Part 4

Problem solving

Diseases – what causes them and how are they managed?

CHAPTER 8

Common disease problems in Australian prawn farms

The most common diseases observed in Australian prawn farms are:

- Mid-crop Mortality Syndrome
- Bacterial Septicaemia
- Haemocytic Enteritis.

Viruses

The most significant viral disease in prawn farming in Australia is Mid-crop Mortality Syndrome (MCMS), a disease is associated with a varying combination of viral pathogens. Animals that are dying can be infected with a combination of Gill Associated Virus (GAV), Spawner Mortality Virus (SMV), Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV) and Mourilyan virus (MoV). The only realistic definition of clinical signs of MCMS is that an outbreak (as defined below) is occurring and no other cause (such as Bacterial Septicaemia) is identifiable.

Remember the definition of an outbreak in Chapter 3: An outbreak in a pond occurs when an additional 10 prawns per day aggregate around the edges of a pond on five consecutive days — that is, at least 10, 20, 30, 40, 50 prawns.

This definition then covers the massive range of variable clinical signs that may be seen with the disease (such as redness or fouling of the body, stunting, nerve necrosis, eye necrosis) that are not necessarily there or observable in every case. Various histopathology procedures can be used in a disease laboratory to investigate further but the costs involved may be difficult to justify. It also covers the fact that a prawn can look completely normal but actually be dead. These prawns are dying from uncontrolled programmed cell death associated with the presence of viruses (see below).

If you have observed sick prawns in your ponds, but cannot determine what is the cause, go to Chapter 9 for a guide to the clinical signs of known diseases in the Australian prawn industry

Most of the prawn health research in Australia has been conducted on GAV in MCMS, so it can be used as the indicator virus where the majority of therapies that control it would be effective against other viruses as well.

Typically, 50 per cent of all black tiger prawns will be infected with GAV within one month of being stocked into ponds. When prevalence or intensity increases by another 20 per cent and 30 per cent respectively, the likelihood of an outbreak or chronic low-grade mortalities is extremely high. However, uncertainties about what causes GAV remain; GAV may not be detectable in every affected prawn suggesting other viruses may play a role in MCMS.

Bacteria

The majority of diseases occurring in ponds are probably due to bacterial infection (such as Vibriosis) or problems related to septicaemia (bacterial toxins in the blood). Poor pond preparation, poor food control and inefficient sweeping of the bottom with paddlewheels can all contribute to harmful bacteria getting out of control. If toxicants such as ammonia become excessive, infection of hepatopancreatic (liver) tubules can occur but usually without any initial effect. However, once many tubules are damaged or the bacteria break through into the haemocoel, then animals start to die.

For an informative guide to diseases occurring in prawns and other aquaculture species, refer to the CD or publication *Identification Field Guide, Aquatic Animal Diseases Significant to Australia,* 2004, available from the Department of Agriculture, Fisheries and Forestry, Canberra: www.daff.gov.au.

Haemocytic Enteritis

Haemocytic Enteritis can be diagnosed only by the correct use of histopathology. Pond signs usually include stunted animals and prawns off their feed. This will often be in conjunction with a cyanobacterial bloom (blue-green algae) and possibly a phytoplankton bloom crash. The most common triggering event is an oversupply of phosphate as either fertiliser or uneaten food due to an overestimation of the number of live prawns in a pond. In-crop liming may reduce the amount of cyanobacteria, but more careful use of feed trays and fertilisers is the best option.

Diseases and the reasons for their outbreaks

Disease can be defined as 'any process that limits the productivity of a system'. Disease can be split into two categories: infectious disease caused by microbes that can breed and spread; and non-infectious disease caused by environment, genetics and husbandry practices (such as feed quality) with no ability to spread. This section will focus largely on infectious diseases, as psychologically they are more damaging and they are more likely to send you bankrupt.

Infectious disease agents need to spread to new prawns faster than the infected prawn dies to keep a wave of infection going. Since it is easier to cross a small distance than a large distance, diseases can spread more efficiently and rapidly when animals are close together. This usually means the higher the stocking density, the higher the likelihood of a disease outbreak. This leads to the first way to prevent and combat disease: lower the stocking density either by partial harvests or at initial stocking. By stocking at 10 prawns/m^2 farmers have been able to keep growing black tiger prawns for over 300 days without a disease outbreak. In contrast, by stocking at 30 prawns/m^2 farmers can start to encounter problems after 120 days.

The great majority of diseases occur when three conditions are met: the prawns have to be present (obviously), the disease agent or pathogen must be present, and there is an environmental stressor or trigger (see Chapter 3 for more information). This leads to two ways to combat disease: remove the pathogen, or minimise, remove or prevent the stressor.

A defined outbreak does not have to occur to lower productivity: for example, a virus may not kill the prawns in an outbreak, but infected animals grow slowly, leading to losses in yield and overall production.

Stress factors that can lead to disease

As mentioned above, stressors are often needed to trigger a disease outbreak. The possible causes of stress to prawns can be diverse and complex but essentially are related to the pond environmental factors described in earlier chapters.

These stressors include rapid changes in salinity, temperature, pH or oxygen (bloom crashes, paddlewheel failures), transport and pathogens. The most difficult water quality stress to deal with on a farm is salinity change as it will affect the whole farm at the same time. This can be more significant in farms located in the dry tropics of northern Australia that can become hypersaline (over 38 ppt) in the summer and where the ability to reduce salinity by adding freshwater or pumping more seawater is often limited (see Chapter 2). Prawns encountering salinities either higher or lower than their natural salinity tolerances respond by increased osmoregulation (see Chapter 4), with subsequent increased stress and the potential for disease outbreaks to occur.

A more common water quality stress is related to the accumulation of dissolved nutrients in the water column and subsequent unstable water chemistry. For example, if feeding rates are high and water exchange has not been possible, prawns may be stressed by:

- wider dissolved oxygen fluctuations, such as 9 ppm at dusk and 3 ppm at dawn
- wider pH fluctuations, such as 9.5 at dusk and 6.5 at dawn (daily fluctuation should not exceed 0.5)
- increased levels of toxic ammonia, nitrite or nitrate in the water column

Figure 8.1 Sick prawns lingering in shallow water

- regular sub-lethal low dissolved oxygen concentration — for example, below 3.0 ppm several times over a few weeks
- increased shell fouling
- algal bloom becoming dominated by blue-green algae
- algal bloom becoming very dense and then crashing.

Other events that can lead to prawn stress include:

- sudden weather changes that change the temperature or dissolved oxygen concentrations
- a sudden drop in atmospheric pressure during cyclonic weather
- consistent high water temperatures during summer or low temperatures in winter
- equipment failure (say, aeration system) or serious management errors (such as excessive water exchange).

Prawns have a natural 'immunity' process in place to keep viruses in check by phagocytosing them (engulfing and consuming them) and locking them away to prevent other cells becoming infected. However, if an environmental stressor damages any proteins, the prawn can then produce a 'shock' protein to stabilise the damaged proteins. If the stress is too large, the shock protein cannot protect or repair the damaged proteins and an unstoppable process called apoptosis (programmed cell death) will occur, leading to the death of the prawn. Most prawns carrying viral loads are susceptible to this uncontrolled apoptosis, and when it occurs the prawns may not show any clinical signs (other than death). Often no remedial action is possible. The only option is to consider emergency harvesting of the remaining crop before significant prawn losses result in the crop making a financial loss.

Are my prawns sick?

There are various indicators to look out for if you think your prawns are sick or under stress.

Healthy prawns:

- feed well with an increasing appetite as they grow
- are active and regularly looking for feed in the shallows
- groom themselves to keep clean of skin parasites
- have a firm skin with minimal abrasions
- moult regularly
- are difficult to observe from the bank.

Sick prawns:

- are lethargic or non-responsive
- do not feed or groom themselves
- have difficulty in moulting (that is, they do not moult, or they die during a moult)
- show abnormal colour, or lesions on the gills, body or appendages

- have fouling of the gills (because they do not groom their gills)
- have shell fouling — a significant proportion of the prawns have algae or barnacles growing on the shells and/or appendages (the prawns are not grooming themselves effectively)
- aggregate around the edges of the pond — sick or lethargic prawns often rest in the shallows at the side of the pond (Figure 8.1) or near areas of higher oxygen, such as the water inlet. By the time prawns are seen at the pond edge, the problem is already well advanced. Careful monitoring of pond environmental conditions, as well as daily examination of prawns in feed trays and weekly cast netting, should give early warnings
- reduce feeding —monitoring of the feed trays shows that the amount of feed consumed per day is dropping. Note that this can be normal during moulting or when temperatures drop
- attract more birds — an unusual number of birds may congregate around one particular pond, and obviously prey on vulnerable prawns near the surface.

Fixing the problem

One way of reducing stress on prawns suffering from water quality problems is to undertake a large exchange in an effort to flush the pond. However, flushing is not always possible or desirable because:

- large water exchanges can create rapid change in the water quality conditions and may lead to additional stresses on the prawns
- licence restrictions may limit the volume of effluent water you are allowed to release from the farm per day.

In such cases the following techniques can be used to improve the water quality in 'problem' ponds:

- decrease the feeding rates
- increase aeration.

Important points to note:

1. If prawns are gathering around the edges of ponds, it is usually because they are sick. However, it may also be because the prawns are underfed and are searching for food. The simple way to differentiate is to sprinkle feed in the shallows and gauge the level of activity. Hungry prawns are usually very active, often searching in and out of the shallows in small arc patterns.
2. Pond bottom fouling can stress prawns and deter them from occupying some areas of the pond bottom. If the aerators have not been placed correctly the resulting 'sweeping' water currents will be ineffective and parts of the feeding area on the pond floor can become fouled. When this occurs prawns may not feed actively in these areas, leaving feed to decompose. This can have a major effect on water quality, often leading to heavy blooms, dissolved oxygen crashes, and blue-green algae. The problem is often compounded by prawns feeding preferentially off the feed trays as

Sending in a sample of prawns that you have already 'fixed' in preservatives will speed up the diagnostic process by 24 hours, so that pathology results will be ready sooner than if you send only live prawns. This is advantageous if you are anxiously awaiting test results. In Queensland you can request a disease testing kit from the Oonoonba Veterinary Laboratory, Department of Primary Industries and Fisheries, Townsville by calling 13 25 23. The farm kits contain equipment and sample bottles with instructions for 'fixing' prawns, enabling you to preserve prawns on site.

they are clean surfaces: this may mislead you into thinking the prawns are feeding well.

Health checks and farm disease testing kits

Checks on prawn health should be carried out regularly throughout the crop. Daily and weekly checks of prawns in each pond on the farm are recommended for early detection of disease. A good way to check prawns is to sample 5 to 10 prawns on the feed tray and use a cast net to sample approximately 30 prawns in other areas of the pond. It is advisable to have a health records sheet (or an extra column on the daily water quality sheet), where daily prawn health checks are recorded, and normal and abnormal findings are recorded and reported to the farm manager. Ponds with any signs of abnormality should be monitored closely. Prawns should be checked for movement, size, colour and any abnormalities. The gills, head, body, tail and all appendages should be checked.

If you have concerns about possible disease problems in a particular crop, you can use the disease guide in Chapter 9 as part of an initial diagnosis. If any abnormalities are detected, they should be recorded on your daily monitoring sheet and the pond should be monitored closely until the situation changes. Any abnormal lesions suggestive of an endemic or exotic disease should be reported immediately to the nearest state government veterinary authority.

A veterinary officer can give advice over the telephone or carry out field investigations on your farm to determine the cause of the abnormal lesions, behaviour or deaths. You can take samples of sick prawns and send them to the nearest veterinary laboratory to determine the cause of any abnormality or deaths. Live or fixed prawns can be sent to the laboratory. The veterinarian will advise you what to send, depending upon what tests you require (see Chapter 9). Manuals used by shrimp farmers in other countries can also be helpful references (Chanratchakool et al. 1994; Johnson 1995).

Disease testing kits

Farm kits for prawn farmers are available from the Department of Primary Industries and Fisheries at the Tropical and Aquatic Animal Health Laboratory (TAAHL) at Oonoomba in Townsville. These kits were developed for prawn farmers to use in the event of a disease emergency (that is, sudden death of large numbers of prawns) or a suspected exotic disease outbreak. If you experience a sudden loss of large numbers of prawns, or a large number of prawns gather at the edge of the pond, or you suspect an exotic disease, immediately contact your nearest state veterinary authority for advice. If you suspect an exotic disease outbreak has occurred, seek veterinary advice before moving live infected prawns from the farm premises (see Chapter 9).

Table 8.2 Prawn disease testing procedures by Queensland DPI&F

Sample type	Class of test	Diseases tested
Postlarvae, juvenile and adult prawns — live or fixed	Histopathology	Parasitic e.g. epibiotic fouling Bacterial e.g. vibriosis Fungal e.g. larval mycosis Viral e.g. *Penaeus monodon*-type baculovirus Other e.g. haemocytic enteritis, shell disease, gut and nerve necrosis
Postlarvae, juvenile and adult prawns — live or fixed	Bacteriology	Bacterial diseases e.g. Vibriosis—caused by *Vibrio harveyi*
Postlarvae — live or fixed Juvenile, adult prawns — live or fixed	Parasitology	Protozoan diseases (e.g. microsporidiosis, gill fouling), helminths and other parasites such as epibiotic fouling, *Zoothamnium* sp., *Epistylis* sp.)
Postlarvae, juvenile and adult prawns — live or fixed	Mycology	Detection of fungal diseases, e.g. larval mycosis
Postlarvae, juvenile and adult prawns — live or 70% ethanol preserved	Molecular or DNA test	White Spot Virus Syndrome Virus(WSSV) Yellowhead Virus (YHV) Taura Syndrome Virus (TSV) Gill Associated Virus (GAV) Infectious Hypodermal Haematopoietic Necrosis Virus (IHHNV)
Juvenile, adult prawns — live or fixed	Necropsy	Parasitic Bacterial General health check

The farm kits can also be used to send fixed (preserved) sick prawns to a state veterinary laboratory for disease testing. Prawns should be sampled, packed and sent appropriately and according to the methods outlined in Webb (1998).

Samples of sick prawns can be taken by the farmer and sent to the nearest veterinary laboratory to determine the cause of illness. Live or fixed prawns can be sent to the laboratory. The veterinarian will advise you what to send, depending upon what tests you require.

Available tests for prawns

The Department of Primary Industries and Fisheries (DPI&F) has accredited veterinary laboratories that conduct diagnostic and health testing for prawn samples. The range of tests covers parasitic, bacterial, fungal and viral diseases.

In Queensland, under the *Fisheries Act, 1994,* an aquaculturist is required to report any suspected disease outbreak to a DPI&F fisheries officer (see: Aquaculture disease services at Department of Primary Industries and Fisheries—Aquaculturists' responsibilities—at the website: www.dpi.qld.gov.au. In other states contact your relevant Primary Industries Department.

The availability of these tests may vary depending on which regional branch of the DPI&F laboratory you submit your prawns to. You are encouraged to contact the laboratory nearest to you to discuss your testing requirements with the duty veterinary pathologist. Table 8.2 lists the current tests that are available for prawns in DPI&F laboratories.

Laboratory fees

To encourage prawn producers to submit samples, DPI&F in Queensland offers a free laboratory testing service for diagnostic samples. Such samples must satisfy the following criteria to qualify for exemption from laboratory fees:

- Samples of sick prawns must be taken from a pond or batch of prawns that show signs of disease or mortality.
- Sufficient history on the case — that is, mortality rate, morbidity rate, any treatments given, dates of occurrence, prawn movements and other relevant information — must be recorded on the submission/history form or communicated to the veterinary fish pathologist or laboratory.
- Samples must not be taken as part of a health testing program, or health certification for translocation.
- Samples must be of suitable quality and quantity (discuss this with the veterinary fish pathologist or laboratory before submitting).

Where samples do not qualify for exemption from fees, scheduled laboratory fees will be charged to the submitter. You are advised to discuss with the fish pathologist or laboratory the estimated laboratory fees chargeable before submitting:

- samples for private or commercial benefit
- samples required for health certification and interstate translocations
- samples in which there is no active disease or mortality current at the time of submission.

Laboratory fees can be expensive, depending on the types and number of tests required as well as the size and number of prawns to be tested. In general, the fees reflect the high costs of providing high standards of quality assurance, technical expertise and reporting associated with each submission in order to provide accurate, relevant and timely health and disease information to the prawn producer.

See the Department of Primary Industries and Fisheries document in Appendix 4: *Guidelines on aquatic animal specimens accepted for testing at QDPI&F veterinary laboratories and service fee exemptions*:

Availability of test reports

Table 8.3 shows the average time farmers can expect to wait for reporting on test results of samples submitted. However, always ensure that that you allow sufficient time for the completion of all required test procedures when submitting samples to the laboratory. Always discuss with the veterinary fish pathologist or laboratory when you

Table 8.3 Laboratory testing sampling and reporting time

Type of test	Number and size of samples	Working days* for results from the date of laboratory receipt
Histology	150 postlarvae 60 postlarvae 5 juveniles, 10 cm length 60 broodstock	5–7 2–3 3–5 5–10
Bacteriology	Haemolymph samples	5–10, depending on type of bacterial isolate detected
Molecular — PCR test	Postlarvae 60–150 Juveniles and broodstock	2–3 2–3
Necropsy	5 juveniles, 10 cm length 60 broodstock	2–3 2–3

*Working days means weekdays and excludes weekends or public holidays.

can expect test reports to be finalised. This will prevent any inconvenience or unexpected delays.

If health certification is required for certain samples, always allow ample time for administrative procedures required to verify the certificates or pathology reports by third party authorities when sending samples to the laboratories.

The laboratory services endeavour to deliver finalised results as soon as possible as long as:

- prior discussion has taken place and arrangements have been made with the veterinary fish pathologist
- good-quality samples are delivered without delay to the laboratory specimen reception.
- all relevant sample information and submitter's contact details are provided to the laboratory at the time of submission.

At a glance

- A range of stress factors can lead to disease and there are some typical indicators of sickness or stress that you may observe.
- If you have prawns in a pond that you suspect are sick, you can use a disease guide to check what stress factors may be causing it and how to deal with the prawn diseases that are known to occur in Australia.
- Health checks and disease testing kits are available for you to check the health of postlarvae and monitor the pond for disease. Regular testing or monitoring for disease during the crop is an important part of maintaining farm biosecurity.

CHAPTER 9

Guide to prawn diseases

Why are my prawns looking sick?

Some diseases of prawns show no clinical signs other than death, which can make it difficult to identify the cause and decide on preventative management through examination of prawns alone. Most diseases or health problems have a number of contributing causes: that is, the prawns succumb to an infection by an opportunist pathogen after becoming weakened by stress from an environmental or other cause. For this reason, you must keep proper records for each pond (as described in Chapter 3), so that you can identify possible causes of stress in the preceding days or weeks. In some cases, even when you have identified the cause, it will be too late for corrective action to prevent significant losses, but you will be forewarned in relation to subsequent crops.

How to use the guide to prawn diseases

The disease guide in this chapter describes observations of some diseases and stress-related prawn health problems, and how to prevent and treat them. You can search by category of clinical signs, and then decide whether they match the identifying clinical signs of some known causes. You can then learn more about possible treatment and prevention of these health problems if they occur on your prawn farm.

Feature	Identifying clinical signs	Causes
Prawns with abnormal body colour or markings (see page 113)	Reddening of the legs and body	Cause 1: GAV-related disease
		Cause 2: Vibriosis
	Black marks or lesions	Cause 1: Healed wound
		Cause 2: Bacterial shell disease
		Cause 3: Black splint disease
	White spots in the cuticle	Cause 1: Non-viral conditions
		Cause 2: Exotic viral disease White Spot Syndrome Virus (WSSV)
	White muscle	Cause 1: White Cotton Disease
		Cause 2: Extreme pond temperatures (heat stress)
	Red midgut	Cause: Haemocytic enteritis (gut infection)
Prawns with abnormal gill colour (see page 119)	Red gills	Cause: Stress
	Black gills	Cause : various
Prawns with deformities or external problems (see page 120)	Tail cramping	Cause : Assumed to be caused by effects of high temperatures and/or salinities
	External fouling	External fouling
	Abnormal appearance	various
	Runts in the crop	Disease (haemocytic enteritis) or genetic growth variation
	Tumours or abnormal growth(s) anywhere on the body	Genetic disease, chemical pollution
Abnormal prawn behaviour (see page 122)	Abnormal swimming, burrowing, congregating	Various water quality problems
	Prawns fail to moult	Various water quality problems
Empty gut (see page 123)	Empty gut, anorexia	various

Australian prawn diseases

Prawns with abnormal body colour or markings

Reddening of the legs and body

Identifting clinical signs

Sick prawns often show red discoloration, usually involving the legs and tail fan (Figure 9.2). In severe cases, the entire body surface, including appendages, is red.

Cause: Reddening of the legs and/or body is associated with a number of diseases (described below) and therefore cannot be used in isolation to identify a disease.

Cause 1: GAV-related disease (virus)

Identifying clinical signs

Prawns affected with GAV-related disease (part of MCMS — see the description in Chapter 8) are typically lethargic or moribund, and congregate at pond edges during the second half of the growout period. Often their bodies and appendages are red, and some appendages, usually antennae or pereiopods, are partially amputated (Figure 9.3).

Treatment

There are no treatments for viral diseases of prawns, including GAV-related disease. Implementation of better management practices, as part of a biosecurity program for the farm, is the best means of reducing the risk of outbreaks. For

Figure 9.1 (right) Black tiger prawn with reddening of the legs

Figure 9.2 (below left) Two healthy black tiger prawns and a third with reddening of the body, appendages and gills

Figure 9.3 (below right) Black tiger prawn with red colour

GAV, these should focus on keeping the viral load in the pond low (see below for information on this) and, as you would be doing anyway, maintaining optimum pond conditions during growout.

Prevention

Recent research in Australia (Munro et al. unpublished) suggests that the risk of GAV-related disease outbreaks in ponds can be significantly reduced by stocking postlarvae with a low prevalence of GAV infection, and maintaining an optimum pond environment (that is, minimising stress to prawns) during growout (see Chapter 8). At present, PCR tests for GAV infection status of postlarvae before stocking are not generally available, and cheaper, simpler tests (ELISA and dipstick) are still under development. Until these tests are commercially available, try to source your postlarvae from broodstock collectors and hatchery operators who use best management practices to minimise the viral load in broodstock (Cowley et al. 1999). This will help minimise the viral load in the postlarvae.

Cause 2: Vibriosis

The term 'vibriosis' refers to infections of prawns caused by species of bacteria within the genus *Vibrio*. In general, *Vibrio* spp. are opportunist pathogens that occur commonly in the pond environment. Their pathogenicity (ability to cause disease) varies between species and even between strains within a species. They are usually associated with disease in prawns stressed for a wide range of reasons. Vibriosis in an individual prawn can be either a localised or systemic (generalised) infection. Systemic vibriosis is often associated with poor environmental conditions or is superimposed on another disease as the prawn's condition deteriorates. For this reason, *Vibrio* spp. can usually be isolated from haemolymph (blood) or internal organs of any terminally ill prawn, regardless of the primary cause of the problem; bacterial culture results from the laboratory therefore need to be interpreted in the context of other laboratory findings and pond history, particularly environmental records.

Identifying clinical signs

Acutely affected prawns with systemic vibriosis can be lethargic and gather at pond edges; in some cases they will be red-coloured. Prawns with localised vibriosis will usually not be red.

Treatment

Treatment of vibriosis requires improving the pond environment to reduce poor water quality conditions and allow natural conditions to prevail. Failure to improve pond conditions will cause the problem to continue and spoil the overall quality of the crop. Improvement in water quality may involve reductions in feed, pond water flushing and more aeration.

Black marks or lesions

Identifying clinical signs

Brown to black marks on the shell of prawns. Legs may be shortened with blackened tips. Parts of appendages, such as antennae or eye stalks, can be absent, again with blackened tips. Erosion of legs and body parts, often starting on tail first. Multiple brown to black shell lesions can develop to a point where

the entire thickness of the shell is eroded. In these prawns underlying muscle, gills and organs (with or without blackening) may be visible. Shows as distinct black marking or edging when prawns are cooked.

Melanin is a black pigment that is produced by the prawn in response to an injury, foreign body or invasion by bacteria or parasites. As melanin is produced, chemicals toxic to bacteria and other micro-organisms are released at that site. Melanin hardens the shell and makes it more impervious.

Cause 1: Healed wound

Any type of damage to the outer layer of the shell allows normal environmental bacteria to proliferate and grow in the damaged shell. One of the common injuries is the black 'scratches' seen on the tail caused by bird capture. Underfeeding will cause prawns to chew the appendages of other prawns. For those prawns that live on the pond bottom, pond bottom fouling will cause erosion and blackening of the tips of the tail, legs and antennae. The erosion of the legs and tail follows exposure to low pH and other toxic chemicals in the anoxic sediment and exposure to bacteria.

Shell necrosis (deep infections) caused by Bacterial Shell Disease (cause 2) may recover and show melanin scarring (persistent blackening) of cuticle.

Treatment

Improve water quality in the pond through water exchange, reduce pond bottom fouling and make sure the prawns are all being fed. The black marks will be lost at the next moult.

Figure 9.4 (top left) Tail rot on a black tiger prawn

Figure 9.5 (top right) Black marks (necrosis) on a black tiger prawn

Figure 9.6 (below left) Black marks (necrosis) on a black tiger prawn

Figure 9.7 (below right) Black marks (necrosis) on a black tiger prawn

Prevention

Manage the ponds to avoid pond bottom fouling. Minimise abrasive injuries to prawns from barnacles or other sharp objects on screens, aerators and walls, or from partial harvesting. Control bird activity that may lead to injuries.

Cause 2: Bacterial shell disease

A more severe form of bacterial disease can occur on the shell of prawns. Some of the bacteria that begin to grow on the damaged outer layer of the shell can produce enzymes that eat away the deeper shell layers. This is more likely if the shell is cracked. Once the haemolymph (blood) begins to leak into the site of shell injury the bacterial growth becomes even more abundant, producing deep, erosive lesions. If the prawn's immune system cannot wall off this proliferation of bacteria, the bacteria can spread internally into the prawn's body to cause multi-site haemocytic granulomas. If pond conditions are not corrected, many prawns may succumb to opportunistic bacterial septicaemia (such as *Vibrio harveyi*) with significant die-offs. Bacterial shell disease is a consequence of very poor pond conditions. It follows high bacterial loads in the water and pond bottom, and poor water quality. This may be a reflection of the stocking density and indicate excessive feeding or previous algal bloom crashes in the pond.

Treatment

No chemical treatment effective. Reduce stocking densities by partial harvesting. Improve water quality and reduce pond bottom fouling.

Prevention

It is important to remove built-up organic waste sediments in the pond between cycles of production. Liming with quicklime (or other disinfecting lime) and effective drying of the pond bottom is important to prevent the build-up of pathogenic bacteria, such as *Vibrio harveyi,* in the pond. Establish a balanced pond environment with desirable algae during pond preparation. Manage the pond to avoid pond bottom fouling. Control feeding rates and water exchange to avoid excessive bloom development and bloom crashes. Do not overfeed the prawns.

Cause 3: Black splint disease

Occasionally a disease is seen where there are internal black lines or large black nodules in the centre of the tail muscles. It is assumed that black splint disease develops from an infection of bacterial shell disease because lesions develop in the shell where adjacent tail segments rub on one another. These become progressively deeper and are not lost at moulting. It seems that the bacteria cannot be controlled and a deep tunnel-like lesion in the tail muscle develops, with proliferating bacteria at the centre surrounded by melanised haemocytes. It has been suggested that low salinities and specific bacteria such as *Vibrio alginolyticus* that proliferate in the lower salinities can cause black splint disease. It is likely that a specific set of pond conditions and any proliferation of bacteria in the pond water can lead to black splint disease. Affected prawns must be removed at processing.

Treatment

No treatment is effective. Remove affected prawns at processing.

Prevention

Follow the principles described above for the other black mark syndromes. Manage the pond to avoid pond bottom fouling. Control feeding rates. Avoid sudden salinity changes.

White spots in the cuticle

Identifying clinical signs

White spots in the cuticle, particularly in the head.

Cause 1: Non-viral conditions

White spots in the cuticle of black tiger prawns, similar to those in WSSV but caused by bacterial infection, have been seen occasionally. Exposure of prawns to high alkalinity has also been associated with formation of white spots unrelated to WSSV or bacterial infection. These non-viral white spot conditions do not cause significant mortalities in affected prawns.

Treatment

Correct alkalinity as necessary; maintain optimum pond conditions. Keep a close watch on the pond; if mortalities continue, contact state authorities.

Prevention

Maintain optimum pond conditions.

Cause 2: Potential for exotic viral disease White Spot Syndrome Virus (WSSV)

See page 125 and Chapter 3. The clinical signs and appearance of prawns affected with WSSV (see below) are often non-specific. Therefore, you should consider any rapidly increasing mortality event in a prawn pond as potentially being due to WSSV.

Treatment

Occurrence of WSSV on an Australian prawn farm would invoke Commonwealth and State government control measures to prevent the spread of the exotic disease.

Prevention

Biosecurity management and control at farm and national level.

WSSV does not occur in Australia but is a severe disease problem in other shrimp-farming countries. You must be vigilant about such diseases and be aware of your responsibilities to report such clinical signs if you happen to observe any (see Chapter 3).

White muscle

Identifying clinical signs

White opaque textured muscle.

Cause 1: White Cotton Disease

Caused by the microsporidian parasite *Agmasoma penaei.*

Treatment

No established, effective treatment. Discard affected stocks. Dry and lime affected ponds.

Figure 9.8
White Cotton Disease in banana prawns

Prevention

This condition is a common disease in wild prawns and has caused a 20 per cent loss in captive wild broodstock. The prevalence reported has been 1–10 per cent in some wild populations. Transmission occurs via spores, which are ingested, and the parasite enters the host by the gut. The parasite multiplies in the muscle. Fish that eat infected prawns may spread the spores in the aquatic environment. There is no current evidence to suggest that the parasite is infectious for humans, but with such a heavy infection of the muscle and muscle damage the prawns would be of a poor quality. These animals are often discarded by processing plants. It is advisable to use inlet and outlet screens to exclude wild prawns and fish from farmed stocks of banana prawns.

Cause 2: Extreme pond temperatures (heat stress)

The muscle is opaque or white with muscle necrosis, may occur with tail cramping (see below) in response to handling during high temperatures and/or salinity.

Treatment

Provide water exchange to reduce temperatures and/or salinities, avoid handling or harvesting at this time.

Prevention

None, wait for cooler temperatures.

Red midgut

Identifying clinical signs

Red colour in midgut. Reduced growth rate and increased variation in sizes in the crop. Stunting of individual prawns, weak prawns in shallows, may have fouling on shell.

Cause: Haemocytic enteritis (gut infection)

Assumed to be caused by prawns eating toxic algae (such as blue-green algae) occurring on the bottom where it can be mixed with the feed; algal toxicity causes damage to the gut lining. Phosphate-rich fertilisers that are used to

start phytoplankton blooms enhance blue-green algae growth, so fertilisers like ammonium nitrate tend to minimise blue-green algal blooms, but allow eukaryotic algae to grow.

Treatment

None.

Prevention

Minimise the growth of blue-green algae species such as *Oscillatoria* spp. by encouraging a micro-algal bloom to shade the bottom (see Chapter 7). Pay particular attention to your feed-monitoring trays and underfeed slightly if possible. Certainly do not overfeed. The preventative pond management procedures described in 'Black gills' will also help reduce the proliferation of blue-green algae on the pond bottom.

Prawns with abnormal gill colour

Healthy prawns regularly groom their gills, but stressed or sick prawns often have abnormally coloured gills.

Red gills

Identifying clinical signs

Pink to red gills.

Cause: Stress

For example, from low dissolved oxygen or high toxin (such as ammonia or hydrogen sulfide) concentrations.

Treatment

Examine pond records; identify and correct any environmental problem. Examine the pond environment, particularly the condition of the pond bottom, and correct as necessary.

Prevention

Maintain optimum pond environment.

Black gills

Identifying clinical signs

Prawn gills clogged with brown to black material, giving a dirty or muddy look. Melanisation of gills produces a blackening discolouration. Check the fouling of gills under a microscope to confirm.

Causes :

Several possible causes include:

- significant organic fouling in the pond bottom or algae die-off
- blue-green algae growing on gill filaments
- infectious damage to the filaments and melanisation
- exposure to iron salts.

As kuruma prawns like to burrow or hide in the pond bottom, they can be more susceptible to black gill disease.

Figure 9.9 Black gills in black tiger prawn

Figure 10 Black gills in juvenile prawn

Treatment

Water exchange to improve water quality. Reduction in feed rates. Adjustment to reduce stocking densities. No chemical treatment effective.

Prevention

Deterioration of the pond environment, unstable algal plankton population and excessive stocking densities are areas of pond management that need improvement so that optimal water quality is maintained for the prawns. The following checklist may be used to improve the pond environment:

1. Check for acid sulfate soil in ponds.
2. If acid sulfate free, drain and clean out the pond bottom by scraping and then liming, otherwise the filamentous algae will tend to regrow. If acid sulfate soils are present, do not scrape the pond — use wet cleaning method to flush bottom well before filling and liming.
3. Seed pond water with phytoplankton from a good pond.
4. Use secchi depth to evaluate and manage the health of algal blooms.
5. Aerate the pond as for high stocking densities (>30 prawns/m^2) for a 1 hectare pond.
6. Lime the ponds.

Prawns with deformities or external problems

Tail cramping

Identifying clinical signs

Prawn tail is cramped up and will not relax, usually after handling, such as cast net sampling. Some may show white muscle from stress (could be same problem as in 'White muscle' above).

Cause

Assumed to be caused by effects of high temperatures and/or salinities when combined with the stress of handling (may not occur without handling).

Treatment

Provide water exchange to reduce temperatures and/or salinities, avoid handling or harvesting at this time.

Figure 9.11 Fouling of barnacles on black tiger prawn

Figure 9.12 Epibiotic fouling including ciliates on black tiger prawn

Prevention

Minimise handling or delay harvesting until the problem is solved.

External fouling

Identifying clinical signs

Commensal organisms such as barnacles, protozoa, worms or algae in the pond attach to the cuticle of the body (or gills, see below), giving the prawn a fuzzy appearance. These organisms live in the pond environment, and will attach to prawns if they fail to groom or moult.

Cause: Failure to groom or moult

Failure to groom or moult indicates illness or stress. Shell fouling is usually associated with high nutrient loads in the water column, a drop in temperature or a heavy biomass (for example, towards the end of a crop). Excessive growth of commensal organisms on the cuticle, such as filamentous blue-green algae, diatoms, and various species of protozoa (*Vorticella, Epistylis* and others).

Treatment

Reduce feeding rates to reduce nutrient loading in ponds. It may be better to conduct an early harvest and treat the product with citric acid before sale (see Chapter 7).

Prevention

Improvement in water quality of the pond by changing or reducing feeds, increasing water exchange and/or aeration, increasing water circulation. Changing pond salinity may help reduce the problem if conducted slowly to minimise stress on prawns.

Abnormal appearance

Abnormal appearance of the head, bent rostrum, tail or appendages can result from disease, trauma, cannibalism or genetic mutation.

Runts in the crop

Identifying clinical signs

Prawns smaller than average crop size.

Figure 9.13 Runt or anorexic black tiger prawn

Cause

Disease (haemocytic enteritis), genetic growth variation. Sometimes a bimodal growth distribution (a larger group of prawns and a smaller group of prawns in the same crop) can occur if prawns have been chronically infected with haemocytic enteritis.

Treatment

None. Submit runt prawns to the laboratory for histological analysis.

Prevention

Ensure when stocking postlarvae that they are of same age and size. Ensure that adequate feed, space and growth conditions are provided (do not overstock ponds). Ensure that ponds do not have blue-green algal blooms, as prawns ingesting blue-green algae have been known to develop a disease of the gut known as haemocytic enteritis (see above).

Prawns with tumours/abnormal growths

Identifying clinical signs

Tumours or abnormal growth(s) anywhere on the body.

Cause

Genetic disease, chemical pollution.

Treatment

None — remove affected prawns, preserve and send to laboratory for histological analysis.

Prevention

None. If multiple prawns in many ponds are affected, then further disease and more extensive water quality investigations including chemical analysis should be considered.

Abnormal prawn behaviour

Identifying clinical signs

Abnormal swimming, burrowing (cool pond water), prawns congregating at edge of pond.

Causes

Extreme pond temperatures (too cool or too hot), heat stress, low dissolved oxygen, sudden drop in pH, high salinity, thick algal bloom, shell or gill fouling, disease.

Treatment

Check all pond water conditions and correct or improve any abnormalities as necessary: lower salinity, reduce thickness of algal bloom by water exchange, increase aeration to improve dissolved oxygen levels, sample prawns at edge of pond for signs of disease and send to laboratory.

Prevention

Constant daily monitoring of prawn behaviour and pond water quality including pond temperature, pH, thickness and type of algal bloom, dissolved oxygen, salinity; regular examination of prawns on feeding trays for abnormal behaviour and signs of disease.

Prawns fail to moult

Identifying clinical signs

Moulted skin still attached or soft shell (for example, dead prawn with a skin hanging off the carcass) or prawn with heavily fouled shell that has not moulted.

Causes

Disease, pollution, stress, shell fouling, poor water quality with low alkalinity or low salinity. Accumulation of sediments and organic matter in the pond can result in shell fouling and failure of prawns to moult.

Treatment

Water exchange can help to stimulate a moult (also refer to A6). Alkalinity can be corrected by adding carbonated lime. Add high-salinity water to increase salinity. Submit a sample of prawns to the laboratory for disease analysis.

Prevention

Ensure good-quality feed and good water quality with adequate oxygen, pH, salinity, alkalinity, a good algal bloom and temperatures all within normal ranges for farmed prawn species. Improve the water quality of the pond by changing or reducing feeding, increase water exchange or aeration, increase water circulation. Changing pond salinity may help reduce the problem if conducted slowly to minimise stress on prawns.

Empty gut

Identifying clinical signs

Empty gut, anorexia.

Cause

Anorexia (not feeding) can be associated with disease, stress, rancid or poor-quality feed, lack of feed, poor water quality.

Treatment

Check and improve pond water conditions. Check prawns for signs of disease and remove some affected prawns, preserve and send to laboratory for disease analysis. Check freshness of feed and look for signs of mould or rancidity. If you suspect feed is mouldy, rancid or of poor quality, change to a fresh batch of feed. Feed can be tested at various laboratories for presence of aflatoxins (substances produced by fungi that grow on mouldy feeds) and rancidity. Contact the laboratory for procedures on how to correctly sample and send feed for various tests.

Prevention

Do not store prawn feeds for over three months in tropical climates (less than one month is preferable). Ensure that feeds are stored in a cool room at 5ºC away from direct sunlight, moisture and humidity to avoid mould or rancidity. Ensure that fresh feeds are purchased regularly so that feed turn-around times are rapid (monthly if possible). Ensure that pond water has adequate oxygen, pH salinity, alkalinity, a good algal bloom and temperatures all within normal ranges for farmed prawn species.

Exotic diseases found in shrimp in other countries

Australia is free of many prawn diseases that occur in other countries. Prawn diseases exotic to Australia include White Spot Disease (WSD), Yellowhead Disease (YHD), Taura Syndrome (TS), and Infectious Hepatopancreas and Haematopoietic Necrosis (IHHN). White Spot Disease alone has resulted in a global economic impact amounting to US$3 billion (McColl et al. 2004). In Australia, there is one YHD-like virus, Gill Associated Virus (GAV) and its senior synonym Lymphoid Organ Virus (LOV) that occurs in the black tiger prawn. This viral strain is native to Australia, and it is similar in genetic structure to the exotic viruses, but is not the exotic virus type. GAV causes mortalities in Australian prawns, but does not cause mass mortalities as does the exotic YHD (see below). A strain of IHHN virus also occurs in Australian black tiger prawns, but again, it does not result in mass mortalities as does the exotic virus.

Remind yourself of the biosecurity issues for your farm in Chapter 4.

It is important that all disease outbreaks that occur on prawn farms are reported to your local state government veterinary authority. This is necessary for several reasons. It is important to determine whether the disease is endemic (native to Australia) or exotic. If an exotic disease is detected, then steps can be taken to control and eradicate the disease, and prevent it from spreading, both within your farm and to other farms. This is necessary to protect the whole prawn-farming industry both within the state and throughout Australia. It is also important to maintain the high value of Australian prawns in export markets. This can only be achieved by vigilant reporting by farmers to the relevant state veterinary laboratory when a disease outbreak occurs.

It is also important that we protect our native prawn fisheries from disease. Exotic diseases could be spread from discarded infected prawn carcasses, prawn waste, infected bait and non-treated infected discharge water from infected prawn ponds, although the risk for each varies according to many factors (Baldock 1999).

White Spot Disease

White Spot Disease has had catastrophic effects on prawn farming industries in many countries including Japan, China, India, Indonesia, Korea, Malaysia, Thailand, Vietnam, USA and South America countries. White Spot Syndrome Virus (WSSV) infects many species of penaeid prawns including the black tiger prawn *Penaeus monodon,* banana prawn *Ferropenaeus merguiensis*, *P. vannamei*, *P. setiferus, P. stylirostris, P. indicus*, *P. chinensis,* kuruma prawn *P. japonicus, P. semisulcatus*, and the freshwater prawn *Macrobrachium rosenbergii*. White Spot Disease also infects other crustaceans such as crabs, lobsters and copepods. These crustaceans can carry the virus and act as vectors for the virus. To avoid similar problems with Australian viruses such as Mid Crop Mortality (see Chapter 3), it would be wise to exclude these crustacean species from your ponds if possible (see Chapter 3).

WSSV causes mass mortalities of mainly juvenile prawns, with up to 90 per cent of prawns dying in two to four days. Rapid fluctuations in pond water quality that may stress prawns, such as a sudden change in water temperature, salinity, alkalinity, pH, or dissolved oxygen levels dropping lower than 2 ppm, can make an outbreak worse.

WSSV can infect and cause disease in all species of prawns farmed in Australia. WSSV outbreaks can occur at any stage of growout and the first signs of a problem can be a sudden, rapid increase in the number of sick and dead prawns at pond edges. Sick prawns will often (but not always) have white, initially circular, spots within the cuticle and/or an overall red body colour.

Identifying clinical signs

Clinical signs of WSD include anorexia, red discoloration of the body and appendages, lethargy, a loose cuticle with white spots on the inside of the carapace, and rapid deaths. WSD is transmitted from infected adult broodstock to postlarvae at spawning, or in adult prawns by cannibalism of infected prawn

Figure 9.14 White spots on prawn carapace

carcasses. Farmed prawns can contract WSD from feed that is contaminated with the virus, or by cohabitation with other crustaceans that carry the virus, such as crabs or copepods. The disease is diagnosed by histology, molecular methods (PCR), electron microscopy, and in-situ hybridisation tests (OIE 2005).

Cause

White Spot Disease is a viral disease of prawns caused by a Whispovirus.

Treatment

There is no cure or treatment for WSD. Occurrence of WSD on an Australian prawn farm would invoke Commonwealth and State government control measures to prevent the spread of the exotic disease.

Prevention

It is important for Australian prawn farmers to know that WSD does not occur in Australia and that importation of broodstock from other countries is not allowed under Commonwealth regulations.

Remember the need to manage ponds for stable water quality conditions to minimise stress — slow incremental water exchanges are better than rapid or large exchanges.

In countries where WSD is known to occur, the disease can be prevented by screening all broodstock with diagnostic tests for WSSV to ensure that they are free of the virus. If an outbreak occurs, it is necessary to disinfect all infected equipment and water that has been in contact with infected prawns. Do not give fresh feed of aquatic animal origin (such as fresh imported prawns or other crustaceans) to farmed prawns, as this can transfer the virus to them. Viable White Spot Syndrome Virus has been found in frozen prawn products imported into Australia for human consumption from south-east Asia (McColl et al. 2004).

Yellowhead Disease

Yellowhead Disease (YHD) is a viral disease of prawns that attacks the blood cells (haemocytes), blood-forming organs (haematopoietic organs), gills, muscles and internal organs, causing widespread cell death. YHD occurs in China, India, Thailand and the Philippines and in Texas, USA. YHD is exotic to Australia, but has the potential to affect black tiger prawns and banana prawns. YHD has also been shown in laboratory experiments to affect other prawn species including the red endeavour prawn *Metapenaeus ensis* (Herfort and Rawlin 1999). YHD is transmitted from prawn to prawn, and survivors of an outbreak may carry the virus. Several crustaceans are suspected of transmitting the virus to farmed prawns, including the brackish water shrimp *Acetes* sp. and *Palaemon styliferus* (Bondad-Reantaso et al. 2001). Environmental factors associated with outbreaks include rapid pH change and prolonged periods of low dissolved oxygen (<2 ppm).

YHD causes mass mortalities, with up to 100 per cent mortalities in three to five days from the time clinical signs are first noticed. YHD most commonly affects postlarvae from 20 days old to subadult prawns.

Identifying clinical signs

Clinical signs include a yellow head (from a swollen hepatopancreas), yellow, pink or brown gills, and a pale body. However, these signs are not always present in diseased prawns.

Figure 9.15 Yellow head and gills in black tiger prawn

Figure 9.16 Yellow head clinical signs in black tiger prawn

Affected prawns feed at an unusually higher rate than normal for several days then cease feeding altogether. Infected prawns aggregate at the edge of the pond or at the surface (Bondad-Reantaso et al. 2001). Factors associated with disease outbreaks include high stocking densities in ponds and poor water quality. The disease can be diagnosed by clinical pathology (haemocyte and gill smears), histology, molecular tests (PCR) and transmission electron microscopy (OIE 2005).

Cause

Yellowhead Disease is a viral disease of prawns caused by an Okavirus of the family Nidovirales.

Treatment

There is no treatment or cure for the disease. Prevention is by screening all broodstock with diagnostic tests for YHD to ensure that they are free of the virus, and not importing broodstock from areas where YHD is known to occur. Postlarvae can be screened before stocking. Pond water quality should be optimal at all times to avoid triggering an outbreak. Should an outbreak occur, seek veterinary advice immediately. Do not feed fresh feed of aquatic animal origin (especially crustaceans) to farmed prawns, as this can transfer the yellowhead virus to them. Viable yellowhead virus has been found present in frozen prawn products imported into Australia for human consumption from south-east Asia (McColl et al. 2004).

YHD outbreaks are controlled by eradication of all infected stock and any potential carriers. This is necessary to control the virus and prevent it from spreading to other ponds, to other farms and to wild prawns. This includes chlorination of ponds to destroy all infected stock, disinfection of all equipment and water in contact with infected prawns, and burial or incineration of infected stock. Infected water is chlorinated and held for four days before discharge. It is also necessary to disinfect farmers' footwear, hands, clothing and vehicle tyres, and any equipment that has come into contact with contaminated prawns to prevent spread of the disease.

Infectious Hypodermal and Haematopoietic Necrosis

The virus which causes Infectious Hypodermal and Haematopoietic Necrosis (IHHN) infects many species of prawns including *Penaeus monodon, P. japonicus, P. stylirostris, P. vannamei, P. semisulcatus, P. occidentalis* and *P. californiensis* but is not known to infect other crustaceans. IHHN has been reported in Central and South America, India, Indonesia, China, Taiwan, Thailand, Malaysia, Philippines, Hawaii, Guam, French Polynesia, New Caledonia and Israel (Bondad-Reantaso et al. 2001) but has not been reported in Australia.

Identifying clinical signs

Penaeus stylirostris with acute IHHN show mass mortalities, with up to 90 per cent death rate. Juveniles are most affected. Adults can carry the disease without showing signs of infection. Clinical signs include reduced feeding, blue body colour and opaque abdomen, and habit of slowly rising to the surface of the water, motionless, then rolling over and sinking. White or cream spots can develop on the tissue directly beneath the cuticle of the carapace, resulting in a mottled appearance (Bondad-Reantaso et al. 2001). *Penaeus vannamei* juveniles with chronic IHHN show 'runt deformity syndrome' (RDS). There is a wide range of sizes, with many smaller or 'runted' prawns in the population. Prawns have bent or deformed rostrums, rough cuticle, wrinkled antennal flagella and other cuticular deformities. Diagnosis is by histology, molecular tests (PCR), and in-situ hybridisation tests and transmission electron microscopy (OIE 2005). *Penaeus monodon* infected with the IHHN virus typically show no abnormalities.

Cause

IHHN is a viral disease of prawns caused by a parvovirus. The virus infects the cells lining the gut, the nerve tracts, blood-forming organs, gills, gonad and other internal organs. The disease is transmitted from broodstock to offspring at spawning, or from infected carriers that have survived an outbreak to native prawns.

Treatment

There is no treatment or cure for this disease. Occurrence of IHHN on an Australian prawn farm would invoke Commonwealth and State government control measures to prevent the spread of the exotic disease.

Taura Syndrome

Taura Syndrome is a viral disease of prawns caused by a picornavirus. The Taura Syndrome Virus attacks the cells of the gills, gut, legs, tail, muscle, oesophagus and stomach, resulting in cell death. There is little host response to the disease. The disease has occurred in many countries of South America and south-eastern states of America, Hawaii, Taiwan and China. The disease affects many species of penaeid prawns, particularly *P. vannamei*, but also *P. stylirostris* and *P. setiferus*. Other species shown to be infected in laboratory experiments include *P. monodon*, *P. japonicus*, *P. chinensis* and *P. duorarum*. Of the species in Australia, *P. monodon* and *P. japonicus* are susceptible to infection and may show signs of disease.

Clinical signs

In the acute stage of this disease, juvenile *P. vannamei* (not farmed in Australia) often have pale red bodies and tail fan. Although *P. monodon* and *P. japonicus* have been experimentally infected there is no information about the clinical signs that might be seen in pond outbreaks.

Postlarvae stocked within 14 to 40 days in ponds or tanks are most affected. There are three stages to the disease: an acute stage, a transition stage and a chronic carrier stage. In *P. vannamei* most mortalities (40–90 per cent) occur in the acute stage. Survivors pass into a transition period and then become chronic carriers (that is, they carry the disease but show no clinical signs of it). Clinical signs in the acute stage include lethargy, a pale red body (especially the tail fan), soft shell, empty gut and death on moulting. Clinical signs in the transition stage include randomly placed small black lesions on the cuticle on the head and body. In this stage prawns may or may not show anorexia, soft shell and red discoloration (Bondad-Reantaso et al. 2001).

The disease is transmitted horizontally (from prawn to prawn) by cannibalism, or from survivors of Taura Syndrome outbreaks (subclinical carriers), aquatic insects and seabirds and by feeding infected frozen shrimp products. The disease can also be spread vertically from infected broodstock to offspring.

Diagnosis of the disease is by histopathology, bioassay, transmission electron microscopy, molecular methods (PCR) and immunology methods (OIE 2005).

Treatment

Control is by eradication of all infected stock and disinfection of the hatchery or farm. Occurrence of Taura Syndrome on an Australian prawn farm would invoke Commonwealth and State government control measures to prevent the spread of the exotic disease.

At a glance

- Understanding the known common diseases of prawns occurring in Australia and the various reasons they may occur (for example, stress caused by poor water quality) is an important part of the knowledge required for managing a prawn farm.
- It is also important to know about the significant exotic diseases that occur in most other shrimp-farming countries around the world (but are not found in Australia), because of the potential threat to your farm and the Australian industry.

Appendix 1

Planning for profit

The development of economic decision tools, namely the PrawnProfit series developed by DPI&F, has gone a long way towards enabling users to assess the economic viability of various operations before a sod is turned. In generic terms, these models will aid decisions by farmers and investors in terms of:

- assessing the real costs associated with production
- providing tools to assess the effects on business profitability of decision making, various management options, alternative farming methods, and changes in operational costs
- developing risk profiles around price and yield fluctuations.

The income, expenditure and investment levels for a prawn farm will vary according to the size of the site, production target, capital expenditure and many other factors. Once a conceptual design and business structure have been developed in the PrawnProfit model for a particular prawn-farming situation (so that data can be used in the models and various scenarios tested) it will allow comparisons and decisions to be made regarding available alternatives.

As it is not possible to encompass all possible price and product permutations in this manual, an analytical tool such as the PrawnProfit model should be used to develop relevant profiles of different situations. PrawnProfit is a complete information package for prawn farmers and potential investors. It includes a comprehensive risk analysis section. The CD also contains other reference material and a comprehensive list of contacts for government agencies and the Australian Prawn Farmers Association (APFA).

Marketing issues

Farmers often make the mistake of devoting all their energies to producing a product then sitting back and hoping for the best when the time comes to sell it. Another common mistake is to grow what *they* want, but not necessarily what the market wants or needs. The Australian and international markets for prawns have changed significantly in the period 2003–06 with the major increases in production and export of *Penaeus vannamei* shrimp farmed in Asian countries (mostly China, Indonesia and Thailand). Costs of production are significantly lower in those countries and the product is imported into Australia with heavy discounts on the wholesale and retail markets. Australian prawn farmers need to find ways to maintain competitiveness and adopt niche or specialised marketing strategies to maintain profitability in such a new market situation.

Contact the National Food Industry Strategy for further information about seafood marketing: www.nfis.com.au.

Australian producers need to be very strategic in their approach to marketing, particularly in light of the fact that they are often not price-competitive due to factors such as their competitors being subsidised. Unless farmers position

themselves in niche markets, they will be caught in the commodity trap. First, they must identify their point of difference — is it quality, traceability, or safe or environmentally friendly production systems? Second, they must identify the markets that are prepared to pay a premium for those attributes. Concurrently, they should examine the supply chain and look for greater opportunities to collaborate with those who handle, distribute, pack and sell their product. This collaborative approach enables everyone in the chain to develop a focused approach to maintaining and expanding the business.

What is PrawnProfit?

PrawnProfit is a complete information package for prawn farmers and potential investors. The CD also contains other reference material and a comprehensive list of contacts in government agencies and the Australian Prawn Farmers Association. In conjunction with the reference material, a farm model is provided to allow potential farmers to evaluate the economics of prawn farming, using their own input parameters, before any construction occurs.

The model is based on the cost-benefit analysis technique. Cost-benefit analysis is a conceptual framework for the economic evaluation of projects, in this case, prawn aquaculture projects. This approach differs from financial appraisal in that it considers all gains and losses. The basic purpose of cost-benefit analysis is to help farmers make decisions in regard to the allocation of resources. In particular, PrawnProfit helps farmers decide whether or not to invest in prawn aquaculture.

Existing farmers can also use PrawnProfit. After entering the data into the model a farmer can use the computer version of his farm to determine the impact of different management decisions. For example, the farmer may wish to know how a change in food conversion ratio (FCR) will affect his feed cost.

Food Conversion Ratio = weight of feed used to grow a crop of prawns/ weight of prawns harvested

FCR = feed used (kg)

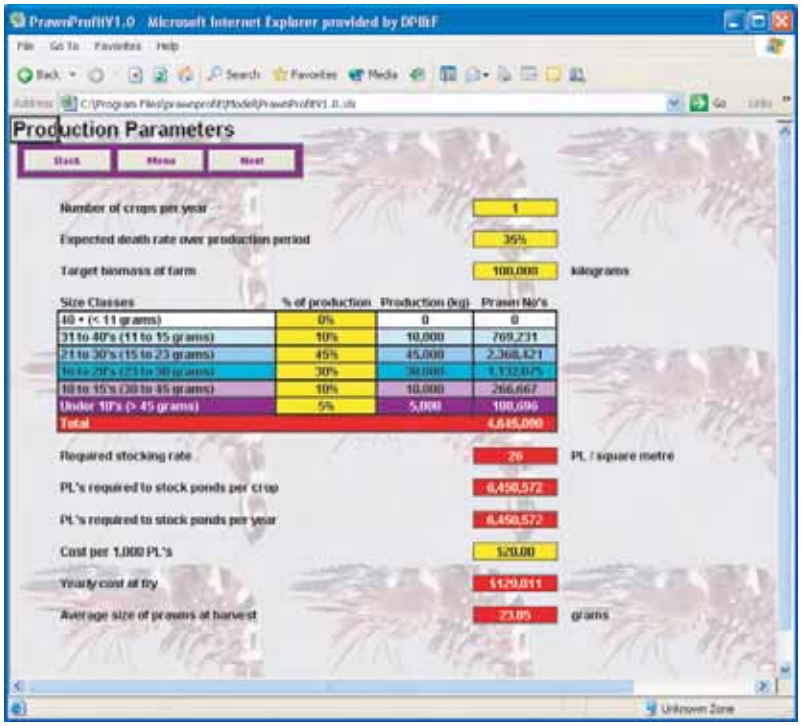
prawns harvested (kg)

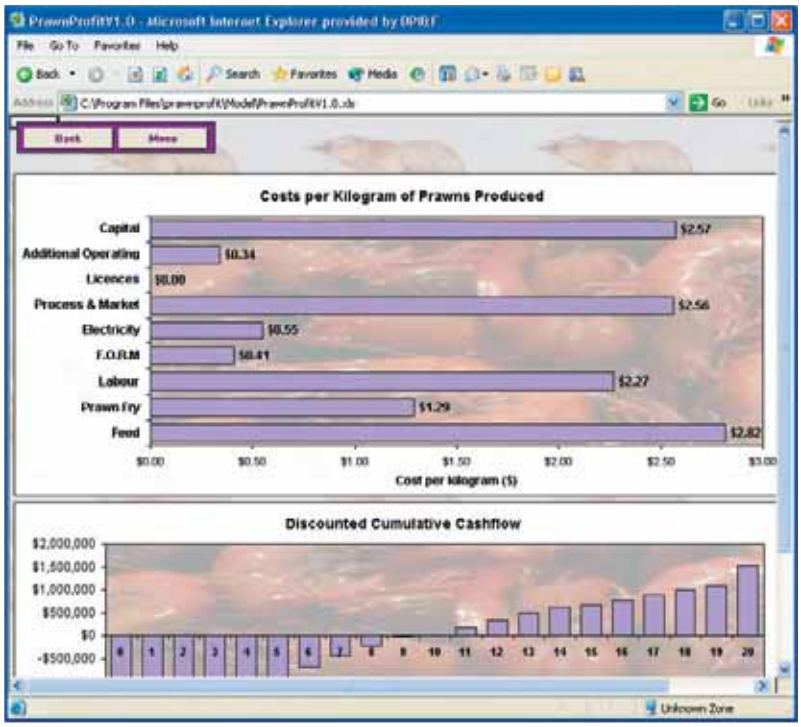
Note: Pellet feed is a dry feed and this FCR calculation does not account for the difference in wet weight of prawns and the dry weight of the feed.

The model is easy to operate and it is better to be as accurate as possible with data entry in order to get the best possible results. It is simply a matter of entering data into the input cells of the different sections:

1. The physical description of the farm — general property description, dimensions and water requirements for the ponds etc.
2. On-farm production scenario, including method of farming, stocking density, survival rates etc.
3. Feeding: food conversion ratio (FCR) and the price of feed
4. Marketing of the product, including processing, packaging and freight — methods you wish to use in marketing your prawns, choice of different processing methods
5. Labour requirements for the farm operation — there are categories for casual labour and permanent labour
6. Additional operating expenses — include fuel, oil, repairs, maintenance and insurances and the remainder of the operating expenses for the farm

Example pages of PrawnProfit showing graphed results





7. Revenue — the price you expect for your product
8. The capital expenditure section provides for the summary of the capital required to establish the farm and allows you to allocate future revenues to the replacement of capital items.

After entering all the data you can view the summary statistics for the farm. All the statistics used are explained in the model itself. Basically, the farm is run

over a 20-year period. The output includes the expected annual returns, when the farm is paid off and the interest rate at which you can borrow funds to invest in the project. The summary statistics will also provide a breakdown of costs on a per kilogram basis.

Risk and uncertainty are features of most business and government activities; in prawn farming they need to be understood in the context of aquaculture technology and the Australian seafood market to ensure rational investment decisions. PrawnProfit includes a comprehensive risk analysis section. The process involves:

1. *Defining your model* — modelling business operations
2. *Defining uncertain variables* — price and yield
3. *Assigning probability distributions for each of the uncertain variables* — allocating probabilities to categories of minimum, poor, average, good and maximum
4. *Running the simulation and analysing the results*.

The models are set up in Microsoft Excel as a spreadsheet. All the sheets contained in the model are labelled for easy reference and there are buttons in the menu for easy movement between sections. If you have any further queries regarding the operation of the program contact your local aquaculture extension officer, or the Department of Primary Industries and Fisheries, Queensland.

Useful websites

www.ausindustry.gov.au

www.frdc.com.au

www.austrade.gov.au

www.apfa.com.au

www.australian-aquacultureportal.com/

www.seafood.net.au

Engaging with government — assistance and information

Australian prawn farming has had a strong collaboration with government during its development into a sustainable and viable industry. This includes a level of funding for research and development in areas such as genetics work that would be difficult for industry to achieve by itself but that is critical to its long-term sustainability. Individual farmers can also collaborate with a range of research agencies to trial new innovative technologies. Contact the Fisheries Research & Development Corporation and AusIndustry for more information.

Assistance with innovation in all areas of the business, from husbandry aspects through to environmental management systems, is also available. In Queensland contact the Sustainable Industries Program in the Environmental Protection Agency, the Commonwealth Government Department Austrade for the EMS rebate scheme and Seafood Services Australia for EMS training and farm management plans. The National Aquaculture Council (NAC) is the peak body representing the aquaculture industry across Australia and manages the Aquaculture portal website, which is an informative site with access to many other agency websites that can assist you in formulating information and ideas for an aquaculture venture. The various State agencies supporting aquaculture also have informative websites that you can use to gather information on prawn farming (see below).

Another way to engage with government is to get involved in industry forums that help the government shape future policy and legislation. You can join the Australian Prawn Farmers Association (APFA) and gain direct access

State	Department	Contact	Web
Queensland	Department of State Development, Trade and Innovation	Email to: aquaculture@sdi.gov.au or telephone Regional State Development Centres (phone numbers available on the website)	www.sdi.qld.gov.au/aquaculture
New South Wales	NSW Department of Primary Industries	Port Stephens Fisheries Centre 02 4982 1232	www.dpi.nsw.gov.au (link to Fishing and Aquaculture)
Northern Territory	Department of Primary Industries and Fisheries	Aquaculture Development Officer 08 8999 2144	www.fisheries.nt.gov.au
Western Australia	Department of Fisheries	Pearling and Aquaculture Program 08 9482 7333	www.fish.wa.gov.au

to industry issues.For exporters, there are myriad assistance programs that range from market development to assistance in-market on issues such as trade barriers and quarantine matters. Contact AusTrade for further information.

An industry fully engaged with government lays the foundation for its long-term survival and health.

Licences and permits for setting up a prawn farm

The approvals process for establishing a new prawn farm can be very lengthy and expensive, depending on the scale and location of the project. A typical new prawn farm in Queensland requires a Development Approval that may include authorities to conduct commercial aquaculture, discharge water, remove or maintain mangroves and undertake other environmental activities. If you want to establish a prawn farming venture of any significant size you will have to apply to local, State and Commonwealth governments and may need a consultant to assist in environmental impact assessments, farm design and lodgement of applications.

See the pre-planning guide for aquaculture development approvals in this appendix. It is also available online at www.sdi.qld.gov.au: visit Key Industries/ Aquaculture.

In Queensland, aquaculture developments are managed by the Department of State Development and Innovation, and regional officers will assist you in developing your proposal and coordinating a whole-of-government process for a Development Approval application.

It is also important to consider environmental management in your planning for a new prawn farm. The Australian industry has committed to an appropriate self-managed Code of Practice that ensures the continued sustainability of the industry. It is vital to incorporate the features of the Code in your design and operation to reduce your licensing and compliance costs.

Establishing your prawn farm in Queensland

When you consider taking up prawn farming you (or your consultant) will benefit from contacting various government departments:

Department of Primary Industries and Fisheries (DPI&F) can assist you with ideas about what type of prawns you might best grow and the best place to locate a farm. PrawnProfit, an economic decision tool that can be obtained from DPI&F, will help you establish your expected income.

DPI&F extension services are available to assist you once you have your business established. These services provide production advice and a wide range of information associated with farm management and export opportunities. This information is available through the DPI&F Call Centre on 132523.

The Environmental Code of Practice for Australian Prawn Farmers is available from the Australian Prawn Farmers Association website: www.apfa.com.au.

DPI&F has prawn-farming research facilities in south-east and north Queensland. In addition to these facilities there are opportunities for prawn farmers to work with DPI&F and other agencies in collaborative on-farm research projects. If you have an idea for potential collaborative research contact the DPI&F Call Centre on 132523.

Department of State Development and Innovation (DSD&I) has produced a 'Pre-planning guide for aquaculture' (Table 1). This guide details the planning processes you will need to go through and covers the regulatory applications and how to lodge them.

Project facilitation for aquaculture developments: DSD&I's client management system provides a single coordination point for investors to deal with all government agencies. If you have a good project idea, contact the Department of State Development and Innovation: aquaculture@sdi.qld.gov.au.

Aquaculture land classification system: This service identifies coastal land suitable for medium- to large-scale marine aquaculture using pond systems and can assist in site surveys and selection. For further information contact the Project Manager at aquaculture@sdi.qld.gov.au.

Business development programs: This service provides a range of assistance to small business start-ups including business licensing information, business readiness diagnosis, government support and advice. Ongoing skills development is available for business owners and small business start-ups through a range of seminars, workshops and one-on-one advisory service. The Department also offers manufacturing related programs such as:

- Eco-efficiency
- Product and process improvement
- Export mentoring and management.

Financial assistance may be available under the Department's various grant schemes.

Table 1 Pre-planning guide for aquaculture developments in Queensland
(from Queensland Department of State Development & Innovation)

Stage 1 Aquaculture business decision	→	Species Economic size of operation Production system Water quality and quantity Translocation issues	→	**Initial enquiry** Department of Primary Industries and Fisheries
↓				
Stage 2 Regional and broadscale site constraints	→	National and regional plans and policies that will determine the compatibility of the proposed project plan with the statutory and strategic planning for the state. Considerations include: • statutory planning, e.g. planning scheme, national parks, marine parks, fish habitat areas, Ramsar wetlands, and • government policies, e.g. environmental values and water quality objectives. Investigations need to consider plans and policies in preparation that may affect the application at time of lodgement.	→	**Multi-agency information** State Development and Innovation Access to spatial tools and coordination of information requirements from: • Local Government • Natural Resources and Mines • Queensland Fisheries Service • Environmental Protection Agency • Environment and Heritage (Cwlth) • Great Barrier Reef Marine Park Authority
↓				
Stage 3 Site-specific characteristics and constraints	→	A comprehensive description of the proposed activity should be prepared. This will ensure that government can provide details on assessment level and information requirements for assessment of the development.	→	**Preparation for whole-of-government meeting** State Development and Innovation implement client management system, coordinate and facilitate whole-of-government meetings
↓				

Stage 4 Business, technical issues and preliminary advice on community Issues	➔	Business planning and feasibility studies Community attitudes — historical perspective on community attitudes	➔	**Local information** Local Government (Local Council Planning Officer and/or economic development officer) State Development and Innovation Centre (Aquaculture Contact Officer)
➔				
Stage 5 Detailed site investigation, project development and planning	➔	A comprehensive description of the proposed activity and surrounding environment needs to be prepared. The amount of detail required will vary depending on the scale and type of aquaculture system proposed. Specific details on the information required by government will be provided at the whole-of-government meeting (Stage 3) (see Guidelines for Preparing for a Whole of Government Meeting). Community consultation — in addition to statutory public notification requirements (Stage 7) it is recommended that community consultation be undertaken.	➔	**Addressing information requirements of agencies for licensing** State Development and Innovation to facilitate additional whole-of-government meetings as required. State Development and Innovation can provide guidance on communication strategies
➔				
Stage 6 Lodge application	➔	Provision of above studies and outcomes of consultation program including mitigation options	➔	**Information stage** Agencies review applications and request additional information (if necessary)
➔				
Stage 7 Post lodgement	➔	Public notification (if required) Provision of additional information (if required)	➔	**Assessment stage** Whole-of-government meeting if required.
➔				
Stage 8 Decision	➔	Decision & client notification	➔	**Decision stage** (by Assessment Manager)
➔				
Stage 9 Post decision dealings	➔	Review or amendment	➔	**Review or amendment** Meet with relevant approval agency.

Appendix 2

Queensland Government
Department of Primary Industries

DPI Notes

Water quality in Aquaculture

Prepared by staff of Animal and Plant Health Services at Oonoonba Veterinary Laboratory with assistance from Fisheries and Aquaculture staff at Bundaberg, Bjelke Peterson Research Station, Bribie Island Aquaculture Centre, Northern Fisheries Centre and the Freshwater Fisheries and Aquaculture Centre, QDPI.

Introduction

A crucial requirement for successful aquaculture is the management of water quality. "Water quality" is a general term referring to a number of physical and chemical parameters of water that affect the growth and health of cultured animals. Aquaculturists can achieve maximum productivity from a system by managing water quality parameters within optimal ranges for the cultured species. Water of sub-optimal quality can lead to the death of cultured species or reduce productivity by reduced feeding, decreased growth, suppressed gonad development, reducing spawning quality or quantity and increased susceptibility to disease. This DPI Note gives specific recommendations for water quality parameters for species cultured in Queensland aquaculture industries.

Water quality parameters

Water quality parameters that are known to be important in the health of aquatic animals are temperature, dissolved oxygen, pH, salinity, ammonia, nitrate, nitrite, hardness, alkalinity, turbidity and the levels of toxic agents such as heavy metals, herbicides and pesticides. For the maintenance of good health and growth rate, the generally accepted ranges of the critical water quality parameters are provided below.

Water Parameter	Recommended Range		Water Parameter	Recommended Range
	Freshwater	Marine		General Aquatic
Dissolved Oxygen	>4 mg/L	> 4 mg/L	**Arsenic**	<2 mg/L
Temperature (°C)	21 - 32	24 - 33	**Cadmium**	<0.003 mg/l
pH	6.8 - 9.5	7.0 - 9.0	**Chlorine**	<0.003 mg/L
Ammonia (Total)	<1.0 mg/L	<1.0 mg/L	**Chromium**	<0.1 mg/L
Ammonia (NH_3, unionised form)	<0.1 mg/L	<0.1 mg/L	**Nickel**	<0.01 mg/L in soft water. <0.04 mg/L in hard water
Nitrate (NO_3)	1 - 100 mg/L	1 - 100 mg/L	**Cyanide**	<0.005 mg/L
Nitrite (NO_2)	<0.1 mg/L	<1.0 mg/L	**Iron**	<0.5 mg/L
Salinity	0 - 5 ppt	15 - 35 ppt	**Lead**	<0.03 mg/L
Hardness ($CaCO_3$)	20 - 450 mg/L		**Manganese**	< 0.01 mg/L
Alkalinity ($CaCO_3$)	20 - 400 mg/L	50 - 200 mg/L	**Mercury**	<0.00005 mg/L
Turbidity (secchi)	<80 cm	25 - 40 cm	**Copper**	<0.006 mg/L in soft water
Calcium / Magnesium	10 - 160 mg/L		**Tin**	<0.001 mg/L
Hydrogen sulphide	<0.002 mg/L			

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The culturist should be aware that all of the levels recommended in this article, except for salinity bath, refer to long term exposure levels. Salinity baths are often used for short periods to treat parasitic infestation and the levels expressed indicate how high a salinity certain freshwater species can tolerate. Short term variation of water quality outside the recommended levels may not affect survival but should prompt the culturist to undertake some form of water quality adjustment. Particular species will have a smaller range within the generally recommended values that allows optimal health and production.

Water quality parameters for Freshwater species

The major freshwater fish species cultured in Queensland is the barramundi, *Lates calcarifer*. Other fish species cultured include eels, *Anguilla reinhardtii* and *A.australis*, silver perch, *Bidyanus bidyanus*, jade perch, *Scortum barcoo* and sleepy cod *Oxyeleotris lineolatus*. The culture of freshwater crustaceans is limited mainly to redclaw crayfish, *Cherax quadricarinatus*. The table below lists the recommended levels of water quality parameters for optimal growth of particular freshwater culture species. In some cases no species-specific information is available and culturists should refer to the general recommendations presented in the previous table. The larval stage of barramundi culture requires saltwater and information for barramundi larvae is provided in the marine species section.

Water Parameter	Barramundi	Eel	Silver Perch	Jade Perch	Sleepy Cod	Redclaw
Dissolved Oxygen	4 - 9 mg/L	>4 mg/L	>4 mg/L	>4 mg/L	>4 mg/L	>4 mg/L
Temperature (°C)	26 - 32	23 - 28	23 - 28	23 - 32	22 - 31	23 - 32
pH	7.5 - 8.5	7.0 - 8.5	6.5 - 9.0	6.5 - 9.0	7.0 - 8.5	7.0 - 8.5
Ammonia (TAN)		<1.0 mg/L			<1.0 mg/L	<1.0 mg/L
Ammonia (NH_3, unionized form)*pH dependant.	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.05 mg/L
Nitrate (NO_3)	<50 mg/L		< 100 mg/L			
Nitrite (NO_2)	<1.5 mg/L	<1.0 mg/L	< 0.5 mg/L		<1.0 mg/L	<1.0 mg/L
Salinity (extended periods)	0 - 35 ppt	0 - 35 ppt	<5 ppt	<5 ppt		<4 ppt
Salinity bath	0 - 35 ppt (may use hyper-saline for short periods)	0 - 35 ppt (may use hyper-saline for short periods)	5 - 10 ppt for 1 hour	5 - 20 ppt for 1 hour	max. 20 ppt for 1 hour	5 - 20 ppt for 1 hour
Hardness ($CaCO_3$)	>50 mg/L	>50 mg/L	>50 mg/L	>50 mg/L	>40 mg/L	>50 - 500 mg/L
Alkalinity ($CaCO_3$)	>50 mg/L	>50 mg/L	100 - 400 ppm	50 - 400 ppm	>40 mg/L	>50 - 500 mg/L
Turbidity (secchi)	30 - 70 cm	30 - 70 cm	30 - 70 cm	30 - 70 cm	30 - 70 cm	30 - 70 cm
Chlorine (Palin test)	<0.04 mg/L				<0.04 mg/L	
Hydrogen sulphide	0 - 0.3 mg/L				0 - 0.3 mg/L	
Iron	<0.1 mg/L		<0.5 mg/L	<0.5 mg/L	<0.1 mg/L	<0.1 mg/L
Spawning Temperature (°C)	Marine	NA	23 - 28	23 - 28	>24 for more than 3 days	23 - 28
NA= Not Applicable ppt=Parts per thousand ppm=Parts per million max=Maximum <=Less than >=Greater than						

Water quality parameters for Marine species

The predominant marine fish species cultured in Queensland is the barramundi, *Lates calcarifer*. The water quality parameters recommended for barramundi are presently applied to experimental marine reef fish culture including mangrove jack, *Lutjanus argentimaculatus,* barramundi cod, *Cromileptes altivelis*, flowery cod, *Epinephelus fuscoguttatus* and goldspot cod, *E.coioides*. The predominant marine crustacean cultured is the black tiger prawn, *Penaeus monodon*, however other species including the brown tiger prawn, *P.esculentus*, banana prawns, *P.merguiensis* and kuruma prawns, *P.japonicus* are also cultured. There is limited information about the requirements of mud crabs and rock lobsters. The table below provides water quality information specifically for marine species of significance in Queensland aquaculture. In some cases species specific recommendations are not available and culturists should refer to the general recommendations presented in the table on page 1.

Water Parameter	Barramundi		Black Tiger Prawn		Kuruma Prawn
	Hatchery	Grow out	Hatchery	Grow out	Grow out
Dissolved Oxygen	>6.5 mg/L	> 4.0 mg/L	> 4.0 mg/L	> 3.5 mg/L	> 4.0 mg/L
Temperature (°C)	28-30 (optimum) 25-31 (range)	28-30 (optimum)	28-30	26 - 32 (optimum) 15 - 36 (range)	24
pH	8	8	8	7.0 - 9.0	7.0 - 9.0
Ammonia (TAN)		0.1 – 0.5 mg/L	<0.25 mg/L	<1.0 mg/L	<0.5 mg/L
Ammonia (NH_3, Unionized Form)	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.1 mg/L
Nitrate (NO_3)	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L	<1.0 mg/L
Nitrite (NO_2)	<0.2 mg/L	<20 mg/L	<0.2 mg/L	<0.2 mg/L	<0.2 mg/L
Salinity	28 - 31 ppt	0 - 35 ppt	28-32 ppt	10 - 25 ppt	30 - 35 ppt
Alkalinity ($CaCO_3$)		105 - 125 mg/L		50 - 200 mg/L	50 - 200 mg/L
Turbidity (secchi)				30 - 40 cm	30 - 40 cm
Hydrogen sulphide		<0.3 mg/L			
Iron		<0.02 mg/L		<1.0 mg/L	<1.0 mg/L
Spawning Temperature (°C)	NA	28-32 *strain dependant	NA	27 - 32	28-30
NA= Not Applicable ppt=Parts per thousand ppm=Parts per million max=Maximum <=Less than >=Greater than					

Contact the DPI Notes Coordinator (Allen Hibberd, 07 3824 9515) for the Agdex Number (in header at top of page 1) and File Number.

Further information

DPI Aquaculture and Fisheries Extension staff provide free information to culturists regarding water quality. For the contact details of an Extension Officer in your region please contact the DPI Call Centre on 132523. Alternately contact information for Extension Staff can be found on the DPI web site www.dpi.qld.gov.au/fishweb/ choose the **Aquaculture** link and then the **Aquaculture contacts** link . ■

Appendix 3

Feed Tables

(modified from CP Group, Thailand)

Table 1 Feeding program for first 30 days in intensive prawn ponds in tropical regions (summer growing conditions)

Days	Average body weight (g)	Quantity of feed/day per 100 000 prawns	Feed size
1	0.01	2 kg	0.5–1 mm Crumble
2–10	0.01–0.8	300 g/day increase	0.5–1 mm & 1–1.5 mm Crumble
11–20	1.0–1.5	400 g/day increase	1–1.5 mm Crumble
22–30	1.5–3.0	500 g/day increase	1.5 2 mm Crumble

Table 2 Feeding program for first 50 days in subtropical regions (average daytime temp <28°C)

Days	Average body weight (g)	Quantity of feed/day per 100 000 prawns	Feed size
1–5	0.01–0.02	1 kg	0.5–1 mm Crumble
6–15	0.02–0.12	100 g/day increase	0.5–1 mm Crumble
16–25	0.12–0.35	200 g/day increase	0.5–1 mm & 1–1.5 mm Crumble
26–35	0.35–0.7	300 g/day increase	1–1.5 mm Crumble
36–45	0.7–1.4	400 g/day increase	1–1.5 mm & 1.5–2mm Crumble
46–50	1.4–2.0	500 g/day increase	1.5–2mm Crumble

Table 3 Feeding program for intensive ponds in tropical regions from 30 days (>2–3 g) to 150 days. Note: From 1 to 40 days feed 4 times a day; after 40 days feed 5 times a day.

Days since stocking	ABW (g)[a]	% to feed[b]	Feed pellet size (diameter in mm)	Feed tray amount (g/kg)[c]	Check time (hours)[d]
31	3–5	7.5–6.0	1.5–2 mm Crumble & 1.5 mm Ø, 2–3 mm long	3	2.5
40	5	6.0	1.5 mm Ø, 2–3 mm long	3	2
50	6	5.5	1.5 mm Ø, 2–3 mm long	3	2
55	7	5.3	1.5 mm Ø, 2–3 mm long	3	2
60	8	5.1	1.5 mm Ø, 2–3 mm long	3	2
65	9	4.9	1.5 mm Ø, 2–3 mm long & 1.8 mm Ø, 2–3 mm long	3	2
70	10	4.5	1.8 mm Ø, 2–3 mm long	4	2
74	11	4.4	1.8 mm Ø, 2–3 mm long	4	2
77	12	4.35	1.8 mm Ø, 2–3 mm long	4	2
80	13	4.3	1.8 mm Ø, 2–3 mm long	4	2
83	14	4.25	1.8 mm Ø, 2–3 mm long	4	2
86	15	4.1	1.8 mm Ø, 2–3 mm long & 2 mm Ø, 3–4 mm long	5	2
89	16	4.0	2 mm Ø, 3–4 mm long	5	2
92	17	3.8	2 mm Ø, 3–4 mm long	5	2
95	18	3.6	2 mm Ø, 3–4 mm long	5	2
98	19	3.5	2 mm Ø, 3–4 mm long	5	2
101	20	3.3	2 mm Ø, 3–4 mm long	6	2
103	21	3.1	2 mm Ø, 3 - 4mm long	6	2
105	22	3.0	2 mm Ø, 3–4 mm long	6	2
107	23	2.9	2 mm Ø, 3–4 mm long	6	2
109	24	2.85	2 mm Ø, 3–4 mm long	6	2

111	25	2.8	2 mm Ø, 3–4 mm long	7	2
113	26	2.65	2 mm Ø, 3–4 mm long	7	2
115	27	2.5	2 mm Ø, 3–4 mm long	7	2
117	28	2.35	2 mm Ø, 3–4 mm long	7	2
119	29	2.2	2 mm Ø, 3–4 mm long 2.3mm Ø, 3–4 mm long	7	2
121	30	2.1	2.3 mm Ø, 3–4 mm long	7	2
123	31	2.0	2.3 mm Ø, 3–4 mm long	7	2
125	32	2.0	2.3 mm Ø, 3–4 mm long	7	2
127	33	2.0	2.3 mm Ø, 3–4 mm long	8	2
130–150	34–38	1.8	2.3 mm Ø, 3–4 mm long	8	2

a) ABW (g) = average body weight in grams of the prawns in the pond, determined during the weekly biomass estimates

b) % to feed = percentage of estimated prawn biomass to be provided in feed per day

c) Feed tray amount = amount of feed to place on the feed tray when feeding (in g/kg of feed in the ration fed at that time)

d) Check time = number of hours to elapse after feeding before feed trays are inspected

Table 4 Feeding program for intensive ponds in subtropical regions (average daytime temperature <28°C) from 50 days (>2–3 g) onward. Note: From 1 to 40 days feed 4 times a day; after 40 days feed 5 times a day.

Days	ABW (g)[a]	% to feed[b]	Feed pellet size (diameter in mm)	Feed tray amount (g/kg)[c]	Check time (hours)[d]
51	2.0–3.0	7.0–6.5	1.5–2 mm Crumble	3	2.5
60	3	6.5	1.5–2 mm Crumble & 1.5 mm Ø, 2–3 mm long	3	2.5
64	4	6.0	1.5 mm Ø, 2–3 mm long	3	2.5
67	5	6.0	1.5 mm Ø, 2–3 mm long	3	2
70	6	5.5	1.5 mm Ø, 2–3 mm long	3	2
74	7	5.3	1.5 mm Ø, 2–3 mm long	3	2
78	8	5.1	1.5 mm Ø, 2–3 mm long	3	2
82	9	4.9	1.5 mm Ø, 2–3 mm long & 1.8 mm Ø, 2–3 mm long	3	2
86	10	4.5	1.8 mm Ø, 2–3 mm long	4	2
89	11	4.4	1.8 mm Ø, 2–3mm long	4	2
92	12	4.35	1.8 mm Ø, 2–3 mm long	4	2
95	13	4.3	1.8 mm Ø, 2–3 mm long	4	2
97	14	4.25	1.8 mm Ø, 2–3 mm long	4	2
100	15	4.1	1.8 mm Ø, 2–3 mm long	5	2

104	16	4.0	2 mm Ø, 3–4 mm long	5	2
107	17	3.8	2 mm Ø, 3–4 mm long	5	2
110	18	3.6	2 mm Ø, 3–4 mm long	5	2
114	19	3.5	2 mm Ø, 3–4 mm long	5	2
118	20	3.3	2 mm Ø, 3–4 mm long	6	2
120	21	3.1	2 mm Ø, 3–4 mm long	6	2
123	22	3.0	2 mm Ø, 3–4 mm long	6	2
125	23	2.9	2 mm Ø, 3–4 mm long	6	2
128	24	2.85	2 mm Ø, 3–4 mm long	6	2
130	25	2.8	2 mm Ø, 3–4 mm long	7	2
133	26	2.65	2 mm Ø, 3–4 mm long	7	2
135	27	2.5	2 mm Ø, 3–4 mm long	7	2
138	28	2.35	2 mm Ø, 3–4 mm long	7	2
141	29	2.2	2 mm Ø, 3–4 mm long & 2.3 mm Ø, 3–4 mm long	7	2
143	30	2.1	2.3 mm Ø, 3–4 mm long	7	2
146	31	2.0	2.3 mm Ø, 3–4 mm long	7	2
147 – 170	32 – 38	1.8	2.3 mm Ø, 3–4 mm long	8	2

a) ABW (g) = average body weight in grams of the prawns in the pond, determined during the weekly biomass estimates

b) % to feed = percentage of estimated prawn biomass to be provided in feed per day

c) Feed tray amount = amount of feed to place on the feed tray when feeding (in g/kg of feed in the ration fed at that time)

d) Check time = number of hours to elapse after feeding before feed trays are inspected

Appendix 4

Department of Primary Industries and Fisheries, Queensland

Aquaculture guideline

Guidelines on aquatic animal specimens accepted for testing at DPI&F veterinary laboratories and service fee exemptions

Introduction

The Department of Primary Industries and Fisheries (DPI&F) veterinary laboratories provide the Queensland Government with specific and objective surveillance data on disease occurrence in commercial aquaculture industries and wild fisheries. DPI&F veterinary laboratories in Queensland also provide information to the Commonwealth on reportable diseases of aquatic animals from both commercial aquatic enterprises and wild fisheries. The state offers financial support for this task as the data is used to support Queensland's participation in the national and international trade of animal products.

These guidelines have been developed to direct resources to areas that offer the most efficient means of gathering aquatic animal health surveillance data. Accordingly, preference will be given to investigating disease problems affecting commercial aquaculture. Subject to the conditions outlined below this will be undertaken free of charge to the producer

Note: samples from any aquatic species will be accepted regardless of background if a disease incident is deemed to present an unacceptable risk to the health of the community, wild fisheries or aquaculture. Subject to the conditions outlined below samples accepted under these circumstances will be processed free of charge.

Specimens accepted for processing

Acceptance of specimens and exemption from a service fee will be based on the following six criteria:

1. their public benefit component
2. the extent to which clinical history, epidemiological and other relevant information is provided
3. the appropriateness of specimens to the clinical history and disease(s) suspected
4. the duration of laboratory involvement in a long-running investigation
5. the depth of laboratory investigation required in solving complex multifactorial diseases

6. where specimens are not associated with disease and form part of health and export testing, certain accreditation schemes or are referred from other laboratories for testing.

1. Public benefit component

A submission will be regarded as having substantial public benefit under the following circumstances and will NOT attract a service fee:

Clinical disease in one or more animals under the following categories:

a) exotic disease

b) notifiable disease

c) specified diseases and approved government programs. This category includes:

- quarantine specimens (including those from public aquaria)
- high morbidity and / or high mortality outbreaks of disease
- diseases suspected of having public health significance
- new or emerging diseases include investigations considered by the duty pathologist to be likely to provide new information or an improved understanding of aquatic animal health in Queensland.
- other targeted endemic disease surveillance programs under annual review.

d) fish kills — a significant number of wild fish reported dead by the public or the Environmental Protection Agency.

Laboratory testing services are conducted for diagnostic cases without charge to the submitter at the discretion of the veterinary pathologist where a disease process or animal mortalities require investigation. An appropriate and sufficient history is required with the submitted samples to justify a diagnostic investigation.

Clients will be promptly advised if a submission under these categories falls outside DPI&F requirements and is subject to a service fee.

2. Incomplete information

A submission will be regarded as having incomplete information under the following circumstances and will not be processed or results withheld until relevant information is provided:

- the information provided was insufficient to determine the public benefit component as described above
- the information provided was insufficient to determine whether the specimens supplied were consistent with the clinical history and disease(s) suspected
- essential epidemiological data was not supplied.

3. Inappropriate specimen

A submission will be regarded as having inappropriate specimens under the following circumstances and **will not** be processed:

- specimens are not consistent with the clinical history or disease(s) suspected
- specimens are sufficiently compromised by autolysis[1] (either directly by hours after death at collection or indirectly through poor preservation in transit) as to render them of no relevant diagnostic use
- hazardous presentation by way of specimen containment or external contamination as to render them unsuitable for processing.

4. The duration of laboratory involvement

When the laboratory is involved in the investigation of a major outbreak of endemic disease service fees may apply after the diagnosis has been established. The details of these fees and their application would be negotiated on a case-by-case basis.

5. The depth of laboratory investigation required

The laboratory may become involved in the investigation of complex disease syndromes that are either multifactorial in nature or require special expertise or an experimental approach. Depending on the consequences for the industry, these investigations could be given special project status. Alternative funding may be required under these circumstances to ensure proper design and costing for the project.

6. Where specimens are not associated with disease

Where there is no clinical disease the submission will not be exempt from fees. This would be expected with:

- health and export testing, for example for translocation of fish, crustacean, mollusc and other aquatic species to intrastate, interstate or overseas destinations
- specific quality assurance testing, for example for the accreditation of health status of a farm
- tests referred from other laboratories.

The laboratories should be consulted for an up-to-date schedule of test charges.

Examples of non-exempt submissions

These are some examples of submissions that will attract a fee. The list is not all-inclusive.

- Barramundi fingerlings for sale interstate/internationally or for movement into restricted drainage areas (see the Health Protocol for the Importation and Movement of Live Barramundi (Aquaculture Protocol FAMPR002) for more information)
- Prawn larvae for interstate movement where there is a requirement from that state for health certification.

[1] Specimens submitted from fish kill investigations showing autolysis will be accepted at the discretion of the duty pathologist as any information indicating an infectious aetiology is critical to determine if an emergency disease response is required.

Fee schedule

An estimate of testing fee for the following types of submissions is provided in the tables below (for histology the costs depend on the number of slides that need to be prepared and examined).

Specific requirements for special testing such as bacterial culture, PCR tests and virus culture/isolation vary according to the specific test and pooling of individual animals; please contact the laboratory for a quotation. Specimens submitted for routine health testing are typically processed according to that outlined in the table below and the fees can be considered as an indication of expected costs. The cost variation will depend on the species, size and number of animals and batches to be tested.

Fees and charges for all tests shall be invoiced to the submitter and not referred to the owner. The laboratory does not pay for courier fees; all such costs are the responsibility of the submitter.

Example calculation of laboratory fees for health tests

The following table is based on a per histological block fee (2005/06 fee schedule effective 1 November 2005) as currently most health tests are still primarily dependent on histopathological examinations. The numbers of animals and age of animals are reflective of the current, typical health test requirements.

Aquatic animal by age	Number of individual animals examined in test	Animals per block or blocks per animal – an estimate	No. of blocks for health test	Laboratory fee (inc. GST): $15.95	Interpretation – first slide (inc. GST): $55.60	Interpretation – subsequent slides (inc. GST): $17.15/slide	TOTAL
Prawns:							
PL5	60	25 per block	3	15.95	55.60	34.30	$105.85
	150	25 per block	6	15.95	55.60	85.75	$157.30
PL15	60	10 per block	6	15.95	55.60	85.75	$157.30
	150	10 per block	15	15.95	55.60	240.10	$311.65
Juveniles/ adults	30	1–3 blocks per animal	30–90	15.95	55.60	497.35–1526.35	$568.90–1597.90
	60	1–3 blocks per animal	60–180	15.95	55.60	1011.85–3069.85	$1083.40–3141.40

Other current charges related to health testing:

Special stain ($19.65/slide preparation and $17.15/slide interpretation) = $36.80/slide

Bacterial/fungal/thioglycollate Perkinsus isolation = $30.55 per sample

Virus isolation = $105.15 per sample

Nodavirus nRT-PCR = $76.00 per sample

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Glossary

ACIAR	Australian Centre for International Agricultural Research
acid sulfate soils	buried soils derived from decay of ancient marine vegetation, containing iron pyrites and sulfides, highly acidic with the potential to release toxic heavy metal compounds when exposed to air. Common along many areas of Queensland's coastline
alkalinity	concentration of base (expressed as calcium carbonate) in water or soils, measured in mg/litre
amphipods	small, shrimp-like crustaceans occurring as zooplankton in the water column of prawn ponds. Most amphipods are marine, although a few live in freshwater or are terrestrial. Marine amphipods may be pelagic (living in the water column) or benthic (living on the pond bottom).
anaerobic	living or active in the absence of free oxygen, or in pond or water quality conditions without oxygen
anaerobic bacteria	bacteria that can live without oxygen
anoxic	relating to or marked by a severe deficiency of oxygen in tissues or organs
aquifer	underground bed or layer yielding groundwater for wells and springs etc.; groundwater resource that may flow along porous underground layers
benthic	of or relating to or happening on the bottom under a body of water
benthos	organisms (plants and animals) that live at or near the bottom of a sea, or in a pond
biomass	in this manual, standing stock (for example, in kilograms) of a crop of prawns at any particular time
bioremediation	effluent treatment using biological systems, enabling the culture of other species from the effluent water of an aquaculture crop
broodstock	mature prawns used as breeders in a hatchery; could be collected from the wild or be bred in captivity as domesticated broodstock (see spawner)
cod end	the sock-like end of a drain harvest net, with an opening tied off to collect the prawns and opened to empty them into an ice bin, similar to a trawl net cod end used in the fishing industry
copepods	minute marine or freshwater crustaceans occurring as zooplankton in the water column of prawn ponds, usually having six pairs of limbs on the thorax; some are abundant in plankton and others are parasitic on fish.
crusticide	chemical poison used to kill crustaceans (not available in Australia)

cyanobacteria	blue-green algae; predominantly photosynthetic prokaryotic organisms containing a blue pigment in addition to chlorophyll; occur singly or in colonies in diverse habitats; can be a significant component of the phytoplankton in prawn ponds but can also occur as benthic algae (e.g. *Oscillatoria* spp.) forming mats that may lift to the surface and accumulate in the windward corners of ponds.
detritus	decaying organic material on the pond floor, such as dead algae and zooplankton, prawn excreta and uneaten feed
diatoms	a major group of eukaryotic algae occurring as phytoplankton in prawn ponds; one of the most common types of phytoplankton in aquatic ecosystems. Most diatoms are unicellular, although some form chains or simple colonies, encased within a unique cell wall made of silica; usually consist of two symmetrical sides with a split between them, hence the group name.
denitrification	the loss or removal of nitrogen or nitrogen compounds; specifically reduction of nitrates or nitrites commonly by bacteria (as in the water column or in pond sediments) that usually results in the escape of nitrogen into the air
dinoflagellates	marine protozoans occurring as phytoplankton in the water column of prawn ponds, of the order Dinoflagellata, characteristically having two flagella and a cellulose covering and forming one of the chief constituents of plankton. They include bioluminescent forms and forms that produce red tide.
ELISA	enzyme-linked immunosorbent assay, a laboratory test for detecting a pathogen or its antibody, used as a diagnostic test for various viral diseases
endocrine system	gland system providing hormones to the blood
eukaryotic	(single-cell organisms) having cells with 'good' or membrane-bound nuclei
eyestalk ablation	a hatchery technique of macerating or destroying the eyestalk gland in female broodstock prawns to encourage spawning
feed tray	a wire-framed tray covered with small mesh, lowered to the floor of a prawn pond to monitor feed consumption rate
FCR	Food Conversion Ratio — weight of feed used to grow a crop of prawns divided by the weight of prawns harvested
flagella	lash-like appendages used for cellular locomotion by some phytoplankton and zooplankton
GAV	Gill Associated Virus, a virus occurring in the Australian prawn farming industry that can cause diseases such as Mid Crop Mortality Syndrome

HACCP	Hazard Analysis Critical Control Point, program of quality assurance used in seafood processing
hardness	measure of calcium and magnesium concentration in water, expressed as concentration of equivalent calcium carbonate in mg/litre, related to alkalinity
HAT	Highest Astronomical Tide, elevation of land above sea level on the tide zone where the highest tide of the year will reach (may go higher when combined with storm activity)
hepatopancreas	an organ of the digestive tract of arthropods and crustaceans; acts as the digestive gland. It provides the functions which in mammals are provided separately by the liver and pancreas.
haemocoel	internal body cavity of a crustacean, in which most of the major organs of the crustacean body are found. It is filled with the fluid haemolymph (the crustacean equivalent of blood), which is pumped by a heart and which circulates among the organs directly without the use of capillaries.
haemolymph	internal body fluids of a crustacean, similar to blood in mammals
IHHNV	Infectious Hypodermal and Haematopoietic Necrosis Virus, a virus that can cause Infectious Hypodermal and Haematopoietic Necrosis Disease, occurring in the Australian prawn farming industry and overseas shrimp-farming countries
MBV	Monodon Baculovirus, a viral disease occurring in the Australian prawn farming industry
MCMS	Mid Crop Mortality Syndrome, a viral disease occurring in the Australian prawn farming industry
megalopa	a larva, in a stage following the zoea, in the development of crustaceans. In this stage the legs and abdominal appendages have appeared, the abdomen is relatively long, and the eyes are large. Also used adjectively
MoV	Mourilyan Virus, a virus occurring in the Australian prawn farming industry
monk	aquaculture pond outlet structure, with timber boards held in slots to maintain water level but allow overflow through screens to keep prawns in the pond
necrosis	the localised death of living cells, tissue or cuticle (as from infection or the interruption of blood supply) that tend to go black in crustaceans (melanisation)
orthophosphate	a salt or ester of phosphoric acid, considered the 'biologically active' fraction of phosphorus
osmoregulation	a physiological process that occurs in crustaceans for the active regulation of the osmotic pressure of bodily fluids to maintain the homeostasis of the body's water content in response to variable salinities; it keeps the body's fluids from becoming too dilute or too concentrated.
PCR	polymerase chain reaction, a laboratory test for detecting a specific nucleic acid, as a diagnostic test for various viral diseases
pereiopod	walking leg of a prawn, also used to gather food

pH	water chemistry measure for acidity. On a scale of 0–14, less than 7 is increasingly acid, 7.0 is neutral, and greater than 7 is increasingly alkaline.
phytoplankton	photosynthetic or plant constituent of plankton; mainly unicellular algae, microscopic free-living (planktonic) algae, unicellular or multicellular, including blue-green algae
phagocytosis	process in which phagocytes engulf and digest micro-organisms and cellular debris; an important defence against infection
photosynthesis	physiological process in plants using chlorophyll to capture solar energy and convert carbon dioxide and water into carbohydrates (sugars)
postlarvae (PL)	the juvenile stage of prawns, typically in the nursery stage after changing from the zoeal stage in a hatchery. PL is the acronym generally used for post larva(e) purchased from a hatchery. PLs are usually purchased as PL15s (15 days from the megalopa stage).
protozoa	single-celled micro-organisms occurring in prawn pond water column and detritus; can be photosynthetic, can be planktonic or attached.
rostrum	the pointed nose or horn on the head of a prawn
rotifers	minute aquatic multicellular organisms occurring as zooplankton in the water column of prawn ponds, having a ciliated wheel-like organ for feeding and locomotion; constituents of freshwater plankton
turbidity	measure of water clarity or transparency, in pond management expressed as secchi reading in centimetres. A secchi disk is a black and white disk that is lowered into the water until it can no longer be seen; that depth (secchi depth) is then recorded as a measure of the transparency of the water (inversely related to turbidity).
SMV	Spawner Mortality Virus, a viral disease occurring in Australian prawn farming
spawner	broodstock prawn in spawning condition (mature gonad, recently mated female or mature male)
SPF	specific pathogen free, for hatchery-reared postlarvae that have been reared free of a particular disease; may have certification for sale to a farm
TSV	Taura Syndrome Virus; can cause Taura Syndrome, a viral disease occurring in overseas shrimp-farming industries but not in Australia.
vibriosis	infection in prawns caused by various species of bacteria within the genus *Vibrio*
WSSV (WSD)	White Spot Syndrome Virus that can cause White Spot Disease, occurring in overseas shrimp-farming industries but not in Australia
YHD	Yellowhead Disease, a viral disease occurring in overseas shrimp-farming industries but not in Australia
zooplankton	animal constituent of plankton; mainly small crustaceans and fish larvae