Fisheries Research Report No. 227, 2012

Assessment of the risks associated with the release of abalone sourced from Abalone Hatcheries for enhancement or marine grow-out in the open ocean areas of WA

J. Brian Jones and W.J. Fletcher
Completed August 2011

Government of **Western Australia**
Department of **Fisheries**

Fisheries Research Division
Western Australian Fisheries and Marine Research Laboratories
PO Box 20 NORTH BEACH, Western Australia 6920

Correct citation:

Jones, J.B. and W.J. Fletcher. 2012 Assessment of the risks associated with the release of abalone sourced from Abalone Hatcheries for enhancement or marine grow-out in the open ocean areas of WA. Fisheries Research Report No. 227. 24p.

Enquiries:

WA Fisheries and Marine Research Laboratories, PO Box 20, North Beach, WA 6920
Tel: +61 8 9203 0111
Email: library@fish.wa.gov.au
Website: www.fish.wa.gov.au
ABN: 55 689 794 771

A complete list of Fisheries Research Reports is available online at **www.fish.wa.gov.au**

ISSN: 1035 - 4549 ISBN: 978-1-921845-36-9

Contents

1.0 Executive Summary

The virus that causes Abalone Viral Ganglioneuritis (AVG) is considered to be exotic to Western Australia (WA). The known distribution includes Victoria, Tasmania and Taiwan. There are a number of known strains of the virus; Tasmanian strains do not (to date) cause mortalities in wild abalone (but do so in farms and processing facilities). Victorian and Taiwanese strains cause high mortalities in wild abalone. Despite active surveillance, the virus has not been found in NSW, South Australia or Western Australia but there is a low likelihood that WA specific strains may exist undetected.

The risk posed by AVG virus occurring in juveniles sourced from hatcheries in WA and translocated to the open ocean in southern Western Australia either for stock enhancement (re-seeding) or for marine grow-out (sea-ranching) purposes has been assessed using standard risk assessment methodology with the outputs having been independently reviewed.

While the likelihoods of the AVG virus occurring in the hatchery range from "negligible to "low" should no additional management measures be applied, the consequences of detection (including biological, economic and environmental) are generally "High" and in two cases the resultant risks were "unacceptable" with just the current legal management requirements. Given that the initial risks associated with oceanic deployment of abalone were assessed as Moderate to High, additional formal management intervention is required to reduce these to acceptable levels.

The primary concern is that the virus could become established in a hatchery facility and then be more likely to infect wild stock through the release of hatchery released juveniles into the oceanic waters. The likelihood of this outcome occurring has been assessed as very low if the suggested hatchery management measures that could be applied to mitigate the risk to an acceptable level are adopted. Protocols are in place to ensure that any emergence of AVG in a hatchery would be detected. If the virus was ever detected in the hatchery the water supply should be immediately shut down. This can be done using existing legislation (FRMA r177(2) so there is no legislative impediment to limiting effects of a disease outbreak in a hatchery). The placement of grow out structures and juvenile releases could also be planned in a manner to both minimise the likelihood of transmission to wild stocks and limit the spread of any infection.

2.0 Background

Abalone viral ganglioneuritis was first identified on abalone farms in Victoria in 2005 and subsequently spread to the wild abalone fishery where it caused substantial mortalities. Subsequently, there were outbreaks of AVG in Tasmanian live-holding processing facilities in 2008 and 2009. In December 2010 there was a further outbreak of AVG disease in Tasmanian abalone. The disease was initially detected in abalone processors facilities and subsequently spread through untreated discharge to the marine environment and to a local abalone farm, resulting in the compulsory destruction and decontamination of all of the affected facilities. As a result, some members of the wildstock fishery in WA have raised concerns over the risk of AVG disease in Western Australia relative to the current and proposed projects that involve releasing hatchery-reared abalone back into the wild.

3.0 Methodology Adopted In This Report

Risk Assessment was undertaken using the approach outlined in Jones & Stephens (2006) and in Diggles (2011). This methodology is consistent with the Australian Standard AS/NZS ISO 31000:2009. A risk assessment requires several steps:

- Establish the 'scope' or context;
- Hazard identification or 'risk identification' (what can go wrong);
- Risk analysis and 'risk evaluation' (how likely is it to go wrong?);
- Risk management (what can we do about it?);
- Monitor and regularly review the effectiveness of all steps in the process.

3.1 The Scope

The scope is to assess the risk posed by AVG in the translocation of juveniles sourced from any Abalone hatchery in WA to the open ocean.

3.2 Hazard identification

Hazard identification was accomplished using "Failure Mode Analysis". Failure Mode Analysis is an engineering technique used to identify critical steps that lead to systems failure (in this case, an outbreak of AVG among wild abalone on the South Coast caused by the abalone hatchery). The diagrams of the pathways identified for "failure" to occur are shown in Figure 1.

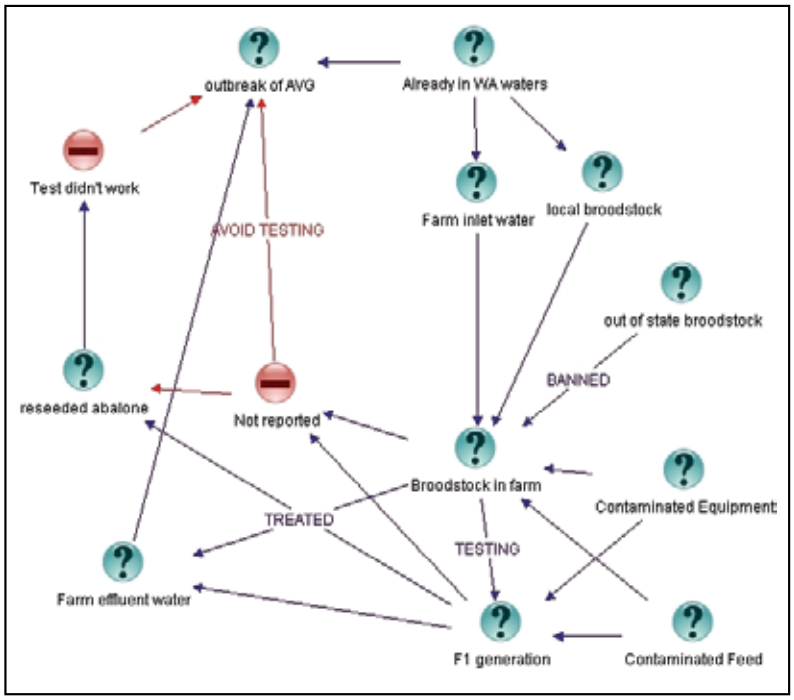

Figure 1. Compendium map of potential pathways leading to an AVG outbreak originating from farm activities in Western Australia. "Avoid testing" refers to a possible pathway by which animals are released without health checks.

3.3 Assessment of Risk

The assessment of risk can be undertaken in a quantitative manner, in which the likelihood and consequences are expressed in mathematical terms and the risk is expressed in terms such as "one event in 100 years". This approach presents particular challenges (Murray 2002) and usually involves Monte Carlo simulation modelling (Vose 2000). This approach was used in estimating the risk of abalone escaping from an abalone farm (Hawkins & Jones 2002). An alternative approach, particularly where information is scarce, or time is short, is to use a qualitative or semi-quantitative method where likelihood and consequences are expressed in terms such as "high", "medium" or "low". This approach was used in the Tasmanian abalone industry risk assessment (Anon. 2007) and is the one that was used in this report.

Likelihood estimation. Likelihood is a general description of probability or frequency. For the purposes of this project, 'likelihood' has been described according to the likelihood table (Table 1).

Table 1. Nomenclature for the qualitative likelihood estimations used in this RA (modified from Diggles 2011).

Likelihood (score)	Definition
High (6)	The event would be very likely to occur (>55%)
Moderate (5)	The event would occur with an even probability
Low (4)	The event would be unlikely to occur (20-45%)
Very Low (3)	The event would be very unlikely to occur (1-19%)
Extremely low (2)	The event would be extremely unlikely to occur (0.9-0.1%)
Negligible (1)	The event would almost certainly not occur (<0. 1%)

Consequences assessment. These are the outcomes, or impact of a given event. In a disease based risk assessment it is usual to have a range of four or five consequences ranging from negligible to severe (Jones & Stephens 2006, Diggles 2011). The general consequence table and levels used in this assessment are shown in Table 2.

The overall level of risk is usually calculated as the mathematical product of the likelihood and consequence levels (Risk = Likelihood x Consequence) and is called the 'risk value'. These values are usually displayed as a 'risk matrix table' (Table 3). From the 'risk value' each issue can be assigned a 'risk ranking' depending upon where a risk value falls within one of a number of predetermined categories or criteria (Table 4).

Though the method is based on an arithmetic scale for ease of calculation, the nature of 'consequences', in particular, is not linear. The risk values in Table 3 have been separated into three risk ranking categories. Risk ranking categories may be more or less than three, but three is a commonly used number (HB 436: 2004).

Table 2. The General Consequence Levels for Assessment of Disease Impacts

Level	Descriptor
Low (1)	Establishment of the disease has mild biological consequence and would be amenable to control or eradication and/or; May harm economic performance at an enterprise level but be of limited significance at an industry level and/or; Effect on environment would be minor or temporary.
Moderate (2)	Establishment of the disease has moderate biological consequences and disease may be amenable to control or eradication, at a significant cost and/or; May harm economic performance at an industry level and/or; May affect the environment, but not seriously and may be reversible.
High (3)	Establishment of the disease would have serious biological consequences (high mortality or morbidity etc) with effects that would be felt for a prolonged period and would difficult to control or eradicate and/or; Will significantly harm economic performance at an industry level or regional level and may cause serious harm to the environment.
Catastrophic (4)	Establishment of the disease would significantly harm economic performance at a national level and/or; May cause long-term or irreversible harm to the environment.

Table 3. Risk Matrix – numbers in cells indicate Risk Value, the colours/shades indicate Risk Rankings (see Table 4 for details)

Likelihood		Low	Moderate	High	Catastrophic
		1	2	3	4
Negligible	1	1	2	3	4
Extremely Low	2	2	4	6	8
Very Low	3	3	6	9	12
Low	4	4	8	12	16
Moderate	5	5	10	15	20
High	6	6	12	18	24

Table 4. Risk Rankings and Outcomes

Risk Rankings	Risk Values	Likely Management Response
Negligible, Acceptable	1 – 5	Risks are acceptable and are managed through current procedures.
Moderate, Management	6 – 10	Risks are acceptable provided Risk Reduction measures are implemented to reduce risk to acceptable level.
Extreme, Unacceptable	11 – 24	Risk is unacceptable. Risk management measures will be required to achieve “acceptable risk”, or it may not be possible to meet the “acceptable risk” at all.

Acceptable risk. The acceptability of risk in a particular circumstance is perceived differently by different individuals and organizations including governments. Governments accept taking risks because of the net community benefits (which may be environmental, social or financial) that are expected to accrue from their risk-taking behaviour. The amount of risk they will tolerate (i.e. the 'expected loss' if things go wrong) is known by a variety of terms including 'acceptable level of risk' (SPS Agreement), 'tolerable risk' (HB 436: 2004) or the 'appropriate level of protection (ALOP)' (Biosecurity Australia).

3.4 Risk management

This involves the process of identifying, evaluating and monitoring measures that can be taken to ensure that the risk is reduced to a level consistent with the acceptable level of risk. This can be done either by reducing the probability of the event occurring (preventative measures), or by reducing the consequences should the event occur (mitigation measures). The measures that are implemented must be the minimum required to achieve the acceptable level of risk and are not to be used as a disguised restriction on trade. They must also be "transparent" i.e. readily available to interested parties and the scientific justification provided as required.

4.0 What We Know About AVG?

Abalone Viral Ganglioneuritis is caused by highly virulent herpes-like-virus (AbHV-1) that affects the nervous tissue of abalone causing rapid mortality (Hooper et al. 2007, Savin et al. 2010). The species known to be susceptible to AbHV-1 in Australia are the greenlip abalone (*Haliotis laevigata*), blacklip abalone (*H. rubra*) and hybrids of these two species (Hooper et al. 2007). Clinical signs consistent with AVG have not been reported in other molluscan species in areas where AbHV-1 is suspected to be enzootic.

The AbHV-1 virus spreads through direct contact, through the water column without contact and it can also be spread to healthy abalone by offal, mucus, shells, contaminated fishing equipment or people who have been handling abalone (Crane et al. 2009). The mucus from infected abalone is thought to be the main pathway through which the disease can spread.

The AbHV-1 virus first appeared in abalone farms in southern Victoria in late 2005, and subsequently spread to the wild abalone fishery along 280 km of coastline at a rate of 5 to 10 km/month (Hills 2007), causing a reduction of total allowable catch (TAC) in the fishery from 280 tonnes to 16 tonnes (Mayfield et al. 2011). Outbreaks of AVG in both farmed and wild abalone populations in Victoria were associated with high mortality rates (up to 90%) in all age classes (Hooper et al. 2009). Subsequent outbreaks of AVG occurred in Tasmanian processing facilities in 2008, in 2009 and again during December 2010 and January 2011. On the latter occasion an abalone farm neighbouring one of the processors at Bicheno was also infected, with high mortalities (DPIPWE situation report Feb 2011). The wild fishery abalone at Bicheno also tested positive for the virus after the outbreak, but without mortalities (ABC News 21/1/2011). Sampling of sites identified by trace-back from the affected processor in 2008 resulted in one wild abalone from the southern D'Entrecasteaux Channel returning a weak PCR positive for AbHV-1. (DPIW situation report dated 21 Oct 2008). Surveys have shown that AbHV-1 occurs naturally at very low prevalences (3 out of 1625 abalone = 0.18% prevalence) in subclinical infections of wild populations of abalone in Tasmania (Corbeil et al. 2010). The virus also occurs in the coastal waters of western Victoria at moderate prevalences (Crane et al. 2009, Corbeil et al. 2010).

Diagnostic testing: The ORF-49 TaqMan PCR test for AbHV-1 developed by Australian Animal Health Laboratory was validated using abalone from both the Victorian and the initial Tasmanian disease outbreaks (Corbeil et al. 2010). However, during 2009 it was found that clinically affected abalone did not provide positive results using the ORF-49 TaqMan PCR test and alternative TaqMan tests (ORF-66 and ORF-77) were required to confirm the presence of AbHV-1. This development led to the conclusion that there were probably a number of strains of the virus present in Tasmania, and not all would react consistently with a given TaqMan PCR test. At the present time the Victorian strain and each of the three known Tasmanian strains are considered distinct variations of the same virus. (Corbeil 2011, Mark Crane pers. com.).

5.0 The Assessment

5.1 Hazard identification

The diagram of pathways identified through which a "failure" – AbHV-1 in the environment resulting in risk of an AVG outbreak either by the abalone farming operations or by the enhancement proposal, are shown in Figure 1. Using the pathways identified in this figure a table of Consequence and Likelihoods has been constructed (See Table 5).

The assessments of risk presented in Table 1 separates those associated with the current aquaculture operations from those potentially additional risks associated with the proposed stock enhancement of juvenile abalone sourced from the aquaculture facility.

Summarising from Table 1 the following issues require consideration of risk reduction measures:

5.2 Issues for which Consideration of Additional Treatments is Required

- ISSUE 5 ABHV-1 in broodstock generated from importing interstate broodstock. (Risk Score of 6)
- ISSUE 6 ABHV-1 carried into hatchery on incoming equipment and people from interstate (Risk Score of 9)
- ISSUE 8 ABHV-1 in farm effluent (Risk score 9)

5.3 Issues Requiring Additional Treatments to Be Acceptable

The following issues with the currently levels of controls in place represented unacceptable risk, requiring risk management:

- Issue 3 AbHV-1 is already present but undetected in WA wild abalone and a mutation or environmental event (possibly due to culturing system increases it's virulence) affects broodstock. (Risk score 12 in absence of any additional mitigation controls outlined below)
- Issue 9 ABHV-1 is in F1 generation abalone in hatchery or farm but undetected due to no testing being done or the test does not work on the strain. These infected individuals are put out into the ocean infecting the local wild stock with a virulent strain (Risk score 12 in absence of any additional mitigation controls outlined below)

6.0 Possible Management Measures to Mitigate the Risk

The detailed set of potential risk mitigation measures that could be implemented to reduce the risks associated with the abalone aquaculture facility and abalone re-seeding or sea ranching are presented in Table 6.

Summarising from Table 6 the following mitigation measures have been identified which cover operations of the hatchery, deployment of juveniles into the ocean and recommendations for management.

6.1 Hatchery

The Hatchery should review its current Biosecurity Plan to ensure that it is comprehensive and that staff are suitably trained. Attention must be given to:

- Routine decontamination of personnel at all entry points
- Routine decontamination of all incoming equipment
- Independent audit of the Biosecurity Plan
- Routine testing of broodstock and other selected animals from the hatchery and adjacent farm (underway)
- Maintenance of broodstock in tanks spatially separated from all other abalone, all equipment used with broodstock not to be used elsewhere, and effluent water from broodstock tanks must not be reused or discharged to the sea.

- Use of effluent pond to dilute outflow.
- Positioning of outlet pipes away from wild abalone fishery areas
- Use of abalone feed that is free of abalone products

6.2 Marine Growout and Enhancement Protocols

The areas used to place the artificial structures for the marine grow-out of hatchery reared abalone would best be located on sandy substrates without direct contact to reefs, preferably away from reefs where significant level of harvesting of wild capture stocks of abalone is undertaken.

- The trials of enhancement should be completed on reefs which are spatially separated from the remainder of the fishery.

6.3 Management

In considering ongoing management, the following is recommended:

- Adopt as formal policy the 5 nm separation of aquaculture/processing facilities
- Ensure regular compliance visits, inspecting farm records
- Ensure vigilant compliance to prevent uncontrolled interstate and intrastate movements of wild abalone
- Adopt as formal policy the compulsory shut down of water supply on detection
- Adopt as formal policy the compulsory cessation of reseeding activity and traceback if AbHV-1 detected in abalone (either broodstock or F1 juveniles) from the hatchery or elsewhere in WA. (application of Fisheries Resource Management Regulation 177(2))
- Use the 99% confidence level when setting sample sizes for translocation. This was agreed by the Department in 1999[1] .
- Maintain the present close linkages with the OIE reference laboratory on AVG (AAHL Geelong)
- Continue to use histology as well as qPCR for routine health testing

1 The level of disease testing for imported abalone has been set at 99% confidence (Application to translocate aquatic organism. Statement of decision dated 22 June 1999). However, the disease testing and certification procedures used are based on probability theory - typically the probability of detecting a disease in 99% of the animals tested. Examining 300 animals gives a 99% assurance that a disease of at least 2% prevalence in the test population would be detected, assuming the method was completely accurate and no mistakes were made.

7.0 Independent Review

This risk assessment has been reviewed by Dr Ben Diggles of DigsFish Services Pty Ltd. http://www.digsfish.com/[2] .

8.0 References Cited

Anon. 2007. Risk Assessment of abalone fishing and farming activities using Abalone viral ganglioneuritis as a case study. Department of Primary Industries and Water, Tasmania.

AS/NZS ISO 31000: 2009. *Risk management - Principles and guidelines.* Standards Australia, Standards New Zealand, Sydney, 24p.

Corbeil, S., Colling, A., Williams, L.M., Wong, F.Y., Savin, K., Warner, S., Murdoch, B., Cogan, N.O., Sawbridge, T.I., Fegan, M., Mohammad, I., Sunarto, A., Handlinger, J., Pyecroft, S., Douglas, M., Changs, P.H., Crane, M.S. 2010. Development and validation of a TaqMan PCR assay for the Australian abalone herpes-like virus. *Diseases of Aquatic Organisms* **92**: 1-10.

Corbeil, S. 2011. (Abstract) Abalone viral ganglioneuritis: Current status of research. 5th National Abalone Convention Hamilton Island, Queensland, 21 - 23 July 2011.

Diggles, B. 2011. *Risk Analysis – aquatic animal disease associated with domestic bait translocation.* Fisheries Research and Development Corporation Draft Final Report 2009/072. 295p.

Jones, J.B., Stephens, F. 2006. *Aquatic animal health subprogram: development of a national translocation policy using abalone and prawns as templates for other aquatic species.* Fisheries Research and Development Corporation Final Report 2004/080, 86p.

Murray, N. 2002. *Import Risk Analysis: Animal and animal products.* New Zealand Ministry of Agriculture and Forestry, Wellington. 184p.

Hawkins, C.D., Jones, J.B. 2002: Larval escape through abalone culture effluent systems an analysis of the risk. *Journal of shellfish research* **21**: 805-809.

Hills, J. 2007. A review of the abalone virus ganglioneuritis (AVG). NZ Ministry of Fisheries . http://www.biosecurity.govt.nz/files/pests/paua-avg-virus/avg-virus-review-julie-hills-nov07.pdfn

Hooper, C., Hardy-Smith, P., Handlinger, J. 2007. Ganglioneuritis causing high mortalities in farmed Australian abalone (*Haliotis laevigata* and *Haliotis rubra*). *Australian veterinary journal* **85**: 188-193.

HB 436: 2004. *Risk Management Guidelines. Companion to AS/NZS4360: 2004.* Standards Australia, Standards New Zealand, Sydney. 116p.

Mayfield, S., McGarvey, R., Gorfine, H.K., Peeters, H., Burch, P., Sharma, S. 2011. Survey estimates of fishable biomass following a mass mortality in an Australian molluscan fishery. *Journal of Fish Diseases* **34**: 287-302.

Savin, K.W., Cocks, B.G., Wong, F., Sawbridge, T., Cogan, N., Savage, D., Warner, S. 2010. A neurotropic herpesvirus infecting the gastropod, abalone, shares ancestry with oyster herpesvirus and a herpesvirus associated with the amphioxus genome. *Virology Journal* **7**: 308.

Vose, D.J. 2000. *Risk Analysis: A quantitative Guide.* John Wiley & Sons Chichester. 418p.

2 Core business for Digfish includes import risk analysis, development of environmental risk assessments and environmental management systems. This business has undertaken risk assessments for Australian state and federal government and overseas Governments

Table 5. Risk Table for assessing the risk of developing AbHV in wild stock abalone associated with the current aquaculture production of abalone and the potential re-seeding of abalone

Issue/Hazard	Comments	Likelihood and Consequence Scores for Aquaculture Facility Operations	Current Risk Ranking from Aquaculture Facility Operations	Additional Risk associated with Reseeding Trials and Sea ranching
DISEASE PROBLEMS BEGIN IN WILD STOCK				
1. AbHV-1 Is already present but undetected in WA wild abalone and it is found by increased or improved testing.	The presence of AbHV-1 in Victorian and Tasmanian waters was not known until outbreaks occurred in live holding processing facilities. For Tasmania the virus was endemic, but the situation and origin of the disease in Victoria is less clear	Consequence LOW Likelihood LOW	RISK - NEGLIGIBLE	No increase
Farm blamed but not affected.	There is a Low likelihood that AbHV-1 may already exist in the wild in WA and is not currently causing significant disease issues. Abalone farms have been operating in Bremer Bay for a number of years without AbHV-1 being detected, and testing of abalone in WA using PCR specific for the known strains of AbHV-1 and histology, which picks up the nerve changes caused by all known strains of this virus, have all been negative. If a strain of AbHV-1 is already here that is not causing problems, the impact on the wild fishery may not change. Thus the consequences are assessed as low			

Issue/Hazard	Comments	Likelihood and Consequence Scores for Aquaculture Facility Operations	Current Risk Ranking from Aquaculture Facility Operations	Additional Risk associated with Reseeding Trials and Sea ranching
2. AbHV-1 Is already present but undetected in WA wild abalone and a mutation or environmental event occurs that increases it's virulence. Farm blamed but not affected.	Given that there is no defined cause for the initial outbreak in Victoria or Tasmania, it is possible that this was due to a change in the nature of an endemic disease that became more virulent. In Victoria the virus caused mass mortality in the wild. However, In Tasmania it has always been a disease in processing live holding facilities until this last December when it spread from a processor to the wild, then into an adjacent farm (150metres away) where it did cause mortalities. Though detected in the wild, it did not cause any wild mortalities, just the farm. Given the absence of any evidence of current endemic infections, here in WA, the potential consequence if this arose naturally in the wild could be MODERATE The likelihood of this level of consequence actually happening based on this scenario is extremely low.	Consequence MODERATE Likelihood EXTREMELY LOW	RISK - NEGLIGIBLE	No increase
DISEASE PROBLEMS BEGIN IN FARMS				
3. AbHV-1 Is already present but undetected in WA wild abalone and a mutation or environmental event due to culturing system increases it's virulence and affects broodstock.	It is possible that the change in virulence could be facilitated or exacerbated by culturing methods.	Consequence HIGH	RISK HIGH	Consequence - HIGH

Issue/Hazard	Comments	Likelihood and Consequence Scores for Aquaculture Facility Operations	Current Risk Ranking from Aquaculture Facility Operations	Additional Risk associated with Reseeding Trials and Sea ranching
	Two farms have operated on the site (now amalgamated) since 1999 without any evidence of high mortalities or of AbHV-1. Since 1999 over 1000 abalone have been examined, by histology, for disease. If this did happen the potential consequence would be HIGH. Given that this has not occurred in the past 10 years, the likelihood is Low to Very Low.	Likelihood LOW		Likelihood: No additional controls – LOW With additional controls – VERY LOW RISK: High (no additional controls) Moderate (with additional controls)
4. AbHV-1 enters by farm inlet water or other invertebrate vectors near inlet.	For this to occur, the AVG virus must already be in wild abalone in vicinity of the hatchery and if it is virulent it would have already been accounted for above. Unlike the Tasmanian experience, there are no live holding processors or other farms or hatcheries in the vicinity from which the virus could arise independently. The likelihood of ABHV-1 that are endemic to WA being in the water supply appears to be Extremely Low, based on no detection since 1999 but the potential consequences of ABHV-1 in the inlet water could be a problem for the farm because once in the inlet water, deaths in the farm would occur (based on the Tasmanian and Victorian experience). But the consequence would not be that high for the wild stock if there is no evidence of mortalities beforehand.	Consequence: Moderate (Wildstock only) Likelihood: EXTREMELY LOW	RISK Negligible	No Increase

Issue/Hazard	Comments	Likelihood and Consequence Scores for Aquaculture Facility Operations	Current Risk Ranking from Aquaculture Facility Operations	Additional Risk associated with Reseeding Trials and Sea ranching
5. ABHV-1 in broodstock generated from importing interstate broodstock.	Only abalone broodstock from the area where release will occur are allowed. The potential consequences of finding ABHV-1 in the broodstock are High. Interstate importation of live abalone is prohibited and there are only disincentives for local industry to use imported broodstock. Given the current protocols the Likelihood of this outcome occurring is Extremely Low	Consequence – HIGH Likelihood - EXTREMELY LOW	Risk - Moderate	No Increase
6. ABHV-1 carried into hatchery on incoming equipment and people from interstate.	The hatchery and the farm would face major losses and threaten health of wild stock if ABHV-1 occurs, hence the consequences are High The hatchery has already identified this as a biosecurity issue in their Biosecurity Plan and has measures in place to prevent it occurring. In addition, the long distances between Victoria and WA ensure that equipment is unlikely to arrive in a dirty wet condition NOTE - The likelihood of this outcome occurring is initially rated as Very Low but with the industry protocols in place the likelihood would be reduced to Extremely Low.	Consequence – HIGH Likelihood – VERY LOW (based on legal requirements – not on current practices which would reduce this to extremely low)	Risk - Moderate	No Increase
7. ABHV-1 contaminated feed	There is a negligible possibility that the disease could be introduced via contaminated feed. Abalone products are not used in the processed feed used in the hatchery. In the wild, the abalone will eat natural plant material.	Consequence – High Likelihood- Negligible	Risk - NEGLIGIBLE	No Increase

Issue/Hazard	Comments	Likelihood and Consequence Scores for Aquaculture Facility Operations	Current Risk Ranking from Aquaculture Facility Operations	Additional Risk associated with Reseeding Trials and Sea ranching
8. ABHV-1 in farm effluent	For this to occur there would need to already be an infection in the farm (see above). The Hatchery does not discharge into the sea. The consequences depend on the flow rates, flow duration and farm being near suitable abalone habitat but have been assessed as “high”.	Consequence – HIGH Likelihood - VERY LOW	MODERATE	No Increase
9. ABHV-1 is in F1 generation abalone in hatchery or farm but undetected due to no testing being done or the test does not work on the strain. These infected individuals are put out into the ocean infecting the local wild stock with a virulent strain	For this to occur, the F1 generation from the hatchery would have had to have contracted the ABHV-1 from the inlet water (Likelihood is Extremely Low), contaminated equipment (Likelihood is Extremely Low with controls) or be generated from infected locally sourced broodstock (Likelihood Low) which have gone undetected (Likelihood is Extremely Low with additional controls). The rationale for the likelihoods associated with each of these events are discussed elsewhere in this table. To affect the wildstock these infected individuals must also have not been tested prior to seeding or the test used was not effective for detecting the strain. The Likelihood of this occurring is Low given that the current PCR tests have not always picked up all strains, but the testing of nerve ends should identify affected individuals.	N/A	N/A	Consequence – HIGH Likelihood: No additional controls - LOW With additional controls – VERY LOW RISK: High (no additional controls) Moderate (with additional controls)

Issue/Hazard	Comments	Likelihood and Consequence Scores for Aquaculture Facility Operations	Current Risk Ranking from Aquaculture Facility Operations	Additional Risk associated with Reseeding Trials and Sea ranching
	Plus there must have been no evidence of problems in the rest in the rest of the farm broodstock, or other growout individuals, or these problems were ignored. Given the rapid impacts in the farms in Tasmania and Victoria the Likelihood of this is VERY LOW. Consequently, the overall Likelihood of having infected animals being reseeded and impacting the wildstock if no additional controls are in place is LOW. If additional controls for testing and isolating animals to be reseeded are instigated, the Likelihood would be reduced to VERY LOW of the farm broodstock, or other growout individuals, or these problems were ignored. Given the rapid impacts in the farms in Tasmania and Victoria the Likelihood of this is VERY LOW. Consequently, the overall Likelihood of having infected animals being reseeded and impacting the wildstock if no additional controls are in place is LOW. If additional controls for testing and isolating animals to be reseeded are instigated, the Likelihood would be reduced to VERY LOW.			

Table 6. Possible Mitigation Measures

Issue	Risk score	Nature of unacceptable risk	Possible Risk Management Measures	Risk Score with additional Mitigation
Issue #3. ABHV-1 detected in broodstock	12	Threat of AVG infection of abalone populations in hatchery, including abalone used for reseeding	Screening of all broodstock, biosecurity protocols that require holding broodstock completely separate to other abalone in the hatchery or on farm, including no reuse of broodstock effluent water Comprehensive Biosecurity Plan and trained staff Compulsory cessation of reseeding activity and traceback if AbHV-1 detected in any abalone from the hatchery or the farm	Consequence – HIGH Controls reduce Likelihood from Low to Very Low Risk Score now = 8 (Moderate),
Issue #9. ABHV-1 detected in F1 generation of abalone in hatchery or farm	12	Threat that infected abalone in hatchery and those used for reseeding could infect wild abalone	Routine testing of selected animals from the hatchery and the farm Compulsory cessation of reseeding activity and traceback if AbHV-1 detected in abalone from the hatchery	Consequence – HIGH Additional controls reduce the Likelihood from Low to Very Low Risk Score = 8 (Moderate)
Issue #9 (part) ABHV-1 infects the F1 which is not detected or before these are deployed	12		Ensure that the abalone juveniles released for grow out are spatially separated from significant local densities of wild stock by situating the grow-out structures on sand away from reefs. For enhancement purposes, use sections of reefs that are spatially separated from the rest of the population These would both further reduce likelihood of infection passing to wild stock This separation should also reduce the consequence level to Moderate or Low if infection did occur because it would restrict its spread to other locations.	Consequence Moderate – Low Likelihood - Very Low Risk Score = 6 (Moderate)

Issue	Risk score	Nature of unacceptable risk	Possible Risk Management Measures
Issue # 4 ABHV-1 in farm/ hatchery inlet water or other invertebrate vectors	4	Threat to abalone populations on farm	Testing of abalone and other gastropod populations adjacent to farm inlet
Issue #5. ABHV-1 in broodstock abalone from interstate.	6	Threat that infected abalone could be bought into the facility and used as broodstock, resulting in threat to abalone populations in hatchery	Screening of broodstock, testing of abalone before they leave broodstock area, Biosecurity protocols that require holding broodstock completely separate to other abalone, including disposal of broodstock effluent water Comprehensive Biosecurity Plan and trained staff Regular compliance visits and audit of records
Issue #6. ABHV-1 carried into hatchery on incoming equipment and personnel.	9	This is a risk that is recognised in the Farm Biosecurity Plan and management controls are in place to ensure that it doesn't happen. However, the consequences of an outbreak of AVG in the farm are severe both in terms of control measures (destocking and decontamination) and in public relations.	Routine decontamination of incoming equipment Independent audit of the Biosecurity Plan Regular compliance visits Routine testing of selected animals from the farm
Issue #8 (part). ABHV-1 detected in farm/ hatchery by staff but not reported to Department	6	Reporting unexplained mortalities is a requirement under the regulations. However, this scenario actually happened in a processing plant in Tasmania so the likelihood has been assessed as extremely low but not negligible. The consequences, for everyone involved, are very high	Regular compliance visits, inspecting farm records Independent audit? Comprehensive Biosecurity Plan and trained staff Routine testing of selected animals from the farm

Issue	Risk score	Nature of unacceptable risk	Possible Risk Management Measures
Issue #8 (part). ABHV-1 in farm effluent	9	The presence of ABHV-1 in farm effluent (however caused) would have serious socio-economic consequences. The impact on the wild fishery is difficult to predict (Victorian experience differs from Tasmanian experience)	Use of effluent pond to dilute outflow. Positioning of outlet pipes away from wild fishery areas Adoption of 5 nm separation of farms/ processing facilities Routine testing of farm animals (underway) Comprehensive Biosecurity Plan and trained staff Compulsory shut down of water supply on detection (as in Tasmania, but not practiced in the original Victorian outbreak)
Issue #9 (part). Abalone not submitted for testing	6	Failure to detect ABHV-1 when it may be present	Regular compliance visits, inspecting farm records Independent sampling and audit Comprehensive Biosecurity Plan and trained staff Routine testing of selected animals from the farm
Issue #9 (part). ABHV-1 not detected by testing	9	The PCR test is very sensitive, but the continued finding of strains in Tasmania is problematic. A paper on sample sizes used in testing was written for the pearling industry in 1998 (attached). The ABHV-1 gene has been sequenced by AAHL and SARDI, and the sequence will be used by them to develop new tests based on conservative genes.	Use the 99% confidence level when setting sample sizes for translocation. This was agreed by the Department in 1999. Maintain close linkages with the OIE reference laboratory on AVG (AAHL Geelong) to ensure latest tests are used. Use histology as well as qPCR for routine health testing