A literature review as an aid to identify strategies for mitigating ostreid herpesvirus 1 in *Crassostrea gigas* hatchery and nursery systems

Supplementary annexes of existing published guidelines for control of OsHV-1

Annex S1. AQUAVETPLAN Disease Strategy: Infection with ostreid herpesvirus-1 microvariant, Australia (Anon, 2015)

Disease control strategies that could be adopted if OsHV-1 µVar is detected in new areas:

- Eradication: in principle, the scale of eradication may be national (eradicate from a whole country), local (eradicate from a local farm) or somewhere in between (eradicate from a region or state). National eradication of OsHV-1 µVar is not considered feasible if the virus is well established in some estuaries or zones. For new outbreaks, local or state eradication remains an option in specific circumstances (e.g. hatcheries) but is likely to be unfeasible in open waters;
- Containment, control and zoning: includes measures to exclude OsHV-1 µVar from defined geographic areas and unaffected populations (e.g. by quarantine) and contain the virus to areas with enzootic infection;
- Control and mitigation of disease: measures are aimed at managing the frequency and severity of disease episodes in infected populations and keeping them within acceptable levels.

Each disease control strategy option will involve the use of a combination of strategies, which might include:

- Quarantine and movement controls on molluscs and culture equipment within declared areas to prevent infection spreading;
- Prompt destruction of diseased molluscs in a quarantine area to prevent further shedding of virus;
- Decontamination of facilities, equipment and vehicles or vessels to eliminate and prevent virus spreading;
- Surveillance to determine the source and distribution of infection and freedom of infection;
- Zoning to define and assist in maintaining virus-free zones;
- Hygiene and biosecurity measures to mitigate on-site impacts of OsHV-1 µVar.

Surveillance is necessary to:

- Define the extent of the infection;
- Detect new outbreaks;
- Establish restricted and control areas to which quarantine and movement restrictions are applied;
- Establish infected and non-infected areas and zones for an OsHV-1 µVar zoning programme;
- Monitor the progress and success of a control or eradication strategy.

Annex S2. Options to strengthen on-farm biosecurity management for commercial and non-commercial aquaculture – Technical Paper No: 2016/47, Ministry for Primary Industries, Aquaculture New Zealand (abridged from Georgiades *et al*., 2016)

Basic general concepts for biosecurity programmes include:

- The prevention of introduction and spread of disease,
- Requirement to know the health status of all animals entering a facility,
- The reduction and elimination of factors predisposing sites and live-stock to diseases,
- The establishment of procedures to prevent disease introduction and establishment,
- The reduction of disease incidence,
- The maintenance of an environment, management systems and husbandry that use best practice for maintaining animal health and welfare,
- The establishment of standard monitoring and reporting procedures to ensure adequate animal health surveillance, early warning of any potential health or welfare problem, rapid action and follow-up.

Annex S3. OsHV-1 mortalities in Pacific oysters in Australia and New Zealand: the farmer's story, Cawthron Report No. 2567 (Castinel *et al*., 2015)

The most effective approaches amongst the preventive strategies explored by producers in Australia and New Zealand were seen as:

- Adopting a collective risk management plan (e.g. with neighbouring farmers);
- Varying the sources of spat (juvenile oyster) (e.g. more than one supplier including hatchery/wild);
- Systematic on-farm biosecurity measures (most likely to be applied of all the proposed measures) (e.g. cleaning and disinfection of equipment, movement records, separating age classes, disease response plans).

Other prevention strategies included: diversification of farmed species (e.g. maintain production with mussels or other oyster species) and environment monitoring (i.e. early disease detection).

The most likely control strategies considered by producers in Australia and New Zealand were (in order of perceived importance):

- Stop all movements of oyster stock (including farming equipment);
- Zoning (only allow movements of stock and gear within the same zone or from a non-affected to an affected zone);
- Cleaning and disinfection (e.g. farming equipment);
- Local community education (e.g. prevent the introduction of disease into a non-affected area with potential vectors, such as with kayaks, fishing gear, etc.);
- Clean vehicles (e.g. barges and trucks) used for transporting oyster stock or equipment from an infected farm;
- Test all shellfish stock for OsHV-1 before moving (only allow movements of stock with negative results).

The main farming method changes considered by producers in Australia (New South Wales) were:

- Diversity of species farmed (e.g. increase the ratio of alternative oyster species);
- Use local natural spat (i.e. no introduction of spat from another area or estuary).

The main farming method changes considered by producers in New Zealand were:

- Switch to single-seed oyster farming (i.e. use hatchery spat);
- Diversify sources of natural spat (e.g. mixing hatchery/natural spat or varying the sites for natural spat collection);
- Delay spat catching (e.g. spat caught later in the season have better survival);
- Increase the quantity of spat initially stocked on-farm (e.g. provide sufficient to reach market size);
- Reduce stress on animals (e.g. avoid handling stock).

In a production sector survey, the areas of focus for better management in Australia and New Zealand were identified as:

- Biosecurity (e.g. industry level stock management, response plan and quarantine);
- Communication and training (e.g. neutral coordination, better industry and science reporting, community education, improve industry/government collaboration);
- Spat and selective breeding research (e.g. oyster disease resistance, local stock, import resistant stock, industry breeding programme);
- Environment (e.g. improve management of urban impacts, increase monitoring and sampling);
- Husbandry (e.g. polyculture, modify husbandry to allow hatchery spat, diversification);
- Other research (e.g. increase on-farm research, improve knowledge of wild oysters, environment factors).

Annex S4. Report on the impact of recent *Crassostrea gigas* mortality in France and its consequences to oyster farming in Northern Ireland (Richez, 2012)

Sanitary measures to reduce the dissemination of OsHV-1 µVar:

- Opt for farming at lower density and avoid over-crowding of farming structures at a basin level,
- Avoid site proximity,
- Wherever possible, seed should be separated from older generations to avoid horizontal transmission,
- Take hydrodynamic factors into account to avoid the spread of disease between production sites,
- Avoid oyster transfer during critical temperatures in the summer,
- Favour late seed transfer, according to local conditions,
- Choose the supply of locally produced seed and avoid mixing different origins in the same production areas,
- Avoid keeping all the seed at the same site,
- Seed should be kept at cooler sites in the summer, or higher up the shore to try to reduce risk of mass mortalities,
- Testing for OsHV-1 should be carried out for all new transfers,
- Disinfect equipment before transfer of oysters from bay to bay.

Annex S5. HERPEMOL Guidelines for autocontrol of Ostreid herpesvirus, Spain

(Abollo Rodríguez and Villalba García, 2013; translated from the Spanish original)

Sector recommendations:

- Prevention is the main recommendation for avoiding the introduction of the pathogen, since it is not known how to eradicate it in the environment;
- Prudence is the best tool for efficient prevention by obtaining supportive information before taking decisions that involve a risk for cultivated stocks.

General recommendations:

- Do not import animals without a health certificate (infection-free stock);
- Do not import animals from other countries or zones affected by the disease;
- Do not carry out uncontrolled movements of animals for restocking between different production zones;
- Do not collect broodstock from natural beds that have not been certified disease free.

Hatchery recommendations:

- Train staff correctly in hygiene and disease prevention methods for herpesvirus;
- Isolate each hatchery unit or zone and use separate equipment for each one;
- Disinfect/sterilise gloves, boots and any material going to be used in different tanks of the same unit;
- Maintain strict control of material and staff when tanks are detected with diseased animals;
- Take extreme precaution with equipment and materials used to transport oysters, since they could have been in contact with oysters infected by the virus.

Grow-out facility recommendations:

- In zones where the virus is present, starting grow-out (“fattening”) with seed larger than 30 mm will substantially reduce the mortality rate;
- In affected zones, if the available seed is small (<30 mm), start grow-out in the months when the seawater temperature is less than 16 ºC. By starting grow-out in the autumn, the seed could be larger than 30 mm before the temperature is greater than 16 ºC;
- When mortalities are detected, the affected cohorts should be completely removed before introducing new stock.

Expedition/depuration centre recommendations:

- After introducing oysters from affected zones, effective effluent treatment that inactivates herpesvirus should be carried out, with the aim of reducing the risk of disease transmission to the marine environment.

Annex S6. International OsHV-1 µVar Workshop, Cairns, Queensland, Australia (Anon, 2011)

Control measures:

Strategies currently being used, or under research, for controlling the disease when it is already present include:

- Breeding Pacific oysters for resistance;
- Use of alternative, resistant species;
- Growing hatchery spat to a larger size before stocking;
- Avoidance of stocking susceptible animals during periods of warmer water temperature;
- Stocking larger numbers of spat to compensate for the expected losses;
- Emergency harvest in the face of possible outbreaks.

Contingency plans:

Further develop industry, state and national contingency plans to allow rapid response to mortality events that may be due to OsHV-1 µVar. Components of the contingency plan should include:

- Restricting movements of oysters, equipment and other shellfish out of affected estuaries;
- Establishing systems for rapid diagnostics;
- Development of standard biosecurity guidelines for farmers and provide training in the application of the guidelines;
- Development of documented Good Management Practices for data collection, response, control and surveillance;
- Training of stakeholders in responsibilities and responses during an outbreak, including industry training in sample collection;
- Providing advice to industry on testing protocols and costs;
- Providing advice to industry on management measures as well as technical, financial and personal resources available should the disease become established.