Rural R&D for Profit Program

Easy Open Oysters

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Plain English Summary

Many consumers are unwilling to shuck oysters, which is a huge barrier to any attempt by the industry to increase sales.

This project attempted to overcome the shucking barrier by developing the idea of an *Easy Open* oyster suggested by Mr Robert Simmonds, owner of Oyster Bob Pty Ltd. This entailed making a slit in the edge of the oyster shell and resealing it with wax so that the oyster remained alive but could be easily opened later by placing a knife through the slit and cutting the muscle that holds together the two shells of the oyster. To enable production of sufficient volumes of *Easy Open* oysters the process had to be automated. It then had to be evaluated under commercial conditions.

This project used robotic technology plus vision and sensing systems based on three dimensional laser cameras to automate the *Easy-Open* process.

A prototype machine was designed and manufactured by Scott Automation and Robotics Pty Ltd and was evaluated for commercial suitability by Oyster Bob at a seafood processing factory in Adelaide.

Success criteria were established at the start of the project, as follows:

- At least 30 dozen oysters processed per hour, with minimal rejects.
- Processed oysters remain alive for at least eight days.
- Wax covering is neat and does not crack or break off during transport.
- Processed oysters can be easily opened by an unskilled person.
- Little or no shell dust found inside the oyster after cutting.
- Customer feedback is positive.
- Labels can be attached to the processed oysters.

All of these criteria were ultimately met. The process of cutting and waxing oysters is now protected by Australian Innovation Patent number 2018100256, owned by FRDC.

An additional objective, of designing and manufacturing a disposable plastic opening tool, was not attempted and replaced with a more urgent need to develop a new wax delivery system. This was also achieved.

The machine and the finished products were shown to fifteen oyster wholesalers across Australia. All of these companies were impressed with the product and expressed interest in obtaining the product for their customers. Three of these wholesalers would consider co-investment in the production of additional machines, as soon as the machine is deemed to be sufficiently reliable.

Testing of vacuum packed *Easy Open* oysters held at 5°C, showed that shelf life could be extended for at least 17 days.

Thirty consumers were given the opportunity to open an *Easy Open* oyster, consume the contents and provide anonymous, written feedback on the product. Twenty-seven people described the opening process as “very easy” or “easy”. When asked to indicate if they would buy

Easy Open oysters in future, 27 people responded that they would be "very likely" or "likely" to do so.

The *Easy Open* concept has some unique benefits:

i. Treated oysters remain alive, and therefore remain fresh, providing consumers with an eating experience identical to freshly shucked, unopened oysters.
ii. Because the *Easy Open* oysters are alive, they have an extended shelf life. All other systems used to facilitate oyster shucking result in the death of the oyster, thus limiting shelf life to a few days.
iii. Consumers are genuinely and pleasantly surprised by ease of opening.
iv. Ease of opening and freshness means that *Easy Open* oysters appeal to new customers who do not normally buy oysters.
v. For the first time, oyster growers will be able to guarantee consumers of the provenance of their oysters by attaching labels to the wax.

While the project conclusively demonstrated the success of the *Easy Open* concept, the prototype machine has numerous inadequacies that must be overcome to achieve commercialisation. The following issues were identified for future research:

i. Unreliable start up and frequent stoppages.
ii. The software does not have a user friendly interface, and frequent rebooting is required.
iii. Although the machine is operating at the speed specified at the beginning of the project, the production rate needs to be increased at least two or three fold to be profitable.
iv. The manual loading and unloading of oysters requires two staff, which is unprofitable. The system needs to be reconfigured to facilitate manual handling and automatic loading and unloading must be incorporated in future machines.
v. The machine was designed to process large oysters (65mm). With oysters in short supply it is necessary to modify the system to accept smaller oysters.
vi. The robot gripping arm needs redesigning to accommodate oysters of variable shape.

A new project to resolve the above problems is planned by FRDC and Scott Automation.

Once the newly designed machine is available and commercially proven, it will deliver a revolutionary approach to oyster retailing based on the unique opening experience and the proven provenance of each labelled oyster. This will be the first time oyster provenance can be guaranteed by oyster growers. Ultimately, this invention should contribute to growth in the value and volume of oyster production in Australia. Unfortunately, this will not happen for at least three years due to the widespread outbreak of the disease POMS which has decimated the supply of Pacific Oysters.

Of wider benefit to Australia will be the income and royalties from international machine sales.

In addition to funding provided by the Rural R&D for Profit Program and FRDC, this project received significant support from Scott Automation, the Seafood CRC Company Ltd, Oyster Bob Pty Ltd, The Fish Factory, and Sydney Fish Market.

Abbreviations and glossary

SAR – Scott Automation and Robotics Pty Ltd

FRDC – Fisheries Research and Development Corporation

SARDI – South Australian Research & Development Institute

SFM – Sydney Fish Market

1 Project rationale and objectives

1.1 Rationale

Oyster sales in Australia have been relatively static for the last decade. While confirmed oyster lovers continue to consume, the industry has not undertaken any marketing or technological initiatives to attract new consumers and thereby grow the industry.

The need to shuck oysters is the biggest barrier to increasing oyster consumption. Shucking is a learned technique, requiring a special knife, strong wrists and a means to prevent trauma to the hands. Therefore, most people, and nearly all women, avoid shucking oysters and consequently have not experienced the taste of fresh oysters. Most consumers have only experienced pre-opened, half shell oysters that have been rinsed and often stored two or more days prior to consumption. This produces a very inferior product and does not encourage increased consumption.

The Seafood Cooperative Research Centre (2007 – 2015) attempted to overcome the shucking problem by developing an idea suggested by Mr Robert Simmonds, owner of Oyster Bob Pty Ltd. This entailed making a slit in the edge of the oyster shell and resealing it with wax so that the oyster remained alive but could be easily opened up to seven days later by placing a plastic knife through the slit. This enables food service outlets and consumers to store the live, treated oysters and easily open them on demand, thereby ensuring the customer experiences truly fresh oysters.

An additional benefit of the wax coating placed on the oysters during the process is that it provides a substrate to affix a label, thereby providing the first ever reliable method of ensuring provenance claims for oysters.

However, for this invention to gain wide application the process of partially opening and resealing thousands of oysters per day had to be automated.

This project used robotic technology plus vision and sensing systems utilizing three dimensional laser profiling to automate the new *Easy-Open* process.

1.2 Objective

The immediate objectives of this project were:

- To develop an automated *Easy-Open* system
- For three participating oyster wholesalers to use the new system under commercial conditions and evaluate its performance.

1.3 Desired Outcomes

The measurable desired outcomes of this project are:

- At least a 15% premium on the price received by farmers for provenance-guaranteed *Easy-Open* oysters.

- Three years after the introduction of the machine, at least 10% of Pacific Oyster sales in Australia should be in the *Easy-Open* format. (Pacific Oyster production in 2016 was 9.8 million dozen.)
- The longer term desired outcome is to increase both the volume and annual GVP of oyster sales in Australia.
- Export sales of the new system and *Easy-Open* process under license.

2 Method and project locations

2.1 Methods

2.1.1 Machine Development

The new system was developed by Scott Automation and Robotics Pty Ltd (SAR). This company joined the project to utilize its experience gained in automating meat processing.

Three oyster wholesale companies were recruited to assist in commercial evaluation of the new system.

At the beginning of the project a committee composed of staff from the three wholesalers, SAR and FRDC met to assess the concept in detail and to set the specifications for the performance of the machine once completed.

On the advice of the committee some research was conducted to test cutting the oyster shell at the hinge, or proximal end rather than the distal end. This would have a fundamental impact on the design of the machine. The research and laboratory testing found the hinge end to be unsuitable and work proceeded to develop a system to open the oysters from the distal end. (See SARDI research report, Appendix 6.1a)

It was originally intended to manufacture three machines, so that each participating oyster wholesaler could have one machine for commercial evaluation. But after the initial setup meeting it became apparent that the cost would be prohibitive. (See SAR engineering report, Appendix 6.1b) Therefore, it was decided to make one machine that would be shared between the three oyster wholesalers.

The specifications set by the project committee for the ultimate performance of the machine were (see Appendix 6.1c for committee report):

- At least 30 dozen oysters processed per hour, with minimal rejects.
- Processed oysters remain alive for at least eight days.
- Wax covering is neat and does not crack or break off during transport.
- Processed oysters can be easily opened by an unskilled person.
- Little or no shell dust found inside the oyster after cutting.
- Customer feedback is positive.
- Labels can be attached to the processed oysters.

To build the new system the following components were designed and/or manufactured by SAR:

- A human-to-robot oyster loading interface in the form of carousel that is loaded with six oysters and is rotated to deliver each oyster to the robot.
- A grip on the end of the robot effector arm to pick up and hold the oysters
- SICK™ laser camera 3D image analysis set up and software to determine where the cut should be made in each oyster shell.
- A cutting technique combined with an air blast that minimized shell grit entering the oyster body cavity.

- Modification of a commercially available hot glue machine to melt wax and apply it accurately along the slit made in the oyster shell.
- A wax bath for dipping the oyster once the slit was sealed.
- A water cooling bath to solidify wax on the finished oysters.
- The software to enable a Kuka KR16™ robot to carry at each of the above functions.
- The cabinet to hold the entire unit, suitable for installation in a seafood processing plant.

Two waxes were used interchangeably throughout the project:

- Sonneborn Cheesewax Red 438
- Sonneborn Cheesewax KW734 Neutral

These were supplied by IMCD Australia Ltd, Melbourne.

During initial testing it became apparent that the hot glue machine used to melt the wax had insufficient flexibility and precision. Also, since it was not waterproof, it could not be exposed to the washing down procedures in seafood processing facilities. Therefore, SAR designed and manufactured a new, prototype wax delivery system that is more accurate and water proof.

2.1.2 Disposable plastic opening tool

It was originally anticipated that with each purchase of *Easy-Open* oysters a specially designed, disposable plastic cutting implement would be supplied for consumers to open the oyster through the waxed slit. Various designs of the cutting implement were made from acetal and polycarbonate plastic sheets and tested alongside commercially available plastic disposable knives.

2.1.3 Commercial evaluation

Three oyster wholesalers were recruited for the commercial evaluation:

- Oyster Bob Pty Ltd (Oyster Bob)
- Angelakis Bros Pty Ltd (Angelakis)
- Tassal Group Ltd (Tassal)

Tassal withdrew from the project just as the machine was ready for evaluation. They were replaced by Sydney Fish Market Pty Ltd (SFM).

Angelakis was keen to be involved in commercial evaluation but the company was sold in April 2018. The new owners did not wish to continue involvement in the project.

In response to this change of project participants it was decided to commission the machine initially at the Sydney facility of SAR. This enabled SFM to carry out their evaluation of the new system for its commercial potential. While that evaluation was underway the system was also observed in detail by the chairman of Southern Cross Marine Culture Pty Ltd, Australia's largest oyster farming business.

Evaluation by Sydney Fish Market

This evaluation was undertaken by SFM quality assurance staff, with the assistance of SARDI, while the machine was at the SAR facility in Sydney. Fifteen dozen oysters were obtained directly from commercial oyster farms. Ten dozen oysters were processed through the machine and five dozen left untreated as controls. Half the treated and control oysters were held by SFM

for qualitative assessment and the other half were transported to SARDI for quantitative assessment.

Commissioning the Machine under Commercial Conditions
The machine was commissioned at The Fish Factory in Adelaide, under commercial conditions oversighted by Oyster Bob. Installation and testing by SAR required seven days, which was much longer than anticipated. Procedures carried out included replacement of the wax delivery system, reprogramming, rewiring and extensive fault diagnosis and repair. Once the machine was stabilized it was used to produce more than 100 dozen oysters. However, its operation was found to be unreliable and additional diagnostic and repair work is ongoing.

Evaluation by Oyster Bob
Two evaluations were conducted to assess shelf life and consumer acceptance.

To assess shelf life, 15 dozen oysters were processed using the *Easy Open* machine and one dozen of the same batch kept as controls. The oysters were placed in trays and vacuum sealed, then held in a cool room at 5°C. After nine and 17 days the oysters were opened and assessed for quality parameters such as appearance, smell and taste.

Consumer response was assessed with 30 people at a social function at the Cruising Yacht Club of SA. After a brief presentation on the *Easy Open* concept was given to the whole group, individuals were invited to come to a separate area to participate in the evaluation. Each individual was given a processed oyster, plus a standard oyster knife. They proceeded to open the oyster, consume the contents, then complete a feedback form.

2.2 Project locations

The machine was designed and manufactured in the SAR research facility in Dunedin, New Zealand.

The machine was moved to another SAR research facility at Rydalmere, NSW for preliminary commercial evaluations.

The machine was then moved to The Fish Factory in Adelaide for final commercial testing.

3 Project Outcomes

3.1 Project level achievements

The project successfully achieved its primary objective to develop an automated *Easy-Open* system.

3.1.1 The *Easy-Open* Prototype machine

Full details of the machine are provided below. Engineering specifications of the machine are provided in the engineering design drawings (Appendix 6.1d).

A video of the machine in operation is provided separately, and can be downloaded from:

https://www.dropbox.com/s/7nk3cpo3m53t83a/Easy%20Open%20oyster%20processing%20v2.mp4?dl=0

An Operator Manual for the machine and instructions for use on the factory floor are provided in Appendix 6.1e.

The overall features of the machine are described below.

Presentation
The machine is encased in a stainless steel and darkened clear plastic cabinet. This prevents human accidental interaction with the robot and creates a dark environment for effective operation of the laser camera system. (Figures 1, 2).

Figure 1. External view

Figure 2. Internal view

A minimum space of 3m x 3m is required for installation of the machine in an oyster processing facility. Connections to single phase 32 amp electricity and dry compressed air are essential. An internet connection is provided to enable SAR engineers to make machine adjustments remotely. One person is required to operate the machine.

Loading/Unloading

Loading of oysters is done manually using the carousel. (Figure 3, 4,). Finished oysters exit on a conveyor belt.

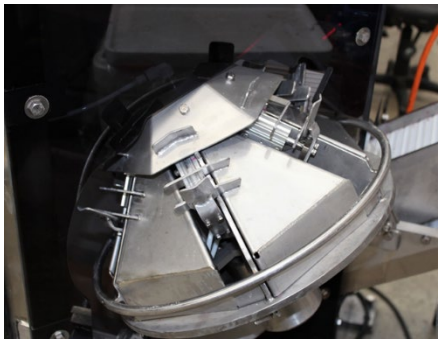

Figure 3. Loading carousel

Figure 4. Carousel loaded

3D Image Analysis

The robot effector arm (Figure 5) collects the oyster from the carousel (Figure 6) and passes it through the dual scanner laser beams. One laser camera is visible at the top of Figure 6. This determines where the oyster will be cut. The software that controls this process is part of the novelty of the machine.

Figure 5. Effector arm

Figure 6. Robot picking up oyster from the carousel

Cutting Process

The cutter is a high speed cutting mill with Sandvik™ tungsten carbide cutters (figure 7). It is surrounded by a guard and a cyclone fan blows shell chips away from the cut. (Figure 8).

Figure 7. Cutting mill.

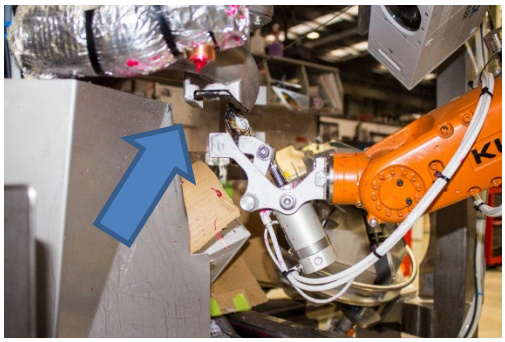

Figure 8. Cutting operation. Arrow shows guard

The ideal cut results in a slit 2.0cm long and 1.5 – 2.0 mm wide, with no damage to the interior mantle. Shell dust is removed by air that is constantly vacuumed from the site into a filter. The design of the cutter is critical to ensuring that oyster shells chips do not enter the oyster

Initial Waxing System

A two stage waxing process is used. The first stage is the accurate placement of a bead of wax along the length of the slit to reseal the oyster (Figure 9). This was achieved with a commercially available hot glue dispenser, modified to dispense the wax. The second stage involves inverting the oyster and dipping it in a wax bath (Figure 10), then gently placing it in a cooling bath. This reinforces the seal.

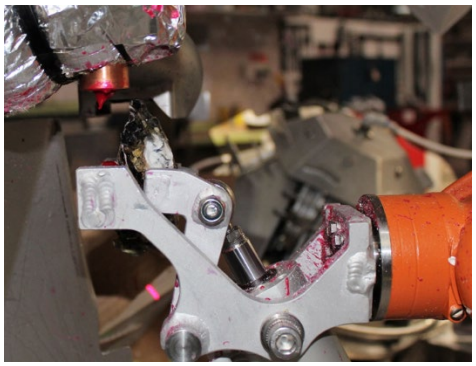

Figure 9. Wax bead application

Figure 10. After the wax dip

Improved Waxing System

During the final commissioning process, the heated glue dispenser was removed from the machine and the new component was installed (figure 11). The new dispenser was designed and purpose built by SAR. It consists of a small wax reservoir containing a submerged pump, a heating/cooling block and a dispensing nozzle. The temperature of each of these components is controlled separately, to provide maximum flexibility of the wax dispensing process. The nozzle extrudes the molten wax as a ribbon that can be laid along the slit in the oyster shell.

A detailed description of the new wax dispenser is provided in Appendix 6.1t.

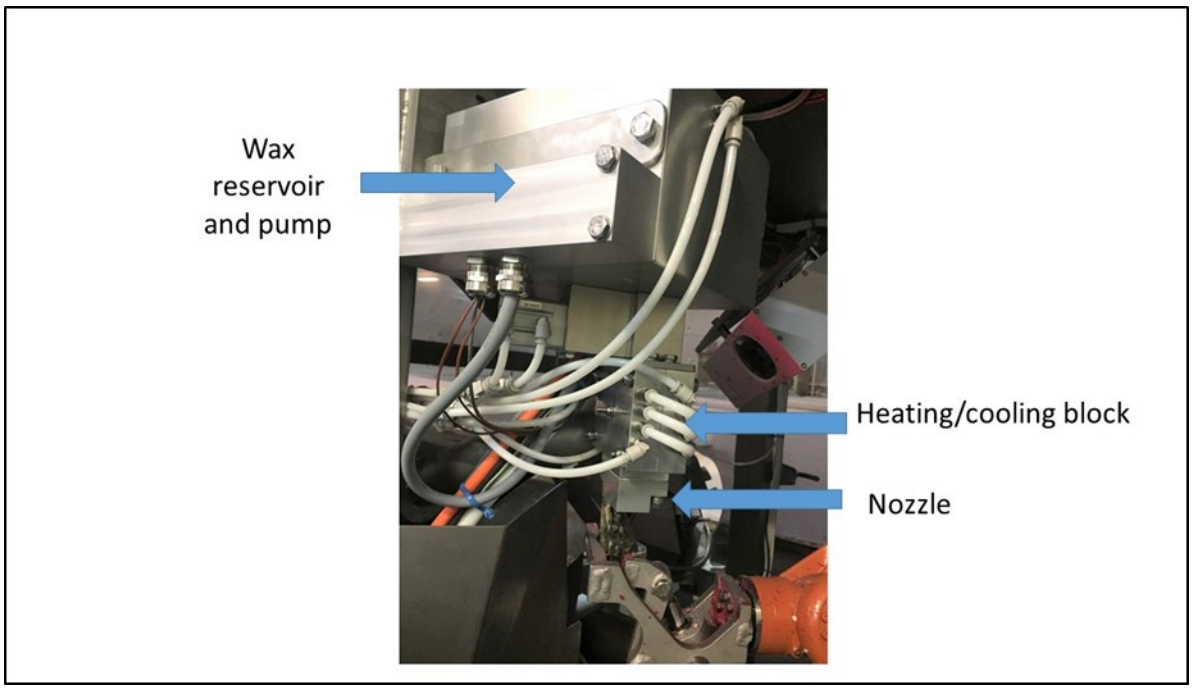

Figure 11. New Wax dispenser installed

During development it was noted that differing wax finishes and adhesion levels could be achieved according to how moist the shell was prior to the wax application. Wax applied to a wet shell does not stick strongly and is easier to peel off for opening.

Finished Oysters

A selection of finished oysters is shown in Figure 12. To open the oysters, the wax is peeled away revealing the slit (Figure13) and a knife inserted to cut through the adductor muscle.

Figure 12. Finished product

Figure 13. Wax peeled away to reveal slit in the oyster shell

3.1.2 The disposable plastic opening tool

A suitable design for the disposable plastic opening tool was finalised. The tool has a hockey stick shape with a sharpened internal edge. It can be introduced through the slit in the oyster then slid around the adductor muscle and pulled back through the slit, thereby cutting the adductor muscle and releasing the two halves of the shell. More detail of the tool is shown in Figure 14. Its use is demonstrated in the video.

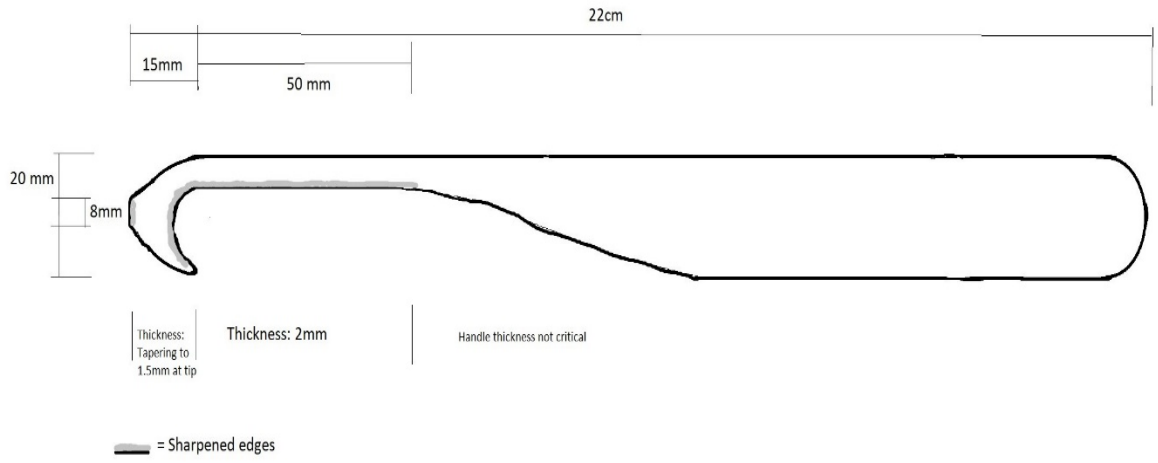

Figure 14. Diagram showing specifications for the disposable plastic opening tool.

During testing of the opening process, it was also found that commercially available, disposable plastic knives worked almost as well as the special tool. One brand in particular had the required strength and shape (Chinet Premium).

A full report of evaluation of the plastic opening tool is provided in Appendix 6.1f.

As part of its in-kind contribution to the project, SAR was to have manufactured 50,000 special plastic tools for use in the early commercialisation stage. However, since the commercially

available plastic knives were suitable for initial marketing of *Easy-Open* oysters it was decided to replace this in-kind contribution with design and manufacture of the new wax delivery system.

All the information about the tool has been provided to Oyster Bob who proposes to arrange manufacture of his own, branded version. The information will also be provided to other companies that show interest in the system.

3.1.3 Evaluation by Sydney Fish Market and SARDI

This evaluation was conducted while the machine was still in Sydney at the SAR facility. It was hampered by variability in the size and shape of the oysters used. These oysters had not been graded or rumbled at any stage of their growth and so had significant shell frill that the machine software has not been programmed to deal with. This resulted in approximately one third of the processed oysters being rejected because the cut in the shell was too small.

SFM assessed the oysters three and eight days after processing. Quality, taste and liquor content in the processed oysters was equal to controls at three days and better than controls at eight days. The report from SFM can be found in Appendix 6.1g.

Scientists at SARDI assessed the following attributes one and three days after the oysters were processed:

- Integrity of seal/gaping and nominal dimensions of cut;
- Volume of liquor remaining;
- Aroma;
- Presence of internal grit and visual damage to meat;
- Ease of wax removal and presence of internal wax

While the oysters were all fresh and had adequate liquor remaining, there was an unacceptable level of liquor leakage and gaping in treated oysters. Grit and wax was also found in the oyster cavities and the wax was difficult to remove, due to the ridges in the oyster shell. The complete report from SARDI is provided at Appendix 6.1h.

This study provided some valuable insights that were addressed in the subsequent evaluation. Most importantly was the need to obtain smooth shelled oysters without excessive shell frill for processing. Uniformity of shape and size of each batch of treated oysters is also important to a high success rate. It was also found that the temperature of the applied wax was critical to establish a wax viscosity that would produce a thick, strong coating and prevent leakage.

Assessment by Marine Culture

This company is a large investor in the oyster industry and the Chairman, Dr Tim Pauly assessed the concept from the perspective of a potential investor. His conclusion can be summarised as being very supportive of the concept and the unique marketing edge it provides. However, he also observed that the process is still at an early stage that would involve considerable risk for early adopters. The report from Marine Culture is available at Appendix 6.1l.

3.1.4 Commissioning the Machine under Commercial Conditions

The machine was transported to Adelaide and installed at The Fish Factory, 248 Grand Junction Rd, Athol Park, on 17 June 2018. Replacement of the hot glue melting machine with the new wax dispensing system and final commissioning was completed by SAR engineers who also provided training and safety checking. The machine was placed under the control of Oyster Bob, for the purpose of extended commercial evaluation.

Initially the machine worked well. The new wax delivery system correctly applied a ribbon of wax over the slit in the oyster prior to dipping. Precise temperature control (to within 0.1C) meant the viscosity of the wax could be adjusted to give the best possible appearance and strength.

Five dozen (60) oysters were processed through the machine. In most cases, the machine coated the oysters perfectly and created a slit of the correct dimensions in the oyster shell. There were minor imperfections in the width of the cut and covering of wax in five oysters (8%). In most cases these imperfections can be remedied by re-dipping the finished oysters in the wax bath. Cycle time, including hand loading, was 12 seconds, or five oysters per minute, which is slower than earlier testing. More details are provided in the commissioning report at Appendix 6.1i.

Evaluation by Oyster Bob continued over the period June to November 2018. Unfortunately, the machine progressively became unreliable. There were numerous incidents when the machine would not start or was jammed, necessitating the SAR engineers to log in remotely to diagnose the problems. Repairs were then conducted by Oyster Bob with guidance from SAR engineers by phone. There were also problems unrelated to the machine, such as compressor failure and loss of electricity supply.

An additional problem was that the occurrence of the disease POMS reduced the availability of oysters for testing. Throughput of oysters through the Oyster Bob company was reduced from 700 dozen per week, to less than 50 dozen per week. This limited the number and quality of oysters available for testing. On some days there were no oysters available.

Never-the-less, the project team persisted with the machine and demonstrations were arranged for individual growers and wholesalers. Sufficient oysters were also produced for use in the shelf life and consumer studies reported below. Work also commenced on packaging and labelling options. An example of the finished product in a vacuum packed tray with a provenance label is shown in Figure 15.

Figure 15. Waxed, *Easy Open* oysters, vacuum packed and labelled

3.1.5 Evaluation by Oyster Bob

Opinions of other wholesalers
The machine and the finished product was shown by Oyster Bob to fifteen oyster wholesalers across Australia. These were companies with which Oyster Bob has commercial relationships. All of these companies were impressed with the product and expressed interest in obtaining the product for their customers. Three of these wholesalers would consider co-investment in the production of additional machines, as soon as the machine is deemed to be sufficiently reliable.

There is no doubt that the supply chain for distribution of *Easy Open* oysters is in place and ready to activate.

Shelf life evaluation
This evaluation, of vacuum packed *Easy Open* oysters held at 5°C, showed that shelf life could be extended for at least 17 days. The vacuum packing functioned well, extending shelf life by at least ten days compared to the study conducted by SARDI using *Easy Open* oysters held unpackaged at 5°C. A report prepared by Oyster Bob is provided at Appendix 6.1s.

Consumer Evaluation
Thirty people were given the opportunity to open an *Easy Open* oyster, consume the contents and provide anonymous, written feedback on the product. Twenty-seven people described the opening process as "very easy" or "easy". When asked to indicate if they would buy *Easy Open* oysters in future, 27 people responded that they would be "very likely" or "likely" to do so. *Easy Open* oysters were attractive to people who do not normally buy oysters. It was apparent during the study that clear opening instructions will be needed on the packaging. A full report is provided at Appendix 6.1t.

3.1.6 Overall Commercial Evaluation

Positive Aspects

Over the past year the video of the Easy-Open system has been shown to over one hundred people in the oyster trade in Australia and overseas. With very few exceptions, everyone who has seen the concept has supported the idea and can see its commercial potential. A small consumer study confirmed the product's appeal.

Ideas have been proposed for use of the concept in restaurants, hotels, food service, speciality retail and supermarkets. Most ideas involve consumers opening the waxed oysters themselves. But some restaurants see the technology remaining in the kitchen because it allows them to offer freshly shucked oysters at any time.

The *Easy Open* concept has some unique benefits. These are:

- Creating the slit in the shell and resealing it with wax does not harm the oyster. As a result, the oyster remains alive, just the same as whole, unprocessed oysters remain alive for several weeks when removed from the water and kept cool. This means the current supply chain for oysters does not need to be altered.
- *Easy Open* oysters are always fresh! Because the *Easy Open* oysters are alive, they have an extended shelf life. All other systems used in Australia and overseas to facilitate oyster shucking result in the death of the oyster, thus limiting shelf life to a few days.
- The oysters are easy to open! Consumers are genuinely and pleasantly surprised by the experience.

- Ease of opening and freshness means that *Easy Open* oysters appeal to new customers who do not normally buy oysters.
- For the first time, oyster growers will be able to guarantee the provenance of their oysters to consumers.

It is Oyster Bob's intention to gradually introduce *Easy-Open* oysters to some selected retailers and restaurants in order to test various approaches to presentation, packaging, labelling and pricing. This will require an investment of at least $50,000 on packaging and labelling machines and marketing.

However, in its current state the prototype machine has several inadequacies that preclude full commercialisation. These are described in the next section.

Negative Aspects
The following problems were identified during extensive evaluation of the prototype machine:

- Unreliable start up and frequent stoppages. The extensive safety componentry of the machine means that even the smallest defect prevents it from starting. Often the defect is difficult to identify, causing extended down time and intervention by specialist engineers.
- The software driving the machine does not have a user friendly interface, which further prevents staff using the machine being able to respond to break downs. The software gives the impression of being unstable in that frequent rebooting is required.
- Although the machine is operating at close to the speed specified at the beginning of the project, the commercial evaluation has demonstrated that production rate needs to be increased at least two or three fold in order to be profitable.
- At the beginning of the project, automatic loading and unloading of oysters to and from the machine were seen as long term objectives, since it was presumed that manual loading and unloading would be satisfactory during early commercialisation. However, the current set up requires two staff, which is unprofitable. At a minimum, the loading carousel needs to be reconfigured to facilitate manual loading, but automatic loading should be included in the specifications for future machines. A system is also needed for collecting finished oysters.
- The machine was designed to process large oysters (65mm). With oysters in short supply it was necessary to modify the loading mechanism to accept smaller oysters too. This was only partially successful and the software needs to be improved to handle small oysters.
- The effector / oyster gripping arm of the robot needs redesigning to accommodate oyster of variable shape.

3.1.7 Performance against success criteria

Seven success criteria for the system were determined at the start of the project. The performance of the machine against those criteria was as follows:

1. At least 30 dozen oysters processed per hour, with minimal rejects.
During factory testing the robot cycle time was 8.5 seconds. This equates to seven oysters per minute, or 35 dozen per hour. Under commercial conditions the cycle time including manual

loading was 12 seconds. This equates to five oysters per minute or 25 dozen per hour. The rejection rate is minimal if oysters are graded to remove those with odd shapes prior to feeding into the machine. The rejection rate can exceed 25% if odd shaped oysters are treated, particularly oysters that have not be rumbled to remove shell frill.

2. Processed oysters remain alive for at least eight days on average.
This criterion was achieved during the development of the *Easy-Open* concept. Survival of oysters processed in the new machine was tested by Oyster Bob with vacuum packed *Easy Open* oysters held at 5°C. These oysters were still fresh and edible after 17 days.

3. Wax covering is neat and does not crack or break off during transport.
The wax application is accurately controlled and its thickness can be varied according to preference. There was no cracking or breaking of the wax observed unless the wax became overheated. In some instances, oysters with wax defects had to be re-dipped manually.

4. Processed oysters can be easily opened by an unskilled person.
Oysters were easily opened by untrained consumers once they had seen it done. Some consumer education material will be valuable in future to show consumers how to cut through the adductor muscle without damaging the oyster body.

5. Little or no shell dust found inside the oyster after cutting.
There was no dust or shell chips noticed during consumption of the tested oysters. Small beads of wax were occasionally found inside oysters but these were easily removed and did not deter consumers

6. Customer feedback is positive.
All fifteen wholesale customers who were shown *Easy Open* oysters and the prototype machine were very supportive and willing to place orders.

Thirty consumers were asked to evaluate *Easy Open* oysters. Twenty-seven consumers said that opening *Easy Open* oysters was easy and they would be likely to buy the product in future.

7. Labels can be attached to the processed oysters.
This was tested during earlier development when it was found that labels commonly used on single pieces of fruit would readily adhere to the wax. Oyster Bob has used vacuum packing and automatic labelling to label trays of *Easy Open* oysters according to region of production.

3.1.8 Significant Achievements

The significant achievements during development of the machine include:

- Identifying that 3D laser imagery could be used to accurately assess where to cut each oyster.
- Development of a high speed cutting mill that minimized the amount of shell dust entering the oyster.
- Development of a two-stage waxing method.
- Provision of adjustment switches to enable the operator to adjust the machine for differing types of oysters
- Evaluation of different coloured waxes, including a clear wax the makes it easier for the consumer to find the slit in the shell.

- Design of a novel wax dispensing system that is precise, water resistant and can operate in a wet food processing environment
- Very strong consumer and wholesaler support for the finished product.
- Suitability for provenance labelling.

3.1.9 Areas for further development

Areas for further development include:

- Reliability and robustness of the machine must be improved so that breakdowns are a rarity. Currently the rate of breakdowns of the machine is a barrier to further commercialisation.
- Capacity to process smaller oysters – As the supply of oysters declines due to POMS, it will be necessary to process oysters that are smaller than those for which the machine was designed. Options for achieving this have already been tested and require further development by SAR. See Appendix 6.1u.
- Processing speed – although the machine met the required specification, it will need to be faster to gain more commercial acceptance. This will hopefully be achieved by SAR in future models.
- Loading and unloading oysters - Technologies exist in the food industry to automate these two processes. However, this was beyond the scope of this project but it will be an essential feature of the next generation of machines.
- Cost of the Machine – Preliminary advice from SAR is that the cost of a single machine in future will be around $275,000. Orders for five or more machines could reduce the unit price by 25 percent. This price is still a significant barrier to early adopters.
- User comfort – It might be better if the operator controls were placed on the same side as the carousel.
- Robot grip for the oyster – Use of a grip with rounded “teeth” of hard rubber might improve the grip and reduce rejects due to movement of the oyster during processing.

3.2 Contribution to program objectives

The singular concept driving this project was to use robotics to make oyster shucking so easy that anyone can do it. This will increase the number of people who eat oysters and will improve the eating experience of all oyster consumers by delivering a freshly opened taste and texture. In so doing the demand for oysters should increase, thereby increasing both the volume and annual GVP of oyster sales in Australia. This will mean more income for oyster growers.

This outcome will not be realised until the *Easy-Open* concept is widely adopted throughout Australia. Unfortunately, this will not happen for at least three years due to the widespread outbreak of the disease POMS which has decimated the supply of Pacific Oysters in most growing areas. Pacific Oyster production in 2018-19 is expected to be less than 3 million dozen, compared to 9.8 million dozen in 2015-16.

In the meantime, some oyster retailers will likely use the system to provide a high margin, value added product, based on the unique opening experience and the proven provenance of the oysters which the new system delivers. This will be the first time oyster provenance can be

effectively guaranteed in Australia because each oyster can have a label attached to its wax coating.

The other significant benefit of this technology will be to reduce reliance on manual shucking currently carried out by wholesalers to service the half shell market. All wholesalers have difficulty in maintaining a team of oyster shuckers, because the work is unpleasant and has a high rate of injury. The *Easy-Open* system provides these businesses with an option to be less reliant on manual labour.

Of wider benefit to Australia will be the income and royalties from international machine sales.

3.3 Collaboration

3.3.1 Project Partners

The project partners were:

Fisheries Research and Development Corporation (FRDC)
The Seafood Cooperative Research Centre (Closed in August 2017, with work carried on by Dr L Stephens under contract to FRDC)
Scott Automation and Robotics Pty Ltd
Simmonds Marketing Pty Ltd (Oyster Bob)
Angelakis Bros Pty Ltd (Sold in April 2018)
Tassal Group Limited (DeCosti) (Withdrew in February 2018)
Sydney Fish Market Pty Ltd (Replaced Tassal in February 2018)
The Fish Factory, Adelaide

The involvement of FRDC in this project greatly assisted in bringing the parties together. FRDC staff provided assistance to all parties as needed and facilitated project management. They also provided photography and video services as part of their in-kind, and will assist with future communication and extension.

As the Seafood CRC wound up, FRDC was also able to take over ownership of the intellectual property and continued to pay patent attorney fees (from non-project funds) as the patent application went through the examination process.

Research collaborations in this project were limited because one party (SAR) undertook the bulk of the research. Design and manufacture of the machine had to be achieved by SAR before the oyster wholesalers could make any meaningful contribution to the project, other than at the start-up meeting.

It was only when the machine was "real" and demonstrated to the participating wholesalers that the possibility of collaborations between wholesalers emerged. Such collaboration is difficult because the wholesalers are competitors, although they did contribute ideas in design and marketing at project meetings. At the end of the project, planning was underway for Angelakis and Oyster Bob to work together to use the prototype machine to bring the first products to the market. Unfortunately, this did not occur due to the sale of Angelakis.

Sydney Fish Market holds a unique position of trust in the industry and an option being considered is for SFM to acquire one of the first machines to be manufactured in a collaboration with several retailers or oyster growers.

During the commercial evaluation Oyster Bob delivered his in-kind commitment to the project by providing large volumes of oysters for testing. He also supplied a new air compressor, valued at $4,000 labelling machine, valued at $2,000 and a vacuum packing machine valued at $5,000. Staff at The Fish Factory in Adelaide also collaborated in the evaluation by providing factory facilities for the machine and access to retail customers. Installation of power and internet cabling cost The Fish Factory approximately $1,000.

The South Australian R&D Institute, a party to the original patent on the invention, also conducted the hinge opening research and conducted shelf life evaluations of finished product at cost.

As the machine becomes used in the market, collaborations between oyster growers and the wholesalers are expected to increase. This will happen through the ability to guarantee provenance of individual growers' oysters through wax labelling.

4 Extension and commercialisation

The fact that the commercial evaluation of the machine was only completed in November 2018 means that most of the planned activity to encourage adoption is yet to occur. This activity was dependent on the positive outcome of the commercial evaluations, because the path to adoption of the *Easy-Open* technology is primarily one of commercialisation.

The primary adopters of the technology will be oyster wholesalers, who will need to make a significant investment to buy a machine. They must be convinced that the machine works and will produce a good return on investment.

It is likely to be very difficult to achieve this in Australia over the next few years, due to the shortage of oysters and the prototype status of the machine that requires ongoing technical input. For that reason, Oyster Bob will be supported by FRDC after the project completion to assist where possible in establishing *Easy-Open* oysters as an ongoing proposition. If Oyster Bob is successful, other companies will definitely follow. Numerous companies have openly stated their intention to monitor the performance of *Easy-Open* oysters in the Adelaide market, before making any investment to adopt the technology.

As described in the project Commercialisation, Communication and Extension Plan (Appendix 6.1j) communication and extension activities will continue to be directed toward wholesalers, oyster growers and consumers to increase their awareness of the new technology. This will be done by Oyster Bob, in conjunction with FRDC where appropriate.

4.1 Commercialisation

4.1.1 Intellectual Property

In the early stage of the project it was thought that the *Easy-Open* system would be patented and licensed to the three participating wholesalers. This would enable them to establish a market with limited competition.

Full patent applications were lodged in Australia, New Zealand, North America and the European Union. The examination of these patents was deliberately delayed while the machine was developed. As it became obvious that it would take a long time to bring the technology to market, the business value of patent protection declined. Also, reports eventually received from patent examiners identified several barriers to the granting of patents. Consequently, the patent process was discontinued.

However, the process of cutting and waxing oysters is protected by an Australian Innovation Patent number 2018100256 (Appendix 6.1k).

The know-how to make the *Easy-Open* machine cannot be covered by patent, but it is solely owned by FRDC under the terms of the project agreement with SAR. This means that although SAR is the maker of the machine, anyone wishing to purchase one will first need approval from FRDC. This will not be relevant in Australia but may enable FRDC to select cooperative partners overseas, especially in the early stages of commercialisation.

As described below, FRDC and SAR will work together to achieve sales of the machine. A small royalty will be paid by SAR for sales in Australia and a larger royalty for overseas sales.

4.1.2 Easy-Open Machine Manufacturing Arrangements

The project has produced one machine, which in its present state is not commercially viable. However, the *Easy Open* concept has been proven and there is a significant market for the product.

Before more machines can be manufactured the problems detailed in section 3.1.9 need to be overcome. This objective will be pursued in a new project by FRDC, Oyster Bob and SAR if additional funding can be secured. An outline of the new project is provided in Appendix 31.v.

If the updated machine is successful, Oyster Bob will begin commercial production and marketing of *Easy Open* oysters. It is anticipated that success of the product in the market will result in the emergence of buyers for more machines. Oyster Bob ad FRDC will work to facilitate this. The immediate target would be to obtain firm orders for five machines. This is the minimum number SAR needs to commit workshop facilities to the task of producing machines at a reasonable cost. SAR has advised the cost of a single machine would be $275,000, whereas, with an order of five, the unit cost would be approximately $200,000.

As discussed above, it is unlikely that SAR will receive orders for the machine until it is proven in the market by Oyster Bob. The time required to build another machine could be six months or more. Consequently, it is likely to be at least one to two years before *Easy-Open* machines are being used by other wholesalers.

4.1.3 Longer Term Outcomes

Section 1.3 of this report lists the desired long term outcomes from the project. It was anticipated that growers would receive a premium for *Easy Open* oysters and three years after completion of the project *Easy Open* oysters would achieve ten per cent market penetration.

While these aims are still achievable they will be delayed for two reasons. The first is that the machine is not yet ready for full commercialisation. The second is the ongoing negative impact that POMS is having on Pacific Oyster production. Currently, supply is less than 40 percent of normal and prices have increased commensurately. In two to three years when oyster supply recovers, there is expected to be a glut which will depress prices. Launching a new, high margin product under both of these scenarios is commercially risky and it is likely that wholesalers will move slowly at first.

4.2 Extension

4.2.1 Extension to Oyster Wholesalers

To encourage wholesalers to purchase a machine, an assessment of the likely return on investment and payback period for a machine has been prepared (Appendix 6.1m). The biggest variable in the analysis is the size of the premium that wholesalers could charge retailers for *Easy-Open* oysters. For example, a premium of $2/dozen with the machine processing 50 dozen oysters 8 hours a day delivers a payback period of 275days.

Oyster Bob contacted 15 wholesalers to make them aware of the *Easy-Open* concept. Without exception they are all very interested in the concept. However, the high cost of the machine is a

significant barrier and the common response has been that they will wait to see to what extent Oyster Bob's product is adopted by consumers.

While this conservative approach is disappointing, it is to be expected in light of the poor oyster supply. It also means that any discussion with wholesalers about licensing the technology is pointless. The search for entrepreneurial investors will continue (eg SFM), but it is likely that uptake will be delayed while the industry assesses the Oyster Bob product.

Work has been done to investigate the potential for overseas sales. In April 2018, SAR promoted the *Easy-Open* concept by showing the video on their marketing stand at the European Seafood Trade fair in Brussels. Four companies expressed interest in the concept and may visit Australia to see the machine in action.

Also an evaluation of the market in USA identified potential investors (Appendix 6.1n). These will be pursued in conjunction with SAR when opportunities arise.

4.2.2 Communication with Consumers and Retailers

Oyster wholesalers who purchase a machine will need to invest their own funds in advertising the new oyster product to develop the market, as the project cannot fund this activity. However, the video made as part of the project will be available for this purpose.

When the Oyster Bob product is showing success in the market and wholesalers have committed to purchasing a machine, FRDC will work with those wholesalers to plan public relations events and will assist in having articles about *Easy-Open* published in food and trade publications.

The Commercialisation, Communication and Extension Plan describes this activity in more detail.

4.2.3 Extension to Oyster Growers.

As with communication to consumers and retailers, the Commercialisation, Communication and Extension Plan describes a series of extension activities directed to growers. This will be done to raise awareness of the technology with oyster growers and encourage them to sell oysters through the system using its provenance labelling capability. Some project funds have been used for this activity but most will be done as in-kind by FRDC after the project is completed.

5 Lessons learnt

There were multiple delays to this project resulting in this final report being delivered more than 12 months after the original due date. The delays were due to industrial action by SAR factory workers, changes to the participating wholesalers, the outbreak of the oyster disease POMS that reduced the availability of oysters for testing and a range of technical problems with the machine and ancillary equipment during commercial evaluation.. None of these was predictable or avoidable.

The level of involvement of the wholesalers was minimal until the very end of the project. By this time two wholesalers had withdrawn. Fortunately, the level of interest in the project was such that finding replacement wholesalers was not difficult. However, if the project was repeated it might be worth obtaining a financial commitment from wholesalers who wish to be involved, rather than merely a commitment of in-kind. If this was not successful, an alternative would be to wait until the prototype machine was operational and then call for expressions of interest from wholesalers interested in buying into the project to evaluate it. This approach was not appropriate in this case because Oyster Bob has moral rights to the technology.

An observation made during the years of the Seafood CRC and repeated in this project was that it is very hard to get seafood processors and wholesalers to work cooperatively. They are natural competitors and sharing research concepts does not come easily. The involvement of a project manager is therefore essential to bring the parties together. In order to benefit oyster growers, it is important to have multiple processors involved so that the technology is widely adopted. Individual wholesalers might prefer to limit use of the new technology to a high margin, low volume business if they have a monopoly. This would not contribute significantly to an increased GVP of the oyster industry.

It is now known in hindsight that it would have been preferable for the machine to have a faster processing speed. When the specifications for the machine were set at the start-up meeting it was thought a processing speed equivalent to a human working in an oyster processing factory would be sufficient (approx. 30 dozen oysters per hour). It is now apparent that the machine could and should have been made faster, which would encourage more commercial uptake. Speed will now have to be upgraded in future models and SAR engineers have various options available to achieve this.

6 Appendix - additional project information

6.1 Project, media and communications material and intellectual property

The following documents are provided as Appendices:

6.1a - SARDI Report. *Easy-Open* oysters: processing at hinge

6.1b – Scott Automation. Engineering project start-up report

6.1c – First Project Meeting. Machine specifications

6.1d - Scott Automation. Final engineering drawings

6.1e – *Easy-Open* oyster machine operator manual

6.1f – Evaluation of plastic opening tools for *Easy-Open* oysters

6.1g – Sydney Fish Market Evaluation

6.1h – SARDI Evaluation

6.1i – New Wax Dispenser Installation and Commissioning Report

6.1j – Commercialisation, Communication and Extension Plan

6.1k – Innovation Patent Certificate

6.1l – Tim Pauly, Marine Culture. Review of *Easy-Open* machine.

6.1m – Payback period analysis

6.1n – Report on potential markets for *Easy-Open* oysters in the USA

6.1o – Scott Automation. First design drawings

6.1p – Scott Automation. Factory acceptance test

6.1q – Project meeting report, 23 January 2018

6.1r – Jtech Pty Ltd. Plastic tool proposal.

6.1s - Oyster Bob Quality and Shelf Life Evaluation

6.1t – Oyster Bob Consumer Evaluation

6.1u – SAR *Easy Open* Machine Upgrade Proposal

6.2 Equipment and assets

A single asset, the *Easy-Open* oyster machine was created by this project.

During the project the following components of the machine were purchased:

Item purchased	**Date of purchase**	**Purchase price (GST exclusive)**
KUKA KR6 R900 Agilus Robot	August 2017	$25,000
SICK 3D Laser Scanners (2)	August 2017	$18,000

6.3 Monitoring and evaluation

The final project evaluation report is provided as Appendix 6.3a

6.4 Budget

Provide a statement of funds and contributions received and spent.

If practical, this section may be the final financial report (see grant agreement), containing:

- financial statements for the receipt, holding, expenditure and commitment of the grant, including a full reconciliation against the budget in the grant agreement and statements clearly showing expenditure against the grant
- a report of the receipt of other contributions (including the grantee's contributions), or if other contributions were not received as projected, an explanation of action taken in response to this shortfall
- the interest that the grantee has earned on the grant.

If not practical to satisfy requirements for the final financial report at the time of submitting the final report, please use this section to give a summary statement of the budget for the life of the project and submit the final financial report within 60 days of submitting the final milestone report.

As part of its in-kind contribution to the project, SAR was to have designed a special disposable plastic tool to open the waxed oysters. It would then manufacture 50,000 tools for use in the early commercialisation stage. However, it was found that the plastic tool was not essential to enter the market and a greater need was the design and manufacture.

Appendix 6.3a - Monitoring and Evaluation.

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
1.1	Confirm the engagement of a project manager (Output l(a)).	Achieved	July 2016	The PM is Dr Len Stephens, manager of the original *Easy-Open* oyster project in the Seafood CRC	PM in place
1.2	Provide the agreed membership, governance arrangements and terms of reference for the project steering committee (Output l(b)).	Achieved	July 2016	A steering committee has been established comprised of representatives from all parties involved in the project. The committee is advisory to FRDC	Steering committee in place
1.3	Provide a list of all partner organisations and the status of partner agreements, including the date signed or the date expected to be signed (Output l(c)).	Achieved	August 2016	Partner agreements have been signed with FRDC, Scott Automation and Robotics, and the Seafood CRC Company Ltd (later novated to Dr Len Stephens as a sole trader). Agreements with the three seafood wholesalers were not deemed necessary until the *Easy-Open* was complete and ready for evaluation.	Agreements signed
1.4	Provide a list of cash and in-kind contributions for each partner, for each financial year of the Activity and the total amount of funding and in-kind contributions (Output l(d)).	Achieved	29 Sept 2016	This information has been provided with each milestone report.	FRDC and Seafood CRC have paid their cash contributions. Scott Technology has provided its in-kind contribution. Two of three wholesalers have provided their in-kind contribution
1.5	Provide a project plan	Achieved	February 2017	This was approved by DAWR (email from S Dimovski, 3 March 2017)	Projects plans in place

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
1.6	Provide a Communication and Extension Plan	Achieved	February 2017	This was approved by DAWR (email from S Dimovski, 3 March 2017)	Communications and Commercialization plan in place
1.7	Provide a monitoring and evaluation plan	Achieved	27 July 2016	The key evaluation process for this project was agreement by the seafood wholesalers on the criteria to be used to evaluate the commercial suitability of the Easy Open machine. These were agreed at the first steering committee. The criteria for consumer evaluation were developed with each wholesaler prior to the work commencing.	This plan.
1.8	Communication and Extension Activities	Achieved	Dec 2016	See notes under KPI 1.6	Press release and media event in Adelaide on 29 June 2016 with Senator Anne Ruston to announce the funding of the project.
1.9	Provide a summary of progress in designing and setting specifications for the oyster-opening system. (Output 4 (a), 4(b) and 4(c) and 8(a)). Output 8(a) no longer applicable, see below.	Achieved	15 April 2017	*Output 4(a) – Plan the machine specifications workshop, including identifying suitable participants, such as engineers and oyster farmers, wholesalers and retailers.* This was reported as achieved in Milestone report 1 and a copy of the workshop minutes provided. *Output 4(b) – Conduct at least one workshop to define machine design specifications and oyster opening system operational requirements. Performance indicators of the oyster opening system will include reliability, low wastage, speed of operation, simplicity of operation, cost*	Machine specifications set. See Methods section of Final Report

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
				of production, and capacity for further automation through loading and unloading. This was reported as achieved in Milestone report 1 and a copy of the workshop minutes provided which contained the specifications. Scott Technology work plan was also provided. *Output 4(c) – Prepare specifications for building the machine.*	Building specifications are now provided in detail in Output 5, below.
1.10	Provide a summary of progress in the manufacturing of the system (Output 5(a) and 5(b)).	Achieved	15 April 2017	*Output 5(a) – Prepare a report demonstrating process steps and suitability for scaling up to a production prototype machine with 30 dozen oysters per hour (10 secs cycle time) capability.* Each operational activity of the machine has been set up as a single station in the design workshop. The stations are gripping, scanning, cutting, wax bead, and wax dip. The function of each station has been optimized and the robot programed to move the oyster through each station. Cycle time will not be accurately defined until the prototype is built, but will meet the 10 second requirement *Output 5(b) - Design and construction of production prototype machine. Submit 3D CAD reviews and GA drawings showing completion of the design phase.* The attached drawings show the way in which each component will be oriented around the robot to enable oyster loading, processing and	Each function required of the machine has been optimized individually. This was an essential step prior to combining all the functions in to a single robot platform and proceeding to the prototype design. Drawings have been provided, Appendix 6.1o

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
				unloading. The footprint of the whole machine has also been minimized.	
1.11	Provide a concise evaluation of the system trial and decision to proceed (Output 5(c) prepare a report on the suitability of proceeding to manufacture the prototype system.	Achieved	15 April 2017	*Output 5(c) - FRDC will review the results of outputs 5(a) and 5(b) and decide whether to proceed to manufacture of the prototype system.* The work to date has further proven the concept of the oyster opening machine and has established the capacity of a robot guided by 3D laser vision analysis to carry out each step of the process. This is sufficient justification to proceed to the next stage, being design and construction of a machine that will integrate all the required processes. CAD drawings have been submitted that show that this approach is feasible.	It is recommended that the project proceeds with manufacturing of the prototype machine.
2.5	Provide a summary of progress in the design of the system and suitability for scaling up to production prototype (Output 6{a) Output 6{b) and Output 6{c)).	Achieved	11 October 2017	*Output 6a. Manufacture and commissioning of system with 30 dozen per hour capability.* Achieved. The machine has been built, factory tested with oysters, and found to be satisfactory, in that the specifications set at the beginning of the project have been met. *Output 6b. Demonstrate the machine at Scott Automation & Robotics Pty Ltd and obtain feedback from wholesalers, farmers and engineers.*	The machine has been manufactured and is fully operational. A video, photographs and engineering drawings of the completed machine have been provided in the Results section of the Final Report. See signed factory acceptance test report, Appendix 6.1p.

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
				The machine was then shipped to the Scott facility in Sydney for initial viewing and testing by wholesalers. See detailed report, Appendix 6.1q. *Output 6c. Prepare an evaluation of the system showing achievement against agreed performance criteria.* Achieved	The design engineers are satisfied with the machine operation. They have several proposed modifications to improve future machines. Wholesalers continue to express interest in the machine. Farmers have not yet sighted the machine. The machine was tested using 5 dozen oysters and met all the specifications that could be tested in a factory setting.
2.6	Provide a final summary of the evaluation of the system in three commercial facilities; future commercial use of the system and arrangements for commercial manufacture of the Easy Open system (Output 7 (a), 7(b), 7(c) and 7(d). *Please note; in Variation 2 dated 25 August 2017 there are two KPI 2.6s. Also, there is no Output 7(d) in the Project Agreement.*		Due 28 Feb 2018. New date 30 April 2018	*Output 7(a). System installed and tested in commercial seafood processing facilities. The system will be tested in 3 commercial facilities* *Output 7(b). Prepare an evaluation report on the performance of the system in commercial applications against performance criteria* *Output 7(c). Prepare a concise evaluation of the system including the extent to which introduction of the machine can improve returns to growers, including through provenance labelling and improving demand for oysters as a category.* Achieved The first exposure of the completed machine occurred in Sydney on 23 January 2018. Two oyster wholesalers attended the demonstration and were impressed with progress. These wholesalers are committed to conducting a full commercial evaluation in Adelaide, but advised	The results showed that the oysters produced by the machine are highly attractive to consumers and that full commercialization is feasible. There some improvements to the machine required, including better

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
				that it would not be possible until April, owing to the lack of supply of Pacific Oysters. One wholesaler(Tassal) withdrew from the project and was replaced by Sydney Fish Market (SFM). Angelakis Bros was sold in April 2018 and their involvement placed on indefinite hold. One consumer evaluation and controlled shelf life trial was conducted with SFM and SARDI on 23 February while the machine was still in the Scott Automation facility in Sydney. The Chairman of Australia's largest oyster grower (Marine Culture) also observed this trial to assess the commercial potential of the system. The machine was relocated to Adelaide and placed under commercial conditions with Oyster Bob. The machine worked well but was unreliable, having an unacceptable level of breakdowns. Shelf life and consumer evaluations were conducted by Oyster Bob.	capacity to process oysters that vary a lot in size and shape. See Appendix 6.1g and 6.1h for evaluation reports by SFM and SARDI See Appendix 6.1l for report. See Appendix 6.1s for the shelf life report. See Appendix 6.1t for the consumer report.
2.7	Provide an update of the design and manufacture of the disposable plastic cutting implement. Output 8(a)	Milestone Variation	28 Feb 2018	*Output 8a. Undertake design and manufacture of disposable cutting implements…..* Although the manufacture of the plastic tool is no longer a contractual requirement, work is still on-going. A manufacturer has been identified to prepare a design that is optimized for volume manufacturing. The wholesalers	See Appendix 6.1r for proposed approach to plastic tool design from JT Plastics Pty Ltd.

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
	This KPI is changed to: Report on design, manufacture and installation of new wax dispensing device. *See email from A McMorrow, 7 Dec 2017*	Achieved	New date 31 March 2018	involved in the project will have to pay for the tools to be made. Modified Output 8a. design, manufacture and installation of proof of concept wax dispensing device Achieved The new wax delivery system was installed at commissioned on 28 May 2018.	The new wax system is now fully operational as an integral component on the prototype machine. See full report in Appendix 3.1.i
	Final Report	Achieved	New Date 30 Nov 2018		
2.1	Provide the final evaluation of the Activity				This report
2.2	Provide a list of any prepared, submitted published findings (Output 3(b)) .				There have not been any academic publications arising from this work.
2.3	Provide a final report on communication and extension activities (Output 3(a), 3(b), 3(c) and 3(d)).				See this report, Section 4.
2.4	Provide a summary of progress in the manufacture and commissioning of system (Output 6(a) and 6(b)).				See milestone report no 4. October 2017.
2.5	Provide a summary of the system demonstration and feedback from wholesalers, farmers, and engineers and performance against criteria (Output 6(a), 6(b) and 6(c)).			The machine was demonstrated to a wide range of industry participants during June – November 2018.	See this report, sections 3.1.6 and 3.1.7. and 4.2.1. – 4.2.3
2.6	Provide a final summary of the evaluation of the system in three commercial facilities; future commercial use of the first system and arrangements for commercial manufacture of future Easy Open systems (Output 7(a), 7(b), and 7(c))			The machine was evaluated by two companies in the SAR factory and one company in Adelaide under commercial conditions. Before more machines can be manufactured the problems detailed in section 3.1.9 need to be overcome. This objective will be pursued in a new project by FRDC, Oyster Bob and SAR if	See this report, sections 3.13 – 3.1.5. The project has produced one machine, which in its present state is not commercially viable. However, the Easy Open concept has been proven and

KPI no.	KPI description	Status	Due Date	Progress achieved against KPI	Outputs
				additional funding can be secured. An outline of the new project is provided in Appendix 3.1u.	there is a significant market for the product. See this report, section 4.1.2.