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Tactical Research Fund: Development and Validation of Effective and Affordable Oyster Production Systems in the Face of POMS Disease of Pacific Oysters and QX Disease of Sydney Rock Oysters - Evaluation from a Production, Research and Economic Perspective.

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Development and Validation of Effective and Affordable Oyster Production Systems in the Face of POMS Disease of Pacific Oysters and QX Disease of Sydney Rock Oysters - Evaluation from a Production, Research and Economic Perspective

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Oyster Farmers interviewed and consulted during the project

Abbreviations

PO = Pacific Oysters

DPO= Diploid Pacific Oysters

TPO= Triploid Pacific Oysters

POMS= Pacific Oyster Mortality Syndrome

QXR = QX-Resistant

POMSR = POMS resistant

SRO= Sydney Rock Oyster

HR= Hawkesbury River

Flupsy = floating upwelling system

Executive Summary

Hawkesbury River (HR) oyster farmers suffered a sudden and virtually complete loss farm stock and farming income over 4 days in January 2013. The disease caused rapid and significant death amongst juvenile and market sized triploid Pacific Oysters. The identified causal agent - Pacific Oyster Mortality Syndrome (POMS or OsHV-1) was known to be devastating to Pacific Oyster (PO) production elsewhere in the world since early 2000's, but until 2010, unknown in Australia. Despite rigorous containment efforts, the disease spread to the Hawkesbury and is regarded as having significant potential to spread to other PO growth regions. These key regions (SA & Tasmania), like the Hawkesbury River grew single species of oysters. The purpose of the report is to chronicle and analyse a farmer based and led review of options and potential responses. The Hawkesbury River had suffered QX disease of Sydney Rock Oysters (SRO) 10 years before and alternate oyster species are limited (as with SA & Tas).

A representation of oyster growers were interviewed to gain insight on current NSW oyster farm practices and to identify possible oyster farming options which may be taken up or developed by HR oyster growers in the face of POMS losses. Risks associated with possible production/stocking options were considered and reviewed regarding impact on Hawkesbury River (HR) oyster farmers in the wake of POMS disease of Triploid Pacific Oysters and pre-existing QX disease of Sydney Rock Oysters. Scenarios were analysed in detail to identify and rank the different options. The process represents a grower based methodology to pre-define risks and responses for other PO growing oyster regions in Australia.

11 possible farming production/stocking options were identified, assessed for risk and discussed for adaption/adoption. A POMS resistant Pacific Oyster (assumed to be available in 2018) is clearly the farming production choice for growers. Farming QX resistant Sydney Rock oysters in the interim is the least risk interim production option. An assessment of options available demonstrates that farming disease resistant oysters is the lowest risk option assuming that they will become available in the future, it does not address the issue of no farming income for HR oyster farming businesses in the growth cycle interim. Survival is highly dependent on:

1. Availability of suitably resistant oysters. Hatchery production of QX-Resistant SRO spat has been highly variable and none would be available until late 2013/early 2014. Availability of POMS resistant Diploid Pacific Oyster's (DPO) or Triploid Pacific Oyster's (TPO) is currently undefined and longer term.
2. Available cash flow – to restock/re-establish, operating funds are needed to both purchase replacement stock and to meet business-running expenses. Farming QX resistant SRO's represent a 2 to 3 year production cycle before cash returns to farmers.
3. Understanding the viability of farming during "disease free" production months. These "disease free" windows are not precisely defined (for POMS or QX) and the production impediments in these windows (stock supply, environmental stresses, cost of replacement, biosecurity) are unknown.
4. Managing and reviewing regulatory issues such as biosecurity, genetics, system transparency, the structure and management of breeding programs and funding availability.

Key potential actions for HR oyster farmers were identified through this project:

1. Establish systems to access affordable operational and re-stocking cash flow options (available to other farming sectors) which they will enable business survival.
2. System development should include grower training on risk management including species diversification, disease and environmental management.
3. Growers to develop and establish reliable and affordable sources of suitably sized non-resistant oyster stock to farm disease free windows as a short growth cycle option for cash flow.
4. Pursue strongly all avenues for timely access to quality and affordable disease resistant oyster stock:

    a. QX resistant Sydney Rock oysters – Encourage reliable hatchery production with preferably more than one source of supply, including systems that unlock the potential of improved genetics currently subject to complex dual path breeding programs.
    b. Encourage fastest possible access to POMS resistant oysters via local breeding programs and assistance tools. Encourage reliable hatchery production and preferably more than one source of supply. Include review and managing impediments and regulatory issues in accessing POMS resistant oysters wherever they may develop first (interstate or internationally)
5. Continue to develop production alternatives that reduce risk in the face or threat of disease via collaborative research programs that seek grower input and direction. This includes farming alternate species, resistant oysters, understanding/defining disease free windows, infrastructure and breeding/hatchery adaptations that reduce impact of disease on farmer choice.
6. Encourage all oyster growers to establish/develop business structures that include species diversity and improved efficiencies and risk management.
7. Resolve regulatory impediments that impact farming flexibility and ability to adapt including biosecurity and food safety compliance measures.

Potential stocking/production options were identified via a structured and interactive review methodology. HR farmers (and other regions) have the potential to pursue oyster farming in the presence serious disease stressors over multiple species of oyster. Grower planning and acceptance of risk management strategies for future farming was identified as an area where industry can improve significantly. Government resourcing in this area is seen as a key way of improving the resilience of oyster farming in NSW. It is critical to progress key research goals around disease resistance of PO and refining SRO resistance. Managing loss by production strategies has been shown to have potential not only on farm, but potentially preserving hatchery production in the face of disease. Resistant oyster strategies are hatchery based and the requirement for cash flow. Response by government to this aspect has affected significantly the ability to of oyster businesses to survive and recover and requires industry/government review for future issues in other estuaries.

Therefore the lack of consistent supply of QX resistant SRO and the limited operating funds have impacted HR farmers most in the after-wash of loss from POMS. Resistant oysters, farming a more diverse range of species and timely access to oyster stock of choice (spat/ongrowing) represent the least risk strategies available to HR oyster farmers. Pacific and Sydney Rock growers (industry) should develop better financial resilience strategies and significantly improved on-farm risk management after the HR example. This development should be an industry/government co-operative goal.

The review and analysis form a pro-forma that can be used by other estuaries when planning oyster cultivation with the threat of POMS infection.

Keywords

Pacific Oyster, *Crassostrea gigas*, Sydney Rock Oyster, *Saccostrea glomerata*, POMS, QX, Hawkesbury, disease outbreak, economic analysis, Hawkesbury River

1 Introduction

The Hawkesbury River, near Sydney NSW, has a long tradition of oyster production.. In 2004, a disease of Sydney Rock Oysters (QX) decimated the Sydney Rock oyster growing industry on the river. A core group of surviving oyster farmers (Broken Bay Oyster Association - BBOA) with the assistance and encouragement of government at all levels invested in new growing techniques centered on a new oyster production system involving Triploid Pacific Oysters. By 2013 oyster production had exceeded pre-QX production figures. The forecast for 2013 production output from the Hawkesbury River of high quality triploid Pacific Oysters was in excess of $6 million. The Hawkesbury River oyster recovery to this point was recognized and acknowledged nationally and internationally as an iconic example of a phoenix industry – emerging from the ashes of the QX disaster. The success of utilizing triploid Pacific Oysters was recognized with more than ten other NSW estuaries submitting or developing applications to expand aquaculture licenses to include triploid Pacific Oysters.

In 2010, a serious Pacific Oyster specific disease Ostreid herpesvirus-1 (OsHV-1) or Pacific Oyster Mortality Syndrome (POMS) was identified in the Georges River, south of Sydney. The syndrome was previously known to industry from the severe impact it had on oyster production in Europe and New Zealand. Hawkesbury River farmers proactively engaged with government and other stakeholders to take all possible precautions to prevent the disease moving into the Hawkesbury River, becoming active locally, by trying to understand the disease and possible ways of managing oyster farming in the face of this new threat. The growers imposed self-administered quarantine and stock and infrastructure handling procedures and invested (in-kind and financially) in local research to develop management plans around POMS.

However, on Tuesday, 22nd January 2013, POMS was confirmed in Mullet Creek, part of the Hawkesbury River oyster production system and a major juvenile growing area for Hawkesbury River oyster farmers. By Wednesday, 23rd, there was an estimated 99% mortality of juvenile oysters in Mullet Creek and by Friday 25th, evidence of infection was found in neighboring Mooney Mooney Creek (a significant on growing area). By February 14, mortality across all sizes of Pacific Oysters was being noted in all reaches of the river system sampled. Later analysis of historical samples taken as part of an ongoing Sydney University research project (FRDC 2012/032) showed the virus was present in Mullet Creek in October 2012, with no visual mortality of oysters. The virus's speed of infection and level of devastation is unprecedented from the 100+ years of oyster farming experience. Growers did not get an opportunity to handle or sell stock before it became un-saleable due to the virus. International and limited experience with the Georges River suggests, once present, that POMS will manifest itself each summer season in susceptible Pacific Oysters. This is similar to QX disease of Sydney Rock Oysters, which has remained active in the Hawkesbury River system since 2004. The presence of QX in Sydney rock oysters and the occurrence of POMS in pacific oysters gave no clear oyster farmer options for Hawkesbury River oyster farmers and have important bearings on future oyster farming.

1.1 Background

An industry workshop and initial review identified key hurdles or barriers present when cultivating Pacific Oysters in the face of POMS disease and Sydney Rock Oysters in the face of QX disease. Here are listed some of the hurdles or barriers identified:

- Production – Australia oyster farmers commercially produce 3 oyster species – Angasi (flat oysters *Ostrea angasi*), Diploid Pacific Oysters (DPO) and Triploid Pacific Oysters (TPO) - *Crassostrea gigas* and Sydney Rock Oysters (SRO) - *Saccostrea glomerata)*.
- Within these species, options of ploidy, source of spat and disease resistance status present a potential matrix of choices for oyster production to evaluate for Hawkesbury River oyster farmers. Each production option potentially involves supply, infrastructure, and environmental and marketing challenges.
- Science or research challenges exist for each choice. Oyster farming presents a range of challenges around disease, growth, conditioning, hatchery and nursery production and environmental robustness. The science/research support or needs required to best utilise the oyster production options identified may vary.
- Oyster farming requires significant investment in infrastructure and stock management. Changes to existing farming techniques, or adaptation to new techniques will require grower investment and time, and the potential costs involved may not be only economic. An understanding of the benefit cost of adopting or adapting to new or modified production options would assist growers in determining the best way forward (disease resistance, quality spat, new infrastructure, changes in production cycles, etc.).
- Oyster farming is now highly regulated in terms of quality assurance, administrative charges and requirements and biosecurity considerations around pests and diseases. Barriers resulting from such regulations to oyster production can restrict, in some cases significantly, the adoption of new opportunities for sustainable oyster production.

2 Objectives

This project addresses the above issues through the following key objectives:

1. Review current oyster production and culture methods and possible oyster production alternatives as they relate to mitigating POMS
2. Determine the feasibility of alternate options via cost benefit analysis
3. Review the current administrative and regulatory barriers and methods to overcome them

3 Methodology

3.1 Industry interviews - review of production methods, associated issues and options:

Face-to-face interviews with growers and researchers were undertaken and manage by OceanWatch Australia. The interviews aimed to review current oyster production methods used by growers cultivating PO and SRO in nearby estuaries to ensure associated production issues that will impact growers with the treat of POMS are considered and future options to assist growers affected by POMS, including potential strategies to mitigate the risk of POMS are captured. Interviews covered a wide range of aspects as listed below:

- Infrastructure types
- Spat management
- Stocking rates
- Spat sources
- Stock availability
- Re-Stocking costs
- Mortality
- On-grow supply
- Marketing challenges
- Disease challenges
- Production challenges
- Environmental challenges
- Pest management
- Biosecurity challenges
- Research challenges
- Breeding challenges
- Management challenges
- Opportunities/ suggestions

Seven growers from four estuaries were interviewed covering two species, two oyster ploidy (diploid and triploid), multiple variations in production methodologies and three disease resistance strategies (Table 1).

The interviews were conducted with anonymity for the growers involved with detailed notes and findings retained on file. The interview skeleton used has been included in Appendix 1 (OceanWatch Australia interview – format – appendix 1.xlsx)

Table 1 – Background information of growers interviewed as part of this project

ID#	River	Sydney Rock Oysters – non QXR	Sydney Rock Oysters – QXR	Pacific Oysters Diploid – non POMS	Pacific Oysters Triploid – non POMS
Grower 1	Shoalhaven River	X			X
Grower 2	Shoalhaven River	X			X
Grower 3	Hawkesbury River	X			X
Grower 4	Hawkesbury River	X	X		X
Grower 5	Georges River	X	X		X
Grower 6	Port Stephens	X		X	
Grower 7	Port Stephens	X	X		

3.2 Determining the risk and feasibility of potential scenarios to sustain oyster production in POMS affected estuaries

3.2.1 Key "stressors"

Current and potential oyster production scenarios, which may be possibly utilised on the Hawkesbury River potentially, carry significant risks and challenges. The presence and persistence of both QX disease of Sydney Rock Oysters and POMS of Pacific Oysters presents a potentially complex and challenging farming environment. Regulatory compliance and biosecurity issues add another layer of complexity. As well as identifying potential production options, grower interviews and industry consultation identified many potential production challenges.

The production challenges facing growers are many and diverse. The challenges were grouped under 11 key "stressors" that were the base of the risk assessment undertaken in order to quantify the impact of the stressor on a number of production scenarios:

- Hawkesbury River farmer experience
- Hawkesbury River business cash flow
- Oyster species, ploidy, size, disease resistance status
- Biosecurity considerations
- Oyster stock availability – wild, hatchery, spat & ongrow
- Cost of re-stocking
- Disease related stressors
- Disease free production windows
- Infrastructure needs
- Market affects
- Genetic sources/breeding capability
- Management

A description of each of the stressors and associated sub-categories considered during the risk assessment has been collated in Table 2

Table 2 – Production stressor when oyster farming with POMS and QX diseases of oysters

HR farmer experience
Single species focus since 2007 has limited experience with alternate oyster species such as Sydney Rock Oyster, Diploid Pacific Oyster and Angasi Oysters
Attempts to diversify in 2011 confounded due to poor supply of QX resistant Sydney Rock Oysters
Current infrastructure may not be suitable to maximise growth or manage for alternate production options or alternate species - focus has been on floating and trays.
Long line development is a relatively recent investment focus of HR growers
HR farmer cash flow
The sudden impact of POMS and loss of juvenile and saleable stock before the majority of seasonal sales occurred has caught farmers without cash for re-stocking or infrastructure re-investment
Significantly reduced cash flow options limit ability to respond to re-stocking or infrastructure needs of any identified production options
Ongoing commitment to remove dead oysters and return infrastructure to shore is also an ongoing cash drain
Lack of government assistance and non-recognition by banks on assets limit identifying and obtaining alternate funding
Biosecurity
Interstate import of larger oysters requires import protocol regulation changes
International import of live oysters requires import risk and regulation reconsideration.
Intrastate import and translocation protocols are limited by biosecurity regulations and restrictions relating to movement of infrastructure, staff and oysters
Intrastate sources of replacement oyster stock (as spat or ongrowing) limited to a few estuaries due to biosecurity issues or government issues related to granting of relevant aquaculture permits for other oyster species
Intra & interstate concerns about disease (and other marine pests) transfer from inter estuary farming practices
Translocation of oyster species subject to government regulation and oversight

Oyster stock availability - Wild sourced stock	
Spat	Reliable supply and continuity of supply is uncertain for all species
	Spat supply is subject to seasonal variation
	Wild sources spat volume varies by species (PO vs. SRO)
Ongrow or larger oysters	Availability of larger oysters for on-growing in a single season during the disease free window is not currently economical and suitable stock is hard to locate and expensive
	Available larger oysters for ongrowing are expensive as some growers and processors market the sizes necessary for HR growers to successfully ongrow in the small disease free window
	Disease and marine pest issues result in limited stock source options and movement restrictions
	Estuary species cultivation varies - limiting source of supply for species (PO vs. SRO)
	Limited sources for some species and oyster types - SRO vs. PO

Oyster stock availability - Hatchery Sourced stock - Spat
Reliable supply and continuity of supply is very uncertain for most species
Spat supply is limited to a few hatcheries and availability for some species is limited to single hatchery sources
Hatchery spat relatively expensive
Hatchery linkages to nurseries not clear and reliable access to species outputs remains very uncertain
Access to the best genetics is uncertain - breeding program management of elite stock and brood stock has resulted in variable outputs and availability
Biosecurity requirements add significant cost to spat handling requirements interstate - Triploid Pacific Oysters
Biosecurity requirements restrict ability to access larger sized spat or oysters - closed water raising systems
Biosecurity requirements limit stock delivery times - seasonal PO over catch in Port Stephens
Stock availability limited by adequate conditioned broodstock
Limited choice of species from hatcheries - location limitations - TPO only from Tas, QXR SRO only from Port Stephens. This impose biosecurity restrictions - Georges River, Tasmania, Victoria
Hatchery stock performance is not well documented against wild stock - anecdotal
Hatcheries are only source of disease resistant stock - very poor record of breeding success and supply in NSW
Farmer uncertainty in the quality of the "elite" lines and poor continuity of supply and poor grower support of purchase over time
Limited supply windows from current hatcheries because of low cost operations and uncertain markets for their output and seasonal difficulties
Inability of the hatchery industry to rapidly respond to change or demand

Oyster stock availability - Hatchery Sourced stock - Larger or On-grow stock	
Availability of larger oysters for ongrowing in a single season disease free window is not currently a significant market and suitable stock is hard to locate and expensive	
Available larger oysters for ongrowing are expensive as some growers and processors market the sizes necessary for HR growers to successfully ongrow in the small disease free window	
Disease and marine pest issues result in limited stock source options and movement restrictions	
Estuary species cultivation varies - limiting source of supply for species (PO vs. SRO)	
Limited sources for some species and oyster types - SRO, QXR SRO, DPO and TPO	
Availability of larger QXRSRO and TPO's is non-existent - no previous demand	
Cost of re-stocking	
Spat/ Young oysters	Perceived cost of wild caught stock vs. hatchery stock Cost of small stock (2.44mm) vs. larger stock from hatchery vs. nursery Consistency of supply of different species and disease resistance types results in cash flow issues for growers Handling costs and expertise in managing small oysters - upwellers, socks, pillows, on-shore tanks etc. Lack of expertise in young stock management and advice for growers - large losses of young stock
On-growing oysters	Available stock of appropriate size is expensive - HR is a new demand in this market and a newer retail market niche for small oysters limits ability to access at appropriate price Limited length of disease free production windows requires HR to access non resistant species at a larger size (and therefore more costly) to be able to ensure a saleable product before the next disease cycle Limited availability (or non existence) of disease resistant stock - poor supply from hatcheries/nurseries Disease resistant stock will be only hatchery stock in the short/mid-term and therefore more expensive

Disease Stessors	
Seasonal	Cooling waters - slower growth, limited access to spat
	Floods or significant freshes slowing growth and changing length of growth windows
	Seasonal affects on length of windows
Environmental	Droughts - changes pest status - snails down south, QX promoter?
	Heat kills - long periods of heat and affect on oyster survivability and disease promotion??
	Storms - impact on oyster stress and stock loss
Pest	Mussel and worm issues - Fresh water inundation and heat impact on disease
	Disease virulence - POMS, QX, Winter mortality, Summer Mortality
	Seasonal variation and affects on pest severity, drought, hot weather, prolonged fresh water
	Algal blooms and impact on oyster health/quality
	Over catch - impact of stress from management options
Handling responses	Stressors evoke necessary production responses from growers - more handling, need for wave boards, predator protection, shade cloth, watering to cool, washing to minimise mud worm, translocation of stock to lesser risk areas (flood, QX)
	Moving stock within estuaries to reduce disease risks/stress
	Complexity of management increases with multi-species farming
	Disease activity windows are not known with certainty
	Disease free windows can change under environmental influence - e.g. floods
	Water quality - poor water quality may enhance risk of disease and influence disease activity windows
Production windows	
Seasonal variations	Floods, drought, disease all influence the length of the available disease free production window and the growth rate of oysters
Disease type	Different diseases are active at different times - QX (SRO's), POMS (PO'S), Winter mortality (SRO's), Summer mortality (PO's)
Pest challenges	Presence of different pests influence management needs and oyster growth rates - mud worm (SRO & PO), mussels (SRO & PO), fish predation (SRO & PO)
Disease challenge	Experience indicates diseases (and pests) can impact at variable severity levels and the window of disease activity is not precise
Length	Disease free production window varies with disease, seasonal conditions severity of disease impact and affect on the species (fast death - no ability to respond)

Infrastructure
Management of disease may involve different infrastructure - long line, floating baskets, growing height changes
Intertidal vs. tidal management systems
Baskets vs. trays - oyster management flexibility
Wild stock vs. hatchery stock - disease tolerance status
Handling needs -ability to dry to reduce disease exposure
Changes in young stock management - consideration of upwellers, FLUPSYS
Utilising Fluppsies (floating upwellers) to hasten growth
Single seed vs. stick culture - growth rates
Cost of new infrastructure implementation when cash flow is depleted
Cost of removing and disposing of old infrastructure and adaptation of existing infrastructure
Available resources and time to move between systems (cash and labour and time)
Impact of new species management on the area or stock number needed to manage within the boundaries of new species or infrastructure investments
Impact on stock cycles and restocking - e.g. Pacific Oysters are less/tray - more trays and more area per cycle

Markets	
Diversification	Impact on management of multi-species farming - different marketing requirement and timelines
	Accessing replacement stock when required to fit new species or farming technique production options
	Window growth strategies may invoke market clutter/competition with more stock to be sold in confined windows - price and sale issues
	Seasonality between species, competition from other oyster areas may affect market access and short term size
	Impact of spawning and marketability windows during disease free windows
	Condition and oyster size pressures to ensure stock is sold before disease risk impacts set in for the season
Adding value opportunities	Retail vs. wholesale vs. ongrowing vs. spat supplier vs. species farmed
	Accessing reliable customers to take stock at a time to suit restrictive window farming
	Market dynamics have created a retail sale market for potential ongrow oyster stocks making access at a reasonable price for adding value difficult
Market timeline	Time to market - access suitable stock that can effectively be value added within the production window timeframes

Genetics	
Disease resistance	Accessing adequate resistance in available stock/species Accessing reliable supply of disease resistant stock Inclusion of other desirable traits - growth rate, shape, conditioning
Program performance	Performance of breeding programs - are outputs timely and relevant? Ability to re-focus on key needs in a timely manner Improve/ensure provision of adequate funding to gain necessary results Support of program outputs- need performing hatcheries and grower support and purchase of production Inclusion of "future proofing" in breeding programs - elite stock location, review and consideration of future threats
Communication	Communicating breeding program goals, performance and outcomes Management of genetics to hatchery - performance goals and business planning with industry Inclusion of production packages as part of the breeding/hatchery outputs to enhance support and success Improvement of communication of needs and outcomes down the value chain between breeder/hatchery/nursery/grower Identifying and input into research goals and research gaps
Management	
Diversification	Multi species on farm production increases complexity of farm management but at the same time enhances diversification as a potential mitigation strategy Multi season overlaps with multi season species and between species complicates production management Infrastructure upgrades or changes (correct choices and affordability) Multi species pest management and on farm response Environmental stressor differences between species and farming methods
Efficiencies	Baskets vs. trays Floating vs. intertidal Socks vs. upwellers/FLUPSY Purchase and use of grading machines Over catch management Proportion of species on farm
Business structure	Co-investment - equipment, production, staff, etc. Co-operations - equipment, production, staff, etc. Inter-estuary partnerships Inter-estuary investments (leases, on-growing) Intra-estuary collaborations & partnerships Marketing co-operations, value adding, move to retailing Transport logistics relating to above points Staff logistics relating to above points

3.2.2 Potential Oyster stocking and Production Scenarios available to Hawkesbury River oyster farmers

To survive and re-establish viable businesses on the HR in the presence of both POMS (TPO & DPO) and QX (SRO) diseases, HR growers need to identify stock access and production issues options

Table 3 - Potential oyster stock availability and stocking/production scenarios available to HR oyster farmers.

Stock supply/production Scenario	Scenario description and summary
#1 - Non-resistant Triploid Pacific Oysters grown from spat - time line shown in Appendix #2	Access non-TPO spat, and grow TPO over the summer in non POMS estuaries where POMS is not an immediate threat, transfer to the HR in May and add value (bulk) to reach a marketable size by the end of the disease free production window (approx. 40mm)) to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. Production cycle approx. 14 months.
#2 - Non-resistant Triploid Pacific Oysters for on-growing - time line shown in Appendix #3	Access larger TPO, transfer to the HR in May and add value (bulk) to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. Suitable purchase pricing for on-grow stock may prove a challenge. Uncertainty of the cessation and recommencement of POMS activity is a significant risk. Production cycle <6 months
#3 - Non-resistant Diploid Pacific Oysters grown from spat – time line shown in Appendix #4	Access non-TPO spat, and grow TPO over the summer in non POMS estuaries where POMS is not an immediate threat, transfer to the HR in May and add value (bulk) to reach a marketable size by the end of the disease free production window (approx. 40mm)) to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. Production cycle approx. 2 years with potential conditioning issues associated with spawning,
#4 - Non-resistant Diploid Pacific Oysters for on-growing - time line shown in Appendix #5	Access larger DPO, transfer to the HR in May and add value (bulk) to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. Suitable purchase pricing for on-grow stock may prove a challenge. Uncertainty of the cessation and recommencement of POMS activity is a significant risk. Production cycle approx. 6 months with potential conditioning issues associated with spawning
#5 - Non-resistant Sydney Rock Oysters grown from spat – time line shown in Appendix #6	Access & grow SRO from spat (hatchery or wild catch) to reach a marketable size by the end of the disease free production window (approx. 30 to 40mm) over the summer in an estuary where QX is not an immediate threat for at least 2 seasons, transfer to the HR in May and add value (bulk) to deliver a potential profit when sold in early summer before QX re-manifests as an infection risk. Production cycle approx. 3 to 4 years with potential mortality and conditioning issues associated with spawning. SRO spawning adds to production and marketing complexity.
#6 - Non-resistant Sydney Rock Oysters for on-growing time line shown in Appendix #7	Access larger SRO, translocate to the HR in May to reach a marketable size and add value (bulk) to deliver a potential profit when sold in early summer. Production cycle approx. 05 to 1 year with potential conditioning issues associated with spawning. Oyster must be sold before QX potentially re-manifests. SRO spawning adds to production and marketing complexity. Suitable purchase pricing for on-grow stock may prove a challenge.

#7 - QX-resistant Sydney Rock Oysters grown from spat – time line shown in Appendix #8	Access QXR SRO spat (hatchery only) and grow to reach a marketable size and add value (bulk) to deliver a potential profit when sold in early summer. Production cycle approx. 2 to 3 years and over-catch is a risk and there are potential conditioning complexities associated with spawning. Spat source has been historically sporadic and would need to be improved. Potential loss from repeated exposures to QX is an issue so oysters should reach market before the second hit of QX. Production will involve intra-estuary stock movement to manage QX exposure. SRO spawning adds to production and marketing complexity.
#8 - QX-resistant Sydney Rock Oysters for on-growing – time line shown in Appendix #9	Access larger QXR SRO to reach a marketable size and add value (bulk) to deliver a potential profit when sold in early summer. Production cycle approx. 05 to 1 year with potential conditioning issues associated with spawning. Suitable purchase pricing for on-grow stock may prove a challenge.
#9 – POMS resistant Triploid Pacific Oysters from spat or for on-growing – time line shown in Appendix #10	Assumption is that POMS resistant TPO spat will be available. Identify and obtain suitable POMSR TPO spat & larger oysters (from NSW estuaries) and translocate to the HR for farming to profitable size & condition - a return to former pre-POMS practice. Spat growth enhancement options may be useful. Oysters grown to a saleable size and bulk and sold year round within 10 to 14 months of spat purchase. If resistance is actually tolerance, then practices to minimise exposure of stock to POMS may still apply.
#10 – POMS resistant Diploid Pacific Oysters from spat or for on-growing – time line shown in Appendix #11	Assumption is that POMS resistant DPO spat available. It is likely POMSR DPO spat will be available before TPO. Identify and obtain suitable POMSR DPO spat (Tasmania or alternate hatchery) & larger oysters (from NSW estuaries) and translocate to the HR for farming to profitable size & condition. Spat growth enhancement options may be useful. Oysters grown to a saleable size and bulk and sold year round within 18 months of spat purchase. If resistance is actually tolerance, then practices to minimise exposure stock to POMS may still apply.
#11 – Flat (Angasi) Oysters from spat or for on-growing – time line shown in Appendix #12	Identify and obtain suitable spat (and larger oysters from NSW estuaries) and translocate to the HR. Oysters grown to saleable size and bulk to add enough value to deliver a potential profit when sold. POMS & QX should not affect flat oysters. Stock production cycle – 36 to 48 months. May be other disease issues such as *Bonamia sp*.

3.2.3 Risk Assessment

An assigned risk value was allocated to each “stressor” (Table 2) in a series of potential stocking/production scenarios (Table 3), a risk analysis was undertaken. Each of the “stressor” sub-categories (Table 2) was assigned an arbitrary risk value (Table 4) based on information secured from interviews and experience associated with the type of stressor. Scenario risks are summarised in Table 5, Figure 2 & Table 6.

Table 4 - Assigned risk value on impact of “stressors” on Hawkesbury River oyster farmers

Assigned Risk Value	Impact
a	Lower risk or lower impact on Hawkesbury River oyster farmers
b	Medium risk or medium impact on Hawkesbury River oyster farmers
c	High risk or high impact on Hawkesbury River oyster farmers

4 Results

4.1 Background of oyster production information to consider during the assessment of future opportunities for growers impacted by POMS

Reviewing the farming practices and strategies (section 3.1) of interviewed growers identified not only significant difference on how each grower approaches production, but also some common production points and issues to consider. A summary of general costs/activities include:

Production handlings –

- Sydney Rock Oysters – involved up to12 to 14 handlings over 3 years
- DPOs – involved up to12 handlings over 18 to 24 months
- TPOs – involved up to 10 handlings over 12 to 14 months

Handling costs -

- The number of oysters handled each time, the handling task (thinning, grading etc.), time of the year and farmers own costing methods means actual cost for a handling will vary. A figure of $2.50 per dozen is proposed to represent the cost of the multiple handlings (developed via multiple consultation with other growers) for the production cycle.

Stock Costs – summarised from various supply sources.

- QX SRO - $0.04 each as 2.44mm spat
- TPO - $0.045 each as 2.44mm spat
- On-grow DPO - $3.50 per dozen for 50mm oysters
- Small – non QX SRO on-grow $2.50/dozen – sell in 6 months for $4.50 to $5.00
- Larger – non QX SRO on-grow $3.50/dozen – sell $6.00 to $6.50

Mortality – non-disease

- SRO – reported as 10 to 15%
- TPO – 5 %

Infrastructure

- Cost of slats were estimated at $30,000 per 100m Multi-species farming
- Cost of long line was estimated at $1,250/100m
- Cost of rack & rail & tray was estimated at $6,500/100m

Benchmarking

- The author approached Oysters Australia and Rural directions for a summary of oyster growing costs in NSW as recorded in their data base - 2013. Rural directions approached the limited respondents to the benchmarking project and 3 growers gave permission to be included.

Grower Type 1	Grower Type 2	Species	% Grown	Species	% Grown	Species	% Grown	Growing Method 1	%	Growing Method 2	%	Growing Method 3	%	*Gross Margin as % income*	Total Operating Costs per Dozen Sold	Net Profit as % of income after imputed labour
		SRO Diploid	50	Pacific Diploid	50			Rack and Rail (all other)	30	Line and Basket/Purse / Cylinder	70			106%	$ 3.76	46%
Finished Oysters	Nursery	SRO Thor'bred	33	SRO Diploid	65	Angasi Diploid	2	Line and Basket/Purse/ Cylinder	2	Rack and Rail (all other)	5	Floating Line	93	80%	$ 4.37	41%
		Pacific Diploid	100					Line and Basket/Purse/ Cylinder	100					96%	$ 2.41	-7%

- The sample is very limited – 3 growers. Diploid costs per dozen are lowest, but profit is better with mixed species farming. Basket farming is potentially more profitable that rack & rail

Cost Other comments

- QXR SRO are slow to condition in the Hawkesbury River (HR) during winter
- Mud worm is worse in winter when SRO growth is slowest
- Winter mortality reported as a sporadic but general issue in the HR – its presence can't be dismissed. Worse in larger oysters? Worse when water cools or when water warms for spring (conflicting reports)
- Purchasing larger spat can reduce production cycle time by as much as 12 months.
- With many variables costed differently by growers associated with production and the number of undefined risks identified, assigning true costs to production/stocking scenarios was determined to have limited value as it would have been specific to the HR.

4.2 Timelines involved with the identified Potential Stock Availability and Production Scenarios available to HR oyster farmers

Undertaking and understanding production changes, which potentially involve different species, different disease tolerance status, different lengths of production cycles and different regulatory restrictions can be complex, but each option involves a production timeline. The 11 stock availability and production scenarios are considered within its timelines (summary of these are included in Appendices #2 to #12. Some oyster species (Sydney Rock Oysters, Angasi Oysters) take between 2 & 5 years to reach marketable size. Diploid Pacific and Triploid Pacific oysters can take between 1 and 2.5 years to reach marketable size. This time span has obvious major impact on business cash flow and the ability for growers to cost and pay for change.

4.3 Risk assessment of the 11 production/stock scenarios

Different stressors impose different degree of risk. Each of the multiple stressor factors was assigned a score in each of the 11 stock supply/production scenarios and the relative number of high, medium or low were added for that scenario. When added across the production scenarios, adding the risk score for the different "stressors" develops an overall risk summary. The results of the risk assessment have been presented as data sets in tables (tables 17 & 18) and as spider graphs (Figures 1 & 2).

On the spider graphs (Figures 1 & 2), the position along the scenario axis of the relative risk (low, medium or high) gives an indication how the scenario rates in terms of risk. The further from the

center the risk ranking crosses the scenario axis, the higher the number of “stressors” falling into the risk rating for the scenario.

Scenarios were evaluated for present conditions (2013) - table 17 & figure 1 and for future conditions (2018) – table 18 and figure 2.

Scenario relative riskiness in “present” (2013) terms

The risk situation for present conditions (2013) is summarised in Table 5 and Figure 1 (i.e. same data set has been shown in different formats). The spider graph below (

Figure 1) demonstrates relative risk of each Stock Supply/Production scenario. As the risk moves to the outer rings of the web there is an increased likelihood (percentage) of the risk occurring. For example of the red line approaches the outside of the web for a specific scenario means that the assessment resulted in an increase of high risk for that scenario. In 2013, all the production scenarios represent medium relative risk (orange line). The green line represents low risk. Present day risk is highly skewed by lack of available resistant stock and cash flow for example and score for low risk are low for all parameters and scenarios. Scenario # 8 – QXR SRO’s (blue arrow) demonstrates the lowest risk scenario against other scenarios, but still has inherent risk because of lack of supply of suitable stock and cash flow to purchase (indicated by the orange line).

Figure 1 - Risk assessment results considering all key “stressors” potentially impacting HR growers by potential production scenarios – current condition in 2013. Blue arrow highlights lower risk scenario

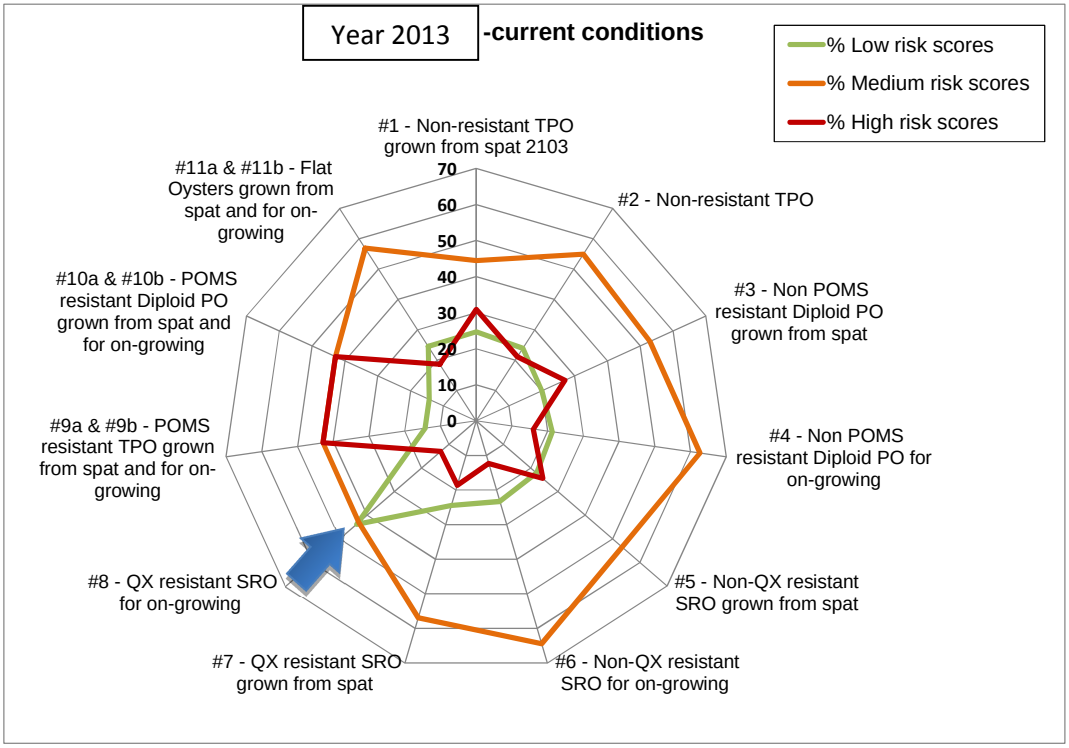


Table 5 - Risk matrix across all key "stressors" potentially impacting HR growers and scenarios – 2013 (low – green, medium – orange & high – red risk)

Cash flow and access to suitable genetics were identified as prominent high risk "stressors" for all production scenarios in 2013.

Year 2013 -existing conditions	Farmers experience	Cash flow	Biosecurity	Wild Stock availability	Hatchery Stock availability	re-stocking with spat	re-stocking with on-grown	Disease stressor	Prod'n window	Infrastructure required	Market options	Genetics	Management
#1 - Non-resistant Triploid Pacific Oysters grown from spat	a	c	b		b	a		c	c	b	b	c	b
#2 - Non-resistant Triploid Pacific Oysters for on-growing	a	c	b		c		b	b	b	b	a	c	b
#3 - Non POMS resistant Diploid Pacific Oysters grown from spat	b	c	b	b	a	b		c	c	b	b	c	b
#4 - Non POMS resistant Diploid Pacific Oysters for on-growing	b	c	b	a	b		b	b	b	b	b	c	b
#5 - Non-QX resistant Sydney Rock Oysters grown from spat	b	c	c	a	a	b		c	c	b	b	c	b
#6 - Non-QX resistant Sydney Rock Oysters for on-growing	b	c	c	a	b		b	b	b	b	b	c	b
#7 - QX resistant Sydney Rock Oysters grown from spat	b	c	c		b	b		b	a	b	b	c	b
#8 - QX resistant Sydney Rock Oysters for on-growing	b	c	c	c	c		b	a	a	b	b	c	b
#9a & #9b - POMS resistant Triploid Pacific Oysters grown from spat and for on-growing		c	b										
#10a & #10b - POMS resistant Diploid Pacific Oysters grown from spat and for on-growing		c	b										
#11a & #11b - Flat (Angasi) Oysters grown from spat and for on-growing	c	c	b	b	a	b	b	b	b	b	b	c	b

Scenarios relative riskiness in "future" (2016) terms

The risk situation changes when assumptions are made to include stock of choice being available (including POMS resistant Pacific Oysters and adequate cash flow being key. 2018 is summarised in Table 6 and Figure 2.

Figure 2 illustrates the change in risk levels. The low risk is represented by the green line. The risk profile of scenarios is very different from figure 1 (present – 2013). Reliable stock supply and disease resistance to POMS and QX reduces the production risk to growers substantially either from spat or as on-growing oysters. Production scenarios 8, 9 & 10 (blue arrows) offer growers the chance to produce resistant stock whilst maintaining suitable risks with their efforts.

Figure 2 - Risk analysis across all key "stressors" potentially impacting HR growers and potential scenarios – 2018.

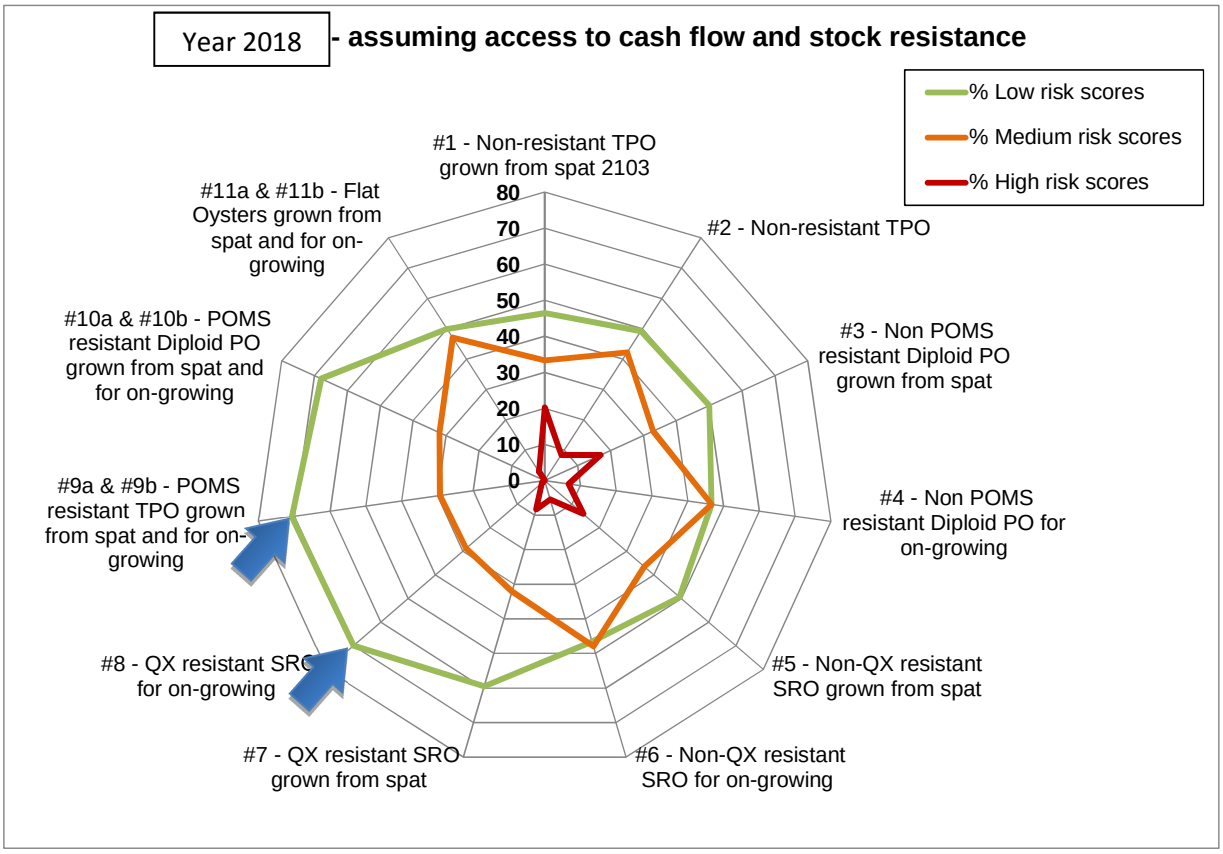


Table 6 - Risk matrix across all key "stressors" potentially impacting HR growers and production scenarios for future conditions in Year 2018 (ie. assuming access to cash flow and access to POMS- resistant stock)

When key risks are managed (assumed for 2018), grower opportunities to diversify oyster supply/production techniques are extended.

Year 2018 -future conditions	Farmers experience	Cash flow	Biosecurity	Wild Stock availability	Hatchery Stock availability	re-stocking with spat	re-stocking with on-grown	Disease stressor	Prod'n window	Infrastructure required	Market options	Genetics	Management
#1 - Non-resistant Triploid Pacific Oysters grown from spat	a	b	b		a	b		c	c	a	a	a	a
#2 - Non-resistant Triploid Pacific Oysters for on-growing	a	b	b		b		b	b	b	a	a	a	a
#3 - Non POMS resistant Diploid Pacific Oysters grown from spat	a	b	b	b	a	a		a	c	a	b	a	a
#4 - Non POMS resistant Diploid Pacific Oysters for on-growing	a	b	b	a	a		b	b	b	a	b	a	a
#5 - Non-QX resistant Sydney Rock Oysters grown from spat	a	b	b	a	a	a		a	c	a	b	b	a
#6 - Non-QX resistant Sydney Rock Oysters for on-growing	a	b	b	a	a		b	b	b	b	b	a	a
#7 - QX resistant Sydney Rock Oysters grown from spat	a	b	b		a	a		a	a	b	b	a	a
#8 - QX resistant Sydney Rock Oysters for on-growing	a	b	b	c	a	b	b	a	a	b	a	a	a
#9a & #9b - POMS resistant Triploid Pacific Oysters grown from spat and for on-growing	a	b	b	a	b	a	b	a	a	b	a	a	a
#10a & #10b - POMS resistant Diploid Pacific Oysters grown from spat and for on-growing	a	b	b	b	b	a	b	a	a	b	b	a	a
#11a & #11b - Flat (Angasi) Oysters grown from spat and for on-growing	a	b	b	b	a	a	b	b	b	b	b	b	a

5 Discussion

5.1 Future opportunities for HR growers affected by POMS

A review of stocking/production options and potential stressors highlighted that the on-growing of non-disease resistant oysters as a strategy to add value out of the window of infection in the Hawkesbury River was one of the highest risks. On the other hand, disease resistant oyster options represent a lower risk scenario, however the earliest that industry will have access to resistant stock will be in 2018.

5.1.1 QX Resistant Sydney Rock Oysters – Scenarios #7 & #8

Farming QXR SRO from spat or on-growing was identified as the lowest risk option currently available to Hawkesbury River oyster farmers. Spat must be purchased from a hatchery/nursery by the HR farmer or as on-growing stock from another estuary in NSW. Pre-QX history suggests the Hawkesbury River is capable of growing SRO over the winter/spring to add value. Limited experience with QXR SRO spat suggests losses are to be expected if exposed to QX over the summer (~15 to 30%). Stock losses occur with each exposure and are worse with small stock such as spat. To grow spat to a suitable market size may be possible in 18 months, but more likely 2 to 3 years. The option to bring in larger oysters to on-grow and add market value represents potentially faster cash flow and perhaps less risk.

QXR SRO must be purchased ex-hatchery/nursery at $0.04 each. This requires access to cash to be able to purchase enough stock to make a viable income. After POMS stripped cash from HR businesses, the ability to afford to re-stock is a primary concern. Banks in NSW generally do not recognise oyster assets to loan against. HR farmers have applied to the NSW Government for low interest disaster loans but this has been unsuccessful. Adequate cash flow to fund individual business recovery is a key concern.

QXR SRO hatchery supply has a poor record of reliability. No successful hatchery production has occurred since mid 2011. QXR SRO spat is currently unavailable for purchase (July 2013). Availability of QXR SRO spat is not anticipated until early 2014 assuming a successful hatchery run in September 2013. Availability of QXR SRO to purchase for on-growing appears to be non-existent in 2013. Key reasons appear to be limited stock availability and purchase support by growers in previous seasons resulting in a scarcity of suitable stock. Currently, supply of hatchery stock is from a single estuary where, if adverse conditions exist they will impact severely on QXR SRO supply. Reliable and ongoing supply of QX resistant Sydney Rock Oysters is a key concern in NSW.

If QXR SRO's were farmed as ongrowing stock (purchasing larger oysters and adding size and therefore value) their disease resistance status removes significant pressure to quit stock before the next QX disease cycle (which can be unpredictable) – adding to production flexibility. HR growers of TPO oysters have adapted to a 12 to 14 month stock cycle. QXR SRO's production cycle is likely to be 3 years (2 if purchased as larger spat). Multiple crops on farm require more rack and infrastructure needs. Holding stock across multiple seasons adds the dimension of over catch, which will require active on farm management. TPO oysters didn't spawn and could be sold all year assuming open harvest status. SRO's are less likely to present year round sales opportunities and must be managed for spawning when harvesting. SRO's are known to be more susceptible to mud worm losses and this would need to be managed accordingly. However, SRO's are more tolerant of fresh water inundation, heat stress and out of water shelf life than TPO's adding to greater farming flexibility.

The breeding program to improve the QX tolerance and performance of QXR SRO's has had mixed success. POMS infection of both the Georges River and Hawkesbury River has resulted in elite stock being "locked-up" at these estuaries limiting the scope and resistance performance of the SRO breeding program. The best QXR oyster line (B2) is now 5 seasons old with no recent line introductions in the program. Poor improvement of QX tolerance and better growth characteristics for QXR SRO's is a key concern.

With the Hawkesbury River now a POMS affected estuary, biosecurity restrictions for movement of farming infrastructure (punts, trays, baskets) impact significantly on off-estuary farming options. Duplication of equipment or forms of co-farming would be necessary in non POMS or non QX estuaries limiting options. Biosecurity restrictions also limit spat or on-growing supply options to other NSW sourced stock entering the Hawkesbury River.

Key points

- QX resistant Sydney Rock Oysters are potentially the lowest risk option
- On-growing from larger QX resistant oysters as opposed to spat represents the best cash flow option in the short term and fewer mortalities from summer exposure

BUT

- Consistent hatchery failures has resulted in no QXR SRO's being available in 2013
- There is a lack of grower cash flow to purchase adequate levels of stock to keep businesses viable if the stock were available
- The current tolerance to resistance to QX results in significant stock losses when subjected to multiple QX exposures for spat reared in QX areas like the HR.

5.1.2 Non Disease Resistant Oyster Scenarios Grown from Spat (Sydney Rock Oysters, Diploid Pacific Oyster and Triploid Pacific Oysters) – Scenarios #1, #3 & #5

With the presence of both QX & POMS, production of non disease resistant oysters from spat in the Hawkesbury River is unlikely. To successfully reach marketable size, spat grown in the Hawkesbury would need to survive at least a disease infection window. Based on mortality levels during the first disease outbreak in the HR it appears that mortalities during the window of infection would be unacceptable. A more likely outcome is for off-estuary production by a supply or contractor or duplicating spat management in another estuary.

QX of SRO's has been known in the George's River and Hawkesbury Rivers for over 10 years. A potential option for future years may include widld caught spat (particularly if there is a degree of disease tolerance) and assume a probable overall mortality percentage and develop a production option based on farming of the survivors. The wild SRO tolerance level to QX and DPO tolerance to POMS is unknown and may offer a more disease tolerant wild caught source of stock. In NSW, DPO spat sources include wild catch from Port Stephens possibly Georges River and hatchery sourced spat from Port Stephens and Tasmania when import protocols are suitably met. Another alternative is for HR growers to work with (or own) production facilities elsewhere and ensure growth enhancement options like up-wellers and FLUPSYS's to maximise growth over the summer to present the biggest oyster for

translocation to the HR during the disease free window. Wild catch SRO spat sources are many in NSW (although influenced by season) and non-resistant SRO spat is available from a number of hatcheries.

Key points

- Production of non-disease resistant SRO's, TPO's or DPO's from spat in the HR exposes stock to maximum disease pressure and very likely significant losses
- To investigate the level of natural tolerance that may be present in the annual surviving wild spat fall in the Georges River (where natural populations have had the longest exposure to both diseases). If tolerance is present, this may offer a medium term stock supply option to HR farmers.

5.1.3 Non Disease Resistant- Sydney Rock Oysters accessed as larger oysters for on-growing – Scenarios #6.

Farming suitable larger non QX resistant SRO stock – initially from hatchery or wild caught - from a QX free NSW estuary and translocate them to the HR in early May – after the major risk of QX disease activity has decreased (infection window will vary season to season). Stock needs to be large enough (approx. 30 to 50mm) by May (after QX disease risk) to gain size and bulk and add enough value to deliver a potential profit when sold in early summer before the next QX disease cycle.

The challenge will be to ensure suitable SRO stock at the beginning of the QX free window (May to November). Such stock is likely to be at least 2 years old when transferred to the HR for finishing. Older underperforming stock should be avoided for this purpose. HR attempts to locate and purchase good SRO, suitably sized non-QX SRO's have proved difficult to purchase in 2013 reducing earning income opportunities for HR growers.

Biosecurity issues with oyster movement restrictions require farm infrastructure hygiene (disinfection) between HR and non-QX/non-POMS estuaries. Movements will need to be meticulous and well documented.

The SRO market is such that many growers sell the oysters required for on-growing to a low-end retail sector making purchase price for on-growing oysters expensive and unlikely to deliver a profit to HR growers. Stock of this type is expensive and difficult to fund with reduced available income after POMS losses.

SRO's are less likely to present year round sales opportunities and must be managed for spawning when harvesting. SRO's are known to be more susceptible to mud worm losses and will need to be managed accordingly. However, SRO's are more tolerant of fresh water inundation, heat stress and out of water shelf life than TPO's adding to farming flexibility. Environmental stressors in the spat production estuary may impact on the amount and timing of supply of suitable oysters to translocate to the HR in May. Delayed growth or spawning can mean delay in the SRO stock reaching appropriate saleable size. If oysters are not sold prior to the next exposure of disease, there is a high risk of stock losses prior to market because stock not sold in time must remain in the HR (can't be translocated to non-QX estuaries because of biosecurity restrictions) being exposed to the disease. The time of sale of on-grown HR SRO's will happen at the same time as the rest of NSW. With the added pressure to sell before the next QX cycle, it will be very competitive for market share. Spawning and closure of harvest areas result in increasing marketing pressure. The issue of multiple crops of non-QXR SRO's on the farm does not apply.

The SRO breeding program also includes other breeding goals like fast growth and winter mortality. The trait options do not present significant benefit to the HR non-QX SRO on-growers. Breeding programs for SRO that do not include disease tolerance have minimal value to HR growers attempting to on-grow in restricted disease free windows.

Biosecurity restrictions for movement of infrastructure (punts, trays, baskets) impact significantly on off-estuary farming options. Duplication of equipment or forms of co-farming would be necessary when cultivating oysters in Non POMS or Non QX estuaries.

Overall Non QX resistant SRO's are susceptible to QX and may represent a temporary but risky production scenario for the Hawkesbury River

Key points

- On-growing from larger non QX resistant SRO represents a risky cash flow option in the face of no QX-resistant SRO's being available in 2013, but does represent a potential cash flow source.

BUT

- Stock is expensive because of an existing retail market for oysters of sizes suitable for ongrowing
- A lack of grower cash flow to purchase adequate levels of stock to keep businesses viable
- QX disease presence when on growing non-QX resistant Sydney Rock Oysters to add value represents a risky option due to disease threat, and growth inhibition during the disease free window (from a number of sources).
- Stock availability is scarce in 2013
- HR growers will need to develop reliable supply options in 2013 for May 2014

5.1.4 Non-POMS Resistant Pacific Oysters (Diploid and Triploid) accessed as larger oysters for ongrowing - Scenarios #2 and #4 .

The HR currently has an aquaculture permit extension to cover DPO production – currently valid until April 2015. The Hawkesbury River has a reputation of high oyster nutrient waters, fast growth and ability to condition over autumn and winter (during the POMS free window) suggesting that on-growing for profit may be possible.

Suitable DPO stock could be accessible from Port Stephens only as biosecurity restrictions rejected the import from Tasmania or South Australia. However, unexplained stock deaths of DPO have recently (2013) occurred in Port Stephens, so no suitable stock is currently available. HR farmers experience with DPO's is minimal. Stock could be small culling's from seasonal sales (18 months to two + years old) or purpose caught wild stock held in Port Stephens until they reach suitable size for on-growing in the HR.

A suitable purchase price for on-growing stock may prove a challenge in future seasons. DPO's and particularly TPO's grow faster than SRO's and reach marketable size in less than two seasons**.** To have stock available in May 2014, arrangements will need to be in place with Port Stephens DPO growers to secure supply. Stock losses in 2013 in Port Stephens may result in very limited DPO stock of suitable size available in 2014.

The scenarios require purchase of larger stock and therefore a higher cost per oysters. Financing re-stocking in 2014 is a significant issue for HR growers.

Production concerns and “stressors” are significant. DPO capability to spawn and minimal knowledge on the start and finish times for the POMS free production window adds to DPO production and marketing complexity. Grower experience with POMS to date suggests the disease presents the grower with no time to potentially harvest and gather susceptible stock for sale. The concern on the actual length and severity of POMS re-infections applies to DPO & TPO production. Un-certainty on the dates that represent cessation and recommencement of POMS activity is a significant risk.

Growth “stressors” that delay growth in on-grown DPO’s and TPO’s may result in stock unsuitable for sale before the next POMS infection cycle. Although on-grown stock is larger, experience suggests stock losses may be significant if exposed to POMS. Risks include floods during the POMS free window and extensive or numerous fresh events (rainfall). Infrastructure needs will be similar to current practice. Installation of baskets that can be lifted higher than current practice may be needed to enhance larger DPO and TPO survival over summer during POMS infection cycles.

Marketing will most likely represent challenges. Hawkesbury River DPO’s and TPO’s will compete directly with Tasmania, SA and Port Stephens and other NSW TPO production estuaries. With the threat of POMS re-infection and the need to sell stock with added value before the next POMS infection cycle, marketing windows are likely to be small. Suitable harvest opening periods and the potential to spawn (DPO’s) will also impact the marketing window.

Key points

- Ongrowing non POMS resistant DPO’s or TPO’s from larger oysters in the Hawkesbury River to add value represents a risky short-term cash flow option in the face of no POMS-resistant DPO’s or TPO’s available in 2013.

BUT

- Suitable sized DPO or TPO stock is not procurable in 2013 for ongrowing
- Stock of suitable size is expensive, mainly because the supply estuary has the opportunity of retail sales in their own right.
- There is a lack of grower cash flow to purchase adequate levels of stock to keep businesses viable
- In the face of POMS presence, on-growing non-POMS resistant Oysters to add value represents a risky option due to disease threat, and growth inhibition during the disease free window (from a number of sources). In the case of POMS, disease onset is rapid with little time for farmer response.
- HR growers will need to develop reliable supply options in 2013 for 2014 supply

5.1.5 POMS Resistant Pacific Oysters (Diploid and Triploid) accessed as Spat or as larger oysters for on growing - Scenarios #9 and #10

Assumption is that POMS resistant (or at least tolerant) DPO and TPO spat will become available in the near future. Once spat is available, the option to access larger oysters (from NSW estuaries) and translocate to the HR for farming to profitable size & condition is also a possible opportunity, particularly if oyster

response to POMS is not resistance but only tolerance. The scenario represents a return to former pre-POMS practice and a production cycle should be 10 to 14 months from spat.

Other estuaries in NSW are likely to be able to match the HR's growth rates, so the opportunities to add value may be limited. The challenge will be to access suitable resistant stock when needed from limited hatchery/nursery/on-grower suppliers.

The most significant challenge for HR farmers will be the ability to purchase suitable stock when they become available. Breeding programs have given no firm date for POMS resistance availability – 2018 access is a best-case scenario. HR growers will need to survive via one or more of the risky scenarios already discussed and build funds in anticipation of resistant stock availability. An option mentioned before is for HR growers to extend production permits to include DPO's (temporary permit already in place for 1 grower in the HR).

Environmental stressors are similar to previous scenarios: Pacific oysters are less tolerant of heat and fresh water inundation than SRO's. However, the quick production cycles reduces the impact of overcatch and mud worm infection.

With more NSW rivers growing TPO's, competition to access suitable spat from hatcheries will be more intense however the HR still enjoys market proximity and fast growth of TPO (and potentially DPO).

Resistance to POMS may not occur in Australia first (indications are that NZ has already developed wild type resistance). Australian biosecurity issues will need review if there is an option to access appropriate genetics developed elsewhere. Restrictions on aquaculture permits regarding the source of triploidy may also pose an issue. Current import issues restricting oyster size from Tasmania may also impact HR grower's ability to quickly take advantage of POMS resistant oysters.

Breeding programs are currently based away from POMS infection sites and are not currently utilising wild Pacific Oyster survivors to enhance POMS resistance in breeding selections. Industry breeding programs attempting to develop tolerance initially identified tolerance in elite breeding broodstock via field tolerance screens in Georges River. Lab based screens have been slow to become available as tools to enhance trial work. Disease resistance to POMS may not be the choice available to growers in the short to medium term, but possibly a degree of resistance may be achieved. The impact of POMS tolerant PO would be significant and should be a breeding goal.

The quest for POMS resistance must involve DPO elite lines. POMS resistance in DPO's is the primary focus of breeding programs (SA and Tasmania rely almost exclusively on purchased spat). HR growers must strive to ensure POMS resistant spat is available as soon as possible and from more than a single source.

Triploid oysters offer some advantages over diploids. Currently, there is only one method of triploidy approved in NSW yet other triploidy methods have been developed. POMS presence and recent surveys of naturalised diploid populations suggest other options should at least be reviewed to expand sources of stock supply

Key points

- POMS Resistant TPOs or DPOs represent a viable resumption of oyster farming for HR producers.

BUT

- No timetables for availability of POMS resistant oysters yet set
- Cash flow access and business survival until POMS resistance is a key challenge
- PO breeding program has not had disease management as a goal, it was focused on growth and quality factors.
- HR growers will need to work with stakeholders to ensure they have access to POMS resistant PO's as soon as the option is available.

5.1.6 Flat or Angasi Oysters accessed as Spat or as larger oysters for on-growing - Scenario #11

Angasi oysters were once the mainstay of a thriving oyster dredging industry. Over fishing and *Bonamia* disease made commercial production un-economic prompting industry to introduce the Pacific Oyster for southern oyster production regions of SA and Tasmania. Today, some specialist growers have adapted modern basket technologies to successfully rear the species for markets. Angasi oyster spat is available from hatcheries with the potential to obtain larger oysters from NSW estuaries for ongrowing. Current biosecurity hurdles would restrict hatchery stock to NSW sources. Wild stock access is unlikely to be a commercial option.

Angasi life production cycle tends to be long (3 to 5 years) and HR growers have had no commercial experience with the species. The oyster is reputed to be less tolerant of prolonged exposure to fresh water. More recent "normal" seasons suggest the HR upper reaches in particular will be lower salinity for some parts of the year. Production may be restricted to more saline production areas.

Although not affected by QX or POMS, Angasi oysters have suffered in other regions extensively from *Bonamia* – the impact of which is unknown in the HR. Also, the long life cycle and the need to be in more saline waters exposes the production to significant over-catch pressure in the HR.

POMS resulted in the sudden loss of income to all HR farmers. Most growers had been re-investing in farm and production improvements. Having available funds to invest in oysters, which are unlikely to return income for 3 to 4 years, will be a challenging call for HR growers.

Marketing flat oysters may represent more challenges vs. SRO or PO's. The consumer market for flat oysters is currently more "boutique" than PO's or SRO's, making the available consumer base smaller. HR growers anticipating investing in this market should confirm acceptability of significantly more supply. As well, flat oysters will spawn over the summer and possibly at significant tide events - managing sales around spawning will need to be considered by growers.

5.1.7 Utilising one or more of the 11 stocking/ production scenarios identified:

When POMS disease was first identified in the Georges River in 2010, Hawkesbury River growers anticipated the need to diversify sensibly to other species. HR growers ordered 1.2 million QX resistant Sydney Rock Oysters in February 2011 to develop experience and establish alternate income sources in the face of POMS affecting TPO's. The order for QX resistant SRO's remains unfilled as of May 2013. The conclusion and farmer recognised need to diversify stock on farms is still valid today. Accessing a reliable supply of QXR SRO's is the key short term aim. Unfortunately, with lack of reliable spat production, access to larger QXR SRO for ongrowing and short term cash flow means this not a viable option in 2013. Accessing QXR SRO in the near future for HR growers will be via spat access and a 2 to 3 year production cycle before any income.

General growth enhancement modifications can be applied to a number of the stocking/production scenarios discussed that include handling the oysters as spat (rather than ongrowns). Spat growth enhancement options may be useful such as upwellers and FLUPSY systems. With POMS, PO's or TPO's are likely to be susceptible to disease at any size likely to be economic from a an upweller or FLUPSY system if based in the HR. The same is likely for non-QX SRO. However, for disease resistant oysters such as QXR SRO, growth enhancement systems may be economically viable. Such systems could also be deployed in non disease affected estuaries - by-passing spat handling on the HR - and returning larger oysters from estuaries with less nutrition to be ongrown for profit. .

For HR farmers, there is an imperative therefore to evaluate and trial one or more of the other (more risky) options identified (ongrowing SRO's or DPO's or TPO's). The sudden loss of stock in the HR, created a demand for suitably sized SRO's for ongrowing, but the demand could not be catered for by the market place. A similar situation exists for DPO's and to an extent – TPO's (complicated by imposed biosecurity impediments). Suitable stock will not be available until May 2014, and availability will revolve around HR growers successfully developing reliable supply channels with other oyster estuaries.

All available production scenarios (QXR SRO, Ongrowing non POMSR DPO's and non QXR SRO's) represent risky business options. Limited cash flow stemming from 2013 losses of stock will limit HR grower's ability to purchase significant stock to test the viability of these scenarios.

5.2 Outputs from ongoing R & D undertaken/underway to managing POM impact via production modifications.

Until the presence of POMS in Pacific Oysters in the Georges River and Hawkesbury River, little trial work had been undertaken in recent years looking at the impact of production techniques on disease management. The HR started as a control treatment (no POMS) for Georges River trials. The key researchers have published a number of papers or they in press as well as an FRDC project.

- Paul-Pont, I., N. Dhand and R. Whittington (2013). "Spatial distribution of mortality in Pacific oysters Crassostrea gigas: reflection on mechanisms of OsHV-1 transmission." Diseases of Aquatic Organisms 105: 127-138

- Paul-Pont, I., N. Dhand and R. Whittington (2013). "Influence of husbandry practices on OsHV-1 associated mortality of Pacific oysters Crassostrea gigas." Aquaculture 412-413: 202-214.

- Paul-Pont, I., O. Evans, N. K. Dhand, A. Rubio, P. Coad and R. J. Whittington (2013). "Descriptive epidemiology of mass mortality due to Ostreid herpesvirus-1 (OsHV-1) in commercially farmed Pacific oysters (Crassostrea gigas) in the Hawkesbury River estuary, Australia." Aquaculture. In press

- Final Report - 2011-053-DLD - Pacific oyster mortality syndrome (POMS) - understanding biotic and abiotic environmental and husbandry effects to reduce economic losses. Modification of aquaculture practices and understanding epidemiology of OsHV-1 disease to develop practical solutions for farmers (FRDC 2011/053 -completed and FRDC 2012/032-ongoing)

This body of work represents the latest available research looking at epidemiology of OsHV-1 disease (POMS) and the impact of oyster production modifications on disease severity. The work recommends a variety of future approaches required to tackle OsHV-1:

1. Develop effective biosecurity protocols and undertake active disease surveillance.

2. Ensure the existence of an effective Mollusc breeding program to develop disease resistant in PO.

3. Undertake fundamental research on immune functions of oysters.

4. Encourage on farm species diversification by growers.

The key R& D outputs can be summarised as:

- The distribution of disease was non-uniform. It was clustered, highly variable in time and space, and clearly dependent on the age of oysters and their growing height or position in the water column.

- The pattern of infection and disease was different on different leases suggesting that underlying environmental factors influence disease expression.

- Spat were highly susceptible to the virus and all spat kept in trays died regardless of growing height. In contrast, the high growing height reduced the

deaths of adult oysters by 40%. The pattern of results was consistent at multiple sites.

- Environmental conditions/triggers or other as yet undiscovered pathogens. Vibrio spp. bacteria, which have been suggested to be involved with OsHV-1 virus in POMS disease in France, did not appear to be involved in this outbreak in Woolooware Bay because their intensity did not increase until after the POMS outbreak had started, the species of Vibrio present did not change over time and a similar number of Vibrio spp. bacteria were present in tissues of healthy oysters in the Hawkesbury River.

- The virus did not appear to be transmitted free in water. There was considerable epidemiological evidence that its distribution was clustered in Woolooware Bay, in the Georges River.

- No clear difference in salinity or temperature of water was observed among sites suggesting that other environmental features influence the onset of the disease. Seawater temperatures were consistently above 24 C during the month preceding mass mortalities with variations (± 3 C) being observed over a few days during this period; however this did not necessarily lead to mortality events when the virus was present.

- Infection prevalence and intensity decreased in surviving oysters suggesting that some individuals may be able to clear the virus.

- While inefficient oyster-to-oyster transmission occurred at two locations, a synchronous infection arising from a common environmental source was required to explain the mass mortalities at the index case (Mullet Creek). The incubation period for mass mortality was <4days, however subclinical OsHV-1 infection was detected three months prior to the first signs of mortality in the index case (first location affected), which suggests that low viral loads of OsHV-1 are insufficient to induce the disease.

- There was no evidence of prior movement of potentially infected oysters or farming equipment into the Hawkesbury River estuary to explain the outbreak.

Integrated Approach to farm Pacific Oysters in the presence of POMS.

The researchers propose a new hypothesis that OsHV-1 may be carried through water by particles, possibly plankton. The hypothesis is also suggested to explain the patchy distribution of mortalities in Woolooware Bay in the Georges River and the pattern of infection noted and monitored closely in the Hawkesbury River. In terms of ways to modify aquaculture practices with practical farmer workable/practical solutions to OsHV-1 disease, the work to date suggests:

- Modification of the growing height - increasing the height on long-lines results in reduced oyster immersion time, reducing exposure to the virus. Oyster growth rates are minimised (slower metabolism) and the increased UV/Heat exposure is known to kill virus and bacteria. Trials tested increasing tray height by 300mm and long-lines by 300mm; 600mm and 900mm. Results over two years indicate oyster survival rates were correlated to increasing cultivation height. Increasing height can result in 13, 25 and 50% respectively increased survival in juveniles and adults. Smaller spat sizes did not show an increased in survival rates by increasing the height. Growth rates were

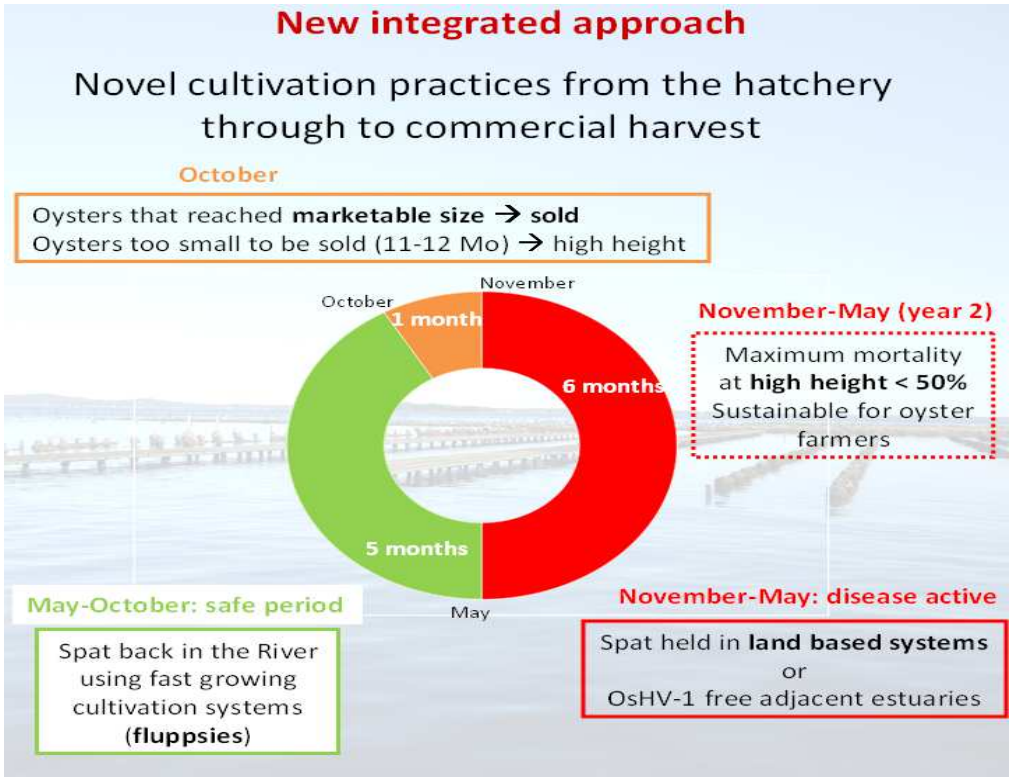
significantly suppressed with increased in height probably due to a reduction of filtration/feeding time.

- Co-cultivation of multiple filter-feeders (i.e. SRO and PO) - other filter-feeders which are not affected by POMS may be candidates to be used as natural bio-filters.

- Spat rearing techniques using different methods of water treatment in land-based spat growing systems. Trials are ongoing and treatments include chilled water, sedimentation of water for 48hr prior to use, UV + filtered water using different mesh filtration sizes prior to use with spat. The filter size required is related to the particle size that the virus is likely attached to. Results so far are encouraging suggesting hatcheries can potentially maintain spat production for longer in POMS infected waters.

The research outputs may allow the modifications of current systems to reduce risk and secure PO production in the presence of disease or reduce losses where disease may occur (Figure 3). The system proposes utilising height adjustment over the disease risk period to reduce losses to <50%, have stock held in non- diseased estuaries before transferring back or hold in land base systems where POMS infection appear to be manageable. Growth can be enhanced with systems like FLUPSYS noted earlier. For HR growers, the investment in infrastructure is competitive with income availability. For oyster growing regions not yet impacted, pre-planning to reduce risk could be a sensible strategy.

Figure 3 – Cultivation modification from hatchery to commercial harvest.



(Figure taken from presentation by Paul-Pont et al, 2013)

5.3 Approximate Costs of key production scenarios to HR Growers

Grower interviews identified some average costs. Utilising the results of the risk analysis earlier, a risk matrix identifying the possible returns to Hawkesbury River oyster farmers (Table 7) can be generated. Consideration of realities of access to vital components to undertake the scenarios for 2013 and 2018 highlights again, the limited options possibly available to HR growers. The two production scenarios identified as lower risk in 2013 and 2018 are not available due to lack of suitable stock. Without access to QX resistant Sydney Rock oysters, all other options represent higher risk for loss of stock and expensive stock purchase prices. The lowest risk option does not provide cash flow to the businesses until 2017, forcing HR growers to look at survival production options while waiting for QXR stock or POMS resistant Pacific Oysters. Access to ongoing business funding is also a significant issue for HR growers.

Table 7 - Review of approximate costs and accessibility for HR growers to production scenarios where suitable stock may be available (POMS resistance excluded)

Production scenario	Productn cycle length (months)	Number of workings	Purchase price/doz	Approx. cost of working	Approx. total cost	Approx. sale price	Approx. profit/doz	Perceived risk of production success if undertaken in the HR	Access for HR grower to option in 2013	Access for HR grower to option in 2014	Cash flow contrib' year to HR business
TPO spat – Tas via Non POMS estuary	12	12+	$0.52	$2.50	$3.02	$6.40	$3.48	poor	Via other estuary - Sept?	Via other estuary?	Late 2014?
TPO ongrow small	6	3+	$3.00	$1.50	$4.50	$6.40	$1.90	poor	Not available	From other estuary	Late 2014?
TPO ongrow large	6	3+	3.5	$1.50	$5.00	$8.00	$3.00	cautious	Not available	From other estuary	2015
DPO spat	18	12+	$0.40	$2.50	$2.90	$6.00	$1.55 (2 seasons to achieve)	poor	Not available	Via other estuary	2015
DPO ongrow small	6	3+	$3.00	$1.50	$4.50	$6.00	$1.50	average	Not available	Likely very limited	2015
DPO ongrow large	6	3+	$3.50	$1.50	$5.00	$7.50	$2.50	cautious	Not available	Likely very limited	2015
SRO spat	36	12+	$0.25	$2.50	$2.75	$8.00	$1.75 (3 seasons to achieve)	poor	Not available	Via other estuary	2017
Non QXR SRO ongrow small	6	3+	$1.50	$1.50	$3.00	$4.50	$1.50	average	Limited numbers	From other estuary	Late 2014?
Non QXR SRO ongrow large	6	3+	$2.50	$1.50	$4.00	$6.00	$2.00	cautious	Limited numbers	From other estuary	Late 2014?
QXR SRO spat/ongrow	36	12+	$0.40	$2.50	$2.90	$8.00	$1.70 (3 seasons to achieve)	average	Not available	Maybe in Jan/Feb	2017
QXR SRO large	6	3+	$2.50	$1.50	$4.00	$6.00	$2.00	best	Not available	Not available	2017

5.4 Review Business, Administrative and Compliance in Relation to Production Options and Potential Responses.

When considering the issues facing survival and the re-establishment of oyster farming businesses on the Hawkesbury River, this report considers not only the barriers imposed by the presence of POMS for Pacific Oyster production, QX for Sydney Rock Oyster production and environmental challenges, but also existing or potential barriers facing grower survival in the HR. These burdens/barriers can be grouped as business, administrative and regulatory barriers as well as barriers associated with production (primarily breeding, hatchery and stock supply).

5.4.1 Business burdens/barriers

Access to operating funds

Oyster farming, unlike most land based farming businesses, does not typically attract bank financial support in NSW as most banks are reluctant or won't accept marine farms leases, farm infrastructure or stock as security. Well-established farms with 20 years of good trading history have been able to get up to 60% of valuation in Tasmania – but this is not common. Lack of access to operating and growth capital is one of the single biggest issues holding farm development back in Tasmania (pers. communication) and is also a limiting step in modernising NSW production and encouraging investors and new entrants. For HR farmers facing total income loss and 2 to 3 years to re-establish an income base, access to ongoing cash flow and capital for restocking, structural investment and diversificationy production is proving critical.

Operational restrictions

The need for optimal water quality for successful oyster farming is undisputed. The requirement for new investors to take on the "poor management" (such as lease disrepair) of former farming failures via lease arrangements also imposes significant barriers to investment. These "failures" are generally present due to former non-compliance with lease agreements and failure to comply with regulation. HR oyster farmers undertook significant clean up following QX and have moved away from tar and cement infrastructure. Infrastructure clean up or investment for diversification or practice change is expensive to purchase (new bags, baskets, plastic trays, posts and rail) difficult and expensive to dispose of because of difficulty of access and removal (water based), weight (wet and mud covered) and the presence of tar deems the waste environmentally toxic. Cleanups are expensive and often difficult to support. The requirement to "clean up" can be a significant deterrent to diversification, new investment and an ongoing cost burden to oyster an oyster business. Ongoing costs associated with Food Authority compliance, marine compliance, lease maintenance, OH&S etc also put cash flow strain on a business struggling following a collapse of income from a disease based disaster.

5.4.2 Administrative and regulatory burdens/barriers

Competition for Water Quality and Water Access from other stakeholders

Optimum water quality is critical to a successful oyster business. High water quality is also has high general social and environmental benefits. Water quality monitoring is therefore in the interest of a large range of potential stakeholders (although different stakeholders may have varying thresholds). The oyster industry is required to monitor the quality of the waterways to ensure the conditions are safe for oyster consumption and in NSW the industry supports an excellent industry set of guidelines that engages all stakeholders - "The NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS)". Compliance adds to the cash flow demand for HR oyster farmers when recovering from almost total income loss.

Biosecurity and review processes to instigate change.

When POMS in Pacific Oysters was confirmed in the Georges River in NSW in 2010, Hawkesbury River growers engaged with government to review options and response actions via consultative meetings. The potential to import and farm larger Triploid pacific oysters was identified as one of the few possible short term solutions to cash flow supplement to HR oyster farmers. Accessing larger Pacific Oysters (in particular TPO's) during disease free windows presented the best short term option to maintain businesses following the collapse caused by POMS. HR growers consulted with NSW government in an attempt to identify a pathway and process for approval. HR farmers funded and engaged industry leading scientists to understand related biosecurity issues and provide supported argument for their case. The application from BBO to import larger triploid Pacific Oysters from Tasmania was refused by NSW biosecurity. The process and rejection illustrated the difficulties faced by industry when attempting to find and utilise process and approval pathways within government.

5.4.3 Production burdens/barriers

Reliable supply of SRO and DPO and TPO stock – hatchery and ongrown.

Significant support from the NSW DPI and the Fisheries Research Development Corporation (FRDC) has been made available to assist NSW for disease resistance breeding and oyster hatchery supply development over recent years - particularly the SRO. However, the QXR SRO has proven challenging to produce reliably in commercial quantities. The history is summarised in the paper, "Chronic failure of attempts by hatcheries to reliably produce commercial quantities of Sydney Rock Oyster seed has occurred in NSW for more than two decades." – (FRDC report 2003/2009) - Sydney Rock Oysters: Overcoming constraints to commercial scale hatchery and nursery production. – Dr Wayne O'Connor).

The SRO also has a number of diseases that have specific geographic ranges and seasonal expression. Prior to the imposition of biosecurity measures to manage disease spread, the NSW industry had relied upon an interstate hatchery in Queensland for spat supply – this has since shut down. Unreliable production, multiple breeding goals and closed river systems trapping elite breeding stock has made optimisation and centralisation of hatchery/ nursery operations is difficult. In NSW, production of elite genetic SRO's is currently restricted to the NSW DPI hatchery at Port Stephens and marketing/distribution has been managed by industry (NSW Farmers) who own the Select Oyster Company (SOCo). SOCo's responsibility is to deliver advanced genetics obtained through selective breeding to growers. SOCo is represented by a volunteer board, and until recently, didn't employ anybody directly to manage the program. It relies on support from the FRDC, Seafood CRC and a levy of $2/thousand on all spat supplied that are from selected broodstock (through agreement with the hatcheries). The model of royalty collection has merit in that it becomes a user pays system to access improved genetics.

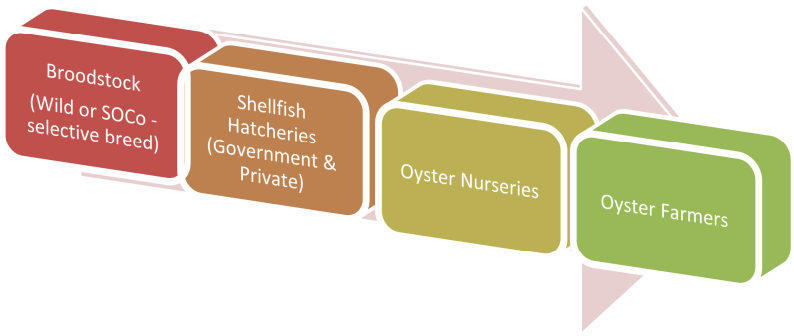
The reliable supply of spat for NSW growers has been addressed in a number of sections of the report. QXR SRO stock was ordered in early 2011 by HR growers from SOCo but was not available or delivered until September 2013. Lack of reliable supply of oyster stock of choice imposes one of the biggest barriers to recovery for the HR. Without reliable access to suitable oyster stock, investment in the recovery of the HR or any other oyster regions after major loss disasters or damage is difficult for growers to justify. This is particularly the case for HR where disease issues means production choices from anything other than disease resistance spat virtually impossible. FOR SRO's, QX resistance and Winter Mortality resistance are the key traits offered from the SRO breeding program. Wild caught spat (not disease resistant) is also offered from various hatcheries. Spat purchase means a cash outlay for growers (costlier if it is disease resistant). Spat demand varies with disease pressures which are not ubiquitous to all estuaries and demand for hatchery spat increases in years where wild spatfall is poor. Investments in hatcheries

for SRO's (be it from government or private sources) must also consider the still prevalent use of wild caught SRO and DPO spat in NSW when planning business opportunities.

Oysters that clearly demonstrate disease resistance, improved growth and condition traits (the value proposition) and are available to growers at an affordable price should result in reliable and consistent purchase by growers if they clearly demonstrate the advantages over 'wild' caught oysters. However, the 'value proposition' attributed to the selected lines has not been well demonstrated in the past, with many growers specifically requesting 'wild' oysters in preference to the SOCo lines as they perceive the wild to have better performance. To effectively communicate a value proposition requires a well planned, adequately resourced and outcome focused breeding program, which in turn works in tandem with hatcheries/nurseries to deliver a product to growers that is resourced and managed efficiently and effectively, delivering sufficient quantity of good quality spat into the market.

In NSW, hatchery supply isn't as straightforward as exists in other regions where the 'hatchery' manages the oysters from broodstock to spat of suitable size and robustness to suit growers systems on farm. The current situation is NSW is a disruptive model that has a distinct hatchery, and then a separate re-nursery phase where the oysters are ongrown to a size that growers can manage on-farm. The undertaking of hatchery runs for QXR SRO's by the research focused hatchery provides spat oysters to the 'commercial' pre-nursery/nurseries at as small a size as possible. These nurseries then supply direct to the growers. The current system imbeds a 'non-commercial' approach to the market and is difficult to change. The result is that the DPI hatchery is supporting the industry, but in doing so, has also built in a structure of pre-nurseries that receive small spat from the hatchery, and then on-grow it to supply growers. The difficulty with this model of production is that value returned to the hatcheries for the capital and technical risk involved in hatchery production is diminished compared with an integrated hatchery/nursery supply model.

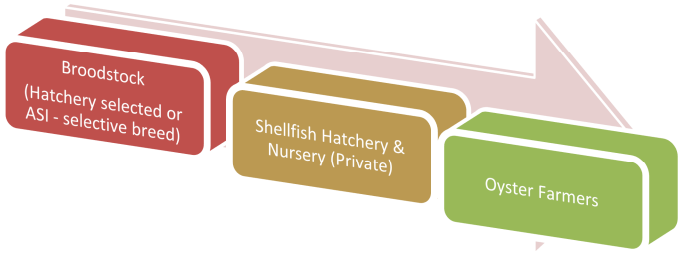
Figure 4 – Current oyster supply spat chain operating in NSW



The current supply chain to NSW oyster farmers (Figure 4) from oyster hatcheries is therefore potentially unnecessarily convoluted. Southern Cross Shellfish hatchery in Port Stephens was supported by DPI to fit with this expectation for small spat to supply pre-nursery and has found itself effectively in competition with the DPI hatchery. The hatchery has had difficulties accessing the structural advantages of delivering further up the value chain because of under-capitalisation committed to commercial development. Under-capitalisation has restricted such hatcheries taking advantage of what should be the principle advantage over "wild" spat – that being selective breeding that addresses disease resistance, and superior production traits.

Commercially successful hatcheries in Tasmania have a more direct supply path to growers and include the capability of the hatchery to manage spat to larger sizes to extract more value, provide more consistent supply, better manage risk through reduction in mortalities for purchasing on growers (larger oysters), better linkage between grower and hatchery to manage demand and meet opportunities. It is also key to allow hatcheries to spread costs and recoup profit (higher prices/oyster) - (Figure 5)

Figure 5 – More typical and commercially viable hatchery supply chain



Current known or intended hatcheries are listed in Table 8. Most current hatcheries/nurseries in NSW produce for their own use. Hatcheries require a permit in NSW to operate if they intend to sell commercially to other growers.

Table 8 - oyster hatcheries currently operating or proposing to operate in Australia

Hatchery Name & Location	Output focus *	non QX SRO	QXR SRO	non POMsR DPO	non POMsR TPO	Angasi	Comments
DPI – Port Stephens	RF & CF	✔	✔	✔	✔	✔	Government research hatchery – non profit
Southern Cross Shellfish NSW	CF	✔	✔	✔			No triploid production. Production has been variable.
David Maidment Narooma, NSW	ON	✔				✔	
Tony Troup Laureton, NSW	ON, CF	✔	?				Start up commercial supplier
David Barker, Georges River, NSW	ON, CF?		✔	✔	?		Owners ex DPI research and keen to pursue opportunities with resistant oysters
Smith, Bermagui, NSW	ON	✔					
Collison, Shoalhaven, NSW	ON	✔					
Shellfish Culture Tas	RF & CF			✔	✔		
Cameron's Tas	CF & ON			✔			
Spring Bay Seafoods, Tas	CF			✔	?		
South Australian Oyster Hatchery	CF	?	?	✔	?		
Rod Grove-Jones, South Australia	CF			✔			
Victorian Mussel Hatchery	CF	?		?		✔	

* Research Focus **(RF),** Commercial focus **(CF)** or own need **(ON)** focus

The variable support by growers for hatchery produced stock in NSW is a key factor in the performance of both successful breeding improvements and the current lack of a viable commercial hatchery based industry for disease resistant SRO's. In the last 2 years, FRDC/CRC has undertaken strategic funding on structural improvements in both the SRO (and PO in Tasmania) breeding programs existing in Australia and the way products are managed to market or hatcheries. It is too early to judge the success of such investments at this stage.

5.4.4 Hawkesbury River Oyster Farmers - Access to Advanced Local Genetics

Access to improved breeding and advanced genetics – NSW & Australia

SRO's - The NSW SRO breeding program currently offers Winter Mortality Resistant (WMR) SRO, QXR SRO and combined QXR + WMR SRO lines (ex SOCo) produced almost exclusively from the DPI hatchery in Port Stephens. Relatively recent attempt to broaden successful QXR production runs in particular in Tomaree and Georges River have met with limited success. A recent initiative to have QXR oyster produced in Victoria is yet to be commercially proven. Non resistant SRO's are available in limited quantities from a few small hatcheries – mainly for private use. QXR SRO (B2 line), the most recent release, is over 5 years old. The breeding program is forced to produce QXR oyster via a parallel family breeding program because of the need to screen for disease resistance in waters where QX is active. Oysters from these waters are restricted to estuaries where QX is already present, so a parallel program in QX free waters is undertaken to allow wider access to the program outputs. A parallel program is not ideal and variation in line performance can't be guaranteed. The B2 line still suffers potentially significant mortalities when exposed to QX over the summer period (Dove et al 2012). The breeding program has had limited success in delivering significant line advances because of the complications of parallel breeding and the increased resources and complexities involved.

Flat oysters hatchery production has some assistance/input from NSW DPI in limited breeding/selection program. Biosecurity restrictions means sourcing from interstate is problematic.

DPO's and TPO's - The ASI breeding program for diploid Pacific Oysters based in Tasmania breeding goals focused on quality parameters (growth and condition) with little attention to disease resistance. ASI elite lines were available in diploids and as a single parent in triploids at a premium from Shellfish Culture. ASI formed significant co-operative links with NSW DPI, which proved advantageous when POMS was identified in the Georges River where parallel families were being cultured and family differences to disease response were noted. Shellfish Culture undertakes some breeding development, particularly with TPO's that are produced under exclusive license arrangements with 4C's company (http://www.4cshellfish.com/about.php). However, the program had no focus on production threats such as disease - potentially reflective of the industries failure to account for disease threats (particularly in light of NSW experience with QX).

When reviewing access to genetics, breeding programs and potential response to disease threats, the reviewer noted a number of issues potentially impeding the recovery of HR oyster businesses. These include:

> **Breeding program performance and outputs** – programs seem poorly assessed against the needs of growers to sustainably grow oysters in the face of known or anticipated future threats. The 2012 Review of Australian breeding programs for Pacific Oysters, Sydney Rock Oyster, Barramundi and Prawns by Dr. Morten Rye, Akvaforsk Genetics Center A/S NORWAY gave both the Sydney Rock Oyster Breeding program (SOCo) in NSW and the Australian Seafood Industries (ASI) Pacific Oyster breeding program in Tasmania reasonable marks from a science perspective, but noted they have performed poorly from a grower adoption perspective. However, the review did not pursue strongly why grower adoption was poor. *Information available to the author would suggest neither the DPI SRO nor the ASI PO breeding program had measurable program performance parameters that linked breeding success to grower adoption. Grower adoption rates, variety production and*

advice information and accessibility to or consultation with the value chain on relative ranking of breeding goals seemed inadequately considered.

Utilising best practice tools and methods. Funding and staffing mechanisms for current breeding programs would appear minimal in relation to the industry size and reliance on such few species. Accessing world class and fast developing breeding assistance tools may be challenging. However, response of programs to meet new threats or switch to priority responses has been shown to be slow. The author's discussion with breeders and growers would indicate poor performance and support of initial releases were key in slow adoption. Performance support data of elite released lines has not been well communicated with growers, particularly in the case of SRO's. The recognition of in-lab challenge systems as a key breeding enhancement tool for POMS was prioritised by industry in 2010, but took some time for funds to be allocated and for work to begin. The inclusion of wild POMS survivors to enhance genetic gain was recognised as a way to improve speed of resistance development in late 2012. The program is yet to be implemented at the time of this report. QX resistance breeding for SRO's via parallel family breeding is complex and until recently, managing broodstock for maximum access to interested hatchery partners was restrictive and subject to environmental impact (elite stock ends 'locked-up' as disease issues spread in estuaries for example There seemed little focus on intimate international industry knowledge – particularly with regard to Pacific Oysters. This interpretation is subjective, but the author's experience with other industry breeding programs suggests intimate knowledge of overseas progress and advanced breeding tools seems lacking.

The observation by the author suggests no one reason will account for these issues, but transparency, improved industry consultation, better industry involvement; increased private investment, simplification of funding methodologies and improving the communication and value chain accountability would all assist improved access to improved oysters for growers. It is also unclear how breeding programs interact or access overseas breeding programs and breeding tool advances. Both programs are publicly funded from research funds, however, neither program regularly released or issued business plans accessible to growers. Both the ASI PO breeding program and the SRO program have been recently restructured in how they manage the path to market for program outputs, in particular, focusing on a more commercial management structure and a wider industry involvement via an expanded management board structure which hopefully will address some of these key issues in the future.

Pathways for genetic transfer into NSW and Australia do not appear optimal or necessarily transparent if access to likely potential disease resistant sources is considered a priority. Importation of breeding/parent genetics is subject to a significant number of biosecurity restrictions and the opportunity or pathway to review and modify impediments, risks and regulations is not easily identified at state or national level.

Monitoring and predicting new breeding or production advances or threats does not appear to have been a breeding or a grower industry priority. International linkages and co-operative programs should be considered as an industry imperative to ensure industry has coordinated response strategies in place developed by industry and administrators co-operatively.

6 Conclusion

A representation of growers were interviewed to gain insight on current actual oyster farm practices and identify possible oyster farming options which may be taken up or developed by Hawkesbury River oyster growers in the face of POMS losses. Risks associated with possible production/stocking options were considered and reviewed regarding impact on Hawkesbury River oyster farmers in the wake of POMS disease of Triploid Pacific Oysters and pre-existing QX

disease of Sydney Rock Oysters. Scenarios were analysed in detail to identify and rank the different options. The process represents a grower based methodology to pre-define risks and responses for other PO growing oyster regions in Australia.

6.1 Production/stocking options

- Different production/stocking options were identified for Hawkesbury River oyster farmers in the presence of QX disease of Sydney Rock Oysters and POMS disease of Pacific Oysters. Each scenario has identifiable significant risks.
- A key unknown or risk for any option is that the start of the disease free window and the beginning of the next disease cycle is not known with enough precision and, in the case of QX at least, can vary season to season.
- Farming (from spat or ongrowing) non-disease resistant oysters represent the riskiest production/stocking options.
- Farming disease resistant oysters (PO or SRO) represents the least risk scenarios. However disease resistant stocks are limited in availability and resistance for SRO and unavailable for PO raising their current risk to high but are scopable as medium to longer term options.
- For 2013 and conceivably for 2014, unavailability or limited supply of suitable disease resistant stock limits adoption of the least significant production/stocking scenario of growing QXR Sydney Rock Oysters.
- Ongrowing non-resistant SRO's or PO's or TPO's to add value during the disease free window has significant risks associated with production, but represent the only identifiable cash flow options available to HR oyster farmers in 2013 & possibly 2014

6.2 Cash Flow

- Loss of existing TPO stock suddenly in January 2013 from POMS has left HR oyster growers with little or no opportunity to develop funds for re-stocking purchases. With POMS and QX present, catching wild spat is not a viable option. Purchasing stock for ongrowing is relatively expensive (15 to 25 cents per larger oyster) vs. 3 to 4 cents or less per oyster for spat. Ongrowing in the waters of the HR (if it is possible in the presence of disease and imprecise disease windows), would result in an income in 6 to 18 months (depending on size of stock purchased). Spat purchase (only QX SRO or Angasi species) would not deliver HR growers' income for at least 2 years. The ability to purchase enough numbers to meet fixed costs and wages is potentially restricted.
- With the risk of loss from disease, growing non-disease resistant oysters from spat in the HR represents a relatively high risk and unknown impact on cash flow.
- QXR SRO's are not available in early 2013 (for ongrowing or as spat) and would not represent an opportunity to earn income in 2013 and represent limited opportunities in 2014 (2 year minimum growth cycle).
- Adding value to larger oysters by taking non resistant oysters into the HR during the disease free window, although with significant risk, represents the only short option available to access short term income from oysters into HR oyster farms. The issue remains on how HR growers are going to pay for or manage to access these oysters, particularly in 2013.
- Access to working capital represents a significant challenge to HR growers for the next 2 seasons at least.

6.3 Barriers to Business and Farming

- Reliable supply and limited supply options (sources) of the oyster stock of need or choice has been - and remains - a significant problem for HR growers. Inability to access desired stock when needed as spat or as larger ongrow oysters in 2013 and probably 2014 represents a significant challenge to HR oyster farmers. Consistent spat supply remains an issue despite previous government investment in breeding supply and spat options for industry (industry wide issue).

- Access to external operating funding sources – generally an issue for oyster farmers in NSW – but in 2013 & 2014 presents as a significant issue for HR farmers. Ability to be access funds for re-stocking or diversification because of collapse of business income suddenly due to POMS is a key issue to business recovery opportuinity. Access to low interest recovery loans to assist re-stocking from government has not been forthcoming to date (late 2013).
- Biosecurity issues – significant impediments/barriers in movements of stock (international, interstate and intrastate) limit economically viable choice or even access to oyster stock of suitable size or condition or price. Alternate species access for HR growers is also potentially limited. Borders/regions or evaluations are state based (eg Qld/NSW border) and not necessarily regionally based. Disease and pest consideration processes are not necessarily transparent or participatory for applicants. Managing existing breeding programs and access to elite stock form breeding programs being locked-up in disease affected estuaries remains an underlying issue in resolving reliable access to improved oyster genetics.
- The appearance of significant disease issues nationally (QX and winter mortality of SRO's and POMS and Summer mortality on PO's) in oysters has created resourcing and goal setting challenges for breeding programs and their ability to meet grower needs in a timely manner.

7 Implications

The impact of a disease of oysters with very high mortality over a short time frame can be devastating to oyster farmers if they do not have adequate risk management practices in place. This analysis on Hawkesbury River farmers clearly demonstrates the vulnerability a single species farming business model such as was practiced by HR growers. The effects to growers are magnified when the disease infects rapidly (days for POMS vs. weeks/months for QX). Implications for industry are significant given the reliance on single species in most oyster growing regions of Australia and the sole reliance on Pacific Oysters in the southern growing regions of Australia.

Quarantining disease – POMS discovery in Australia was identified in a single estuary – rare for a disease incursion. The single infection location in the Georges River allowed a relatively rapid response from industry growers and government in ceasing all movement of infrastructure and Pacific Oysters from the Georges River to other estuaries. NSW has effective oyster stock movement protocols in place which allowed government to effectively minimise oyster movement in a short time. Such actions may be the reason it took POMS two years to move to the Hawkesbury. However, it points out to other major pacific oyster growing regions the importance of recording oyster movements so actions can be undertaken to reduce and slow the spread of disease amongst regions. SA and Tasmania are working through improved stock transfer protocols as a result. From recent work on how POMS transmits, oyster regions would be well advised to have oyster movement protocols and ability to manage them in the face of threat in place as soon as possible.

Alternate species – Reliance on single species farming has shown to be devastating twice in the Hawkesbury River (QX disease on SRO, POMS on TPO). In NSW, alternate shellfish species are currently limited to Sydney Rock Oysters, Pacific Oysters and Angasi Flat Oysters. Although Sydney Rock Oysters offers HR growers an alternate species option, the presence of QX- disease restricted their farming options to QXR SRO which are limited supplied as a result of hatchery run failures. Angasi oysters are also hatchery sourced and are an option for HR growers, however these oysters are very sensitive to floods, which tend to occur often in the Hawkesbury. For regions like SA & Tasmania, alternate species choices are more restricted. The serious effects of POMS on the HR oyster industry and subsequent scramble for alternate income sources highlighted the limited availability of alternate species and in particular, the limited industry research that has been undertaken on growing alternate shellfish in most estuaries in NSW. Industries limited investment in risk management via alternate species farming limits informed commercial options for oyster farmers to diversify. Many other oyster growing regions in the world have alternate options (clams, cockles and more exotic species). With QX and now POMS, oyster farmers should be more aware of the need to reduce risk via alternate species farming and hopefully increase the investment that is necessary to enhance grower choices.

Availability of suitable spat stock choices. In NSW, historical spat supply was (and still is to a significant degree) via wild catch. In Tasmania and South Australia, the industry is entirely dependent on hatchery production. These two scenarios represent significantly different investment scenes for commercial hatcheries. SA & Tasmania support a healthy commercial spat supply industry based on Pacific Oyster spat supply. Despite government efforts to encourage NSW growers to support a commercial hatchery industry, NSW growers have proven difficult to get on board, even with the risk of QX for over 20 years. The implications of not having an industry supported hatchery severely impacted HR growers who, despite a early recognition and request for access to QXR stock following identification of POMS in the Georges River, found industry was unprepared for increased spat request and unable to supply for almost 2 years. Being unable to access alternative species when required proved economically devastating to HR growers with the loss of income from POMS. With multiple disease risks now present in NSW, growers should ensure their own future by supporting reliable supply of choice of species and quality. A reliable and successful hatchery industry in NSW also provides a secure and reliable path to market for research advances in disease resistance and quality improvements and supply of alternate species as they become available.

Farmer Risk Management – the history of the NSW oyster industry implementing risk management is variable. Until recently, the NSW industry was reliant on a single species, slow to change in production methods and had little input into chain value management of its outputs (quality and size). Losses to flood, heat, water quality, disease and unprofitable farms are regularly issues growers expected government to fix. Retraction of support services in agriculture and aquaculture are resulting in growers looking to how they protect their own businesses into the future. From the author's experience in the oyster industry, it is still early days, but changes in production methods to better manage floods, grower led marketing initiatives, structural changes in getting hatchery production to market and a national outlook on the future of the oyster industry are underway and receiving wider grower acceptance. The industry generally does not have well developed access to risk management training, particularly in NSW. Risk management training will assist growers to better utilise and understand the importance of issues faced by the HR farmers in the face of POMS and hopefully better planning to mitigate effects on their own estuaries.

Production strategies – in NSW, **infrastructure** investment in wild catch, trays and post and rail is significant and deeply imbedded in history. The move to baskets requires significant capital investment and a change in how oysters are handled (single seed vs. stick culture). Availability of suitable stock (such as disease resistance), the threat of disease, length of the production cycle, pest and overcatch management, quality assurance obligations and changing market demand (single seed vs. stick, PO vs. SRO) have added significant layers of complexity to traditional oyster farming. Oyster growers are innovators with production techniques so as growers diversify, showcasing and grower interaction will result in speedier adaptation and adoption. In particular, for HR growers, the option of **farming disease free windows** at least as a short term measure to add

value to larger oysters (PO or SRO) prior to onselling for cash flow is a potential option. If the ongrowing oyster is not resistant to the diseases present, the unknown start or finish of infection risk from either QX or POMS uncertain. making the practice high risk. Failure of such strategies has significant implications on mid term commercial oyster production on the HR.

Business management and cash flow – will be critical for purchase of new infrastructure or spat and implementing risk management strategies. In NSW, accessing business operating funds based on the oyster business itself from normal funding sources is very difficult for oyster farming. There is little recognition by institutions of the value of water or land leases or the stock that is on them. Stock insurance is not existent as far as the author has been able to ascertain. The implications of widespread disease incursions will not improve this scenario. Access to government low interest loans would be an important tool for growers to manage normal business needs following loss. The implications for all NSW growers by government not allowing HR farmers access to low interest business loans is wide reaching in how growers must manage cash flow to mitigate unseen risks.

Breeding programs – resistant oyster stock to disease in oysters is the only farm practical answer to disease loss (other than alternate species). Use of disease treatments is unlikely to ever be a practical solution and portioning oysters for their growth cycle from disease risk is unlikely to be economic. Resistance to disease is likely from selection and breeding programs. The existing breeding programs have had some success against QX in SRO and early indications of POMS resistance in PO's. However, current programs are forced to run complex parallel family breeding programs because of lack of ability to screen selections effectively without utilising insitu trials and seasonal conditions in existing waterways and the biosecurity issues this creates. Adding to breeding goals (more disease resistance targets, quality parameters, environmental adaptation adds extensively to the complexity of the program. Current farming practices and water/environmental conditions continue to add to the list of needs from breeders. Industry currently enjoys heavily subsidised breeding programs. As needs increase, growers/private industry will be asked to fund more of the research as government decreases it relative investment. Australia is a small oyster grower globally and spends relatively little on research compared to other regions and countries, yet we grow the same pacific oyster species. As costs increase and issues become more complex, breeding solutions are more likely to be found elsewhere and Australian growers should seek processes allowing access to these results.

Biosecurity – Australia's position as an isolated region free of disease continues to come under more pressure as world markets and tourism globalise. POMS is a likely introduction via ship ballast despite the rules and regulations Breeding program outcomes, access to species diversity, disease resistance and quality advances can be international, interstate or even intrastate. Current interpretation and implementation of biosecurity issue can be a significant inhibitor of efficiencies and production options. The implications for industry of such interpretations and implementations can be significant and in the authors view will become more so unless industry engages more effectively to develop consistent and rational biosecurity application.

8 Recommendations

8.1 Business training, access to cash flow/ suitable re-stocking options and risk management

Sudden loss of all income sources as occurred in the HR from POMS and the subsequent reliance on paying for suitable re-stocking (vs. wild catch) creates a difficult recovery position for an oyster business. Despite earlier examples in NSW with QX, financial and risk management in business by many growers seems minimal. Industry has been shown to be wanting in future proofing oyster farming in relation to preparedness for disease (and other known risks), accessing suitable farm funding and preparing their businesses to have some resilience in the face of stress. Industry and government investment in training and assisting the industry in financial and risk management would be a key initiative. It is the authors recommendation that government policy on reaction to severe loss associated with disaster be reviewed as to the impact it has on business recovery, community & tourism, river health and employment and future responses be targeted at achieving the maximum community outcome.

8.2 Diversification of species farmed.

Current options are limited in most oyster growing regions to 2 or possibly 3 oyster species with/or without disease resistance status. Other oyster productions areas in Asia farm a wider range of shell fish species including various cockles and other bivalves. Little seems known on growing some of these species in regions like the HR. A desktop review to identify likely shellfish (or alternate species) to target followed by a well designed test evaluation program. Results are likely to be valuable and transferable to other estuaries.

8.3 Diversification of production techniques.

Each estuary / production region has its own unique requirements for successful oyster farming related to water availability and environment. Prior to POMS, oyster growing on the HR was mostly floating basket and rack and post based farming single seed TPO oysters. Most growers were beginning to build new hanging basket infrastructure at the time of POMS. With the unlikely availability of POMS resistant PO oysters until 2018 and the subsequent reliance on QX resistant SRO's as a mainstay species, investment in new infrastructure is likely to be minimal and difficult until any surviving business can generate funds for such investment. Proof of concept for FLUPSYs with SRO's to enhance early growth would assist HR (and other) growers in difficult investment decisions.

Farming disease free windows potentially offers a production window for business income generation in the presence of disease. To reduce the risk of such techniques, significantly more knowledge will be needed on the disease cycles of POMS and QX (and other diseases like Winter mortality and Summer mortality), particularly understanding when infection risk is low enough to import stock. Developing economic and suitable disease monitoring protocols and tools would be a significant tool for HR and other regions to manage disease. Better understanding of how estuaries interrelate with disease risks and infection windows would assist growers utilise their own estuaries to improve efficiencies and income stream and better manage risk.

8.4 Timely access to suitable stock.

In the face of ongoing disease risk, access to suitable resistant spat that is affordable and available when needed is critical.

QXR SRO's are the product of a breeding program and only available via hatcheries currently. Historically, reliable supply and demand has been problematic with QXR SRO. Recent review and investment in the system by industry and government has resulted in broadening production and reducing the risk of failure of hatchery runs. Although early, the

changes look promising in improving access and reliability to the breeding program outputs. Grower support (purchasing of spat) of the concept is critical for long term success, and the benefits of improved genetics such as disease resistance, growth rates and quality need to be accepted by growers. Industry should undertake effective support of the investment in supply and educate growers to ensure uptake.

For PO's, reliable supply of non-resistant PO's or TPO's is currently meeting national market demand, all be it from one major location (Tasmania) potentially vulnerable to threat (environmental or disease). The existence of a local breeding program has now included POMS resistance development as a major focus and research currently underway indicates there may be production techniques which may allow survival in the face of POMS for a hatchery.

However, most of the world's oysters are PO, and the opportunity to tap into larger and more commercially orientated programs seems significant. PO's are under pressure from known, new and emerging disease threats. Handling such a wide range of breeding goals is potentially beyond the resources of industry to fund and POMS recently demonstrated that despite biosecurity rules and restrictions, disease still gets to Australian shores. *The Australian PO industry should actively seek relationships and protocols with major breeders internationally to develop sources of genetics that can be rapidly deployed in the face of threat or advances in production.* The protocols should include review of access to the Australian market for international breeding companies and hatcheries – modeled similar to cereals – where genetic gain from completion between breeders has resulted in grower production gains.

8.5 Biosecurity interpretation and application.

Current interpretation and implementation of biosecurity restrictions can be a significant inhibitor of efficiencies and production options for growers. Utilising state borders as a premise for actions may not be appropriate. From the author's knowledge of dealing in agriculture, state based interpretations are giving way to a national perspective in many areas of production. The implications for industry of intra and interstate interpretations and implementations can be significant to oyster business viability in an industry faced with funding a wider range of threats (economic, environmental and production). As noted earlier, Australia is a small player in the oyster production market. There is potentially significant gain in accessing international breeding and spat production for PO's. It seems sensible for industry and government to identify if, what and where such gains are possible and work towards economic and science based ways to allow industry to take advantage.

To sensibly support biosecurity change, industry should be able to identify where, when and how it manages its outputs. Stock movement records and the ability to report and manage would be critical in supporting any relaxation of biosecurity protocols. Just as critical is the ability to minimise incursions via quarantine or isolation. Industry would be well advised to have oyster movement protocols and the ability to manage oyster movement in the face of threat in place as soon as possible.

9 Extension and Adoption

Extension of alternative cash generating and production strategies has been driven by BBO growers themselves with little or minimal DPI (source of industry extension) interaction or extension activities offered or suggested.

The burden of business cash deficit resulting from natural disaster cannot be under estimated on the ability of an oyster business to recover. The effects of POMS on HR oyster farming businesses were dramatic and immediate. HR growers lost well over 80% of the year's income in around 4 days and the losses mounted over the next few months. Business cash flows were devastated and diversification to QXR SRO was delayed due to non-availability of QXR stock until later in 2013. Of the 14 BBO growers and 20 staff present in January 2013, only 4 growers and 2 staff remain in early 2014. All surviving growers have had to move to off-farm income sources to supplement continuing efforts to revive their oyster farming business.

Recognition of on-growing oysters (either non resistant SRO's or PO's) was pursued tentatively by surviving growers in a number of formats in 2013, either purchasing stock outright or via share farming arrangements. Non-availability of suitable PO's or TPO's for 2013 resulted in this option remaining untested.

Accessing suitable non QX SRO stock for ongrowing from other estuaries at short notice proved problematic. Limited quantities were accessed from 3 other estuaries from June to late July with the intent of selling stock before QX made itself known around late December. The effectiveness (cost and production) is yet to be fully assessed.

A number of growers also developed share farming arrangements with growers in southern estuaries and Port Stephens to import non POMSR TPO's during the disease free window of 2014. Most of the growers in other estuaries were new to farming TPO's and the change in production techniques associated with them. Spat was bought and imported from Tasmania and deployed in non POMS estuaries with the intent of importing into the Hawkesbury after POMS threat diminishes (June 2014?). Again, success or otherwise is yet to be determined.

Two growers imported non POMSR TPO spat into the HR in September 2013 and deployed up river where loss from POMS in the summer of 2012/13 was indeterminate from flood losses. In November, 2013, these spat suffered 100% mortality due to POMS.

In late 2013, HR growers have began accessing and purchasing QXR SRO's from nurseries (and some limited numbers directly from hatcheries) and deploying in the HR. It is too early to determine success or otherwise of moving to this new species. Lack of cash flow for re-investment has restricted growing techniques and infrastructure to existing infrastructure.

Alternate species (other than SOR & QXR SRO) evaluation was not embraced by HR growers in 2013 because of the unknown performance of Angasi (the only alternative available) in the HR. Adoption was limited because of the lack of spare business funds within the businesses vs. the perceived less risk (QXR SRO).

Evaluation and adoption of alternate farming methods and species is underway in the Hawkesbury River and it is too soon to assess success or otherwise. Oyster growing regions currently not affected by significant disease (or environmental) impacts are well advised to develop response plans to known and as much as possible, to possible risks to production. Extension and training by government and industry in this area would reduce the impact and demand on the limited services available to oyster farmers.

Appendices

Appendix 1 - Production Interview – Summary Grower

PART I-Species Grown

Which species do you stock in your business?	Triploid PO	SRO (not-QXr)	SRO (QXr)
Percentage grown of that species (%)			
Production (per yr)			

QXr= QX-disease resistant

PART II – Sydney Rock Oysters production

SYDNEY ROCK OYSTERS
Purchase of SRO stock
Purchased in last 12 months
Do these have resitance to Qx parasite
Total oyster brought
Average purchase cost ($ / oyster)
Source of SRO spat
Where do you source spat?
Percentage of spat sourced from this method (%)
Why do you use / not use this method? **(cost/ production / infrastructure / handling / biosecurity / regulations etc.)**
How often do you buy spat?
Does the supply of spat from each method meet your demand?
What size do you buy these in? (mm)
Self-collection of SRO spat
Please estimate the number of oyster caught
Please estimate the length of lease area dedicated to collection (metres)
Which method of collection do you use
Grow-out
What techniques do you use to grow single seed spat?
What methods of cultivation do you use during grow-out?
Why do you use / not use this method? (reasons beyond 'cost' would be helpful)
Mortality
What has been the average mortality for this production year? (%)
What do you believe is the cause of this mortality?
When do these mortality events occur? (month or event)
Stressors & Disease
Which oyster diseases / stressors impact SRO in this estuary?
Do spat sourced from different areas / suppliers respond differently?
Please explain
What month does this typically impact on oyster health?
Is the onset linked to certain events / environmental conditions? (e.g. certain weather events)
How do you attempt to mitigate your exposure?
How do you attempt to mitigate your exposure? (multiple options)
Any other solutions?
Research & Regulations
Are there any relevant research gaps that you are aware of?
Are there any regulations that you think unnecessarily impede your production / management of SRO stocks?
General
Do you think you're producing Sydney rock oysters as efficiently as you can?
What three things would you like to see improved in order to increase the efficiency / effectiveness of your Sydney Rock oyster production?

PART III – Production methods

Production Method	Mesh size	Position	Please estimate the cost to establish 100m of this?	1st deployment
[(*) to choose from different options-drop down menu] Brought 300,000 in from SOCo ~1mm oysters sat on 1000 microns				
Upwellers	500 microns			
Upwellers	1000 microns			
Upwellers	3mm			
Tooltech trays	3mm	Low intertidal (very bottom of the tide to avoid wave action)		
Plastic pillow baskets	5mm	Floating		
Plastic pillow baskets	9mm	Floating		
Mortality				
Any idea why this mortality occurs?				
Does the source of oysters affect mortality?				
Does size affect mortality?				
Sale cocktail (45-55mm)	Price			
Sale bistro (55-65mm)	Price			
Sale plate (65-75mm)	Price			
Sale standard (75-90mm)	Price			
Sale large (90-100mm)	Price			

(*)Options for the grower to choose from to fill in this section:
Collect Spat on: i) sticks; ii) plastic sticks; iii) French tubes; seed trays; seed socks in baskets; long-line (plastic baskets); long-line (plastic pillows); grow-out in thinned sticks; long-line (plastic tumblers); rack & rail (plastic trays); rack & rail (wooden trays); rack & rail (baskets); rack & rail (tumblers); Rafts; Upwellers; Flupsy ;

PART IV – LINKAGES WITH HAWKESBURY GROWERS

WOULD YOU ON SELL OYSTERS TO HAWKESBURY GROWERS?
Would you ever be in a position to consider selling oysters onto Hawkesbury River growers?
What would you consider selling?
1st sale under consideration
What size range would you be looking to sell?
Do you have a rough price in mind? ($ / oyster)
What time of the year would you consider selling these?
Any reasoning for this
2nd sale under consideration
What size range would you be looking to sell?
Do you have a rough price in mind? ($ / oyster)
What time of the year would you consider selling these?
Any reasoning for this
3rd sale under consideration
What size range would you be looking to sell?
Do you have a rough price in mind? ($ / oyster)
What time of the year would you consider selling these?
Any reasoning for this

POTENTIAL PRODUCTION SCENARIOS

Scenarios				What does this mean
1	TPO	Not POMS resistant	30mm+	Shellfish Culture providing TPO spat (30mm+) directly to farmers in the HR
2	TPO	Not POMS resistant		Current scenario - Shellfish Culture providing TPO spat directly to farmers in the HR
3	DPO	Not POMS resistant	30mm+	Sourcing DPO (wild caught) from Port Stephens or Tasmania at a larger size
4	TPO / DPO	POMS resistant		Shellfish Culture providing POMS resistant TPO spat directly to farmers in the HR
5	SRO	Not Qx resistant	30mm+	Sourcing SRO (30mm+) from other estuaries - add value before Qx window
6	SRO	QX resistant		NSW DPI / SOCo family lines of SRO with QX resistance
Additional scenarios				What does this mean
7	TPO	Not POMS resistant		Cooperative nursery lease / upwelling facility / flupsy in Shoalhaven / Port Stephens to increase TPO to 30mm+
8	TPO	Not POMS resistant	30mm+	Sourcing TPO (30mm+) off other farmers
9	Flat oyster			Sourcing spat from hatchery on south coast for grow-out

Scenarios				Impediments
1	TPO	Not POMS resistant	30mm+	Biosecurity issues, stock availability, cost of spat, production window
2	TPO	Not POMS resistant		POMS risk, spat availability to cover loses, research gaps to reduce exposure
3	DPO	Not POMS resistant	30mm+	Regulations, spat availability to cover loses, research gaps to reduce exposure, workings/overcatch, infrastructure changes, s.s. vs. stick
4	TPO / DPO	POMS resistant		POMS resistant spat not available for 3+ years
5	SRO	Not Qx resistant	30mm+	cost & availability of stock, small profits from on-growing a larger oyster, some QX loses, amount of infrastructure, workings/overcatch, s.s. vs. stick
6	SRO	QX resistant		availability of stock, long growing time, amount of infrastructure
Additional scenarios				Impediments
7	TPO	Not POMS resistant		Cost of lease / upweller / flupsy construction and maintenance - transport, time to set up, business management structures
8	TPO	Not POMS resistant	30mm+	Transport, cost of larger spat, willingness of partner farmers, business management structures
9	Flat oyster			New infrstructure / techniques required, new markets etc., suitability of estuary for species

Appendix 2 – Scenario #1 Non POMS resistant Triploid Pacific Oysters grown from Spat

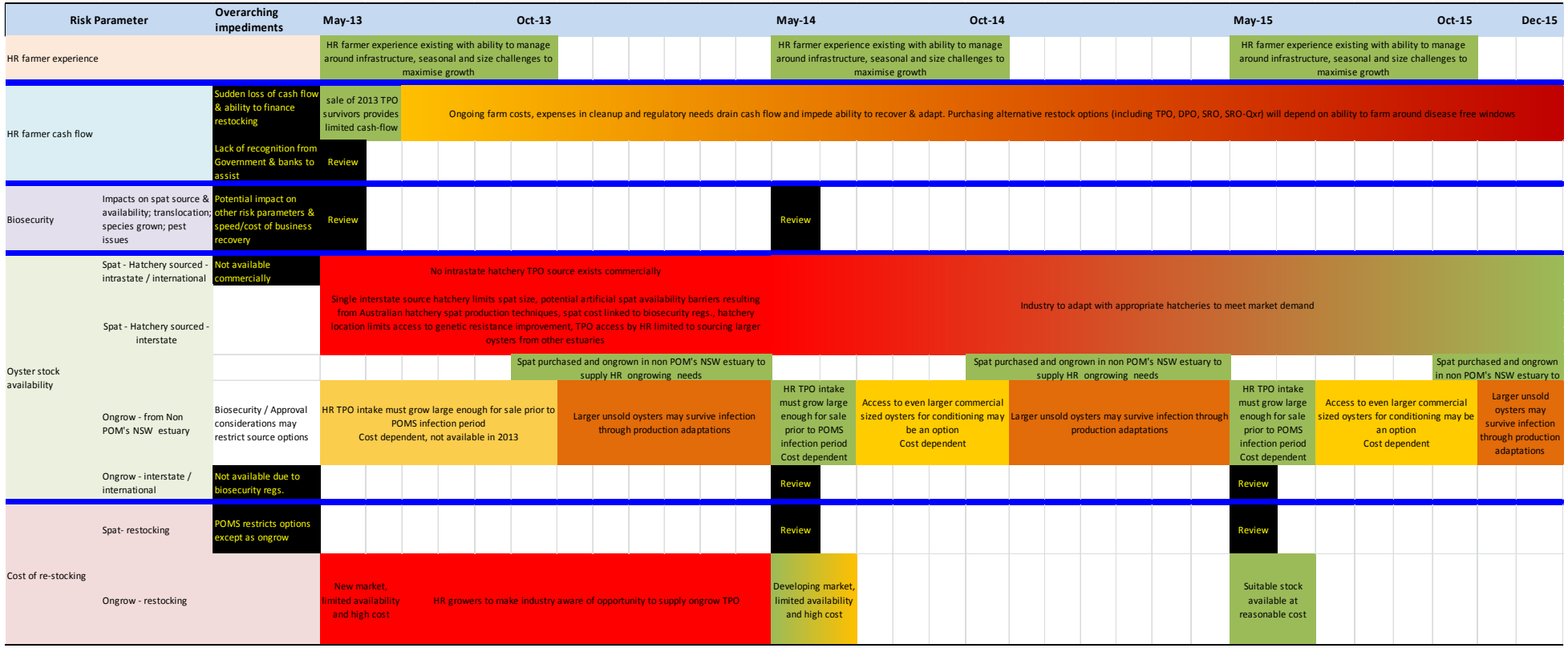
Oyster Species	**Triploid Pacific Oyster**
Production Cycle Aim	**Accessing TPO spat oysters that are grown to suitable size for translocation to HR for ongrowing to saleable size - add value and sell for profit before next disease cycle**
Stock Disease Resistance status	**Non Resistant to POMS**
Stock Source	**Currently, spat must be purchased in Tasmania and translocated to NON POMS NSW estuary for ongrowing**
Production Option Description & Purpose	**TPO spat is likely to be accessed from Shellfish Culture in Tasmania. Spat will need to be grown in a POMS free NSW estuary with an aquaculture permit that allows production of TPO. To reach a marketable size by the end of the disease free production window, TPO's will need to reach approx. 40mm over the summer. The large size and bulk is necessary to add enough value to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. The scenario will require translocating suitable stock to the Hawkesbury River in May after the POMS disease risk diminishes. Uncertainty of the cessation and recommencement of POMS activity is a significant risk.**

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmer experience existing with ability to manage around infrastructure, seasonal and size challenges to maximise growth		HR farmer experience existing with ability to manage around infrastructure, seasonal and size challenges to maximise growth		HR farmer experience existing with ability to manage around infrastructure, seasonal and size challenges to maximise growth		
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Purchasing alternative restock options (including TPO, DPO, SRO, SRO-Qxr) will depend on ability to farm around disease free windows					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on spat source & availability; translocation; species grown; pest issues	Potential impact on other risk parameters & speed/cost of business recovery	Review		Review				
Oyster stock availability	Spat - Hatchery sourced - intrastate	Not available commercially	No intrastate hatchery TPO source exists commercially			Industry to adapt with appropriate hatcheries to meet market demand			
	Spat - Hatchery sourced - interstate /international	use of current closed water import protocol from Tas may be		Spat purchased and ongrown in non POMS NSW estuary to supply HR ongrowing needs		Spat purchased and ongrown in non POMS NSW estuary to supply HR ongrowing needs		Spat purchased and ongrown in non POMS NSW estuary to supply HR ongrowing needs	
Cost of re-stocking	Spat- restocking	POMS restricts options except as ongrow			Review		Review		
	Ongrow - restocking		HR growers to make industry aware of opportunity to buy spat and supply ongrow TPO to HR. TPO spat purchased in Sept/Oct to a non-POMS estuary		TPO grown from spat translocated to HR at 40mm	TPO spat purchased from Tas and grown in non-POMS estuary	TPO grown from spat translocated to HR at 40mm	TPO spat purchased from Tas and grown in non-POMS estuary	
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		
	Pest - mussel		Impact increases over time and requires additional management		Impact increases over time and requires additional management		Impact increases over time and requires additional management		
	Pest - mudworms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - algal blooms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - over-catch		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)		Currently not a problem in HR		Currently not a problem in HR		Currently not a problem in HR		
	Handling responses		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
Production windows in the Hawkesbury River	Available production months		Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
	Impact of seasonal variations		Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
Infrastructure - need & response	Enhance growth rate		No change possible due to time restrictions		Implement enhancements to hasten growth from lessons learnt / experience of others		Implement enhancements to hasten growth from lessons learnt / experience of others		
	Minimise disease loss			Consider enhancing survival of unsold stock e.g. raising height of long-lines for next years stock		Enhancing survival of unsold stock e.g. raising height of long-lines			Enhancing survival of unsold stock e.g. raising height of
	Harmonise with diversification of farmed species	Consider Management issues with multiple species	Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
Markets	Selling stock before next infection window	applies from May 2014				Pressure to quit stock before POMS re-infection window		Pressure to quit stock before POMS re-infection window	
	Potential for market saturation	applies from May 2014				All HR growers will be trying to sell in same period		All HR growers will be trying to sell in same period	
	Consideration of value adding			Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)	
Genetics	POMS resistance	Unavailable			Review		Review		
	Triploidy	only one Triploidy methodology approved			Review		Review		
	Spat	Single source of supply			Review		Review		
Management	Managing multi-species		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
	Exploring efficiencies		Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources						
	Consideration of alternative business structures		Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff						

Appendix 3 – Scenario #2 Non POMS resistant Triploid Pacific Oysters grown from on-growing

Oyster Species	**Triploid Pacific Oyster**
Production Cycle Aim	**Ongrowing from smaller TPO oysters to add value and sell for profit before next disease cycle**
Stock Disease Resistance status	**Non Resistant to POMS**
Stock Source	**Currently, spat must be purchased in Tasmania and tranlocated to NON POM's NSW estuary for ongrowing**
Production Option Description & Purpose	**To Identify and obtain suitable stock and translocate to the Hawkesbury River, Non POMS resistant Triploid Pacific oysters that are large enough (approx. 40 to 50mm) in May (after POMS disease risk diminishes) to continue to gain size and bulk to add enough value to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. Similar to scenario #1, it may fill a niche for TPO growers in non-POMS estuaries where conditioning proves a challenge. Suitable purchase pricing for on-grow stock may be prove a challenge. Uncertainty of the cessation and recommencement of POMS activity is a significant risk.**



Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		
	Pest - mussel		Impact increases over time and requires additional management		Impact increases over time and requires additional management		Impact increases over time and requires additional management		
	Pest - mudworms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - algal blooms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - over-catch		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)		Currently not a problem in HR		Currently not a problem in HR		Currently not a problem in HR		
	Handling responses		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		
Production windows in the Hawkesbury River	Available production months		Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
	Impact of seasonal variations			Presumed low POMS activity / Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
Infrastructure - need & response	Enhance growth rate		No change possible due to time restrictions		Implement enhancements to hasten growth from lessons learnt / experience of others		Implement enhancements to hasten growth from lessons learnt / experience of others		
	Minimise disease loss			Consider enhancing survival of unsold stock e.g. raising height of long-lines for next years stock		Enhancing survival of unsold stock e.g. raising height of long-lines			Enhancing survival of unsold stock e.g. raising height of
	Harmonise with diversification of farmed species	Consider Management issues with multiple species	Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
Markets	Selling stock before next infection window	applies from May 2014				Pressure to quit stock before POMS re-infection		Pressure to quit stock before POMS re-infection	
	Potential for market saturation	applies from May 2014				All HR growers will be trying to sell in same		All HR growers will be trying to sell in same period	
	Consideration of value adding			Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)	
Genetics	POMS resistance	Unavailable			Review		Review		
	Triploidy	only one Triploidy methodology approved			Review		Review		
	Spat	Single source of supply			Review		Review		
Management	Managing multi- species		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
	Exploring efficiencies		Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources						
	Consideration of alternative business structures		Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff						

Appendix 4 – Scenario #3 Non POMS resistant Diploid Pacific Oysters grown from spat

Oyster Species	**Diploid Pacific Oyster**
Production Cycle Aim	**Accessing TPO spat oysters that are grown to suitable size for translocation to HR for ongrowing to saleable size - add value and sell for profit before next disease cycle**
Stock Disease Resistance status	**Non Resistant to POMS**
Stock Source	**Spat can be sourced from wild catch or hatchery in Port Stephens NSW (also potentially from Georges, Hawkesbury & Tasmania) and tranlocated to HR for ongrowing**
Production Option Description & Purpose	**Has common points with scenario #1, except spat more widely available and not necessarily tied to Tasmanian supply. Suitable spat (sourced from Port Stephens, Shellfish Culture in Tasmania) to be grown in a POMS free NSW estuary with an aquaculture permit that allows production of DPO's – currently just Port Stephens. If HR farmer is managing spat, translocations to HR will include lead oysters. Stock is likely to be 1 to 1.5 years old before translocation. Oysters will need to reach approx. 40mm over the summer. The large size and bulk is necessary to add enough value to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. The scenario will require translocating suitable stock to the Hawkesbury River in May after the POMS disease risk diminishes. Hawkesbury River grower minimal experience with commercial production of DPO's and DPO spawning will add complexity to production and marketing opportunities. Currently, aquaculture production permits are 12-month duration. Uncertainty of the cessation and recommencement of POMS activity is a significant risk.**

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmers have had limited commercial experience with Diploid pacific oyster production. Assumption is ability to adapt from TPO experience		HR farmers have had limited commercial experience with Diploid pacific oyster production. Assumption is ability to adapt from TPO experience		HR farmers have had limited commercial experience with Diploid pacific oyster production. Assumption is ability to adapt from TPO experience		
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Purchasing alternative restock options (including TPO, DPO, SRO, SRO-Qxr) will depend on ability to farm around disease free windows					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on stock source & availability; translocation; species grown; pest issues	Potential impact on over catch, but presence of POMS limits issue in short term	HR growers successfully applied for limited permit to grow diploid pacific oysters commercially		HR growers successfully applied for limited permit to grow diploid pacific oysters commercially		HR growers successfully applied for limited permit to grow diploid pacific oysters commercially		
Oyster stock availability	Spat - Hatchery or wild sourced - intrastate & possible interstate. Possible adaptation to closed water protocol to allow international import	Importation of spat from Tasmania should be possible with slight modification of current import protocol		Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs		Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs		Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs	
Cost of re-stocking	Spat - wild or hatchery sources - interstate or international	Not available commercially in early 2013	Limited access to interstate or international spat sources may impact access to genetic advances.	Industry to adapt with appropriate hatcheries to meet market demand, particular if POMS resistance becomes available (DPO's before TPO's)					

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		
	Pest - mussel		pact increases over time and requires additional manageme		pact increases over time and requires additional manageme		mpact increases over time and requires additional managemen		
	Pest - mudworms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - algal blooms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - over-catch		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)		Currently not a problem in HR and size of translocated oysters unlikely to be bothered by fish		Currently not a problem in HR and size of translocated oysters unlikely to be bothered by fish		Currently not a problem in HR and size of translocated oysters unlikely to be bothered by fish		
	Handling responses		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		
Production windows in the Hawkesbury River	Available production months		Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
	Impact of seasonal variations		Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
Infrastructure - need & response	Enhance growth rate		No change possible due to time restrictions		Implement enhancements to hasten growth from lessons learnt / experience of others		Implement enhancements to hasten growth from lessons learnt / experience of others		
	Minimise disease loss			Consider enhancing survival of unsold stock e.g. raising height of long-lines for next years stock		Enhancing survival of unsold stock e.g. raising height of long-lines		Enhancing survival of unsold stock e.g. raising height of long-	
	Harmonise with diversification of farmed species	Consider Management issues with multiple species							
Markets	Selling stock before next infection window	applies from May 2014				Pressure to quit stock before POMS re-infection window		Pressure to quit stock before POMS re-infection window	
	Potential for market saturation	applies from May 2014				All HR growers will be trying to sell in same period		All HR growers will be trying to sell in same period	
	Consideration of value adding			Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)	
Genetics	Improved shape, conditioning etc.			Current breeding program in SA/Tas is based on elite stock - may offer speed of production advantages vs. wild stock spat		Current breeding program in SA/Tas is based on elite stock - may offer speed of production advantages vs. wild stock spat		Current breeding program in SA/Tas is based on elite stock - may offer speed of production advantages vs. wild stock spat	
	POMS resistance	Unavailable			Review		Review		
Management	Managing multi- species		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
	Exploring efficiencies Consideration of alternative business structures		Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff						

Appendix 5 – Scenario #4 Non POMS resistant Diploid Pacific Oysters for on-growing

Oyster Species	**Diploid Pacific Oyster**
Production Cycle Aim	**Ongrowing from smaller PO oysters to add value and sell for profit before next disease cycle**
Stock Disease Resistance status	**Non Resistant to POMS**
Stock Source	**Stock could legally be accessed from Georges and Hawkesbury Rivers, but realistically in commercial quantities from Port Stephens**
Production Option Description & Purpose	**Has common points with scenario #2, except potential on-grow stock basically available only from Port Stephens. Non POMS resistant Diploid Pacific oysters that are large enough (approx. 40 to 50mm) to be translocated to the HR in May (after POMS disease risk diminishes) to continue to gain size and bulk to add enough value to deliver a potential profit when sold in mid-spring before POMS re-manifests as an infection risk. A suitable purchase pricing for on-grow stock may be prove a challenge. Stock is more likely to be small cullings from seasonal sales (2 years old). Minimal HR grower experience with DPO's and DPO spawning adds to production and marketing complexity. Uncertainty of the cessation and recommencement of POMS activity is a significant risk.**

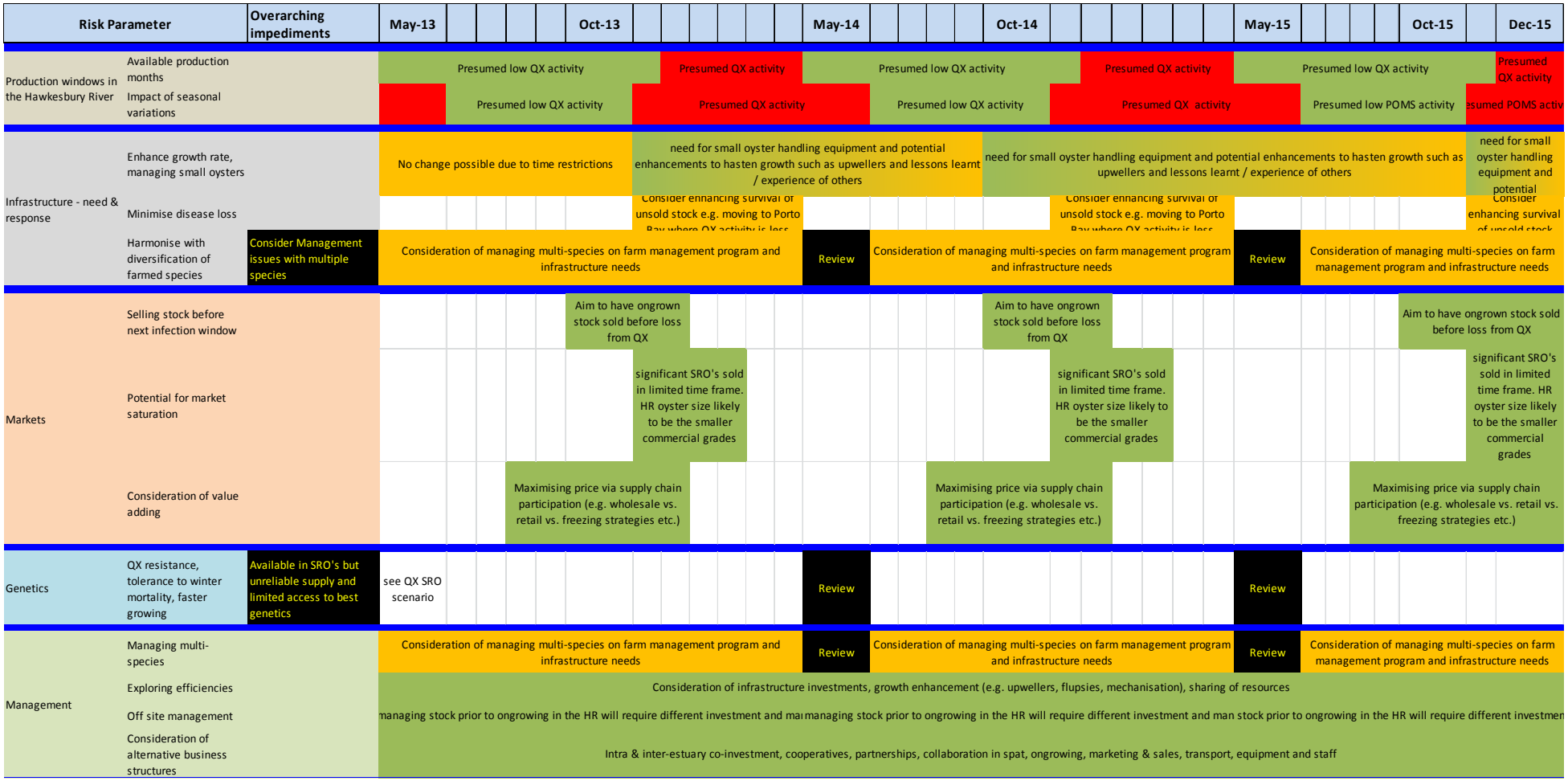
Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmers have had limited commercial experience with Diploid pacific oyster production. Assumption is ability to adapt from TPO experience		HR farmers have had limited commercial experience with Diploid pacific oyster production. Assumption is ability to adapt from TPO experience		HR farmers have had limited commercial experience with Diploid pacific oyster production. Assumption is ability to adapt from TPO experience		
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Purchasing alternative restock options (including TPO, DPO, SRO, SRO-Qxr) will depend on ability to farm around disease free windows					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on stock source & availability; translocation; species grown; pest issues	Potential impact on over catch, but presence of POMS limits issue in short term	HR growers successfully applied for limited permit to grow diploid pacific oysters commercially		HR growers successfully applied for limited permit to grow diploid pacific oysters commercially		HR growers successfully applied for limited permit to grow diploid pacific oysters commercially		
Oyster stock availability	Spat - Hatchery or wild sourced - intrastate			Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs		Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs		Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs	
	Spat - wild or hatchery sources - interstate or international	Not available commercially in early 2013	Limited access to interstate or international spat sources may impact access to genetic advances.		Industry to adapt with appropriate hatcheries to meet market demand, particular if POMS resistance becomes available (DPO's before TPO's)				
	Ongrow - from Non POM's NSW estuary	Port Stephens "flesh heating" disease resulted in very limited ongrow stock in early 2013	HR DPO stock intake must grow large enough for sale prior to POMS infection period Cost dependent	Access to even larger commercial sized oysters for conditioning may be an option Cost dependent / Larger unsold oysters may survive infection through production adaptations	HR DPO stock intake must grow large enough for sale prior to POMS infection period Cost dependent	Access to even larger commercial sized oysters for conditioning may be an option Cost dependent / Larger unsold oysters may survive infection through production adaptations	HR DPO stock intake must grow large enough for sale prior to POMS infection period Cost dependent	Access to even larger commercial sized oysters for conditioning may be an option Cost dependent	Larger unsold oysters may survive infection through production adaptations
	Ongrow - interstate / international	Not available due to biosecurity regs.			Review		Review		
Cost of re-stocking	Spat- restocking	POMS restricts options except as ongrow		DPO spat catch in Port Stephens to include consideration for sale to HR of larger oyster in May for ongrowing		DPO spat catch in Port Stephens to include consideration for sale to HR of larger oyster in May for ongrowing		DPO spat catch in Port Stephens to include consideration for sale to HR of larger oyster in May for ongrowing	
	Ongrow - restocking		New market, limited availability and high cost / HR growers to make industry aware of opportunity to supply ongrow DPO		Developing market, limited availability and high cost		Suitable stock available at reasonable cost		

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during POMS free window		
	Pest - mussel		pact increases over time and requires additional manageme		pact increases over time and requires additional manageme		pact increases over time and requires additional manageme		
	Pest - mudworms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - algal blooms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - over-catch		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)		roblem in HR and size of translocated oysters unlikely to be		roblem in HR and size of translocated oysters unlikely to be		roblem in HR and size of translocated oysters unlikely to be		
	Handling responses		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		
Production windows in the Hawkesbury River	Available production		Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
	Impact of seasonal variations		resumed low POMS activit	Presumed POMS activity	resumed low POMS activit	Presumed POMS activity	resumed low POMS activi		
Infrastructure - need & response	Enhance growth rate		No change possible due to time restrictions		Implement enhancements to hasten growth from lessons learnt / experience of others		Implement enhancements to hasten growth from lessons learnt / experience of others		
	Minimise disease loss			Consider enhancing survival of unsold stock e.g. raising height of long-lines for next years stock		Enhancing survival of unsold stock e.g. raising height of long-lines		Enhancing survival of unsold stock e.g. raising height of	
	Harmonise with diversification of farmed species	Consider Management issues with multiple species	Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
Markets	Selling stock before next infection window - impact of spawning?	applies from May 2014				Pressure to quit stock before POMS re-infection window		Pressure to quit stock before POMS re-infection window	
	Potential for market saturation	applies from May 2014				All HR growers will be trying to sell in same		All HR growers will be trying to sell in same	
	Consideration of value adding			Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)	
Genetics	POMS resistance	Unavailable			Review		Review		
Management	Managing multi- species		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
	Exploring efficiencies		Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources						
	Consideration of alternative business structures		Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff						

Appendix 6 – Scenario #5 Non-QX resistant Sydney Rock Oysters grown from spat

Oyster Species		**Sydney Rock Oyster**	
Production Cycle Aim		**Obtaining SRO spat and grow as a source for ongrowing SRO oysters to add value and sell for profit before next disease cycle**	
Stock Disease Resistance status		**Non Resistant to QX, winter mortality resistance may be an advantage**	
Stock Source		**Stock could be accessed from all estuaries along NSW coast as wild caught spat or from a number of hatchery locations**	
Production Option Description & Purpose			**Identify and obtain suitable SRO spat (hatchery or wild caught) from or to be grown in a QX free NSW estuary. This spat would need to be large enough (approx. 30 to 50mm) in May to be translocated to the HR after the QX disease risk. It is likely this stock will be 2 or 3 years old in most circumstances. If HR farmer is managing spat, translocations to HR will include lead oysters. SRO oysters need to gain size and bulk and add enough value to deliver a potential profit when sold in early summer before the next QX disease cycle. The QX free window is better defined than POMS, but can vary. Growers do get more opportunity to diagnose the disease and quit stock. Limited HR grower experience with SRO's and SRO spawning adds to production and marketing complexity.**

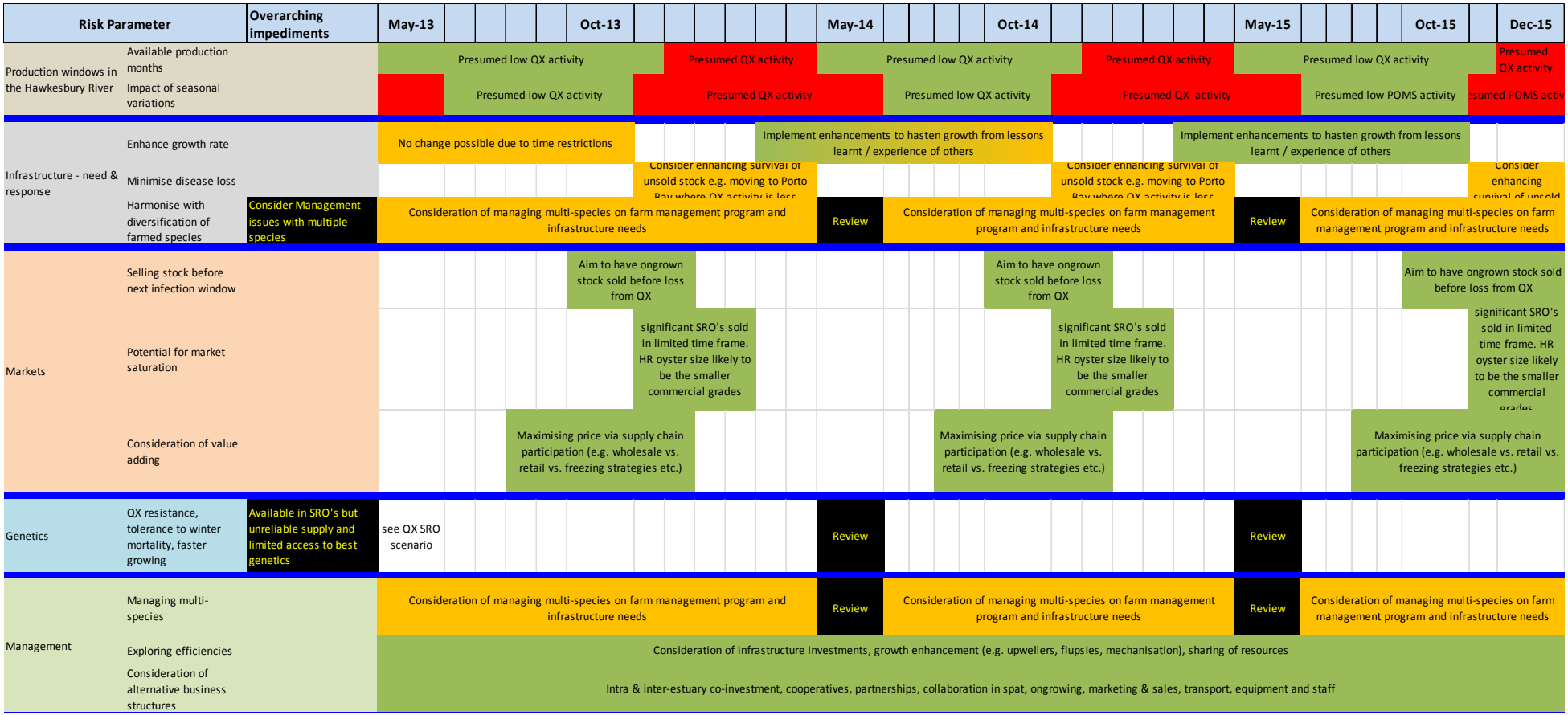
Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmers have had limited commercial experience with non QX resistant SRO's when attempting to grow in the QX free window. A basic assumption is ability to add value during this window and sell before QX returns		HR farmers have had limited commercial experience with non QX resistant SRO's when attempting to grow in the QX free window. A basic assumption is ability to add value during this window and sell before QX returns		HR farmers have had limited commercial experience with non QX resistant SRO's when attempting to grow in the QX free window. A basic assumption is ability to add value during this window and sell before QX returns		
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Purchasing alternative restock options (including TPO, DPO, SRO, SRO-Qxr) will depend on ability to farm around disease free windows					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on stock source & availability; translocation; species grown; pest issues	POMS presence in HR has "captured" elite SRO breeding stock in 2013	SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		
Oyster stock availability	Spat - Hatchery or wild sourced - intrastate			Spat caught or purchased and ongrowing non QX estuary to supply HR ongrowing needs - likely to be 2+ years before large enough to meet HR ongrowing needs		Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs		Spat caught or purchased and ongrown in Port Stephens (2013) to supply HR ongrowing needs	
	Spat - wild or hatchery sources - interstate or international	Not a current commercial option							
Cost of re-stocking	Spat- restocking	QX presence excludes some estuary options for supply	HR a new player in this market	SRO wild spat catch or from hatcheries in non-QX estuaries include consideration for sale to HR of larger oyster in May for ongrowing		SRO wild spat catch or from hatcheries in non-QX estuaries include consideration for sale to HR of larger oyster in May for ongrowing		SRO wild spat catch or from hatcheries in non-QX estuaries include consideration for sale to HR of larger oyster in May for ongrowing	
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during QX free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during QX free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during QX free		
	Pest - mussel		Impact increases over time and requires additional management - can be more challenging with SRO's that		Impact increases over time and requires additional management - can be more challenging with SRO's		Impact increases over time and requires additional management - can be more challenging with SRO's		
	Pest - mudworms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - algal blooms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - over-catch		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)		Size of translocated oysters more likely to be bothered by fish		Size of translocated oysters more likely to be bothered by fish		Size of translocated oysters more likely to be bothered by fish		
	Handling responses		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		


Risk Parameter
Overarching impediments
May-13
Oct-13
May-14
Oct-14
May-15
Oct-15
Dec-15
Production windows in the Hawkesbury River
Available production months
Impact of seasonal variations
Presumed low QX activity
Presumed QX activity
Presumed low QX activity
Presumed QX activity
Presumed low QX activity
Presumed QX activity
Presumed low QX activity
Presumed low POMS activity
Infrastructure - need & response
Enhance growth rate, managing small oysters
Minimise disease loss
Harmonise with diversification of farmed species
Consider Management issues with multiple species
No change possible due to time restrictions
need for small oyster handling equipment and potential enhancements to hasten growth such as upwellers and lessons learnt / experience of others
need for small oyster handling equipment and potential enhancements to hasten growth such as upwellers and lessons learnt / experience of others
need for small oyster handling equipment and potential
Consider enhancing survival of unsold stock e.g. moving to Porto Bay where QX activity is less
Consider enhancing survival of unsold stock e.g. moving to Porto Bay where QX activity is less
Consider enhancing survival of unsold stock
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Markets
Selling stock before next infection window
Potential for market saturation
Consideration of value adding
Aim to have ongrown stock sold before loss from QX
Aim to have ongrown stock sold before loss from QX
Aim to have ongrown stock sold before loss from QX
significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades
significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades
significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades
Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)
Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)
Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)
Genetics
QX resistance, tolerance to winter mortality, faster growing
Available in SRO's but unreliable supply and limited access to best genetics
see QX SRO scenario
Review
Review
Management
Managing multi-species
Exploring efficiencies
Off site management
Consideration of alternative business structures
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources
managing stock prior to ongrowing in the HR will require different investment and man
managing stock prior to ongrowing in the HR will require different investment and man
stock prior to ongrowing in the HR will require different investmen
Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff

Appendix 7 – Scenario #6 Non-QX resistant Sydney Rock Oysters for on-growing

Oyster Species		**Sydney Rock Oyster**
Production Cycle Aim		**Ongrowing from smaller SRO oysters to add value and sell for profit before next disease cycle**
Stock Disease Resistance status		**Non Resistant to QX, winter mortality resistance may be an advantage**
Stock Source		**Stock could be accessed from all estuaries along NSW coast from wild caught spat, hatchery spat, all-ins, single seed or excess stock**
Production Option Description & Purpose		**Has common points with scenario #5. Obtaining suitable SRO oysters to translocate to the HR that are large enough (approx. 30 to 50mm) in May (after QX disease risk) to gain size and bulk and add enough value to deliver a potential profit when sold in early summer before the next QX disease cycle. Stock is likely to be cullings from graded stock and be 2 to 4 years old. Over-catch is a risk. A suitable purchase pricing for on-grow stock may be prove a challenge, and limited HR grower experience with SRO's and SRO spawning adds to production and marketing complexity.**

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmers have had limited commercial experience with non QX resistant SRO's when attempting to grow in the QX free window. A basic assumption is ability to add value during this window and sell before QX returns		HR farmers have had limited commercial experience with non QX resistant SRO's when attempting to grow in the QX free window. A basic assumption is ability to add value during this window and sell before QX returns		HR farmers have had limited commercial experience with non QX resistant SRO's when attempting to grow in the QX free window. A basic assumption is ability to add value during this window and sell before QX returns		
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Purchasing alternative restock options (including TPO, DPO, SRO, SRO-Qxr) will depend on ability to farm around disease free windows					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on stock source & availability; translocation; species grown; pest issues		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		
Oyster stock availability	Ongrow - from Non POM's NSW estuary		SRO stock (of suitable size to be able to add value) imported into the HR for ongrowing		SRO stock (of suitable size to be able to add value) imported into the HR for ongrowing		SRO stock (of suitable size to be able to add value) imported into the HR for ongrowing		
	Ongrow - interstate / international	Not a current commercial option			Review		Review		
Cost of re-stocking	Ongrow - restocking		HR a new player in this market, limited availability and high cost	HR growers to make industry aware of opportunity to supply ongrow SRO	HR market, better availability and acceptable cost		HR market, better availability and acceptable cost		
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during QX free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during QX free window		Impact of flood and prolonged freshwater, storms and slowing of oyster growth during QX free window		
	Pest - mussel		Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up		Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up		Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up		
	Pest - mudworms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - algal blooms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - over-catch		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)		Size of translocated oysters more likely to be bothered by fish		Size of translocated oysters more likely to be bothered by fish		Size of translocated oysters more likely to be bothered by fish		
	Handling responses		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		


Risk Parameter
Overarching impediments
May-13
Oct-13
May-14
Oct-14
May-15
Oct-15
Dec-15
Production windows in the Hawkesbury River
Available production months
Impact of seasonal variations
Presumed low QX activity
Presumed QX activity
Presumed low QX activity
Presumed QX activity
Presumed low QX activity
Presumed QX activity
Presumed low QX activity
Presumed low POMS activity
Infrastructure - need & response
Enhance growth rate
Minimise disease loss
Harmonise with diversification of farmed species
Consider Management issues with multiple species
No change possible due to time restrictions
Implement enhancements to hasten growth from lessons learnt / experience of others
Implement enhancements to hasten growth from lessons learnt / experience of others
Consider enhancing survival of unsold stock e.g. moving to Porto Bay where QX activity is less
Consider enhancing survival of unsold stock e.g. moving to Porto Bay where QX activity is less
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Markets
Selling stock before next infection window
Potential for market saturation
Consideration of value adding
Aim to have ongrown stock sold before loss from QX
Aim to have ongrown stock sold before loss from QX
Aim to have ongrown stock sold before loss from QX
significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades
significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades
significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades
Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)
Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)
Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)
Genetics
QX resistance, tolerance to winter mortality, faster growing
Available in SRO's but unreliable supply and limited access to best genetics
see QX SRO scenario
Review
Review
Management
Managing multi-species
Exploring efficiencies
Consideration of alternative business structures
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Review
Consideration of managing multi-species on farm management program and infrastructure needs
Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources
Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff

Appendix 8 – Scenario #7 QX resistant Sydney Rock Oysters grown from spat

Oyster Species		**Sydney Rock Oyster**	
Production Cycle Aim		**Production of QXR SRO oysters from spat to add value and sell for profit in a minimum time frame**	
Stock Disease Resistance status		**Resistant to QX, winter mortality resistance may be an advantage**	
Stock Source		**Spat can only be accessed from limited hatcheries or nurseries in NSW**	
Production Option Description & Purpose			**Identify sources and obtain suitable QXR SRO spat from potential NSW hatcheries and nurseries (some possibility for interstate hatchery production). Translocate SRO QXR spat to the HR with the goal of minimum on farm time to gain size and bulk to add enough value to deliver a potential profit when sold - probably 2 years minimum - and reduce potential losses from repeated exposures to QX. Production will involve inter estuary stock movement to manage QX exposure. Likely involve investment in up-wellers and other growth enhancement techniques. Current concern with reliability of spat supply and susceptibility to multiple QX exposures. Limited HR grower experience with SRO's and SRO spawning adds to production and marketing complexity.**

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmers have had limited commercial experience with QX resistant SRO's. Experience to date has shown some losses if farmed through the QX active window of summer.		HR farmers have had limited commercial experience with QX resistant SRO's. Experience to date has shown some losses if farmed through the QX active window of summer.		HR farmers have had limited commercial experience with QX resistant SRO's. Experience to date has shown some losses if farmed through the QX active window of summer.		
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	and regulatory needs drain cash flow and impede ability to recover & adapt. Purchasing alternative restock options (including TPO, DPO, SRO, SRO-Qxr) will depend on abi			potential first sales from Sept 2013 hatchery run with QX SRO	Sales of QX SRO's from Sept 2013 hatchery/nursery purchases	
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on stock source & availability; translocation; species grown; pest issues		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.		
Oyster stock availability	Spat - from NSW hatchery or nursery		QX SRO spat unavailable (has been 2 years since last successful production run)	QX SRO spat may be available from hatchery &/or nursery if successful run undertaken in September		QX SRO spat may be available from hatchery &/or nursery if successful run undertaken in September		QX SRO spat may be available from hatchery &/or nursery if successful run undertaken in September	
	Ongrow - interstate / international	Not a current commercial option			Review		Review		
Cost of re-stocking	Purchasing QXR resistant SRO - restocking			Spat available from hatchery or nursery if run at Port Stephens successful in September - numbers available will be a concern - restocking should take into account susceptibility of young spat to have some loss with summer exposure to QX		Spat available from hatchery or nursery if run at Port Stephens successful in September - numbers available will be a concern - restocking should take into account susceptibility of young spat to have some loss with summer exposure to QX			Spat available from hatchery or nursery if run at Port Stephens successful in September - numbers available
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size		Impact of flood and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size		Impact of flood and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size		
	Pest - mussel		Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up		Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up		Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up		
	Pest - mudworms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - algal blooms		Ongoing management required		Ongoing management required		Ongoing management required		
	Pest - over-catch		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)		Size of translocated oysters more likely to be bothered by fish than TPO's		Size of translocated oysters more likely to be bothered by fish than TPO's		Size of translocated oysters more likely to be bothered by fish than TPO's		
	Handling responses		Impact of pests may increase management responses, particularly managing spat, required and therefore increased costs		Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		

Risk Parameter		Overarching impediments	May-13					Oct-13						May-14					Oct-14						May-15					Oct-15		Dec-15
Production windows in the Hawkesbury River	Available production months		Presumed low QX activity							Presumed QX activity					Presumed low QX activity					Presumed QX activity						Presumed low QX activity						Presumed QX activity
	Impact of seasonal variations			Presumed low QX activity					Presumed QX activity						Presumed low QX activity					Presumed QX activity						Presumed low POMS activity					Presumed QX activity
Infrastructure - need & response	Enhance growth rate							Baskets vs. trays to enhance shape?					Implement enhancements to hasten growth from lessons learnt / experience of others											Implement enhancements to hasten growth from lessons learnt / experience of others						
	Minimise disease loss								Consider enhancing survival of unsold stock e.g. moving to Porto											Consider enhancing survival of unsold stock e.g. moving to Porto										Consider enhancing
	Harmonise with diversification of farmed species	Consider Management issues with multiple species	Consideration of managing multi-species on farm management program and infrastructure needs											Review	Consideration of managing multi-species on farm management program and infrastructure needs										Review	Consideration of managing multi-species on farm management program and infrastructure needs						
Markets	Selling stock before next infection window																												likely sales of lead QX resistant spat for September 2013 hatchery production		
	Potential for market saturation																														Significant SRO's sold in limited time frame. HR
	Consideration of value adding																		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)										Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		
Genetics	QX resistance, tolerance to winter mortality, faster growing	Available in SRO's but unreliable supply and limited access to best genetics				commercial hatchery outputs should be available, but consistent failure has meant no successful production for almost 2 years. Next hatchery run scheduled for Spat 2013. HR to negotiate access to significant numbers - ongrowing in other estuaries may represent a risk management strategy							Review			hopefully hatchery production issues resolved. HR to negotiate access to significant numbers - ongrowing in other estuaries may represent a risk management strategy							Review			hopefully hatchery production issues resolved. HR to negotiate access to significant numbers - ongrowing in other estuaries may represent a risk management strategy				
Management	Managing multi-species		Consideration of managing multi-species on farm management program and infrastructure needs											Review	Consideration of managing multi-species on farm management program and infrastructure needs										Review	Consideration of managing multi-species on farm management program and infrastructure needs						
	Exploring efficiencies		Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources																													
	Consideration of alternative business structures		Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff																													

Appendix 9 – Scenario #8 QX resistant Sydney Rock Oysters for growing

Oyster Species		**Sydney Rock Oyster**
Production Cycle Aim		**Ongrowing from smaller QX SRO oysters to add value and sell for profit before next disease cycle**
Stock Disease Resistance status		**Resistant to QX, winter mortality resistance may be an advantage**
Stock Source		**Stock can be accessed from NSW estuaries who grow hatchery QX resistant stock or from Georges River farmers producing larger oysters for finishing in the HR.**
Production Option Description & Purpose		**Identify and obtain larger QXR SRO oysters to translocate to the HR oysters that are large enough to gain size and bulk and add enough value to deliver a potential profit when sold over the summer. Strategy minimizes the number of exposures to QX (and stock loss) and exposure to spat management. The larger size and bulk is necessary to add enough value to deliver a potential profit when sold over summer. HR has a history of being able to sell SRO's in condition year round – may prove an advantage. A suitable purchase pricing for on-grow stock may be prove a challenge, and limited HR grower experience with SRO's and SRO spawning adds to production and marketing complexity. Strategy dependent on reliable SRO QXR spat supply to on-growers**

Risk Parameter		Overarching impediments	May-13					Oct-13						May-14					Oct-14						May-15					Oct-15		Dec-15
HR farmer experience			HR farmers have had limited commercial experience with QX resistant SRO's. Experience to date has shown some losses if farmed through the QX active window of summer. Ongrowing larger oysters may reduce losses and reduce risk associated with uncertain QX active months.											HR farmers have had limited commercial experience with QX resistant SRO's. Experience to date has shown some losses if farmed through the QX active window of summer. Ongrowing larger oysters may reduce losses and reduce risk associated with uncertain QX active months.											HR farmers have had limited commercial experience with QX resistant SRO's. Experience to date has shown some losses if farmed through the QX active window of summer. Ongrowing larger oysters may reduce losses and reduce risk associated with uncertain QX active months.							
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow					Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Purchasing alternative restock options (including TPO, DPO, SRO, SRO-Qxr) will depend on ability to farm around disease free windows																						
		Lack of recognition from Government & banks to assist	Review																													
Biosecurity	Impacts on stock source & availability; translocation; species grown; pest issues		SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.											SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.											SRO stock likely to be 2 years + so potential for overcatch exists. No import restrictions known.							
Oyster stock availability	Ongrow - from NSW estuary		QX SRO stock (of suitable size to be able to add value) imported into the HR for ongrowing											QX SRO stock (of suitable size to be able to add value) imported into the HR for ongrowing											QX SRO stock (of suitable size to be able to add value) imported into the HR for ongrowing							
	Ongrow - interstate / international	Not a current commercial option												Review											Review							
Cost of re-stocking	Ongrow - restocking		HR a new player in this market, limited availability and high cost of QX SRO stock					HR growers to make industry aware of opportunity to supply ongrow SRO						HR a new player in this market, limited availability and high cost of QX SRO stock											better availability and high cost of QX SRO stock							
Non-disease stressors	Environmental		Impact of flood and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size											Impact of flood and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size											Impact of flood and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size							
	Pest - mussel		Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up											Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up											Impact increases over time and requires additional management - can be more challenging with SRO's that are smaller and more difficult to manage using fish to clean up							
	Pest - mudworms		Ongoing management required											Ongoing management required											Ongoing management required							
	Pest - algal blooms		Ongoing management required											Ongoing management required											Ongoing management required							
	Pest - over-catch		Increased problem if imported with stock and requires management response											Increased problem if imported with stock and requires management response											Increased problem if imported with stock and requires management response							
	Pest - others (fish, rays, birds, invertebrates)		Size of translocated oysters more likely to be bothered by fish than TPO's											Size of translocated oysters more likely to be bothered by fish than TPO's											Size of translocated oysters more likely to be bothered by fish than TPO's							
	Handling responses		Impact of pests may increase management responses required and therefore costs											Impact of pests may increase management responses required and therefore costs											Impact of pests may increase management responses required and therefore costs							

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
Production windows in the Hawkesbury River	Available production months		Presumed low QX activity	Presumed QX activity	Presumed low QX activity	Presumed QX activity	Presumed low QX activity		Presumed QX activity
	Impact of seasonal variations			Presumed low QX activity	Presumed QX activity	Presumed low QX activity	Presumed QX activity	Presumed low POMS activity	Presumed QX activity
Infrastructure - need & response	Enhance growth rate		Baskets vs. trays to enhance shape?		Implement enhancements to hasten growth from lessons learnt / experience of others		Implement enhancements to hasten growth from lessons learnt / experience of others		
	Minimise disease loss			Consider enhancing survival of unsold stock e.g. moving to Porto Bay where QX activity is less		Consider enhancing survival of unsold stock e.g. moving to Porto Bay where QX activity is less			Consider enhancing survival of unsold
	Harmonise with diversification of farmed species	Consider Management issues with multiple species	Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
Markets	Selling stock before next infection window			Aim to have ongrown stock sold sap and reduce risk of loss over summer from QX		Aim to have ongrown stock sold sap and reduce risk of loss over summer from QX		Aim to have ongrown stock sold sap and reduce risk of loss over summer from QX	
	Potential for market saturation			significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades		significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial grades			significant SRO's sold in limited time frame. HR oyster size likely to be the smaller commercial
	Consideration of value adding			Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)		Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)	
Genetics	QX resistance, tolerance to winter mortality, faster growing	Available in SRO's but unreliable supply and limited access to best genetics		commercial hatchery outputs should be available, but consistent failure has meant no successful production for almost 2 years. Next hatchery run scheduled for Spat 2013. HR to negotiate access to significant numbers - ongrowing in other estuaries may represent a risk management strategy	Review	hopefully hatchery production issues resolved. HR to negotiate access to significant numbers - ongrowing in other estuaries may represent a risk management strategy	Review	hopefully hatchery production issues resolved. HR to negotiate access to significant numbers - ongrowing in other estuaries may represent a risk management strategy	
Management	Managing multi-species		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
	Exploring efficiencies		Consideration of infrastructure investments, growth enhancement (e.g. upwellers, flupsies, mechanisation), sharing of resources						
	Consideration of alternative business structures		Intra & inter-estuary co-investment, cooperatives, partnerships, collaboration in spat, ongrowing, marketing & sales, transport, equipment and staff						

Appendix 10a & 10b – Scenario #9 POMS resistant Triploid Pacific Oyster grown from spat and for on-growing

Oyster Species			**Triploid Pacific Oyster**
Production Cycle Aim			**Accessing TPO spat oysters that are grown to suitable size for translocation to HR for ongrowing to saleable size - add value and sell for profit before next disease cycle. Option of accessing resistant TPO's from other estuaries for ongrowing and conditioning**
Stock Disease Resistance status			**Resistant to POMS**
Stock Source			**Currently, no resistant TPO oysters available. Likely source of spat may be Tasmania and hatcheries in NSW. The import protocol for spat oysters from closed waters should be adaptable to approved overseas hatcheries as well**
Production Option Description & Purpose			**Assumption is that POMS resistant TPO spat available. Identify and obtain suitable POMSR TPO spat & larger oysters (from NSW estuaries) and translocate to the HR for farming to profitable size & condition - a return to former pre-POMS practice. Spat growth enhancement options may be useful. Oysters grown to a saleable size and bulk and sold year round within 10 to 14 months of spat purchase. Similar to scenario #1, it may fill a niche for TPO growers in non-POMS estuaries where conditioning proves a challenge. Suitable purchase pricing for on-grow stock may be also prove a challenge. If resistance is actually tolerance, then practices to minimise exposure stock to POMS may still apply.**

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmer experience with TPO exists Continue to improve ability to manage around infrastructure, seasonal and size challenges to maximise growth should resistant oysters become available						
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Some form of survival strategy is necessary to enable growers to have adequate cash flow to purchase POMS resistant TPO's when (if) they become available.					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on spat source & availability; translocation; species grown; pest issues	Potential impact on other risk parameters & speed/cost of business recovery	Review		Review	Resistance to POMS may not occur in Australia first. Current restrictions on the Triploidy process used to obtain triploid PO's may restrict import or source access. Current import issues restricting oyster size import from Tasmania may impact HR growers ability to respond quickly			
Oyster stock availability	Spat - Hatchery sourced - intrastate	Not available commercially	No intrastate hatchery TPO source exists commercially - POMS resistant oysters are the primary research focus of PO breeding programs - HR is hopeful of positive outcomes as early as possible						
	Spat - Hatchery sourced - interstate/ international	Not available commercially	No interstate or international hatchery TPO source exists commercially - POMS resistant oysters are the primary research focus of PO breeding programs - HR is hopeful of positive outcomes as early as possible						
Cost of re-stocking	Spat- restocking	Not available commercially			Review		Review		
	Ongrow - restocking	Not available commercially			Review		Review		
Non-disease stressors	Environmental						Impact of flood and prolonged freshwater, storms and slowing of oyster growth		
	Pest - mussel						Impact increases over time and requires additional management		
	Pest - mudworms						Ongoing management required		
	Pest - algal blooms						Ongoing management required		
	Pest - over-catch						Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)						Currently not a problem in HR		
	Handling responses						Impact of pests may increase management responses required and therefore costs		

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
Production windows in the Hawkesbury River	Available production months	should no longer impact on POMS resistant oyster production cycle	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
	Impact of seasonal variations		umed low POMS act	Presumed POMS activity	umed low POMS act	Presumed POMS activity	med low POMS a		
Infrastructure - need & response	Enhance growth rate				Review		Implement enhancements to hasten growth from lessons learnt / experience of others		
	Minimise disease loss				Review		Enhancing survival of unsold stock e.g. raising height of long-lines		
	Harmonise with diversification of farmed species	Consider Management issues with multiple species			Review		Review	Consideration of managing multi-species on farm management program and infrastructure needs	
Markets	Potential for market saturation						Review	All HR growers will be trying to sell in same period	
	Consideration of value adding					Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)	Review		
Genetics	POMS resistance	indication of resistance in elite lines	industry has nominated development of a POMS resistant Pacific Oyster as its #1 priority. POMS resistant DPO's are likely to precede POMS resistant TPO's. Industry should ensure relevant permits are in place intra and interstate and internationally		Review	industry has nominated development of a POMS resistant Pacific Oyster as its #1 priority. POMS resistant DPO's are likely to precede POMS resistant TPO's. Industry should ensure relevant permits are in place intra and interstate and internationally	Review	industry has nominated development of a POMS resistant Pacific Oyster as its #1 priority. POMS resistant DPO's are likely to precede POMS resistant TPO's. Industry should ensure relevant permits are in place intra and interstate and internationally	
	Triploidy	only one Triploidy methodology approved	Industry to explore approval of alternate Triploidy methodologies to maximise sources of POMS resistant oysters when the technology becomes available		Review	Industry to explore approval of alternate Triploidy methodologies to maximise sources of POMS resistant oysters when the technology becomes available	Review	Industry to explore approval of alternate Triploidy methodologies to maximise sources of POMS resistant oysters when the technology becomes available	
	Spat	Single source of supply	Industry to encourage multisource of stock supply to improve reliable and sustainable supply of TPO POMS resistant pacific oysters.		Review	Industry to encourage multisource of stock supply to improve reliable and sustainable supply of TPO POMS resistant pacific oysters.	Review	Industry to encourage multisource of stock supply to improve reliable and sustainable supply of TPO POMS resistant pacific oysters.	
Management	Managing multi- species		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
	Exploring efficiencies		Review efficiencies and production options to enhance production when POMS resistant TPO's are available		Review	Review efficiencies and production options to enhance production when POMS resistant TPO's are available	Review	Review efficiencies and production options to enhance production when POMS resistant TPO's are available	
	Consideration of alternative business structures		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	

Appendix 11a & 11b – Scenario #10 POMS resistant Diploid Pacific Oyster grown from spat and for on-growing

Oyster Species			**Diploid Pacific Oyster**
Production Cycle Aim			**Accessing DPO spat oysters that are grown to suitable size for translocation to HR for ongrowing to saleable size - add value and sell for profit before next disease cycle. Option of accessing resistant DPO's from other estuaries for ongrowing and conditioning**
Stock Disease Resistance status			**Resistant to POMS**
Stock Source			**Currently, no resistant DPO oysters available. Likely source of spat may be Tasmania and hatcheries in NSW. The import protocol for spat oysters from closed waters should be adaptable to approved overseas hatcheries as well**
Production Option Description & Purpose			**Assumption is that POMS resistant DPO spat available. It is likely POMSR DPO spat will be available before TPO. Identify and obtain suitable POMSR DPO spat & larger oysters (from NSW estuaries) and translocate to the HR for farming to profitable size & condition. Spat growth enhancement options may be useful. Oysters grown to a saleable size and bulk and sold year round within 18 months of spat purchase. Similar to scenario #3, it may fill a niche for DPO growers in non-POMS estuaries where conditioning proves a challenge. Suitable purchase pricing for on-grow stock may also prove a challenge. If resistance is actually tolerance, then practices to minimise exposure stock to POMS may still apply.**

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmers have had limited commercial experience with Diploid pacific oyster production. Assumption is ability to adapt from TPO experience. POMS resistant DPO's are likely to be available before POMS resistant TPO's						
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	Ongoing farm costs, expenses in cleanup and regulatory needs drain cash flow and impede ability to recover & adapt. Some form of survival strategy is necessary to enable growers to have adequate cash flow to purchase POMS resistant DPO's when (if) they become available.					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on spat source & availability; translocation; species grown; pest issues	Potential impact on other risk parameters & speed/cost of business recovery	Review		Review	Resistance to POMS may not occur in Australia first. Current restrictions on the Triploidy process used to obtain PO's may restrict import or source access. Current import issues restricting oyster size import from Tasmania may impact HR growers ability to respond quickly			
Oyster stock availability	Spat - Hatchery sourced - intrastate	Not available commercially	Intrastate hatchery DPO source exists commercially - but this source may not be the POMS resistant one. POMS resistant oysters are the primary research focus of PO breeding programs - HR is hopeful of positive outcomes as early as possible. Screen wild catch for tolerance to POMS					Possible POMS tolerance developing in Georges River or HR wild population allowing farming of wild caught spat	
	Spat - Hatchery sourced - interstate/ international	Not available commercially	No interstate or international hatchery DPO source exists commercially - POMS resistant oysters are the primary research focus of PO breeding programs - HR is hopeful of positive outcomes as early as possible						
Cost of re-stocking	Spat- restocking	Not available commercially			Review		Review		
	Ongrow - restocking	Not available commercially			Review		Review		
Non-disease stressors	Environmental						Impact of flood and prolonged freshwater, storms and slowing of oyster growth		
	Pest - mussel						Impact increases over time and requires additional management		
	Pest - mudworms						Ongoing management required		
	Pest - algal blooms						Ongoing management required		
	Pest - over-catch						Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)						Currently not a problem in HR		
	Handling responses						Impact of pests may increase management responses required and therefore costs		

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
Production windows in the Hawkesbury River	Available production months	should no longer impact on POMS resistant oyster production cycles	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
	Impact of seasonal variations		Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity	Presumed POMS activity	Presumed low POMS activity		
Infrastructure - need & response	Enhance growth rate				Review		Implement enhancements to hasten growth from lessons learnt / experience of others		
	Minimise disease loss				Review		Enhancing survival of unsold stock e.g. raising height of long-lines		
	Harmonise with diversification of farmed species	Consider Management issues with multiple species			Review		Review	Consideration of managing multi-species on farm management program and infrastructure needs	
Markets	Potential for market saturation						Review	All HR growers will be trying to sell in same period	
	Consideration of value adding					Maximising price via supply chain participation (e.g. wholesale vs. retail vs. freezing strategies etc.)	Review		
Genetics	POMS resistance	indication of resistance in elite lines	industry has nominated development of a POMS resistant Pacific Oyster as its #1 priority. POMS resistant DPO's are likely to precede POMS resistant TPO's. Industry should ensure relevant permits are in place intra and interstate and internationally		Review	industry has nominated development of a POMS resistant Pacific Oyster as its #1 priority. POMS resistant DPO's are likely to precede POMS resistant TPO's. Industry should ensure relevant permits are in place intra and interstate and internationally	Review	industry has nominated development of a POMS resistant Pacific Oyster as its #1 priority. POMS resistant DPO's are likely to precede POMS resistant TPO's. Industry should ensure relevant permits are in place intra and interstate and	
	Spat	Single source of supply	Industry to encourage multisource of stock supply to improve reliable and sustainable supply of TPO POMS resistant pacific oysters.		Review	Industry to encourage multisource of stock supply to improve reliable and sustainable supply of TPO POMS resistant pacific oysters.	Review	Industry to encourage multisource of stock supply to improve reliable and sustainable supply of TPO POMS resistant pacific oysters.	
Management	Managing multi- species		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	
	Exploring efficiencies		Review efficiencies and production options to enhance production when POMS resistant PO's are available		Review	Review efficiencies and production options to enhance production when POMS resistant PO's are available	Review	Review efficiencies and production options to enhance production when POMS resistant PO's are available	
	Consideration of alternative business structures		Consideration of managing multi-species on farm management program and infrastructure needs		Review	Consideration of managing multi-species on farm management program and infrastructure needs	Review	Consideration of managing multi-species on farm management program and infrastructure needs	

Appendix 12a & 12b – Scenario #11 Flat (Angasi) Oysters from spat and for on-growing

Oyster Species			**Flat or Angasi Oyster**
Production Cycle Aim			**Accessing flat spat oysters that are grown to suitable size for translocation to HR for ongrowing to saleable size or accessing larger flat oysters from other estuaries for ongrowing and conditioning and sale at a profit**
Stock Disease Resistance status			**Not known to be affected by QX or POMS**
Stock Source			**Spat oysters available from NSW hatchery/nursery. Potential source of larger flat oysters for ongrowing unclear at this point.**
Production Option Description & Purpose			**Identify and obtain suitable spat (and larger oysters from NSW estuaries) and translocate to the HR. Oysters grown to saleable size and bulk to add enough value to deliver a potential profit when sold. POMS & QX should not affect flat oysters. May be other disease issues.**

Risk Parameter		Overarching impediments	May-13	Oct-13	May-14	Oct-14	May-15	Oct-15	Dec-15
HR farmer experience			HR farmers have had very limited commercial experience with flat oysters. Suggestion that intolerance to fresh water exposures and low salinity make the HR a difficult environment.		HR farmers have had very limited commercial experience with flat oysters. Suggestion that intolerance to fresh water exposures and low salinity make the HR a difficult environment.		HR farmers have had very limited commercial experience with flat oysters. Suggestion that intolerance to fresh water exposures and low salinity make the HR a difficult environment. .		
HR farmer cash flow		Sudden loss of cash flow & ability to finance restocking	sale of 2013 TPO survivors provides limited cash-flow	d impede ability to recover & adapt. Purchasing alternative restock options. Flat oysters are likely to be a 3 year plus growth cycle, so catch flow is potentiall					
		Lack of recognition from Government & banks to assist	Review						
Biosecurity	Impacts on stock source & availability; translocation; species grown; pest issues		Flat oysters likely to be 2 years. No translocation issues other than book work anticipated as long as movement is intrastate						
Oyster stock availability	Spat and ongrow - from NSW hatchery or nursery or grower		Commercial production in a number of NSW estuaries along with successful hatchery runs. Unknown timing of spat availability and unknown situation with supply of larger oysters for ongrowing		Commercial production in a number of NSW estuaries along with successful hatchery runs. Unknown timing of spat availability and unknown situation with supply of larger oysters for ongrowing		Commercial production in a number of NSW estuaries along with successful hatchery runs. Unknown timing of spat availability and unknown situation with supply of larger oysters for ongrowing		
	Ongrow - interstate / international	Not a current commercial option			Review		Review		
Cost of re-stocking	Purchasing QXR resistant SRO - restocking			Commercial production of flat oysters in a number of NSW estuaries along with successful hatchery runs - offer has been made to supply spat at $0.025 each. Unknown situation with supply of larger oysters for ongrowing		Commercial production of flat oysters in a number of NSW estuaries along with successful hatchery runs - offer has been made to supply spat at $0.025 each. Unknown situation with supply of larger oysters for ongrowing		Commercial production of flat oysters in a number of NSW estuaries along with successful hatchery runs	
Non-disease stressors	Environmental			Impact of flood (noted as a particular issue for flat oysters) and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size	Impact of flood (noted as a particular issue for flat oysters) and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size		Impact of flood (noted as a particular issue for flat oysters) and prolonged freshwater, storms and heat issues over summer - slowing of oyster growth and extending time to saleable size		
	Pest - mussel			Impact increases over the time the oysters are in the water and requires additional management -	Impact increases over the time the oysters are in the water and requires additional management -		Impact increases over the time the oysters are in the water and requires additional management -		
	Pest - mudworms			Ongoing management required	Ongoing management required		Ongoing management required		
	Pest - algal blooms			Ongoing management required	Ongoing management required		Ongoing management required		
	Pest - over-catch			if imported with stock and requires man	Increased problem if imported with stock and requires management response		Increased problem if imported with stock and requires management response		
	Pest - others (fish, rays, birds, invertebrates)			Size of translocated oysters more likely to be bothered by fish than TPO's	Size of translocated oysters more likely to be bothered by fish than TPO's		Size of translocated oysters more likely to be bothered by fish than TPO's		
	Handling responses			Impact of pests may increase management responses, particularly managing spat, required and therefore increased costs	Impact of pests may increase management responses required and therefore costs		Impact of pests may increase management responses required and therefore costs		

FRDC FINAL REPORT CHECKLIST

Project Title:	Tactical Research Fund: Development and Validation of Effective and Affordable Oyster Production Systems in the Face of POMS Disease of Pacific Oysters and QX Disease of Sydney Rock Oysters - Evaluation from a Production, Research and Economic Perspective		
Principal Investigators:	Steven M Jones – BScAg		
Project Number:	2012/229		
Description:	The project reviewed options available to Hawkesbury River oyster farmers following virtually complete loss of production to a new disease introduction – POMS. The evaluation and methodologies are a roadmap for other estuaries as yet unaffected to pre-plan and reduce the risks to oyster farming businesses. It highlights the need for industry capability to produce disease resistance alternatives, access and reliable supply of alternative species and the need for oyster farmers to take more responsibility for planning and risk reduction in their industry		
Published Date:	N/A	**Year:**	2013
ISBN:	N/A	**ISSN:**	N/A
Key Words:	Pacific Oyster, Crassostrea gigas, Sydney Rock Oyster, Saccostrea glomerata, POMS, QX, Hawkesbury, disease outbreak, economic analysis, Hawkesbury River		

Please use this checklist to self-assess your report before submitting to FRDC. Checklist should accompany the report.

	Is it included (Y/N)	**Comments**
Foreword (optional)		
Acknowledgments	Y	
Abbreviations	Y	
Executive Summary		
- **What the report is about**		
- **Background – why project was undertaken**		
- **Aims/objectives – what you wanted to achieve at the beginning**		
- **Methodology – outline how you did the project**		
- **Results/key findings – this should outline what you found or key results**		
- **Implications for relevant stakeholders**		
- **Recommendations**		
Introduction	Y	
Objectives	Y	
Methodology	Y	
Results	Y	
Discussion	Y	
Conclusion	Y	
Implications	Y	
Recommendations	Y	
Further development	Y	
Extension and Adoption	Y	
Project coverage		
Glossary		
Project materials developed		
Appendices	Y	