


Freshwater Crayfish Farming

A Guide to Getting Started

Ernslaw One Ltd.

Acknowledgments

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"Few things in the way of food are amiss to the crayfish; living or dead, fresh or carrion, animal or vegetable, it is all one"

(Huxley, 1884).

Foreword

There exists an opportunity in New Zealand to gain additional revenue by farming freshwater crayfish on land used for other forms of production. By way of example, the next time you fly in New Zealand have a look out the window at the large number of existing farm ponds or irrigation dams and canals where freshwater crayfish could be farmed. In addition, there are many areas where farming or forestry activities cannot be undertaken due to environmental concerns but where freshwater crayfish could be farmed.

This publication synthesizes current information from freshwater crayfish farmers and research undertaken during a 2014-2016 Sustainable Farming Fund Grant (SFF 13/007). The work undertaken as part of the SFF grant has identified the viability of freshwater crayfish farming; it is likely that farming enterprises will increase and this will, in turn, bring about a greater level of knowledge and understanding of the industry.

This publication is aimed primarily at people new to farming freshwater crayfish, but also contains information that may be relevant/useful for current holders of freshwater crayfish aquaculture licences. It is hoped that the sharing of knowledge will reduce the amount of "reinventing the wheel" and speed the development of the industry.

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Habitat

Freshwater crayfish are found in a wide range of freshwater habitats, from sea level to sub-alpine regions, including lakes, dams, irrigation canals and streams. They are associated with both still or slow moving waters, and in pools in swifter flowing streams. Freshwater crayfish can be found in most substrate types although deep soft sediment, particularly if it is anoxic (black colour and often associated with a sulphur smell), does not hold the same densities of freshwater crayfish as other substrate types.

Larger populations of freshwater crayfish are often found where there is abundant refuge (e.g. woody vegetation and riparian plant cover) especially where there is an absence, or low numbers of predators and low levels of pollution. Highest densities of freshwater crayfish are associated with substrate that they can burrow in (clay or dirt) with overhanging riparian vegetation and other refuge in the form of rocks or woody vegetation.

Freshwater crayfish are primarily a nocturnal animal although large crayfish may be observed foraging in daytime, particularly in dark coloured water, which may provide some protection from predators.

Aquaculture

There is a long history of freshwater crayfish farming worldwide, particularly in Europe and the United States with more recent industry development in Australia. In New Zealand a form of aquaculture has been undertaken for hundreds of years by the tangata whenua. This involved placing bundles of bracken fronds along the lake bottom for freshwater crayfish to find and colonise before retrieving the bundles to a canoe for harvesting. This method is still being used today in the Rotorua Lakes area (Kusabs and Quinn 2009). In New Zealand the potential of freshwater crayfish for commercial aquaculture purposes has been investigated since the 1960s.

Freshwater crayfish aquaculture is in an early development stage with no farm currently producing large volumes of saleable stock (<500kg combined total annual production in New Zealand). In 2015 there were 17 licensed freshwater crayfish farms but only four (all in the South Island) were in production. All are selling on the domestic market. Market feedback indicates that there is export potential for New Zealand freshwater crayfish if consistent supply of large quantities can be achieved. Furthermore, with the current world-wide focus on food safety, New Zealand’s generally clean growing environment would have a market advantage.

Although there are many different types of freshwater crayfish farming systems, static ponds (KEEWAI, Sweet Koura Enterprises and Waikoura Springs) and semi-closed parallel raceways (New Zealand Clearwater Crayfish) are currently used in New Zealand. No standard “model” appears to produce better yield than others, with water availability, relief of land and financial considerations generally determining the type of farming that is undertaken.

Differences in environment conditions suggest that Australian or American intensive farming systems may not be suited for New Zealand conditions; (e.g., warmer water temperatures and crayfish that mature in one year). However, there are aspects of freshwater crayfish biology that are consistent across all species that can be addressed to enhance crayfish production.

Aquaculture

Two species of freshwater crayfish are recognised in New Zealand. *Paranephrops zealandicus* (Southern Koura) is found on Stewart Island and the south-eastern side of the South Island while *Paranephrops planifrons* (Northern Koura) inhabits the North Island, Marlborough and the northern half of the west coast of the South Island (Fig. 1). *P. zealandicus* (Fig. 2) have hairy chelipeds whereas *P. planifrons* (Fig. 3) have slightly more elongated and non hairy chelipeds.

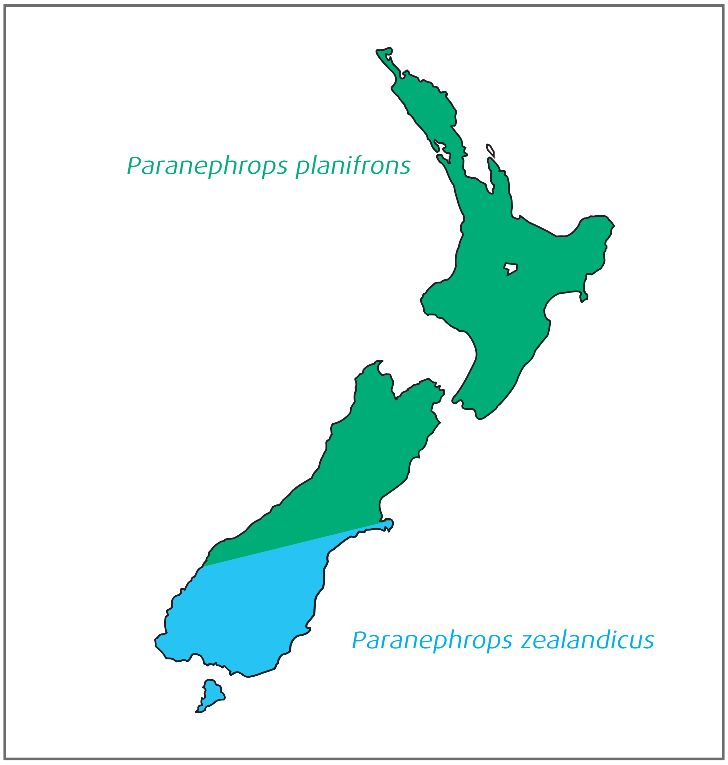


Figure 1. Distribution of *P. Zealandicus* and *P. planifrons.*

Figure 2. *Paranephrops zealandicus.*

Figure 3. *Paranephrops planifrons.*

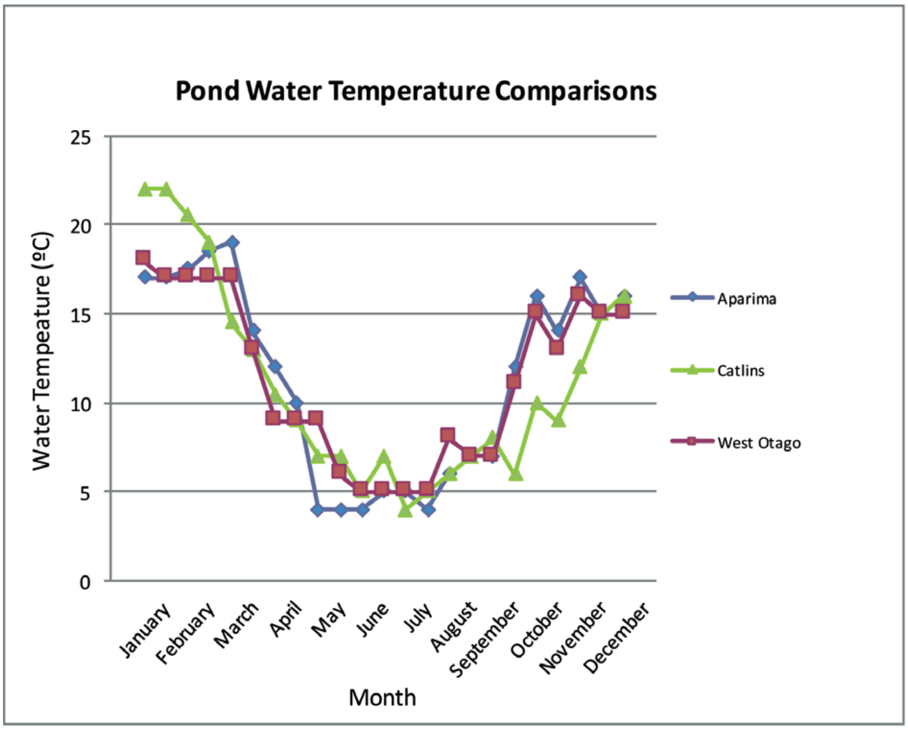
Growth

Freshwater crayfish must moult (shed) their exoskeleton to grow and breed. Growth is not continuous as it is in finfish, but a stepwise process with an inter-moult period of reserve building preceeding moulting and further increases in size. Growth depends upon variables such as water temperature, calcium, available food and daylight hours.

Water Temperature

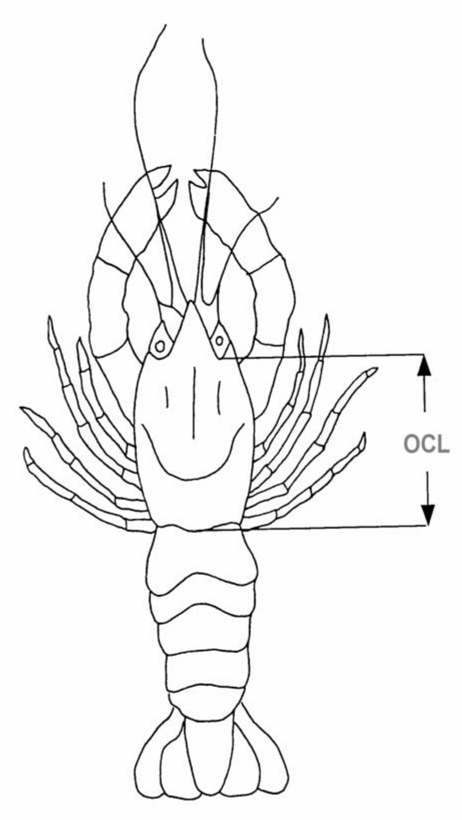
In general, the warmer the water the more often the occurrence of growth events. Growth can be expected all year round, but slows over winter months, and peaks in January and February when water temperatures are at their highest (15 to 20ºC – typically between November and April in Otago). Figure 4, below, shows the annual temperature variation across ponds in three South Island forests. Kusabs *et. al.* (2015) noted that moulting occurred in the Rotorua lakes in April, July and November suggesting that faster growth rates could be achieved in areas where water is likely to be warmer for a longer proportion of the year (e.g., Marlborough or the North Island).

Figure 4. **Annual temperature profiles for three ponds in Otago and Southland Forests.**



The frequency of moulting, and therefore growth events, decreases with age. Newly hatched juveniles moult two to three times a year, whereas a three or four-year-old freshwater crayfish generally moult only once or twice a year. There is an inverse relationship between the increase in orbital carapace length (OCL) (Fig. 5) per moult and the size of freshwater crayfish. Freshwater crayfish of 25mm OCL increase in length approximately 22% per moult whereas a freshwater crayfish of 56mm OCL may only increase 6% per moult.

Calcium



Small white spherical stones (Fig. 6) are occasionally found in the bottom of freshwater crayfish ponds or under the exoskeleton when freshwater crayfish are cooked. These are gastroliths and are produced by freshwater crayfish to store calcium needed to harden a new exoskeleton. Freshwater crayfish will also eat their discarded exoskeleton presumably to obtain any remaining calcium. The new shell is soft for a short time after moulting and during this time the freshwater crayfish are vulnerable to attack by predators.

Figure 5. Orbital Carapace Length (OCL) measurement.

Figure 6. Gastroliths from a two-year-old freshwater crayfish.

Freshwater crayfish survival rates also increase with higher calcium concentrations present in the water (Hammond *et. al.* 2006).

Reproduction

The reproductive organs of the male crayfish (Fig. 7) have two short projections shaped like acorns on the bases of the last (4th) pair of walking legs whereas females (Fig. 8) have openings at the base of the second pair of walking legs.

External openings of the reproductive organs of male and female freshwater crayfish.

Male

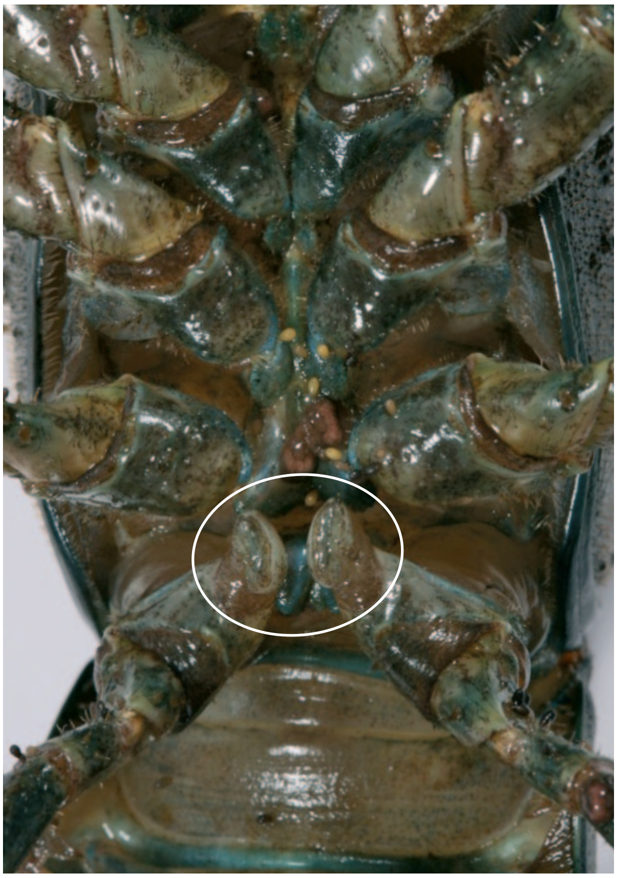


Figure 7. Openings of the sperm ducts.

Female

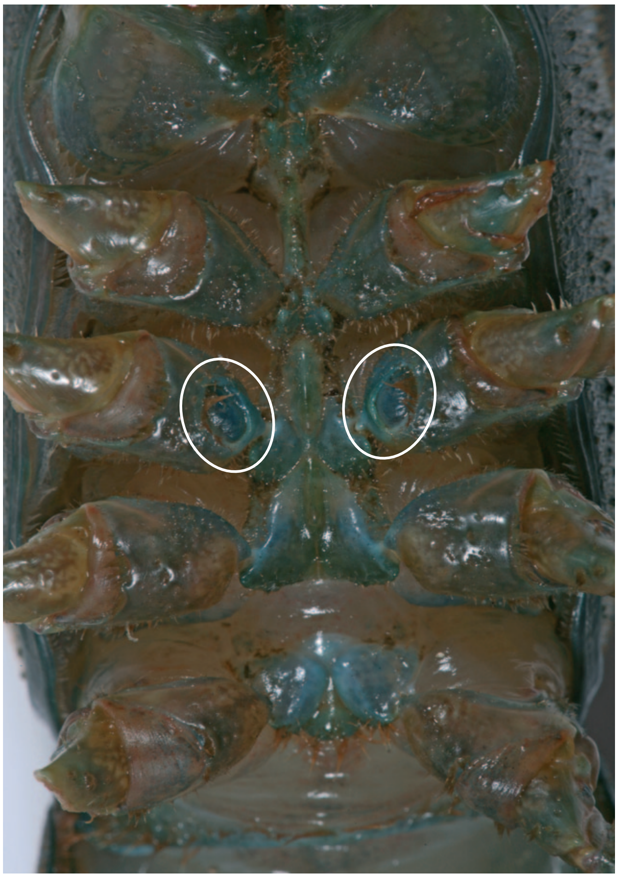


Figure 8. Openings of the oviducts.

Biology

Reproduction

Moulting is also necessary for a female's reproduction; a slightly pliable carapace is required for a female to extrude her eggs (Fig. 9). Once a female has moulted a male deposits a small packet of sperm (known as a spermatophore) near her reproductive openings that fertilises the eggs (Fig. 10). Under the females tail the eggs look like berries and at this stage the females are known as "berried female's" (Fig. 10). As the eggs develop they change in colour from caramel (Fig. 11) to brown (Fig. 12), then grape/red (Fig. 13), and finally grape/red with white polar ends (Fig. 14).

Unlike their marine relatives, freshwater crayfish do not have a free-living larval stage; instead miniature crayfish hatch from the eggs and remain attached to the underside of the female's tail for the first two or three moults of their development (Figs 15) before they become free-living (Fig. 16 and 17). This can take ten to 12 months depending on time of fertilisation and water temperature.

Figure 9. Freshly moulted female freshwater crayfish (top) with its recently shed exoskeleton (bottom).

Figure 10. Female with spermatophore deposited over oviducts (white sticky mass highlighted).

Reproduction

Figure 11: Newly fertilised caramel coloured eggs.

Figure 12: Brown eggs one to two days old.

Figure I3: Grape/red coloured eggs

Biology

Reproduction

Figure 14. Grape/red eggs with white polar ends.

Figure 15. Early juvenile form with remnant egg yolk remaining.

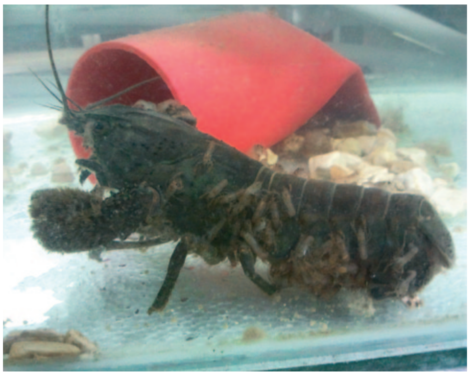


Figure 16. Juveniles on their mother.

Figure 17. Free-living juveniles.

Reproduction

Females produce between 20 to 400 eggs with larger crayfish having more (e.g. a 25mm OCL female has ~50 eggs and a 50mm OCL female ~300 eggs) (Figs 18 and 19). Some females have small numbers of eggs or do not reproduce at all in a given year while others are constantly berried and have large numbers of eggs. Occasionally females have been observed with unfertilized eggs, this is presumably due to a male not finding the female at the time of egg extrusion. The smallest reported New Zealand freshwater crayfish in berry is a 25mm OCL two-year female (Fig.18).

Figure 18. Berried 25mm OCL freshwater crayfish.

Figure 19. Larger female carrying a well developed brood.

Juvenile Survival

In their first free-living year freshwater crayfish are rarely seen as they hide away from both predators and larger freshwater crayfish under rocks or amongst woody vegetation or plant material. They often have a speckled carapace, which may be a camouflage aid to protect them from potential predators. As freshwater crayfish can be hard to find until their second year estimating the juvenile population in ponds can be difficult. However, it is known that five to 15% of the free-living young survive to two to three years of age, with the highest mortality occurring in their first year of life. This mortality is most likely a mixture of predation and unexplained moult related deaths. The addition of large amounts of refuge can increase juvenile survival as it increases the amount of habitat.

Diet

Freshwater crayfish are described as opportunistic omnivores and will eat almost anything. They have a gastric mill which enables them to feed at all trophic levels including filtering phytoplankton, grazing algae, eating other invertebrates (including their own kind), and animal flesh. New Zealand Clearwater Crayfish Ltd based near Blenheim, have developed a commercial food especially for freshwater crayfish.

Biosecurity

Under New Zealand's legislation, it is illegal to bring live freshwater crayfish into the country. As a result, we are generally free of diseases affecting aquaculture elsewhere in the world. However, it is important to monitor and manage possible predation and disease risks with good biosecurity practices. This will minimise this risk and associated production losses and/or trade opportunities. There are five key pathways where pests and diseases can be introduced to a farm. These are stock movements in and out of a farm, water, equipment, people, wildlife and feed. The Ministry for Primary Industries have prepared an Aquaculture Biosecurity Handbook and other resources which provide information useful when selecting a site and/or planning a farming operation (http://www.mpi.govt.nz/news-and-resources/publications/).

Crayfish Health

New Zealand freshwater crayfish have few known diseases and none that currently would hinder the development of a freshwater crayfish industry. Elsewhere in the world diseases are a major constraint to development of crustacean aquaculture, particularly to intensively farm operations. Given that there are few treatments available good farming practices along with preventive management (e.g. good biosecurity practice) is essential to protect farms, the industry and wild populations. It is recommended that any crayfish showing signs of disease be immediately removed from a pond and destroyed or frozen for later analysis. If large numbers of sick or infected crayfish appear in your farm it is advisable to quarantine your farm or individual pond and call the MPI Disease and Pest-Free Hotline on 0800 80 99 66. Below is a list of the pathogens most likely to be encountered in New Zealand

White Tail

Thelohania, known as "white tail" or "porcelain disease", is the most commonly encountered disease. In the later stages of infection it is easily detected as the underside of the tail turns porcelain white (Figs 20-22). It is fatal and appears to be transmitted by ingestion of spores via cannibalism of dead or dying crayfish. In natural populations, the disease infects between one and 11% of the population. In Otago, the distribution of white tail disease is generally restricted to low lying or coastal streams, but it is not found in all streams, even within the same catchment. It has also been reported Lake Taupo and Lake Rotoiti in the North Island. Infected crayfish are hard to detect in the early stages of infection but thin striated white lines can often be observed running longitudinally in the underside of the tail (Fig. 22). Infected crayfish can often be found away from cover in daylight hours and at night in shallow, slow water areas, particularly where there is leaf litter. For some undetermined reason the carapace in infected crayfish is often light brown/orange in colour. Infected freshwater crayfish pose no human health risk, but the cooked flesh is mushy and unpleasant to eat.

Figure 20. Healthy freshwater crayfish.

Figure 21. Freshwater crayfish with "white tail" disease. Note the porcelain coloured flesh.

Figure 22. Freshwater crayfish with "white tail" disease. Note the striations in the flesh.

Burn Spot

Figure 23. Freshwater crayfish carapace with "burn spot". Note the hole in the carapace.

While not technically a disease burn spot occurs when a carapace is damaged, often when crayfish are soft during moulting, but it can also occur due to fighting or damage from predator attacks. It is noticeable by orange/rust colour spot(s) on the carapace, often with a hole completely through the carapace (Fig 23). Burn spot does not spread and often is removed during a moult event. However, in some instances the carapace becomes fused to the flesh and mortality occurs, as the moult cannot be completed.

Ectocommensals

Ectocommensals are organisms found living on the carapace of crayfish. Most do not cause harm, provided the crayfish are healthy and water quality is high. If crayfish become stressed and/or water quality deteriorates then these organisms may cause losses in production or mortality in extreme cases. In New Zealand a commonly found ectocommensal are *Temenocephala* species. These small squid-like animals can be found on freshwater crayfish and are often concentrated around the cheliped and head (Figs. 24 and 25). These are eco-commensal parasites that feed upon particles of food scattered in the water but do not actively harm freshwater crayfish. If care is taken with selection of the initial farm stock *Temnocephala* should not be present, as they are not found in all freshwater crayfish populations. While they are unsightly, and may have market implications, they do not affect the taste of freshwater crayfish. A large proportion of *Temenocephala* fall off freshwater crayfish after a few days in a purging facility, presumably looking for food.

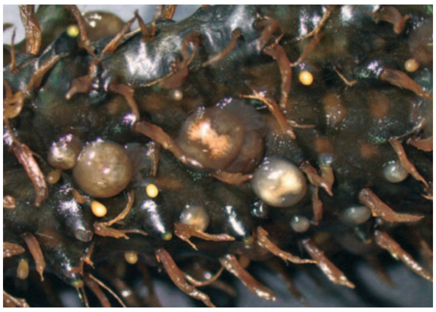


Figure 24. *Temenocephala* spp on freshwater crayfish cheliped.

In nutrient rich ponds crayfish can sometimes develop a layer of white/brown/green coating covering their carapaces. In extreme cases this can clog the gills and result in crayfish mortality. An example of this type of ectocommensal are Epistylis. For more information see: www.fish.wa.gov.au.

Figure 25. *Temenocephala* spp.

Crayfish Plague

New Zealand freshwater crayfish have tested negative for the "crayfish plague" (*Aphanomyces astaci*) which entered Europe last century (apparently carried by plague-resistant crayfish introduced from the United States) and which has since devastated stocks of the native British, Asian and European crayfish. The current legislation prohibits the importation of live freshwater crayfish into New Zealand. An accidental importation of the "crayfish plague" could potentially cause total extinction of our native crayfish stocks and even if the crayfish plague outbreak was able to be isolated it would impact on our ability to export live crayfish. The absence of the crayfish plague gives New Zealand a market advantage, over most other crayfish producing nations, as live export is possible.

Predation

While freshwater crayfish are the largest invertebrate in New Zealand, they are still near the bottom of the food chain and often targeted by animals that live near water. Animals known to predate on freshwater crayfish include stoats and ferrets, hedgehogs, rats, hawks, shags, kingfishers, mallard ducks, dragonfly larvae, eels, galaxiids and trout. Evidence of predation in ponds includes piles of exoskeleton around the pond edge, carapaces with pierce holes and gastroliths. Predation is an important consideration for any aquaculture venture and predator disturbance/control may be required to limit potential losses.

The type of measure required to minimise predation will depend on the species involved and the farm layout. Measures could include filters or grates on water intakes or a fence surrounding a pond (for eels, trout, galaxiids), regular disturbance for birds (our experience is that after several disturbances shags tend not to return) and predator fences (for stoats and hedgehogs).

Water Quality

Water quality is key to the success of freshwater crayfish farming. While freshwater crayfish are able to tolerate a range in the water quality parameters, to get the best growth rates the water needs to be kept close to optimal conditions. In natural ponds, biological processes generally keep levels of harmful bacteria or nitrates within acceptable levels. However, once stocking rates are increased and/or artificial foods added, water quality should be monitored frequently.

The parameters of most importance to freshwater crayfish farming are dissolved oxygen (DO), pH, calcium, water temperature and nitrite/nitrate/ammonia. There are many equipment options available in New Zealand for monitoring water quality ranging from test strips through to hand held devices (e.g., local pets stores, Hach Scientific, Thermo Fisher). Most of these are relatively inexpensive and are accurate enough for freshwater crayfish farming requirements. Regular water testing will provide an understanding of pond water changes in any given season or stocking density. This is important for identifying possible causes of changes in pond appearance or crayfish mortality.

Dissolved Oxygen

The biological carrying capacity of a pond is determined, in part, by the amount of available oxygen in the water. Keeping oxygen levels close to their optimal levels lessens the potential for disease or lower/reduced survival rates and is a key element to successful freshwater crayfish farming. Dissolved oxygen (DO) levels of greater than 5mg/L (5ppm) is the generally accepted minimum level for aquaculture. If DO levels fall below these levels options such as paddlewheels, cascading waterfalls or aeration via blowing low-pressure air through pipes laid along the bottom of ponds may be required. (see Mosig 2003 in the suggested reading list for further information).

Dissolved oxygen levels >5mg/l is recommended as a minimum for freshwater crayfish farming.

Water Quality

Calcium

Better survival rates and yield are obtained from higher levels of calcium and hardness. The addition of 10kg of agricultural lime to a static pond (volume ~200 cubic metres) increased calcium levels from 7.2mg/l to 18mg/l (and pH from 6.7 to 7.4) when measured one year later. The agricultural lime was placed in a 20 litre bucket of water and stirred to dissolve as much as possible before being tipped into the pond around the perimeter.

It is preferable to add calcium prior to the freshwater crayfish being placed in ponds as the pH will change rapidly until full mixing of the pond occurs. It is advisable to add small amounts of calcium at a time to ensure the pH does not exceed recommended levels (see pH section below). Monitoring should be undertaken on a regular basis to ensure that calcium levels remain within the desired range.

Calcium levels of 20 to 30 mg/l are preferable, with >5 mg/l considered a minimum for freshwater crayfish aquaculture.

pH

pH is measured on a scale of 1 to 14, with values below 7 being acidic water and values greater than 7 alkaline water. In Otago freshwater crayfish can be found in waters with pH ranging from 6.4 and 8.0 although the largest populations are typically found in waters with a pH greater than 7.

A pH of between 7 and 8.5 is recommended for freshwater crayfish aquaculture.

Temperature

In Otago and Southland the frequency of growth events is highest at water temperatures up around 20°C. The maximum tolerated temperature for freshwater crayfish has not been defined but 25°C is suggested as an upper temperature maximum.

A temperature range of 10-25°C, with 20°C preferable, is suggested as suitable for freshwater crayfish aquaculture.

Farm Requirements

Where to Farm

Freshwater crayfish will grow in most areas of New Zealand provided the water is of good quality. Production will vary depending on the location. Locations in the North Island are likely to have higher production compared to the lower South Island due to warmer water temperatures. Similarly, locations at lower altitudes or those relying on spring or thermal water will produce greater yields. However, variables such as water source (both quantity and quality), topography (pond layout and pumping or gravity feed water) and adjacent land-use (e.g., negative effects from spray drift or run-off) are key considerations. Farming freshwater crayfish may be possible where the current land use is restricted because of possible environmental considerations (e.g., forestry riparian set backs or wet areas on farms). An area where crayfish farming is yet to be explored is in the existing, or proposed, large irrigation ponds and associated water races throughout the country. These all provide an opportunity for additional income without impacting on existing production.

Water Supply

Although there are numerous potential sources of water available, the quality of supply is important. Options include rainwater, groundwater, seeps, rivers and lakes. Freshwater crayfish are highly susceptible to insecticides and herbicides and care is needed to ensure that upstream water supplies are not contaminated.

Groundwater may elevate water temperatures over winter and, if required, cool water temperatures during summer. This potentially creates a longer growing season, particularly in more southerly regions. Furthermore, locating freshwater crayfish ponds in naturally wet areas (springs or seeps) can ensure stable water levels even in periods of drought.

Rainwater (and runoff) may remove resource consent requirements to take water, as they are not usually deemed takes by regional and unitary councils. However, ponds need to be sized accordingly to accommodate a possible drought period where evaporative losses can exceed rainfall.

Rivers or lakes provide a reliable water source, although resource consents to take water are likely to be required when establishing a freshwater crayfish farm. Care needs to be taken not to introduce naturally occurring predators or invasive aquatic plant species. Thought will also be required on how to separate potential mixing of wild and farmed populations of freshwater crayfish.

Pond Design

Freshwater crayfish will live in all shaped/sized ponds but maximum production will be achieved with ponds that maximise bank area (Fig 26). Freshwater crayfish are found in highest densities alongside bank areas, especially where there is cover. Therefore, any pond design should maximise these features. Rectangular shaped ponds and/or those with islands in the middle provide the greatest bank area to total area ratio. Creating rough or irregular edges also creates more habitat for freshwater crayfish. Ponds that are five to seven metres wide and between 1.0 and 1.2 metres deep are ideal for production and ease of management. The pond profile should have a ~40cm vertical bank before sloping gently down to the deepest point. While the above is suggested as ideal, topography and the economics of soil displacement may dictate the final shape of a pond (Fig 27). When designing the pond layout, it is important to allow for vehicle access (quad bike or 4WD) around all ponds to facilitate easier stock management. If there is a readily available water source the ability to drain and rapidly refill ponds is an advantage for surveying and harvesting ponds.

Figure 26. A one-year-old-pond. The sediment has cleared but needs further rainfall to fill.

Figure 27. A recently created freshwater crayfish pond where the vegetation has been left largely intact demonstrating shape to maximise freshwater crayfish habitat.

Figure 28. An aged pond with refuge suitable for stocking.

Pond Aging

All ponds should be aged (e.g. have riparian plantings and time for the water to clear) prior to stocking with freshwater crayfish (Fig. 28). Ponds with flowing water tend to age quicker than static ponds but 18-24 months is usually required before you can stock a pond with freshwater crayfish. A good test of when a pond is ready is the presence of aquatic life, such as snails and water boatmen, and an absence of filamentous algae growth.

Refuge

Refuge (habitat for freshwater crayfish to hide in) is important as the greater the amount of refuge the greater the number of freshwater crayfish able to live in a pond. Material such as rock, broken concrete, forestry slash, bracken bags, bundles of branches or other vegetation can be used to provide refuge (Figs. 29-33). Care needs to be taken with the refuge material chosen to ensure the water does not become contaminated and to avoid possible health risks to the freshwater crayfish (e.g., tyres may leach heavy metals or other pathogenic toxins and green leafy material can initially lower oxygen levels as they decompose). Refuge should be placed along the centre of a pond with a gap from the bank and other refuge to allow space for the setting of traps when harvesting.

Figure 29. Refuge consisting of an onion bag full of Bracken. Note holes in bag to allow crayfish movement.

Figure 30. Bracken refuge after one year in a pond.

Figure 31. Bundles of Rowan refuge

Figure 32. Bundle of Manuka refuge

Figure 33. *Coprosma* refuge.

Riparian Plantings

Riparian plantings have many advantages in that they provide cover, their roots make it easier for freshwater crayfish to excavate shallow burrows, and they provide a food source as freshwater crayfish eat the growing root tips (Fig. 34). While most plants will provide benefits, any plantings should be non invasive and have a small adult size. In the wild, freshwater crayfish are strongly associated with Carex grasses (C. *geminata*, C. *secta* and C. *virgata*) , watercress (*Nasturtium microphyllum*) and Birdsfoot Trefoil (*Lotus pedunculatus*) (Figs. 35-37).

Figure 34. Plant root structure from pond bank.

Figure 35. Mature *Carex geminanta* and *Carex secta* surrounding a freshwater crayfish pond.

Figure 36. Water cress (*Nasturtium microphyllum*) in freshwater crayfish pond.

Figure 37. Birdsfoot treefoil (*Lotus pedunculatus*) and Cutty grass (*Carex geminata*)

Seed Stock

The sourcing of 'healthy' stock is of the utmost importance to any aquaculture venture. Special permits, under s97 of the Fisheries Act 1966, can be obtained to collect wild stock but there are strict controls imposed to ensure harvesting is done sustainably. There can be a significant labour cost in wild collection and there is the potential to introduce unhealthy stock. For more information on special permits contact MPI at specialpermits@mpi.govt.nz. Alternately, stock may be obtained from current freshwater crayfish farms. There are currently two farms selling *P. zealandicus* (KEEWAI and Sweet Koura Enterprises) and two selling *P. planifrons* (New Zealand Clearwater Crayfish and Waikoura Springs). These farms are all based in the South Island. MPI are able to provide a list of all current freshwater crayfish farmers with stock for sale. Currently you cannot obtain permits to transfer freshwater crayfish outside their natural range to seed a new farm (e.g. Otago freshwater crayfish cannot be used in the North Island or the northern part of the South Island). This has implications as to where you can source seed stock and it is advisable to investigate this prior to applying for permits. For information on fish farm licensing and acquiring stock from another freshwater crayfish farm, contact MPI at fishfarm@mpi.govt.nz. For information on Department of Conservation approvals to transfer and release freshwater crayfish onto your fish farm for the first time: http://www.doc.govt.nz/get-involved/apply-for-permits/interacting-with-freshwater-species.

Initial Stocking

There are numerous approaches to the initial stocking of ponds ranging from stocking a single-size-class through to stocking only breeding adults and/or berried females. There is no set recipe for initial stocking rates, as it will depend on variables such as the age of the pond and the amount of refuge. Stocking ponds with a mixture of adults and berried females provides an opportunity to stock many ponds at once. Ideally, adults should be of similar size to reduce possible aggressive encounters. Initially ponds should contain more males than females, particularly where there are low initial numbers being stocked (the theory behind this is that for females to get in berry a male needs to find them when they are in moult and producing eggs). After three years a sustainable population should be present as the first free-living young will be of reproductive age. An initial stocking ratio of 5:1:1 (male/female/berried female) provides a good balance for seeding ponds. An alternative approach would be the re-stocking of juveniles (two-year olds) every two to three years. This approach would require a reliable stock source and the ability to drain ponds to ensure all sale stock were removed prior to restocking. The approach allows for stocking at higher densities and provides a greater amount of resources such as food and refuge in the farm ponds for the freshwater crayfish (due to their smaller size). However, the number of juveniles should not reach levels where growth rates are potentially reduced due to a lack of food resource. A maximum stocking level of 8-10/m^2 of juveniles is suggested.

Bait

Freshwater crayfish can be attracted to nets with a variety of bait types, with chicken frames, tinned cat food and fish frames all providing consistently good yields. Catch rates can be variable, particularly if there are other food options in a waterway (e.g., zooplankton) but bait with a strong scent will consistently attract freshwater crayfish. Placing bait in a plastic jar (with holes drilled in the side) allows the bait scent to permeate through the water (Fig. 38). The bait should not be thrown into the ponds once the nets are cleared as this may be a pathway for potential disease, water quality issues or attract unwanted predators. Note, the Freshwater Farming Regulations preclude, for freshwater crayfish, the feeding of food that has not been sterilised (Regulation 23).

Figure 38. Bait containers.

Harvesting

Figure 39. Scoop net.

The harvesting method undertaken will be dependant on the type of farming operation. The most effective way to harvest freshwater crayfish is a mixture of partial draining of ponds and hand capture. However, if a farming operation relies on rain or seepage water then draining ponds may not be an option and hand netting and bait trapping will be required. Freshwater crayfish can be difficult to trap in static ponds as the scent of the bait does not carry as far as in ponds where there is flowing water. However, scoop netting, with a net similar to a white-bait net but with a reduced sock (Fig 39), pre and post set netting, along with overnight bait trapping can yield results of >80% capture of freshwater crayfish in any pond.

The most common freshwater crayfish net used in New Zealand is the "opera trap" which can be obtained from most sporting/fishing stores (Fig 40). Traps ideally should be set in the evening and checked first thing in the morning, as freshwater crayfish have been observed exiting these traps once the bait is exhausted.

Figure 40. Opera trap.

Figure 41. Fyke net.

Fyke nets are suitable for freshwater crayfish farming, with the wing guiding crayfish into the trap (Fig. 41). There are numerous other types of nets that can be purchased and as long as the net has a funnel entrance similar to the 'opera trap' then they should catch freshwater crayfish.

The harvesting of larger freshwater crayfish from a pond, results in an increase in the number of sale sized (approximately 50gms) and smaller freshwater crayfish over time. The remaining freshwater crayfish ensure there is a sustainable population for future years' harvests.

Stock Source & Management

Information Recording

A diary/database with information of the history of each pond is an important part of any freshwater crayfish farm management. This allows variables such as water quality and stocking to be monitored over time to ensure pond values are kept at optimum. It will also help in understanding production and future harvest predictions. The recording of stock movement, both in and out, is also important for biosecurity, stock tracking and traceability, as well as overall management.

Purging

The purging of freshwater crayfish prior to sale is important to ensure that a quality product is presented for market. This involves holding freshwater crayfish without feeding to let them empty their stomachs. Purging can take up to four days depending on temperature (cooler water creates slower metabolic activity and therefore greater time to process food). Purging can be achieved by placing freshwater crayfish in holding crates submerged in larger 'purging tanks' or placing freshwater crayfish in 'drip rooms' where water is sprayed over and percolates down through stacked crates. If purging water is to be recirculated then some form of filtration to remove waste products, such as ammonia, may be required. See Mosig (1998) and Mosig & Fallu (2004) for further information on purging crayfish. For design and construction consideration see Lee *et. al.* (2008) in the suggested reading list. If recirculated water is used, it is advisable to test regularly to ensure that the levels of nitrite or ammonia are within acceptable levels.

It is a requirement from MPI is that freshwater crayfish for sale are purged in an animal material depot (AMD) certified facility using potable water. While most water sources (bore or creek) can be certified 'potable' there is an associated requirement and ongoing cost for water testing. An alternative option is to use town supply coupled with a filter to remove chlorine to purge freshwater crayfish (freshwater crayfish mortality occurs in water containing chlorine). When using town water the onus on testing and ensuring potable water standards falls to the council and a certificate of water quality can be obtained to meet MPI requirements.

Production

The yield from a pond can be hard to predict as ponds of a similar size and location can have vastly different yields. In general, ponds with a shape that maximises riparian areas, along with the addition of large amounts of refuge, will increase harvest volumes. In semi-intensive farms, where races are stocked with freshwater crayfish of a similar size class and where supplementary feeding is provided, yields of up to eight saleable crayfish per square metre have been achieved (New Zealand Clearwater Crayfish Ltd). Based on these production figures, a pond with dimensions of 40m by 5m (200m^2) could produce up to 1600 sale sized freshwater crayfish annually.

Stock for Sale

Sales

Currently, in New Zealand, freshwater crayfish are sold solely on the domestic market with prices ranging from $60 to $100 per kilogram. To date no freshwater crayfish have been exported but it is expected the export price will be considerably higher given the advantages of a clean healthy product and that live export sales are possible.

Regulatory

Resource Consents

Resource consents may be required for aspects of freshwater crayfish farming. These are typically: land use consents, and consents to take, use and discharge to water. The availability of water needs thorough investigation with the relevant government agency and other water users early in the planning process (e.g. neighbours or irrigation companies). As part of the licensing process you will need to consult with affected parties. These parties include local Iwi, Department of Conservation, Regional and Territorial authorities and Fish & Game. In addition, you may need to discuss your plans with other groups such as adjacent landowners and/or other water users depending on the size and location of your farm.

It is advisable to consult widely over your plans to farm freshwater crayfish early in the planning process to ensure there are no potential hurdles that you are unaware of. This will help reduce the time and cost to obtain the necessary permits and consents.

Permitting

MPI manages land-based aquaculture under the provisions of the Freshwater Fish Farming Regulations 1983 made under the Fisheries Act 1996. These Regulations require a current Fishfarm License to farm freshwater crayfish. An application form can be sourced from the MPI website (www.mpi.govt.nz) and additional information can be obtained by emailing fishfarm@mpi.govt.nz. Note that while MPI can offer some preliminary advice they are unable to fully consider an application until all necessary resource consents are granted.

In addition, a certification for an Animal Material Depot facility to purge freshwater crayfish prior to sale is required from MPI. This certificate is primarily aimed at ensuring freshwater crayfish are held and packed in facilities that meet food safety requirements (www.mpi.govt.nz)

Future Work

This project has identified methods to extensively farm freshwater crayfish in New Zealand. While the concept, from digging a pond through to selling stock, has been proven, there is still more development required. There needs to be a greater number of farms operating in New Zealand and further research, including studies on intensification, undertaken before markets can be developed. Key areas for development include:

Selective Breeding

In freshwater crayfish populations there are a percentage that grow faster, with some achieving sale size (~50gms) in two years as opposed to three to four years. A proportion of these "faster growing crayfish" should be removed and placed in selective breeding ponds. Over time this may select for faster growing crayfish.

Artificial Egg Incubation

The artificial rearing of eggs has potential benefits as it could produce large numbers of freshwater crayfish for pond stocking in a short period of time. Other benefits of this may include freshwater crayfish that are likely to be healthier, have reduced mortality in the first year of life, and faster egg development as the eggs can be kept at an elevated temperature thereby removing the colder winter period where development is slowed.

Feeding

The feeding of freshwater crayfish will provide benefits that include faster growth and less mortality of young. However, the optimal food type, conversion rates along with the cost benefit analysis of feeding have yet to be defined. Similarly, the affect of artificial feeding on taste and consumer preference for 'natural' freshwater crayfish needs to be fully explored

Freshwater Crayfish Association

The establishment of a professional group to support freshwater crayfish farming in New Zealand is needed. This would help the long-term viability of the industry and assist in market positioning including export opportunities to maximize returns. Until this is established, the International Association for Astacology (IAA) provides useful links to crayfish researchers and scientific publications.

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Glossary

Berried: females carrying eggs.

Carapace: the hard outer shell of a crayfish

Gastroliths: small white stones made of calcium that increase overtime and are absorbed by crayfish to help the initial hardening of the carapace following a moult event.

Cheliped: crayfish leg bearing claws.

Omnivore: feeds on both animal and plant derived food material.

Pathogenic: disease forming organism.

Riparian: the strip of land bordering water margins often referred to as the "riparian zone".

Spermatophore: a parcel of sperm that is transferred to the female during mating. A sticky substance known as "glair" extruded by the females dissolves the parcel releasing the sperm to fertilise the eggs.

Static pond: a pond which relies on rainwater, seeps, springs or rainwater to maintain water level.

If you would like to learn more about how we might help you, please call or email

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