AUSTRALIAN AQUATIC VETERINARY EMERGENCY PLAN

AQUAVETPLAN

Operational procedures manual

Destruction

Version 2.0, 2009

AQUAVETPLAN is a series of technical response plans that describe the proposed Australian approach to an emergency aquatic animal disease occurrence. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

Primary Industries Ministerial Council

This operational procedures manual forms part of:

AQUAVETPLAN

This document will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to:

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AQUAVETPLAN is available on the internet at:
<www.daff.gov.au/animal-plant-health/aquatic/aquavetplan>

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IMPORTANT NOTE: Important regulatory information is contained in the OIE *Aquatic Animal Health Code* (OIE 2008), which is updated annually and is available on the internet at the OIE website: <www.oie.int/eng/normes/fcode/en_sommaire.htm>.

DISEASE WATCH HOTLINE

There is now one single telephone number that connects callers to the relevant state or territory officer to report concerns about any potential animal emergency disease situation. Anyone suspecting an emergency disease outbreak should use this number for immediate advice and assistance.

This number is

1 800 675 888

Preface

This operational procedures manual for the destruction of aquatic animals is part of the Australian Aquatic Veterinary Emergency Plan, or AQUAVETPLAN.

AQUAVETPLAN is a series of technical response plans that describe the proposed Australian approach to an emergency aquatic animal disease occurrence. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

The manual was scientifically reviewed by the National Aquatic Animal Health Technical Working Group of the Aquatic Animal Health Committee. It was endorsed by the Aquatic Animal Health Committee in May 2009.

This second edition of the manual was prepared by Panaquatic® Health Solutions Pty Ltd, in consultation with stakeholders from commercial aquatic animal and government sectors throughout Australia. It revises the previous edition, which was developed by Iain East (Australian Government Department of Agriculture, Fisheries and Forestry) in consultation with a wide range of stakeholders from the aquaculture, recreational fishing and government sectors. The text of this edition was amended at various stages of the consultation and endorsement process, and the policies expressed in this version do not necessarily reflect the views of the authors. Contributions made by others not mentioned here are also gratefully acknowledged.

The revised manual has been reviewed and approved by the following government and industry agencies:

Government	Industry
Australian Animal Health Laboratory CSIRO Livestock Industries	Tasmanian Salmonid Growers Association
NSW Department of Primary Industries	
NT Department of Business, Industry and Resource Development	
Queensland Department of Primary Industries and Fisheries	
Primary Industries and Resources SA	
Tasmania Department of Primary Industries, Water and Environment	
Department of Primary Industries Victoria	
Department of Fisheries, Government of Western Australia	
OCVO, Australian Government Department of Agriculture, Fisheries and Forestry	

Detailed instructions for the field implementation of AQUAVETPLAN are contained in the disease strategies, operational procedures manuals and management manuals. Industry-specific information is given in the **AQUAVETPLAN Enterprise Manual**.[1] The list of AQUAVETPLAN manuals that may need to be accessed in an emergency is shown below.

The format of this manual was adapted from similar manuals in AUSVETPLAN (the Australian veterinary emergency plan for terrestrial animal diseases) and from the **AQUAVETPLAN Enterprise Manual**. The format and content have been kept as similar as possible to these documents, in order to enable animal health professionals trained in AUSVETPLAN procedures to work efficiently with this document in the event of an aquatic veterinary emergency. The work of the AUSVETPLAN writing teams and permission to use the original AUSVETPLAN documents are gratefully acknowledged.

AQUAVETPLAN manuals[2]

Disease strategies

Individual strategies for each disease

Operational procedures manuals

Disposal
Destruction
Decontamination

Management manual

Control centres management

Enterprise manual

Includes sections on:
– open systems
– semi-open systems
– semi-closed systems
– closed systems

Disclaimer

References to proprietary products and commercial companies in this manual are intended for information only and do not constitute or imply endorsement of these products or companies by the author, by the Australian Government Department of Agriculture, Fisheries and Forestry or by the Commonwealth of Australia.

[1] <www.daff.gov.au/animal-plant-health/aquatic/aquavetplan/enterprise>
[2] The complete series of AQUAVETPLAN documents is available on the internet at: <www.daff.gov.au/animal-plant-health/aquatic/aquavetplan>

Contents

1 Introduction

In the context of disease management, the primary purposes of destroying aquatic animals are to control the spread of a disease and/or to eradicate a disease. This manual provides concise information on methods that can be used to destroy aquatic animals for these purposes. 'Destruction' is the process of killing animals by slaughter or euthanasia.[3]

The focus of this manual is on destruction of species of aquatic animals that are farmed in Australia. The principles and procedures are also applicable to wild aquatic animals, but capture of such animals can be a major impediment to effecting their destruction.

Farmed aquatic animals range from vertebrate finfish (e.g. Atlantic salmon, barramundi), which swim freely through the water column, to sedentary invertebrate molluscs (e.g. oysters, mussels). Unlike terrestrial animals, all these species are poikilotherms, and temperature has a significant effect on their physiology.

In contrast to destruction of terrestrial animals, which generally focuses on how to destroy an individual animal in a population, the destruction of aquatic animals often focuses on methods to destroy the entire population. This is because of the often large numbers of aquatic animals involved and the small size of individual animals. For example, in one sea cage containing harvest-size fish, the number of fish may be in the tens of thousands. In a hatchery, the larval stages of an aquatic animal may number in the millions, and individuals may be microscopic.

It is often impossible to visually observe aquatic animals, and it may not be possible to capture all of them, particularly wild ones. Wild aquatic animals that may be in direct contact with farmed aquatic animals (e.g. in a sea-cage system) may be susceptible to the same diseases or capable of carrying diseases that affect the farmed populations. If effective control of a disease requires the destruction of all susceptible aquatic animals in an area or region, it is important to assess whether all of these animals can be captured and destroyed. If they cannot, the decision to destroy aquatic animals as a means of preventing the spread of disease may need to be reconsidered.

Although some insurance companies will cover the loss of aquatic animals that have died of disease, there are currently no formal mechanisms to compensate aquaculturists for the loss of aquatic animals through either voluntary or mandatory destruction. Conflicts can arise where an aquaculturist has insurance cover that will provide compensation for aquatic animals that die from disease, but will not compensate if stock are destroyed as part of a disease management strategy.

[3] Slaughter is defined as the termination of an animal's life for the purpose of human consumption or use. Euthanasia is used to describe the humane killing of animals that are not then consumed (Håstein et al. 2005).

Opinion is divided on whether aquatic animals (e.g. finfish and aquatic invertebrates) are capable of experiencing pain and suffering, and there is ongoing debate in the current scientific literature on this issue. Much remains to be learnt about evaluating and addressing the optimal humane care and welfare of most aquatic animal species. Therefore, it is possible that what constitutes 'acceptable' destruction methods may change as new information is made available. This should not preclude operators from minimising any possible unnecessary suffering of aquatic animals before their destruction by reducing exposure of the animals to conditions that provoke stress and compromise their health.

In the context of disease management, a compromise may be required between the welfare of the individual aquatic animal being destroyed and the ability to rapidly reduce disease spread. For example, when destroying thousands of fish, ensuring that each individual fish has been exposed to an effective dose of anaesthetic agent will considerably prolong the time taken to destroy the population and may allow far greater dissemination of the disease agent than if the fish were removed en masse from the water without individual assessment of anaesthesia.

Aquaculturists, fishers and those managing fisheries (e.g. local fisheries officers) can provide useful advice and should be consulted when considering the destruction of aquatic animals. They usually have an intimate understanding of their production systems and the aquatic animals they farm or harvest.

These same people can suffer both financially and psychologically when their aquatic animals are destroyed. Officers in charge of the destruction process need to be aware of and sympathetic to this. They should also be aware of the health and safety considerations for the destruction team(s), particularly if any activities need to be carried out under water. All legislation, including necessary safety standards, must be strictly adhered to, and safety must be monitored closely during destruction activities.

2 Organisation of destruction operations

2.1 Action plan

Planning is essential to ensure that the destruction process is carried out efficiently and is not impeded by lack of resources.

An action plan should be drawn up by the aquatic animal destruction team leader, in consultation with the owner of the aquatic animals or the owner's agent (for an aquaculture operation) or wild fishers and/or fisheries officers (for wild aquatic animals). In some cases, the destruction of an aquatic animal population(s) may involve emergency harvesting of some or all of the animals.

The action plan should be a concise, written plan that details who has responsibility for the destruction. Factors to consider when developing the plan include:

- the number, species and age groups of aquatic animals to be destroyed and/or harvested
- whether all aquatic animals in the area can be either captured or kept enclosed until destroyed; this is essential if effective management of the disease relies on destruction of all aquatic animals in an area
- the order of destruction; for example, the order in which cages and sheds will be harvested and the order in which wild fish will be captured
- the facilities and equipment available for use in the destruction process
  - on the affected farm(s) or fishery(s)
  - on other similar farms or fisheries (e.g. neighbouring aquaculture farms)
- the timeframe for the destruction process
- the resources available to harvest, store and market the product, if aquatic animals are to be emergency harvested
- the appropriate method(s) for destruction of the aquatic animals (see Section 3)
- the ability of the handling systems for live and dead aquatic animals to keep the stress level for the aquatic animals as low as possible at all times during the destruction process
- potential environmental impacts of the destruction procedure and any relevant legislation (e.g. for use of chemicals)
- the disposal method(s), which should be coordinated with the destruction process; disposal of dead aquatic animals (see **AQUAVETPLAN Disposal**

Manual[4]) has the potential to be a major limiting factor in the efficiency of the destruction

- the decontamination and disinfection method(s), which should also be coordinated with the destruction process; responsibility for coordination and supervision of disinfection should be delegated (see **AQUAVETPLAN Decontamination Manual**[5])
- compensation—currently there are no formal compensation agreements in Australia for the destruction of aquatic animals; if aquatic animals are insured, the insurance usually will not cover destruction of aquatic animals, but will cover loss of aquatic animals through disease, with limitations
- the personal safety of workers—occupational health and safety (OHS) issues must be considered, and all OHS legislation must be observed
- documentation—the entire process must be thoroughly and accurately documented for the purposes of management, insurance, compensation (if applicable), review and training.

2.2 Selection of destruction site

In most cases, destruction will occur where the diseased aquatic animals are located. This will minimise the possibility of disease spread.

Occasionally—for example, if emergency harvesting is to occur—other sites or facilities may need to be used. In these cases, many of the factors listed in Section 2.1 (e.g. the equipment available and the personal safety of workers) will also need to be considered for the other sites. Additional factors to consider for other sites include:

- the ability to effectively quarantine the site or facility (e.g. processors)
- the proximity of the site to the disposal site or to markets (if the aquatic animals are being harvested for human consumption)
- animal biosecurity (e.g. disease factors)
- the acceptability of additional sites to the owner or manager of the site or facility.

2.3 Order of destruction

The order of destruction as recommended by aquatic animal health experts, such as government veterinary staff, should be discussed with the aquaculturists (for an aquaculture facility) or fisheries officers (for wild aquatic animals). The order will be determined by disease control requirements, the facility(s) involved and the resources available.

It may be possible to employ different methods of destruction concurrently. For example, emergency harvesting of aquatic animals that are of market size may

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4 <www.daff.gov.au/animal-plant-health/aquatic/aquavetplan/disposal>

5 <www.daff.gov.au/animal-plant-health/aquatic/aquavetplan/operational_procedures_manual_-_decontamination>

occur at the same time as smaller aquatic animals on the property are being euthanised. Facility-specific considerations may apply. For example, a recirculation aquaculture facility with the ability to disinfect all effluent water may be able to maintain an effective quarantine to allow time for all aquatic animals to reach market size and hence avoid destruction of fish that are not yet of market size.

As noted in Section 1, minimising stress on aquatic animals before their destruction and effective management of disease are both important. The order of destruction that most effectively minimises disease spread may compromise the welfare of individual aquatic animals. For example, it is normally quicker to remove fish from the water while they are alive than to first euthanise the fish, even though destroying the fish while they are in the water column may lessen fish stress. However, destruction in the water may significantly delay their removal, increase OHS risks and increase the possibility of spread of pathogens.

3 Methods of destruction

This section describes methods of destruction of aquatic animals in Australia.

3.1 Choice of method

Experience is very important when choosing the most suitable method to destroy aquatic animals. Aquaculturists, fishers and those managing fisheries understand and have experience with aquatic animals and the aquatic animal environment and should be consulted closely to ensure their experience is used in the decision-making process.

The choice of method will depend on many factors, including:

- the type of aquatic animal to be destroyed
- the number and size of aquatic animals to be destroyed
- the end use of the destroyed aquatic animals
- the potential for zoonoses
- the type of system(s) in which the aquatic animals are contained or live
- any occupational health and safety (OHS) issues
- ethical concerns, which will depend partly on legislative and legal requirements of the jurisdictions involved.

3.1.1 Type of aquatic animal

The major aquatic animal groups addressed in this manual are finfish, crustaceans and molluscs. These groups sit in three different phyla (Chordata, Arthropoda and Mollusca, respectively), in contrast to terrestrial livestock, which sit in one (Chordata, subphylum Vertebrata). Hence, there is a wide range of anatomical and physiological differences among aquatic animals.

Most aquatic animals, unlike terrestrial animals, share the characteristic of being poikilothermic—that is, they are unable to internally regulate body temperature and must rely on the ambient water temperature to regulate their body heat. Scombrids (tunas) and isurid sharks (e.g. makos, porbeagles), however, have the ability to conserve body heat and maintain a body temperature that is considerably higher than that of the ambient water. They can also overheat if over-exerted.

A number of different methods are used for commercially harvesting or capturing aquatic animals within the various aquatic animal industries. These methods are specific to the type of aquatic animal cultured or harvested and may be used when destroying that particular type of animal.

3.1.2 Number and size of aquatic animals to be destroyed

Life stages of aquatic animals vary in size from microscopic (e.g. egg and larval stages of many aquatic species) to many kilograms (e.g. broodstock finfish). Populations of aquatic animals may number many thousands to millions.

If disease management involves the destruction of a population(s) of aquatic animals, there may be very large numbers of animals to destroy. In such situations, it is important to ensure that adequate facilities and resources are available to achieve destruction in a timely manner.

In some aquatic species, methods for capture of the younger, smaller members of the species may not have been developed. For example, in the wild, only the larger, older blacklip abalone (*Haliotis rubra*) are easily found and removed from the rock substrate. Smaller and younger blacklip abalone generally hide during the day in cracks and holes within reefs, making them difficult to capture and remove.

3.1.3 End use of destroyed aquatic animals

If infected or potentially infected aquatic animals without clinical signs are to be euthanised as part of disease control, the chief veterinary officer or director of fisheries of the state or territory involved may allow emergency harvesting for human consumption. In this situation, the aquatic animals must be euthanised using techniques and premises that comply with food safety and sanitary regulations. Harvesting methods used during normal operations will probably be the most appropriate in the event of an emergency harvest, although additional resources may be necessary because of the numbers to be harvested in a short period of time.

Aquatic animals may have been treated with therapeutic medications during an emergency disease outbreak. If so, the appropriate withholding period must be observed. This may preclude emergency harvesting as an option, if destruction must occur quickly.

Routine harvesting of aquatic animals will sometimes involve a period of starvation before harvest, or depuration,[6] before shipping to markets. Whether this is possible in an emergency harvesting procedure will need to be decided based on the disease management requirements.

Routine harvesting of fish may also involve on-site leakage of body fluids and bleeding. Leakage of fluids (including peritoneal, cerebrospinal, mucus and other body fluids) and blood on site is hazardous if it presents a risk of disease transmission, and this risk must be addressed if emergency harvesting of fish is used.

3.1.4 Potential for zoonoses

It is important to quickly ascertain whether or not the disease affecting the aquatic animals has the potential to be zoonotic (i.e. communicable to humans). In contrast to diseases of terrestrial animals, few aquatic animal diseases have been shown to be zoonotic. If a disease is zoonotic or has this potential, necessary precautions for human safety must be observed when capturing, harvesting and processing the aquatic animals.

As a standard procedure, personnel involved in destruction of aquatic animals should be vaccinated against tetanus.

[6] Depuration involves submerging the aquatic animal (e.g. oyster) in a tank of clean water to allow the removal of waste products and potentially harmful microbes.

3.1.5 Type of system

The type of system in which the aquatic animals are contained or live greatly influences options for disease management and the destruction process.

AQUAVETPLAN places aquatic animal enterprises into one of four categories based on the enterprise's ability to control the animals and/or the water in the system. These categories are defined and discussed in detail in the **AQUAVETPLAN Enterprise Manual**.[7]

Open systems

Open systems are systems in which there is no control of either host movement or water flow—for example, wild capture fisheries, where the aquatic animals live wild in the open ocean, rivers or lakes.

Semi-open systems

Semi-open systems are systems in which there is control of host movement but no control of water flow—for example, cage pen culture in estuaries or lakes.

Although there is control of the farmed aquatic species in these systems, there is no control over wild aquatic species that may be in close contact with the farmed species.

Semi-closed systems

Semi-closed systems are systems in which there is control of host movement and some control of water flow—for example, pond culture (fish or prawns) and raceway culture.

Closed systems

Closed systems are systems in which there is good control of host movement and water flow—for example, intensive recirculation systems, hatcheries and aquaria.

Each of the four main types of system has a number of variations, depending on the aquatic species being cultured or captured.

Destruction of aquatic animals necessitates being able to capture or confine them. This is often not possible in, for example, open systems.

Specific methods of destruction suitable for each system are discussed in Section 4.

3.1.6 Occupational health and safety

The safety of personnel involved in the destruction is paramount. Handling of some aquatic animals can be dangerous. Where possible, competent personnel experienced with the aquatic animal and type of system should be involved in supervising any destruction activities, to minimise the risk of human injury.

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[7] <www.daff.gov.au/animal-plant-health/aquatic/AQUAVETPLAN/enterprise>

Destruction of aquatic animals may also involve divers working under water. All relevant legislation and standards must be observed during underwater activities that are part of the destruction process.

Personnel may work prolonged hours to achieve destruction of aquatic animals. Fatigue in personnel can compromise their safety and that of others, particularly if they are working with machinery or in potentially dangerous environments (e.g. on or in water). All personnel involved in the destruction process must be closely monitored for fatigue and any other factors that may compromise their ability to work safely.

3.1.7 Ethical concerns

The Australian Animal Welfare Strategy details ethical concerns and addresses.[8]

3.2 Confirming death

For many aquatic animal species, confirming the point at which an animal is considered dead is difficult, even for an experienced operator.

3.2.1 Finfish

In finfish, stages of anaesthesia have been described (e.g. Brown 1993). The behavioural response at Stage III (surgical anaesthesia) is defined as a total loss of reactivity and a very low respiratory rate (observed by monitoring opercular or gill cover movement) and heart rate. Stage IV (medullary collapse) is defined as total loss of gill movement, followed in several minutes by cardiac arrest and death. Destruction of the brain will cause death in finfish. Fish that have either been decapitated or have been struck with a firm blow to the head followed by exsanguination can be considered dead. Recovery of consciousness after these procedures is highly unlikely, particularly if the fish remains out of water. However, when large numbers of fish are to be destroyed, it may simply not be possible to effect destruction of the brain in every individual fish.

Fish health practitioners do not routinely monitor fish hearts and are not routinely called on to assess death. Depending on the destruction method, assumptions can be made about whether or not an animal is dead, using the above behavioural responses as an indication.

3.2.2 Molluscs

In molluscs, there are usually few behavioural signs that can be used to determine the level of viability. Bivalve molluscs (e.g. oysters and mussels) can remain alive for considerable periods (days) out of water. Firm closure of the shell is a reasonable indication of viability, and loss of closure ('gaping') of the shells can be an indication that the animal is no longer viable.

In univalve molluscs, like abalone, a lack of adherence to the substrate is an indication that the animal's viability is affected (e.g. through disease or

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8 <www.daff.gov.au/animal-plant-health/welfare/aaws>

anaesthesia). Abalone can recover from this state if, for example, it resulted from anaesthesia.

3.2.3 Crustaceans

In crustaceans, a loss of movement and normal posture is usually an indication that viability is affected. Chilling of crustaceans can have the effect of slowing movement and altering posture. Unaffected crabs will retract eyes when touched. No movement indicates that the animal is dead.

3.3 Physical methods of destruction

All the physical methods of destruction discussed in this section involve the removal of the aquatic animal from the aquatic environment to assist in the destruction process.

Removal from the aquatic environment and exposure to air will, by itself, eventually result in death of any of the aquatic animals considered in this manual. The time to achieve death once an aquatic animal is removed from the water will depend on the type of animal and whether or not further methods, such as stunning, are employed to hasten death.

Removal of an aquatic animal from its aquatic environment will result in stress to the animal, and the time between removal from the water and destruction should be kept as short as possible. This applies less to many molluscan species, which have the capacity to tolerate removal from water for periods of hours or, in some cases, days.

Many methods (which will not be discussed in detail in this manual) are used to capture and then remove aquatic animals from the water. Methods that have been developed for commercial application for specific types of aquatic animal are often the most effective. Some methods are also used routinely for research purposes. For example, electroshocking finfish (electrofishing) can be an effective way to stun and allow capture of wild fish. It is not used for molluscs. The technique is most effective in small waterways, lakes and short stretches of streams. Electroshocking can be used to assist in the destruction process, but it may not allow capture of all fish in a body of water.

3.3.1 Stunning

Stunning is used as a method of destruction only in finfish. It involves a percussive blow to the cranium with a club (sometimes called a ‘priest’), with enough force to cause shearing forces in the brain and disruption of normal function. As the immediate insensibility may be reversible if the blow is of insufficient force, further measures are needed to ensure that the fish does not regain consciousness. These can involve cutting all four gill arches on one side, cutting the ventral isthmus (which severs the ventral aorta and causes exsanguination), or decapitating the fish (Southgate & Wall 2001).

Percussion-type stunning equipment is being increasingly used in finfish aquaculture industries to render harvested fish unconscious before bleeding. Care is needed in the design of the delivery system of these stunners to avoid stress to the fish. An example of a percussion stunning operation is shown in Figure 3.1.

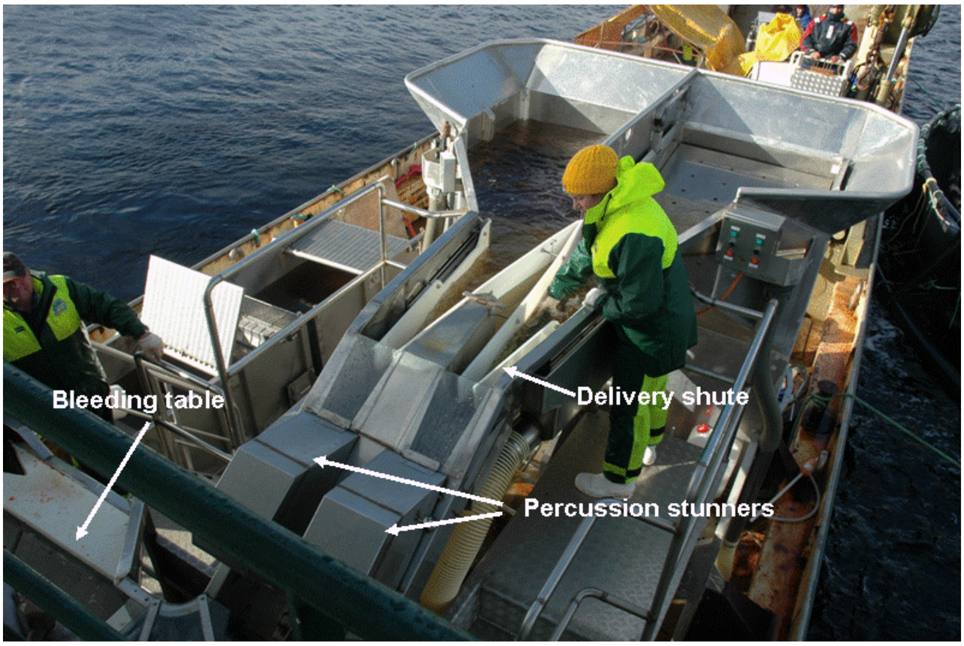

Figure 3.1 Layout of a commercial percussion stunning operation

3.3.2 Pithing

Pithing refers to the use of a narrow blade or spike to penetrate and destroy the brain.

A specific form of pithing is *iki jimi*, the application of a spike into the brain of a fish, followed by deactivation of the spinal cord. This method of slaughter is used routinely in the southern bluefin tuna industry in South Australia. Divers herd individual fish to the area where the operator performs the *iki jimi* operation.

The anatomy of the crustacean nervous system means that it is difficult to kill crustaceans by trauma to a central nervous system. Pithing has been used as a method of killing some crustaceans (e.g. crabs, which have only two main nerve centres), but this requires skill and experience on the part of the operator.

Pithing is not suitable for molluscs.

3.3.3 Hypothermia

Killing by hypothermia involves removing the aquatic animals from the water and placing them into a freezer or into a crushed ice slurry. The time taken for aquatic animals to die when chilled varies with the species. This method is routinely used when harvesting finfish in subtropical and tropical environments, and for crustacean species, but is not routinely used for temperate finfish species.

Killing by hypothermia is the harvest method of choice for some aquatic animal species. It is therefore a viable method to assist destruction of these species during a disease outbreak.

3.3.4 Cooking (hyperthermia)

Cooking may be used as a method of destruction where appropriate and practical. It is currently used after harvest of some crustaceans and may be used for some molluscs. Temperatures and methods for cooking will be determined by the species and end use of the animals being destroyed.

Where organisms may have to be controlled in situ (e.g. molluscs in pipes), heating to more than 60 °C for a set period is effective in killing many species. Heat treatment must be tested before it is implemented to ensure that it is effective for the species involved, particularly if the species is exposed to temperature extremes in its natural environment.

Heating has the benefits of being noncorrosive and nontoxic in contained situations. It may also reduce viability of, or kill, many pathogens. However, there is some debate about whether it is a humane method of destruction.

3.4 Chemical methods of destruction

The Australian Pesticides and Veterinary Medicines Authority (APVMA)[9] assesses, registers and regulates agricultural and veterinary chemical products. Before veterinary chemicals can enter the Australian market, they must go through the APVMA's assessment process to ensure that they meet required standards of safety and effectiveness. The APVMA and relevant state and territory authorities should be consulted to determine the legal requirements for destruction options in a particular jurisdiction.

The APVMA can issue an emergency use permit (EUP) for emergency use of a product that is not registered in Australia, or is registered for use in a different species or for a different use pattern. Before issuing the EUP, the APVMA will verify with the appropriate state and territory coordinators that the emergency is genuine.

Before using any drug or chemical, operators should be familiar with safety precautions and any risks associated with use of the chemical. The APVMA website should be checked for any minor use permits (e.g. emergency permits) that may apply to the chemical's use, and a material safety data sheet must be obtained (e.g. from the manufacturer's website).

It is always the operator's responsibility to adhere to any legal requirements associated with the use of chemicals.

3.4.1 The eugenol family of chemicals

Clove oil, specifically its active constituents eugenol and isoeugenol, is used as an anaesthetic for aquatic animals (Kildea et al. 2004). Isoeugenol (2-methoxy-4-propenylphenol) is available as a commercial preparation registered by the APVMA (registration number 48157) for use in salmonids under the direction of a registered veterinarian. The recommended dose of isoeugenol for heavy anaesthesia of salmonids is 17–25 mL/1000 L of water. The registered product can be used for harvesting salmonids destined for human consumption as there is no withholding period when the chemical is used at the recommended dose rates. Use

[9] The APVMA's contact phone number is 02 6210 4700. Emergency use permit information and application forms are available on the APVMA website at: <www.apvma.gov.au/MORAG_ag/vol_2/category_22.html>

in other (nonsalmonid) aquatic animal species and/or at a dose rate higher than recommended on the label is possible through a recommendation for off-label use by a registered veterinarian; the conditions for this authorisation differ between jurisdictions. Specific requirements should be confirmed with the relevant state and territory authorities.

As with other anaesthetics, a high dose can be used to euthanise aquatic animals. The dose varies with species, size of the animal, temperatures and water quality parameters. Isoeugenol and clove oil have been shown to be promising agents for euthanasia of crabs. Clove oil causes paralysis of crabs in 30 minutes and death in 60 minutes at 0.125 mL/L, while isoeugenol at 0.5 mL/L for 30 minutes also paralysed crabs (Gardner 1997). Isoeugenol is effective for euthanasia of nonsalmonid fish at 100 mg (0.09 mL)/L (Johnson 2008), and may be used to sedate fish before euthanasia (Handlinger 2008). Clove oil has been used for euthanasia of salmonids (Holloway et al. 2004).

3.4.2 Benzocaine hydrochloride

Benzocaine hydrochloride can be added to water to produce a deep anaesthesia followed by death at a concentration of 100–250 mg/L (AVMA 2007; Barker 1999). The required dose will depend on the size of the animal, the susceptibility of the target species and the temperature of the water. Sufficient dissolved oxygen must be maintained in the water in which the aquatic animal is anaesthetised.

Benzocaine powder readily dissolves in ethanol. A stock solution is prepared by dissolving benzocaine in ethanol and then adding this solution to the fresh or salt water in which the aquatic animal is living until a concentration of 100–250 mg/L is achieved. This dose is sufficient to cause deep, stage III anaesthesia (lack of opercular movement) in fish, and loss of adhesion in abalone within a few minutes, depending on temperature.

Benzocaine hydrochloride is currently permitted for use in Australia on finfish and abalone destined for human consumption under minor use permit PER7035.[10] A 500-degree-day withholding period applies; this is the period over which the sum of average daily temperatures is 500 (e.g. if mean daily temperature is 10 °C, the 500-degree-day period would be 50 days). The use of benzocaine requires authorisation from a registered veterinarian.

3.4.3 Rotenone

Rotenone can be used to destroy fish in enclosed waterways, such as rivers and streams. It is currently available for use in this manner in all states and mainland territories except Victoria under the APVMA minor use permit PER9117.[11] Only two products may be used under this permit: Rotenone Liquid Piscicide, which contains 50 g/L of active rotenone, and Rotenone Powder Piscicide, which contains

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[10] Minor use permits expire and may change periodically; hence, it is advisable to check current information on the APVMA PUBCRIS website, at: <services.apvma.gov.au/PubcrisWebClient/welcome.do;jsessionid=tmPLHTZLndP4QpVQhsTlnnb0VDwnkTXrkRQ3NZYn4ZSsyqqKL4Sg!-2130204638>

[11] Minor use permits expire and may change periodically; hence, it is advisable to check current information on the APVMA PUBCRIS website, at: <services.apvma.gov.au/PubcrisWebClient/welcome.do;jsessionid=tmPLHTZLndP4QpVQhsTlnnb0VDwnkTXrkRQ3NZYn4ZSsyqqKL4Sg!-2130204638>

88 g/kg of active rotenone. Under the permit, a dose of 0.025–0.250 parts per million (ppm = mg/L) active ingredient can be used.

Only employees of state and territory government departments responsible for pest fish eradication and persons under their direct supervision may use these products under the permit. Rotenone has been used on numerous occasions to destroy noxious pest finfish species in freshwater systems (e.g. lakes and rivers), rather than for disease control. However, in Norway, eradication of the salmon ectoparasite, *Gyrodactylus salaris,* in some rivers has been assisted by using rotenone to destroy fish (European Commission 2006).

Finfish (and some amphibians and aquatic invertebrates) are highly susceptible to rotenone because it is readily absorbed directly into their blood through their gills (non-oral route) and therefore is not neutralised by digestive enzymes. Some fish with lower oxygen demands (e.g. demersal gobies and gudgeons) are less susceptible to destruction with rotenone than those with higher oxygen demands (e.g. salmonids). The effect of rotenone can be reversible, and fish can be revived in clear, well-oxygenated water if collected quickly. Smaller fish are more susceptible than larger fish. Rotenone is less effective at temperatures below 10 °C and in water with a high level of suspended sediments, where it can combine with the sediment and be effectively removed from reaction.

Rotenone is used by introducing the chemical into the water upstream of the target site. As the current carries it downstream, the fish are killed. A net should be set up at the lower reach of the target area to collect dead fish and other animals.

Rotenone can kill crustaceans at a concentration of 0.15 mg/L. Molluscs can accumulate rotenone over time, and mortalities may occur. Rotenone is not the preferred chemical for destruction of either molluscs or crustaceans, but can be used if circumstances warrant it.

Because rotenone is highly toxic to finfish and aquatic invertebrates, extreme care must be taken with its use. The action of rotenone downstream from the target area can be reduced by inactivation with Condy’s crystals (potassium permanganate). Bags of the crystals are placed in the river or stream at the downstream end of the target site. Potassium permanganate can also be highly toxic to aquatic life, and this should be considered before it is used to neutralise rotenone (Reardon & Harrell 1994).

All animals—fish, insects, birds and mammals—have natural enzymes in the digestive tract that neutralise rotenone, and the gastrointestinal absorption of rotenone is inefficient. Rotenone residues in dead fish are generally very low (<0.1 ppm or mg/kg) and unstable, and are not readily absorbed through the gut of the animal eating the fish (Finlayson et al. 2000). Some Australian freshwater turtles may be affected by rotenone, possibly due to uptake of the chemical through the cloaca (B Herbert, Australian Government Department of Agriculture, Forestry and Fisheries, personal communication, June 2008). It is unlikely that birds and mammals that eat dead fish and drink treated water will be affected by the chemical (Finlayson et al. 2000).

If rotenone is being considered as a means to kill aquatic animals to prevent the spread of disease, the American Fisheries Society handbook for rotenone use (Finlayson et al. 2000) is a useful reference.[12]

3.4.4 S-fenvalerate

S-fenvalerate is a synthetic pyrethroid insecticide that is effective in killing crustaceans. Its use in management of crayfish is described by Francesconi et al. (1995), who used a commercial preparation (Sumi-alpha® Flex insecticide[13]) to destroy freshwater crayfish, *Cherax albidus*. Sumi-alpha Flex insecticide contains the active ingredient at a concentration of 19 g/L.

To destroy crayfish, the insecticide concentrate is mixed with about 50 L of water and added to the body of water to make a final effective dose of 1 mg/1000 L. Some form of agitation or mixing is then applied. Within one hour of application, most of the animals will move to the edge of the pond, where they can be readily removed.

The rate of degradation of the chemical in pond water was found to be rapid. During the trials, at pond water temperatures ranging from 10 °C to 19.5 °C, no S-fenvalerate was detectable in the water or sediment five days after application (Francesconi et al. 1995). Two hours after application of the chemical to the pond water, levels of S-fenvalerate in crayfish tail muscle and hepatopancreas were 0.004 mg/kg and 0.003 mg/kg, respectively.

Minor use permits have previously been issued for use of S-fenvalerate to destroy freshwater crayfish (yabbies, red claw), but these permits had expired at the time of writing.

3.4.5 Sodium hypochlorite

When sodium hypochlorite (bleach) is applied to water, free residual chlorine is formed, which oxidises organic matter and, depending on its concentration and the quality of the water, will kill finfish, crustaceans and molluscs (Brady et al. 1996; Husnah & Lin 2002; Noga 1996). Residual free chlorine has the added advantage of killing microorganisms in the pond, again depending on concentration.

There are no current minor use permits or emergency use permits for use of sodium hypochlorite in this manner. Other hypochlorites (e.g. calcium or potassium hypochlorite) may be used, if appropriate, to produce free chlorine.

The dose of hypochlorite required to kill different aquatic animal species varies, depending on a number of factors, particularly the age of the animal and the amount of organic matter in the water. Chlorine levels as low as 0.10 mg/L can be acutely fatal for finfish where little organic matter is present (Noga 1996). In general, the higher the amount of free residual chlorine in the water, the faster the aquatic animal will die. The effective treatment range is vast; literature sources cite death within minutes for finfish species and many days for molluscan species.

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[12] <www.fisheries.org/units/rotenone/Rotenone_Manual.pdf>

[13] Sumi-alpha® Flex insecticide is available from Sumitomo Chemical Company (501 Victoria Ave, Chatswood, NSW 2067; telephone 02 9904 6499) or <www.sumitomo-chem.com.au/about.html>

Commercial powdered sodium hypochlorite products are usually at a concentration of 12.5% (weight/volume) of active chlorine. This value can be used to calculate the amount of chlorine being added to a volume of water. However, the actual amount of residual free chlorine must still be measured frequently during application.

Chlorine-treated water will need to be neutralised before its discharge into open waterways or sewerage systems if any residual free chlorine remains. Two methods are commonly used for neutralisation:

- vigorous aeration—depending on the amount of sodium hypochlorite added, aeration for 24 hours will usually remove detectable residual free chlorine
- addition of sodium thiosulphate; as sodium thiosulphate is itself toxic, the quantity added should be based on the actual residual free chlorine that is to be neutralised, not the amount initially added.

Before discharge of any water, it should be confirmed that residual free chlorine is below detectable levels.

3.4.6 Other chemicals and piscicides

Although other chemicals have the potential to be used to destroy aquatic animals, for a variety of reasons it is unlikely that they would be used. None are currently registered for aquatic animals in Australia, and all would require a veterinarian's authorisation. They include the following:

- *Injectable agents* could be used to destroy, for example, large aquarium fish. Sodium pentobarbital (60–100 mg/kg of body weight) can be administered intravenously, intra-abdominally or intracoelomically by a veterinarian. The additional stress to fish of being removed from the water and handled makes other methods preferable. Barbiturate residues mean that such fish cannot be consumed (AVMA 2007; Close et al. 1997).
- *Clove oil (generic)* has been effectively used as a fish anaesthetic (Ribas et al. 2007; see Section 3.4.1). It can also be used to euthanise finfish, crustaceans and molluscs. The variation in generic clove oil products means that it is not possible to give accurate concentrations. The use of clove oil is therefore not recommended, although it could be considered in an emergency situation when the aquatic animals are not destined for human consumption.
- *Carbon dioxide* (CO_2) can be used to cause sedation before bleeding, and requires no withholding period. It has therefore been extensively used in aquaculture production to assist in the destruction of fish destined for human consumption. However, it is now considered unacceptable for the destruction of aquatic animals and is rarely used; when fish are exposed to high levels of CO_2, they become highly stressed and display vigorous and excessive avoidance behaviour. This also affects product quality.
- *Copper sulphate* is an effective molluscicide and is toxic to all aquatic life. It has been used to eradicate invasive marine mollusc species in Australia as part of an overall containment and eradication strategy (Bax et al. 2002). Doses and lethal concentrations vary with species and water parameters.
- *2-phenoxy-ethanol* is not widely used on food fish. However, because of its anaesthetic qualities and its miscibility with water it has been used in research, including destruction.

Besides rotenone (see Section 3.4.3), a number of piscicides are used overseas for control of pest finfish species. Dawson (2003) describes both registered and unregistered chemicals available in the United States for this purpose.

The use of piscicides to control pest finfish species in Australia is being investigated by the Invasive Species Cooperative Research Centre.[14] A specific project is the review and development of fish biocides and delivery options. Research into biocides for control of marine invasive species has also been commissioned by the Marine Invasive Species Unit of the Australian Government Department of Agriculture, Fisheries and Forestry.

3.4.7 Environmental considerations

There is increasing public concern about pollution of waterways. Before chemicals are used for destruction of aquatic animals, the relevant state and territory environmental departments and local government must be consulted about potential contamination of surface or groundwater. Any legal requirements must be strictly followed. If Commonwealth lands or waters are likely to be affected, the Australian Government Department of the Environment, Water, Heritage and the Arts[15] will need to be consulted. For these reasons, contingency planning is vital before a disease emergency occurs.

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[14] <www.invasiveanimals.com/research/freshwater_products_and_strategies/4.f.9-review-and-development-of-fish-biocides/index.html>

[15] <www.environment.gov.au/>

4 Preferred methods of destruction for aquatic animals

Where possible, methods with which operators are already familiar should be used for the destruction of aquatic animals. Using new, untried or unfamiliar methods to destroy aquatic animal species in an emergency outbreak situation can be difficult and may expose personnel to increased risks.

Refer to Section 3 for more detailed information on the destruction methods described in this section.

4.1 Finfish

4.1.1 Finfish in ocean, lake or river systems (open systems)

Wild finfish species commonly growing in open systems in Australia include:

- southern bluefin tuna (*Thunnus maccoyii*), pilchards (*Sardinops neopilchardus*) and snapper (*Chrysophrys auratus*)—in salt/brackish water
- Murray cod (*Maccullochella peelii peelii*), silver perch (*Bidyanus bidyanus*), short-finned eel (*Anguilla australis*) and carp (*Cyprinus carpio*)—in fresh water.

Methods of destruction

Under most circumstances, if a decision is made to destroy wild finfish in open systems where there is no possibility of controlling the spread of a chemical, the most practical method of destruction will be to use commercial wild capture techniques to capture the fish before destroying them. Capturing methods include netting, trapping and capturing by line.

Commercial wild capture techniques will not capture all fish in the area and will only reduce the population size.

It is recommended that any commercially caught fish be killed using methods similar to standard practices for that commercial capture technique. Unnecessary suffering of the fish should be minimised.

Where controlling the spread of a chemical is possible (e.g. in a river or lake system), wild fish can be destroyed using rotenone at a concentration of 0.025–0.250 parts per million (ppm = mg/L) (see Section 3.4.3).

4.1.2 Finfish in sea and lake cages (semi-open systems)

Finfish species commonly growing in sea and lake cages in Australia include:

- yellowtail kingfish (*Seriola lalandi*), Atlantic salmon (*Salmo salar*) and barramundi (*Lates calcarifer*)—in salt/brackish water
- barramundi (*L. calcarifer*)—in fresh water.

Methods of destruction

If fish are for human consumption and are of market size, the preferred method of destruction is to use routine harvesting methods to remove them from cages and destroy them. Ideally, fish are euthanised individually—for example, by stunning each fish with a percussion-type stunning device or killing the fish by spiking the brain (*iki jimi*; see Section 3.3.2)—but other methods, such as placing fish into an ice slurry, are acceptable if this is the preferred routine harvesting method.

Depending on the speed required to destroy the fish, death may be caused by crushing and asphyxiation if large volumes of fish are removed from the water rapidly.

Fish can also be destroyed by enclosing a cage(s) with an impermeable liner (e.g. a tarpaulin) and adding a lethal concentration of approved anaesthetic or toxin to the water to euthanise the fish in situ. The cage net(s) may or may not be shortened (i.e. reduced in depth to increase fish density in the cage) before it is enclosed in the impermeable liner. Fish will then need to be removed dead from the water, which can be difficult and time consuming. The amount of chemical that will be released into the environment, which will depend on the size of the cage and the biomass of fish, may be substantial if a large number of fish are destroyed this way. Such release of chemical agents into the environment must be approved by the appropriate authorities.

Epidemiological considerations

If bleeding is required or desirable for product quality, the blood, other leaked body fluids, and any water used to wash or rinse the fish must be captured (e.g. into harvest bins) and disinfected. Harvest bins may be in limited supply in an emergency harvest situation. It is therefore important to ensure that there are enough bins before harvesting begins. Harvest bins must be leakproof, be lined with polyethylene bags and have well-fitting lids that are strapped on tightly. The bins must not be overfilled. Leaking bins or bins with broken straps or poorly fitting lids must not be used. Bins must be disinfected after use. (Refer to the **AQUAVETPLAN Decontamination Manual** for suitable disinfection methods.[16])

If fish are not of market size or the quality of the fish is not important, they can be efficiently removed from cages by shortening the net and then pumping or seining the fish live into a holding vessel. Similar procedures and the same vessels used to capture wild fish may be used.

4.1.3 Finfish in ponds and raceways (semi-closed systems)

Finfish species commonly growing in ponds and raceways in Australia include:

- barramundi (*Lates calcarifer*)—in salt/brackish water
- rainbow trout (*Oncorhynchus mykiss*), Murray cod (*Maccullochella peelii peelii*) and silver perch (*Bidyanus bidyanus*)—in fresh water.

[16] <www.daff.gov.au/animal-plant-health/aquatic/aquavetplan/operational_procedures_manual_-_decontamination>

Methods of destruction

If fish are for human consumption and are of market size, the preferred method of destruction may be to use routine harvesting methods to remove them live from ponds and raceways and destroy them. Ideally, fish are euthanised individually—for example, by stunning each fish with a percussion-type stunning device—but other methods, such as placing fish into an ice slurry, are acceptable if this is the preferred routine harvesting method.

Destruction of fish in ponds and/or static raceways (i.e. where the water has been turned off) can be achieved by the following methods (provided that the oxygenation process ensuring mixing of water and effectiveness of chemical euthanasia is adequate, thereby avoiding asphyxiation due to low dissolved oxygen levels):

- addition of a lethal concentration of anaesthetic to the static water (see Section 3.4)
- addition of a lethal concentration of rotenone to the static water (see Section 3.4).

Dead fish can then be removed from the raceways and ponds before decontamination of the site.

If fish are not destined for consumption (e.g. ornamentals) or are not of market size, they can be removed from ponds and raceways by dragging a net through the water and corralling the fish into one section of the pond or raceway. Fish can then either be pumped or seined live into a holding vessel on land, where they can be collectively destroyed. Depending on the speed required to destroy the fish, death may be caused by crushing and asphyxiation if large volumes of fish are removed from the water rapidly. Although this may cause the death of most fish, it is still important to check and, if necessary, individually euthanise fish (e.g. fish that are lying on top of the pile). Despite the best efforts of operators, some fish may remain in raceways and ponds when using this method. If water cannot safely be released without treatment, the destruction of remaining fish may be effected by the addition of an anaesthetic or rotenone to the pond or raceway at a lethal concentration (see Section 3.4). Alternatively, a high concentration of disinfectant (e.g. sodium hypochlorite at 100 mg/L) can be added to the water. This will result in destruction of any remaining fish and will also reduce the viability of any pathogen in the water.

If water can be released untreated, the water in the ponds and raceways may either be drained or pumped out. Any fish remaining can then be captured and euthanised by a blow to the head, by decapitation at a point where the head joins the body, or by placing into an anaesthetic solution for sufficient time to cause death.

Epidemiological considerations

Using routine harvesting methods in raceways will generally require that water flow be maintained through the raceway during harvesting.

Where routine harvesting involves the on-site bleeding of fish, precautions outlined in Section 4.1.2 should be observed.

If there is a possibility of disease spreading through release of discharge water, turning off the water flowing through raceways and preventing any discharge water from leaving the property may be the first step taken before destruction of fish. Reduction in dissolved oxygen levels can be rapid using this method, depending on the density of fish in the raceway.

Large numbers of dead fish may attract predators (e.g. birds or rats), and strategies must be employed to prevent removal of dead fish by such animals.

4.1.4 Finfish in recirculation systems, including aquariums (closed systems)

Finfish species commonly growing in closed systems in Australia include:

- marine ornamental finfish species, including anemone fish (*Amphiprion* spp.) and dottybacks (*Pseudochromis* spp.)—in salt/brackish water
- barramundi (*Lates calcarifer*), Murray cod (*Maccullochella peelii peelii*), silver perch (*Bidyanus bidyanus)* and golden perch (*Macquaria ambigua ambigua*)—in fresh water.

Methods of destruction

Due to the ability of closed systems to contain spread of disease, speed is not as important for destruction of fish grown in these systems.

If fish are of market size, the preferred method of destruction will be to use routine harvesting methods to remove them live from tanks and destroy them. Ideally, fish are euthanised individually—for example, by stunning each fish with a percussion-type stunning device—but other methods, such as placing fish into an ice slurry, are acceptable if this is the preferred routine harvesting method.

If fish are not destined for consumption (e.g. ornamentals) or are not of market size, the preferred destruction methods are:

- the addition of an anaesthetic to the tank at a lethal concentration (see Section 3.4) and removal of the dead fish
- the addition of an anaesthetic to the tank at a concentration sufficient to sedate the fish, and then removal of the fish while still alive into suitable containers to allow destruction; destruction can be achieved by maintaining a lethal dose of anaesthetic in the container, although death may be caused by crushing and asphyxiation instead if large volumes of fish are removed from the water rapidly.

4.2 Crustaceans

4.2.1 Wild crustaceans (open systems)

Crustacean species commonly growing in open systems in Australia include:

- black tiger prawn (*Penaeus monodon*), kuruma prawn (*Marsupenaeus japonicus*), southern rock lobster (*Jasus edwardsii*), blue swimmer/sand crabs (*Portunus pelagicus*), spanner crabs (*Ranina ranina*) and mud crabs (*Scylla* spp.)—in salt/brackish water

- redclaw (*Cherax quadricarinatus*), marron (*Cherax tenuimanus*) and yabbies (*Cherax destructor*)—in fresh water.

Methods of destruction

Under most circumstances, if a decision is made to destroy wild crustaceans in open systems where there is no possibility of controlling the spread of a chemical, the most practical method of destruction will be to use commercial wild capture techniques (if available) to capture the crustaceans before destroying them. Capturing methods include netting and trapping.

Commercial wild capture techniques will not capture all crustaceans in the area and will only reduce the population size.

It is recommended that any crustaceans caught by commercial capture methods be killed using methods similar to standard practices for commercial capture, such as placing the crustaceans into boiling water for a predetermined time. Boiling has the added benefit of minimising pathogen viability.

Where controlling the spread of a chemical is possible (e.g. in a river or lake system), wild crustaceans can be destroyed by the addition of either S-fenvalerate or rotenone to the water (see Section 3.4).

Epidemiological considerations

Destruction of wild crustaceans using chemicals may result in large numbers of dead crustaceans being available for predation by birds and other predators. As noted in Section 3.4, it is unlikely that the dead crustaceans will be toxic to animals or birds that ingest them. However, there is a risk of disease spread through carriage of carcases by birds or other predators.

4.2.2 Farmed crustaceans in sea/lake cages (semi-open systems)

At the time of writing of this manual, no crustaceans were being farmed in these types of semi-open systems in Australia.

4.2.3 Farmed crustaceans in ponds, raceways or flow-through tanks (semi-closed systems)

Crustacean species commonly held or growing in raceways or flow-through tanks in Australia include:

- black tiger prawn (*Penaeus monodon*), kuruma prawn (*Marsupenaeus japonicus*), banana prawn (*Fenneropenaeus indicus* and *Fenneropenaeus merguiensis*) and blue swimmer crab (*Portunus pelagicus*)—in salt/brackish water
- redclaw (*Cherax quadricarinatus*), marron (*Cherax tenuimanus*) and yabby (*Cherax destructor*)—in fresh water.

Methods of destruction

If the crustaceans are of market size, the preferred method of destruction is to use routine harvesting methods to remove them live from ponds, raceways or tanks and then destroy them using standard harvest practice. This will probably involve emptying the pond or tank of water, trapping the crustaceans in the bottom of the pond. The live crustaceans may then be placed into an ice slurry (which will effectively anaesthetise the animals, eventually leading to asphyxiation and death), or they may be placed into boiling water for a predetermined time, which is standard practice for harvesting of prawns. Boiling has the added benefit of minimising pathogen viability.

Any crustaceans remaining in the pond or tank will be destroyed by the addition of sodium hypochlorite. Alternatively, the remaining crustaceans may be destroyed by adding either S-fenvalerate or rotenone to the pond or tank at a lethal concentration (see Section 3.4). This will kill the remaining crustaceans but will not provide disinfection.

If it is necessary to quickly kill all crustaceans in a pond or raceway and the crustaceans are not destined for human consumption, destruction can be effected either by emptying the pond (as described above) or by adding either S-fenvalerate, isoeugenol or rotenone to the pond at a lethal concentration (see Section 3.4). The pond or tank water can then be disinfected and lowered before collection and removal of the dead crustaceans.

Epidemiological considerations

Some facilities farming crustaceans send crustaceans live to the market place. The suitability of this practice will need to be addressed in the context of overall disease control. If it is unacceptable, alternatives will need to be considered; for example, the crustaceans could be destroyed by boiling before being sent to the market place.

If release of untreated water into the environment is unacceptable, it may be possible to capture and hold discharge water from the harvest pond or tank in a separate pond where disinfection can be achieved before the water is released to the environment. In cases where it is not possible to capture and hold the discharge water, as many crustaceans as possible of market size may be captured and removed live from the pond or tank using nets or traps. The pond or tank water may then be treated by the addition of sodium hypochlorite (as described in the **AQUAVETPLAN Decontamination Manual**[17]).

4.2.4 Farmed crustaceans in hatcheries and recirculation systems (closed systems)

Crustacean species commonly growing in closed systems in Australia include:

- black tiger prawn (*Penaeus monodon*), kuruma prawn (*Marsupenaeus japonicus*), banana prawn (*Penaeus merguiensis*) and mud crab (*Scylla serrata*)—in salt/brackish water
- redclaw (*Cherax quadricarinatus*) marron (*Cherax tenuimanus*) and yabby (*Cherax destructor*)—in fresh water.

[17] <www.daff.gov.au/animal-plant-health/aquatic/aquavetplan/operational_procedures_manual_-_decontamination>

Methods of destruction

Because these systems are closed, the preferred method of destruction is to use routine harvesting methods to remove the crustaceans live from tanks before destroying them using routine harvesting practices.

Crustaceans can be destroyed by boiling before being sent to the market place; this method has the added benefit of minimising pathogen viability.

Where the crustaceans are not destined for human consumption, they can be destroyed by the addition of either S-fenvalerate or rotenone to the tanks at a lethal concentration (see Section 3.4). Dead crustaceans can then be removed.

Isoeugenol has also been used to destroy crustaceans. This product is not registered for use in crustaceans, but may be approved for off-label use for this purpose. In finfish, there is no requirement to withhold animals destined for human consumption after use of isoeugenol.

4.3 Molluscs

Molluscs that may need to be destroyed include bivalves (e.g. oysters, mussels) and gastropods (e.g. abalone). Anaesthetic agents cannot be used with bivalves as they can close their shells to prevent penetration of the anaesthetic agent.

4.3.1 Wild molluscs (open systems)

Mollusc species commonly growing in these systems in Australia include:

- Sydney rock oyster (*Saccostrea glomerata*), pearl oyster (*Pinctada maxima*), abalone (*Haliotis* spp.)—in salt/brackish water
- freshwater mussel (*Velesunio angasi*)—in fresh water.

Methods of destruction

Under most circumstances, if a decision is made to destroy wild molluscs in open systems, the most practical method of destruction will be to use commercial harvesting techniques to collect the molluscs before destroying them. Harvesting methods include removal by divers of individual molluscs from the sea floor (e.g. pearl oyster), or from the reef structure by using a flat-bladed knife (e.g. abalone).

It is recommended that any molluscs harvested by commercial methods be processed in a manner similar to standard practices for the commercial capture technique.

Unmarketable molluscs may be destroyed either by exposing them to sufficient heat to cause the two shells to open (in the case of bivalve molluscs) or by leaving them out of water for a sufficient period to cause death. The exact period will depend on the ambient air temperature; the warmer the temperature, the sooner the mollusc will die.

Non-operculate gastropod molluscs (e.g. abalone) can be destroyed by placing them in a concentrated solution of anaesthetic (isoeugenol or benzocaine).

If the molluscs are located in a body of water where a chemical could be effectively contained, it may be possible to destroy them using a chemical such as copper sulphate. Chlorine and copper sulphate have been used successfully to eradicate pest bivalve species in harbours in northern Australia (see Ferguson 2000). Tests indicated that these agents worked best if chlorine was applied first, followed by copper sulphate. Treatment using heat (60 °C for 30 minutes), chlorine (24 mg/L for 90 hours), detergent (1% v/v for 7 hours) or copper sulphate (1 mg/L for 38 hours) will kill bivalves (Bax et al. 2002). These options must be carefully considered in light of any adverse environmental effects that may result from use of the chemicals.

Epidemiological considerations

It is likely that commercial wild capture techniques will not capture all molluscs in the area and will only reduce the mollusc population size.

Molluscs harvested in this way may be used for human consumption provided that they are of marketable size. Commercially, some molluscs (e.g. abalone) are sent to markets live. Whether this is acceptable will need to be considered, given the potential for disease spread. If it is unacceptable, molluscs will need to be destroyed before being sent to markets.

4.3.2 Farmed molluscs in racks or cages (semi-open systems)

Mollusc species commonly growing in racks or cages in Australia include Sydney rock oyster (*Saccostrea glomerata*), Pacific oyster (*Crassostrea gigas*), pearl oyster (*Pinctada maxima*), abalone (*Haliotis* spp.) and mussel (*Mytilus* spp., *Perna* spp.) in salt/brackish water.

Freshwater farming of molluscs is not known to occur in Australia.

Methods of destruction

If molluscs are for human consumption and are of market size, the preferred method of destruction of molluscs grown on or in rack or cage systems in the ocean or estuaries is to remove them using routine harvesting practices.

Alternatively, molluscs destined for human consumption may be killed by freezing. How this will affect the viability of the disease agent (if present) will depend on the susceptibility of the agent to freezing.

If molluscs are not for human consumption and/or not of market size, the preferred method of destruction is to remove them using routine harvesting practices and then to destroy them by leaving them out of water for a sufficient time to cause death. The exact period will depend on the ambient air temperature; the warmer the temperature, the sooner the mollusc will die.

Non-operculate gastropod molluscs (e.g. abalone) can be destroyed by placing them in a concentrated solution of anaesthetic (isoeugenol or benzocaine).

Chemical methods could also be used to destroy molluscs not destined for human consumption (see Section 4.3.1).

Epidemiological considerations

If the molluscs are loose in cages, they can be taken out of the water and deposited in water-retaining containers or bins on the deck of a boat. Panels, racks or ropes may be treated in the same way. The practicality of this will depend on the size of the boat and the volume of racks or ropes to be removed.

Some bivalve molluscs (e.g. Pacific and Sydney rock oysters, mussels) are sent to markets live. Whether this is acceptable will need to be considered, given the potential for disease spread. If it is unacceptable, the molluscs will need to be destroyed, either by exposing them to sufficient heat to cause the two shells to open (in the case of bivalve molluscs) or by leaving them out of water for a sufficient period to cause death. The exact period will depend on the ambient air temperature; the warmer the temperature, the sooner the mollusc will die.

4.3.3 Farmed molluscs in pump-ashore systems (semi-closed systems)

Mollusc species commonly growing in pump-ashore systems in Australia include abalone (*Haliotis* spp.) in salt/brackish water.

Freshwater farming of molluscs is not known to occur in Australia.

Methods of destruction

Molluscs may be destroyed by normal processing (freezing or canning).

If removing molluscs from tanks is not acceptable (or the molluscs are not of market size), gastropod molluscs can be euthanised in situ by the addition of lethal amounts of isoeugenol or benzocaine to the water. The required concentration will depend in part on how rapidly the animals need to be destroyed.

Alternatively, sufficient anaesthetic can be added to the tank to sedate the animals, which can then be removed and placed into a more concentrated solution of anaesthetic.

Chemical methods could also be used to destroy molluscs not destined for human consumption (see Section 4.3.1).

Epidemiological considerations

If molluscs are for human consumption and are of market size, the preferred method of destruction is to remove them from the tanks using routine harvesting practices.

Ideally, molluscs will be processed on site. If this is not possible, they can be forwarded to an off-site processing facility, provided that this is acceptable with regard to the potential for disease spread.

Fresh chilled and live molluscs are sometimes sent to markets. The acceptability of this will also need to be considered with regard to the potential for disease spread.

4.3.4 Farmed molluscs in recirculation systems (closed systems)

Mollusc species commonly produced or growing in recirculation systems in Australia include abalone (*Haliotis* spp.), pearl oyster (*Pinctada maxima*), Pacific oyster (*Crassostrea gigas*) and Sydney rock oyster (*Saccostrea glomerata*) in salt/brackish water.

Freshwater farming of molluscs is not known to occur in Australia.

Methods of destruction

Mollusc species being grown in closed systems are likely to be the broodstock, egg and larval stages of the species.

For small numbers of larger molluscs (e.g. broodstock abalone), cooking is an appropriate method of destruction.

Destruction can be achieved by removing animals from tanks and placing them into a concentrated bath of anaesthetic.

Egg and larval stages of molluscs can be destroyed using sodium hypochlorite at 100 ppm for at least 10 minutes.

Chemical methods could also be used to destroy immature molluscs (see Section 4.3.1).

Glossary

Aquatic Animal Health Committee	A committee comprised of representatives of the Australian Government; state and territory governments; the major aquaculture, wild capture, aquarium and recreational fishing industries; and CSIRO. The committee provided advice to Primary Industries Ministerial Council on aquatic animal health matters, focusing on technical issues and regulatory policy. *See also* Primary Industries Ministerial Council
Australian Chief Veterinary Officer	The nominated senior veterinarian in the Australian Government Department of Agriculture, Fisheries and Forestry who manages international animal health commitments and the Australian Government's response to an animal disease outbreak. *See also* Chief veterinary officer
AQUAVETPLAN	Australian Aquatic Veterinary Emergency Plan. A series of technical response plans that describe the proposed Australian approach to an emergency aquatic animal disease incident. *See also* AUSVETPLAN
AUSVETPLAN	Australian Veterinary Emergency Plan. A series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.
Chief veterinary officer (CVO)	The senior veterinarian of the animal health authority in each jurisdiction (national, state or territory) who has responsibility for animal disease control in that jurisdiction. *See also* Australian Chief Veterinary Officer
Compensation	The sum of money paid by government to an owner for stock and/or property that is destroyed, possibly compulsorily, because of an emergency animal disease
Control area	A buffer between the restricted area and areas free from disease. Restrictions on this area will reduce the likelihood of the disease spreading further afield. As the extent of the outbreak is confirmed, the control area may reduce in size. The shape of the area may be modified according to circumstances, such as water flows, catchment limits etc. In most cases, permits will be required to move animals and specified product out of the control area into the free area.

Dangerous contact premises or area	An area or premises containing aquatic animals that show no signs of disease but which, because of their probable exposure to disease, will be subject to disease control measures. The type of contact that would suggest exposure will depend on the agent involved in the outbreak but, for example, may involve animal movements or movements of nets or equipment.
Declared area	A defined tract of land or water that is subjected to disease control restrictions under emergency animal disease legislation. Types of declared areas include *restricted area, control area, infected premises, dangerous contact premises* and *suspect premises*.
Decontamination	A combination of physical and chemical procedures that are used to remove soiling and inactivate the target disease organism. Includes all stages of cleaning and disinfection.
Destruction	The killing by humane means (euthanasia) of infected aquatic animals and/or those exposed to infection. *See also* stamping out.
Disease agent	A general term for a transmissible organism or other factor that causes an infectious disease.
Disinfectant	A chemical used to destroy disease agents outside a living animal.
Disinfection	The application, after thorough cleansing, of procedures intended to destroy the infectious or parasitic agents of animal diseases, including zoonoses; applies to premises, vehicles and other objects that may have been directly or indirectly contaminated.
Disposal	Sanitary removal of fish carcases and things by burial, burning or some other process so as to prevent the spread of disease.
Emergency animal disease	A disease that is (a) exotic to Australia or (b) a variant of an endemic disease or (c) a serious infectious disease of unknown or uncertain cause or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications. *See also* Endemic animal disease, Exotic animal disease
Endemic animal disease	A disease affecting animals (which may include humans) that is known to occur in Australia. *See also* Emergency animal disease, Exotic animal disease
Enterprise	*See* Risk enterprise
Epidemiological investigation	An investigation to define the case and then to describe an outbreak in terms of time animal and place. Then it seeks to establish what is causing disease by identifying risk factors associated with the infection or disease.

Exotic animal disease	A disease affecting animals (which may include humans) that does not normally occur in Australia. *See also* Emergency animal disease, Endemic animal disease
Free area	An area known to be free from the disease agent.
Infected premises or area	A defined area (which may be all or part of a premises, lease or waterway) in which an aquatic animal disease emergency exists or is believed to exist, or in which the infective agent of that aquatic animal disease exists or is believed to exist. An infected area is subject to quarantine served by notice and to eradication or control procedures.
Local disease control centre	An emergency operations centre responsible for the command and control of field operations in a defined area.
Monitoring	Routine collection of data for assessing the health status of a population. *See also* Surveillance
Movement control	Restrictions placed on the movement of fish, people and other things to prevent the spread of disease.
OIE Aquatic Code	OIE *Aquatic Animal Health Code* (OIE 2006), viewed 2008, <www.oie.int/eng/normes/fcode/en_sommaire.htm>.
OIE Aquatic Manual	OIE *Manual of Diagnostic Tests for Aquatic Animals* (OIE 2006), viewed 2008, <www.oie.int/eng/normes/fmanual/A_summry.htm>. Describes standards for laboratory diagnostic tests and the production and control of biological products (principally vaccines).
Operational procedures	Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.
Premises or area	A production site for aquatic animals that may range from an aquarium to an aquaculture lease in the open ocean.
Primary Industries Ministerial Council	The council of Australian national, state and territory and New Zealand ministers of agriculture that sets Australian and New Zealand agricultural policy (formerly the Agriculture and Resource Management Council of Australia and New Zealand).
Quarantine	Legal restrictions imposed on a place, fish, vehicles, or other things, limiting movement.

Restricted area	The area around an infected premises (or area), likely to be subject to intense surveillance and movement controls. It is likely to be relatively small. It may include some dangerous contact premises (or area) and some suspect premises (or area), as well as enterprises that are not infected or under suspicion. Movement of potential vectors of disease out of the area will, in general, be prohibited. Movement into the restricted area would only be by permit. Multiple restricted areas may exist within one control area.
Risk enterprise	A defined livestock or related enterprise, which is potentially a major source of infection for many other premises. Includes hatcheries, aquaculture farms, processing plants, packing sheds, fish markets, tourist angling premises, veterinary laboratories, road and rail freight depots and garbage depots.
State or territory disease control headquarters	The emergency operations centre that directs the disease control operations to be undertaken in that state or territory.
Surveillance	A systematic series of investigations of a given population of fish to detect the occurrence of disease for control purposes, and which may involve testing samples of a population.
Susceptible animal	Animal that can be infected with a particular disease.
Tracing	The process of locating animals, persons or other items that may be implicated in the spread of disease, so that appropriate action can be taken.
Vector	A living organism that transmits an infectious agent from one host to another. A *biological* vector is one in which the infectious agent must develop or multiply before becoming infective to a recipient host. A *mechanical* vector is one that transmits an infectious agent from one host to another but is not essential to the lifecycle of the agent.
Zoning	The process of defining disease-free and infected areas.
Zoonosis or zoonotic disease (plural zoonoses)	Disease transmissible from animals to humans.

Abbreviations

APVMA	Australian Pesticides and Veterinary Medicines Authority
AQUAVETPLAN	Australian Aquatic Veterinary Emergency Plan
AUSVETPLAN	Australian Veterinary Emergency Plan
EUP	emergency use permit
OHS	occupational health and safety

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