Department of Primary Industries

Net Returns of Real-Time Sensors and Salinity-Based Management Plans in NSW Oyster Production

completed by Strategy & Policy, NSW DPI.

Key Findings

This report presents findings of a cost benefit analysis to assess the net benefits or Net Present Value (NPV) of replacing rainfall-based management systems with real-time sensors and salinity-based management plans in NSW Oyster production. Real-time sensors provide oyster farmers and NSW DPI with a more timely and accurate report on the water quality in a harvest area, in comparison to a rainfall-based management system.

Values have been estimated for two case study harvest areas Pambula Lake and Cromartys Bay (Port Stephens) using a direct harvest system and a harvest and depuration system.

Results in Table 1 show that the real-time sensor-based system increases annual per hectare returns to oyster producers. This equates to an annual net benefit of $95,736 in Pambula Lake and $15,344 in Cromartys Bay for the current harvest area.

Table 1. Net Benefits or Net Present Value (NPV) estimated in 2020-21 dollars ($/hectare) and Benefits Cost Ratio (BCR)

Scenarios	NPV across 20 years[1] ($/ha)	NPV per annum[2] ($/ha)	BCR
A. Direct Harvest			
• **Pambula Lake**	15,039	1,420	2.8
• **Cromartys Bay**	9,134	862	1.9
B. Direct Harvest and Harvest and Depuration			
• **Cromartys Bay**	9,131	862	1.9

Note: 1. A 20-year NPV is estimated from 2020-21 to 2039-40; 2. Analysis is conducted over 20 years and an annual NPV is estimated.

These estimates are considered conservative as the data used for this assessment is from the drought period 2016-17 to 2019-20. During times of increased rainfall, it is likely that there will be a greater frequency of harvest area closures and benefits from the use of real-time sensors. Data limitations have prevented the estimation of these results.

Incorporation of the environmental and social benefits could also increase the NPVs of this assessment. These include the monitoring of harmful algal blooms and oyster mortality events and a potential reduction in farmer stress (associated with the closure of harvest areas).

Results from the sensitivity analyses also maintain a positive NPV and BCR across all scenarios. This further supports the positive benefits of adopting real-time sensors.

1. Background

Technology

To minimise the risk of contaminants and maintain food quality standards for oyster production, harvesting is prohibited following heavy rainfall. Rainfall-based management systems are currently used in most areas in NSW to open and close harvest areas and to downgrade harvest areas.

Pambula Lake and Cromartys Bay are two harvest areas where real-time sensors and salinity-based harvest area management plans have recently been adopted. Along with improvements in the sensor technology, the application of sensor technology in management plans is providing a more timely and accurate report on the water quality in a harvest area leading to improved management of heavy rainfall events.

Application of this technology is being developed as part of a collaboration between oyster farmers, the Food Agility Cooperative Research Centre, University of Technology Sydney (UTS), NSW Hunter LLS, The Yield and the NSW DPI (Aquaculture Research and Biosecurity and Food Safety).

Case study areas

This CBA is conducted for oyster production in Pambula Lake and Cromartys Bay harvest areas in NSW. Key statistics of the two harvest areas are provided in Table 2.

Table 2 Key statistics of the two harvest areas (DPI Unpublished data)

Item	Pambula Lake	Cromartys Bay	Unit
Current harvest area	67.42	17.8	ha
Maximum potential harvest area	86.59	39.44	ha
Average harvest area per farm[1]	2.4	2.5	ha

Note: 1. Derived from averaging the total harvest area to the number of businesses in Pambula Lake (28 businesses) and Cromartys Bay (7 businesses)

Oyster harvest in Pambula Lake is conducted using a direct harvest system. Whereas, Cromartys Bay has a dual harvest system that allows for either direct harvest or harvest and depuration (during downgrade days) using a depuration facility.

Depuration can be used to treat shellfish with low levels of contamination. It involves placing the harvested shellfish into tanks of high-quality water so they will purge any contaminants stored in their gut. On downgrade days, oysters that are harvested must be depurated in a depuration facility for 36 hours before sale for human consumption. Farmers that do not own or have access to depuration facilities cannot harvest oysters on these days.

2. Methodology

Cost Benefit Analysis is used in this assessment to estimate the net benefit or NPV of adopting real-time sensors and salinity-based harvest management plans. This CBA is in line with the NSW Treasury CBA guidelines and quantifies as many benefits and costs as possible and then assesses the qualitative impacts.

Assessments are conducted using the following options:

Base case — Oyster production using traditional rainfall-based management plans.

Option 1 — Oyster production using real-time sensors and salinity-based management plans.

This assessment is a triple-bottom-line and includes the economic, social and environmental impacts of adopting the new technology. Benefits, costs and NPV of impacts for this CBA are estimated across a 20-year time horizon.

Results presented include the NPV across 20-years from 2020-21 to 2039-40, an annual NPV in 2020-21 dollars that is estimated using the annuity formula, and the Benefit Cost Ratio (BCR).

Measuring benefits and costs

A quantitative assessment is undertaken of the benefits:

- additional revenues from using sensors to increase the number of harvest days or keep harvest areas open longer
- avoided depuration costs as sensors allow for the identification of downgrade days that could be additional direct harvest days

and costs

- change in production costs per hectare from increasing output
- cost of installing and maintaining sensors.

Additional revenue – is estimated as the quantity of production times the average farm gate price. The additional quantity of production is estimated as the 5-year average annual production times the percentage increase in harvesting days. The 2018-19 values are used for farm gate prices.

Avoided depuration costs – depuration costs are avoided in Cromartys Bay harvest area where real-time sensors have adjusted downgrade days to direct harvest days. In this situation a producer will still obtain the revenues from harvesting oysters but will avoid the costs of using depuration tanks.

A range of environmental and social impacts are qualitatively discussed in this report.

3. Data Requirements

Key data and assumptions that are used to undertake this CBA are provided in Appendix A. These include the data to estimate the value of production, present value of benefits and costs, NPV and BCR.

Data on the production and average farm gate price are presented in Appendix B.

Estimates of the additional harvest and downgrade days from adopting real-time sensors and salinity-based management plans are provided in Appendix C.

Operational cost data for both fixed and variable inputs and the cost of sensors is detailed in Appendix D.

4. Results

Base Results

Table 3 shows that there are clear net benefits from adopting real-time sensor and salinity-based management plans, as the present value of benefits outweigh the present value of costs and the BCR is greater than one.

Furthermore, results show the total cost of a sensor may be recovered in the first year of operation in Pambula Lake (at a sensor cost of $429 per business) and the second year in Cromartys Bay (at a sensor cost of $1,714 per business).

Table 3. Benefits, Costs and Net Present Value (NPV) over 20 years and per annum in 2020-21 dollars ($/hectare) and Benefits Cost Ratio (BCR)

Scenarios	Estimates over 20 years			NPV per annum ($/ha)	BCR
	PVB ($/ha)	PVC ($/ha)	NPV ($/ha)		
A. Direct Harvest					
• Pambula Lake	23,426	8,387	15,039	1,420	2.8
• Cromartys Bay	19,968	10,834	9,134	862	1.9
B. Direct Harvest and Harvest and Depuration					
• Cromartys Bay	19,925	10,794	9,131	862	1.9

Note: 1. A 20-year NPV is estimated from 2020-21 to 2039-40; 2. Analysis is conducted over 20 years and an annual NPV is estimated.

Qualitative Analysis

A range of qualitative benefits that are likely to result from the adoption of real-time monitoring include:

- ongoing environmental monitoring (i.e. prediction of harmful algal blooms, water quality) that is critical during emergency events (floods, bushfires, etc.) which can result in harmful algal blooms and oyster deaths (Murray & Ajani, 2020)
- the potential reduction in farmer stress associated with unnecessary closure of harvest areas (DPI, per.comms., 2020)
- inform research on oysters from data collected from sensors (e.g. mortality rates)
- improved planning of business operations (e.g. real-time tidal information to plan work in advance)
- improved cash flow from more contiguous harvest windows
- reduced costs and risk of mortality from holding stock due to delayed harvest.

Sensitivity Analysis

The four sensitivity analyses completed include:

- adjusting the discount rates to 3 and 10 percent
- using the average Farm Gate Price over 5 years (2014-15 to 2018-19) instead of the 2018-19 values
- assuming that the sensor is damaged in year 2 and including a replacement cost.

Results presented in Tables 4 - 6 show that the NPVs are positive for all sensitivity analysis scenarios. Further supporting the decision to implement the new salinity-based management plan with sensors.

Table 4. Sensitivity Analysis Results: Estimates of NPV & BCR – Direct Harvest in Pambula Lake

Scenarios	NPV across 20 years ($/ha)	NPV per annum ($/ha)	BCR
1. Interest rate of 3%	20,388	1,370	2.8
2. Interest rate of 10%	12,396	1,456	2.8
3. Average Farm Gate Price over 5 years (2014-15 to 2018-19)[1]	13,234	1,249	2.7
4. Sensor is damaged in the 2nd year[1]	14,887	1,405	2.7

Table 5. Sensitivity Analysis Results: Estimates of NPV & BCR – Direct Harvest in Cromartys Bay

Scenarios	NPV from (2020-21 to 2039-40)	Annual NPV (in 2020-21 dollars)	BCR
1. Interest rate of 3%	12,566	845	1.9
2. Interest rate of 10%	7,439	874	1.9
3. Average Farm Gate Price over 5 years (2014-15 to 2018-19)[1]	7,692	726	1.8
4. Sensor is damaged in the 2nd year[1]	8,555	808	1.8

Table 6. Sensitivity Analysis Results: Estimates of NPV & BCR – Direct Harvest and Harvest and Depuration in Cromartys Bay

Scenarios	NPV from (2020-21 to 2039-40)	Annual NPV (in 2020-21 dollars)	BCR
1. Interest rate of 3%	12,562	844	1.9
2. Interest rate of 10%	7,436	873	1.9
3. Average Farm Gate Price over 5 years (2014-15 to 2018-19)[1]	7,698	727	1.8
4. Sensor is damaged in the 2nd year[1]	8,552	807	1.8

Note: 1. For both scenarios a discount rate of 7 percent is used.

5. Factors out-of-scope

Factors that have not been included in this CBA assessment, but may affect the outcome are listed below:

Factors that increase the NPV

- Additional harvest days during rainy seasons
- Lost production if depuration tanks have insufficient capacity to depurate oysters produced during rainfall downgrade days
- Data provided by the sensors to support better business and stock management, including over catch.

Appendix

Appendix A. Key data and Assumptions

Case studies	Assumptions

All case studies	• A discount rate of 7 percent with 3 and 10 percent for the Sensitivity analysis 1 and 2.
	• The CBA has a time horizon of 20 years.
	• Oyster are only in a marketable condition 6 months of the year (i.e.183 harvest days):
	  ○ Pambula Lake: January to July
	  ○ Cromartys Bay: December to June
	• The number of businesses (i.e. permit holders) is:
	  ○ Pambula Lake: 28
	  ○ Cromartys Bay: 7
	• Total harvest area (current POAA used) remains fixed across 20 years of analysis.
	• Forecast oyster production quantity is the 5-year average production between 2014-15 to 2018-19.
	• Forecast cost of production is a proportion of reported farm gate price in 2018-19 for the main analysis; and 5-year average between 2014-15 to 2018-19 for the Sensitivity analysis 3.

Cromartys Bay – Direct Harvest and Harvest and Depuration	• Depuration facilities have sufficient capacity to depurate all oysters produced during rainfall downgrade days. • The same quantity of oysters is produced during Direct Harvest and Harvest and Depuration harvest days.

Appendix B. Production and average farm gate prices (DPI Aquaculture Report (2014-15, 2015-16, 2016-17, 2017-18, 2018-19)

a. Pambula Lake

Items	2014-15	2015-16	2016-17	2017-18	2018-19
Production quantity (dozens)					
Large Grade	76,132	54,866	60,136	70,308	65,527
Medium Grade	136,549	131,045	111,201	135,126	142,271
Small Grade	56,096	50,261	75,174	75,512	56,968
Total	268,777	236,172	246,511	280,946	264,766
Average farm gate price ($/dozen)[1]					
Large Grade	9.24	9.50	9.74	10.65	11.15
Medium Grade	7.11	7.39	7.73	8.42	8.93
Small Grade	5.19	5.29	5.59	6.23	6.64
Average weighted farm gate price[1]	N/A	N/A	N/A	N/A	8.94[2]

Note: 1. Note that the main analysis uses the weighted average farm gate price in 2018-19 across grades for future forecasting; 2. Derived using the 5-year average production and average farm gate prices in 2018-19.

b. Cromartys Bay – Direct Harvest only[1]

Items	5-year average production	Unit
Total production by dozens - Sydney Rock Oyster	64,761	dozens
Total production by dozens - Pacific Oyster	3,359	dozens
Total production by dozens - at the harvest area level	68,121	dozens
Total production by dozens - at the farm level	9,732	dozens

Note: 1. Note that in Cromartys Bay – Direct Harvest only, rainfall downgrade days are treated as closure days, hence oyster production on rainfall downgrade days is subtracted from the reported production in the Aquaculture report to differentiate between the two production systems in Cromartys Bay.

c. Cromartys Bay – Direct Harvest and Harvest and Depuration

Items	2014-15	2015-16	2016-17	2017-18	2018-19
Sydney Rock Oyster					
Production quantity (dozens)[1]					
Large Grade	26,499	24,554	29,098	34,926	31,832
Medium Grade	15,692	16,664	18,295	22,939	24,295
Small Grade	16,027	18,237	15,584	18,617	20,893
Total	58,218	59,456	62,978	76,482	77,020
Average farm gate price ($/dozen)[1]					
Large Grade	9.24	9.50	9.74	10.65	11.15
Medium Grade	7.11	7.39	7.73	8.42	8.93
Small Grade	5.19	5.29	5.59	6.23	6.64
Average weighted farm gate price[2]	N/A	N/A	N/A	N/A	9.29

Pacific Oyster					
Production quantity (dozens)[1]					
Large Grade	861	2,479	684	1,074	150
Medium Grade	1,342	3,466	619	1,174	200
Small Grade	1,184	1,644	945	1,258	254
Total	3,387	7,589	2,248	3,506	604
Average farm gate price ($/dozen)[1]					
Large Grade	9.83	10.16	11.90	12.19	11.44
Medium Grade	7.78	7.89	8.78	9.97	10.01
Small Grade	5.83	5.73	5.00	7.62	8.80
Average weighted farm gate price[2]	N/A	N/A	N/A	N/A	10.07
Average farm gate price across Grade and Type of Oyster: $9.68 per dozen					

Note: 1. Note that oyster production in Cromartys Bay is proportionated from Port Stephen's data, using the same proportion of total harvest area in Cromartys Bay to Port Stephens; 2. Note that the main analysis uses the weighted average farm gate price in 2018-19 across grades for future forecasting.

Appendix C. Cost of inputs in production and sensors

The cost of installing and maintaining sensors is estimated at $17,000 in year 1 (including $12,000 to install and $5,000 for maintenance) and $6,000 for maintenance in subsequent years. Note these costs are cheaper for Pambula Lake in which the costs are spread across 28 businesses compared to 7 businesses in Cromartys Bay.

Average production cost per dozens for oyster farm in NSW

Item	Inputs	
FIXED COSTS		
1. Paying annual levy to Government		
a. Fisheries	0.6%	
b. NSW Food Authority	Pambula Lake: 3.3%	Cromartys Bay: 6.4%
c. Crown Lands	1.0%	
2. Water-based capital replacement	4.2%	
3. Land-based and water plant and equipment replacement	3.0%	
4. Insurance	0.3%	
VARIABLE COSTS		
5. Annual spat purchase or on-farm catching	2.2%	
6. Labour	24.6%	
7.Maintenance	1.5%	
8. Expendables (power, fuel, single use lease components such as boxes, bags, cable ties)	2.5%	

Note: 1. Based on a representative suite of farmers with an existing and developed farm in NSW
Source: (DPI, pers.comms., 2020)

Appendix D. Harvest area closure data under Option 1 relative to the Base Case (NSW Food Authority, unpublished data, 2020)

a. Pambula Lake

Item	Average	2016-17	2017-18	2018-19	Unit
Rainfall closures in days where salinity did not decline below 29ppt (i.e. Additional direct harvest days)	**11**	17	8	8	days

b. Cromartys Bay – Direct Harvest only

Item	Average	2017-18	2018-19	2019-20	Unit
Rainfall closures in days where salinity did not decline below 20ppt (i.e. Additional direct harvest days)	**9**	11	7	9	days

c. Cromartys Bay – Direct Harvest and Harvest and Depuration

Item	Average	2017-18	2018-19	2019-20	Unit
Avoided rainfall downgrade days (i.e. Days where the Base Case and Option 1 both harvest oysters, but Option 1 can directly harvest, hence avoid the cost of depuration)	**5.67**	8	7	2	days
Rainfall closures in days where salinity did not decline below 20ppt (i.e. Additional direct harvest days)	**3.33**	3	0	7	days
Rainfall closures in days where salinity did not decline below 20ppt but was within downgrade) (i.e. Additional downgrade harvest days)	**5.33**	7	0	9	days

References

DPI (2019) Aquaculture Production Report 2014-15, 2015-16, 2016-17, 2017-18, 2018-19 < https://www.dpi.nsw.gov.au/fishing/aquaculture/publications/aquaculture-production-reports >.

Murray, S & Ajani, P (2020) Ah shucks, how bushfires can harm and even kill our delicious oysters < https://theconversation.com/ah-shucks-how-bushfires-can-harm-and-even-kill-our-delicious-oysters-131294>

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