too early to quantify any potential impacts from this novel assay. It is likely that inclusion in a multiplex assay would make this a feasible tool in the future. Overall, no benefits were able to be quantified in a BCA at this stage.

References

Ajani, P., Farrell, H., Hallegraeff, G., Helleren, S., Lamb, P., Turnbull, A., Zammit, A., Murray, S.A. (2021). *Risk from Diarrhetic Shellfish Toxins and Dinophysis to the Australian Shellfish Industry*. FRDC Project 2017/203. University of Technology Sydney (UTS). [Online]. Retrieved from: https://www.frdc.com.au/sites/default/files/products/2017-203-DLD.pdf

Burgess, V., Shaw, G. (2001). *Pectenotoxins - an issue for public health - A review of their comparative toxicology and metabolism.* Environment International 27(4), 275-283.

Lee, T.C.-H., Fong, F.L.-Y., Ho, K.-C., Lee, F.W.-F. (2016). *The Mechanism of Diarrhetic Shellfish Poisoning Toxin Production in Prorocentrum spp.: Physiological and Molecular Perspectives*. Toxins 8(10).

Madigan, T.L., Lee, K.G., Padula, D.J., McNabb, P., Pointon, A.M. (2006). *Diarrhetic shellfish poisoning (DSP) toxins in South Australian shellfish*. Harmful Algae 5(2), 119-123.

Quaine, J., Kraa, E., Holloway, J., White, K., McCarthy, R., Delpech, V., Trent, M., McAnulty, J. (1997). *Outbreak of gastroenteritis linked to eating pipis*. New South Wales Pub. Health Bull. 8, 103-104.

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