Department of Primary Industries

The Yabby Unit

Technology Mandatory

Area of Study - Agriculture and Food Technologies

www.dpi.nsw.gov.au

Supporting document

NSW DPI Schools Program

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Contents

Information for teachers

Syllabus context – Agriculture technologies, engineered systems and digital technologies

This Yabby unit of work is mapped to outcomes from the *Agriculture and Food technologies* and *Digital technologies* contexts of the NSW Technology Mandatory (2017) syllabus. It integrates content from these contexts to enable delivery considering the school environment and available resources.

Agriculture (food and fibre production) focuses on the investigation of managed environments, such as farms and plantations. Students learn about the processes of food and fibre production and investigate the innovation and sustainable supply of agriculturally produced raw materials. Students develop deep knowledge and understanding about managed systems that produce food and fibre through designing and producing solutions.

Food technologies focuses on the use of resources produced and harvested to sustain human life. Students learn about the characteristics and properties of food. Students are provided with the opportunities to develop knowledge and understanding about food selection and preparation, food safety and how to make informed choices when experimenting with and preparing nutritious food.

Digital Technologies context encourages students to develop an empowered attitude towards digital technologies, use abstractions to represent and deconstruct real-world problems, and implement and evaluate digital solutions. Students have the opportunity to become innovative creators of digital technologies in addition to effective users of digital systems and critical consumers of the information they convey.

Source: NESA, 2017, Technology Mandatory Syllabus

Learning outcomes

This unit of work provides students with the opportunity to investigate the importance of aquaculture production to our society. This unit supports student learning of Australian freshwater crayfish production.

Resource description

The Yabby unit of work consists of four resources including a workbook, answer guide, and two major design folios.

The workbook provides background information on the freshwater crayfish industry, management, marketing, anatomy and identification, welfare and legislation. Understanding developed from this core learning resource can be used to carry out one of two major design projects:

- Design project 1 "Design and code an aquaponics system"
- Design project 2 "Design and build an aquaponics system"

These resources are designed to be used together however, teachers are advised to alter the resources to suit learners, school facilities and individual skills.

Animal welfare considerations

Ensure that you consult your School animal welfare officer and the NSW Animals in Schools website about welfare, animal requirements and legislation for keeping crayfish in schools for scientific purposes.

Glossary

Key Word	Definition
Agriculture	Agriculture is the science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, fibre, fuel and other products.
Aquaculture	Aquaculture involves the rearing of aquatic animals or the cultivation of aquatic plants for food.
Crayfish	Crayfish are a group of invertebrate animals from the crustacean phylum. Crayfish live in freshwater or marine environments depending on the species. Species include lobsters, marron, red claw, yabbies, Moreton bay bugs and rock lobsters.
Domestic market	Also referred to as an internal market or domestic trading, is the supply and demand of goods, services, and securities within a single country.
Economy	An economy encompasses all activity related to production, consumption and trade of goods and services in an area.
Export market	A country or group of countries to which goods and services from another country are sold.
Extensive aquaculture	Management approach. Characteristics include less management and direct manipulation of the aquaculture system as compared to intensive aquaculture. Management includes possible initial stocking of population until population replacement occurs through natural breeding with no provision of formulated food or pellets. Species usually grow on their own using natural food sources and environmental conditions. Traditionally extensive aquaculture has lower production rates over longer periods. Examples include oyster farming.
Intensive aquaculture	Intensive aquaculture involves intervention in the rearing or growing process through supplemental feeding of formulated food, water aeration and exchange and in some cases environmental manipulation. Traditionally, intensive culture has much higher production rates, shorter grow-out periods, greater overheads due to equipment and production costs and potentially greater returns per unit area. Examples include: prawn farming
Primary industry	Industries including mining, agriculture and forestry, which are concerned with obtaining or providing natural raw materials for conversion into commodities and products for the consumer.

Aquaculture in Australia

What is Aquaculture?

Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants.

Farming implies some form of intervention in the rearing process to enhance production. In aquaculture this could include regular stocking, feeding, providing nutrients, and management of water quality, regular harvesting and providing protection from predators.

Aquaculture has been undertaken globally for centuries. It has rapidly grown as a commercial worldwide industry in the last 50 years.

Aquaculture produces a wide variety of fresh and saltwater animal and plant species including finfish, crustaceans, molluscs, echinoderms, polychaetes, as well as algae, seaweed and other aquatic plants. These products can be used for human or stock consumption, chemical extraction, pharmaceuticals, jewellery and ornamental purposes.

There are a variety of aquaculture production systems. The choice of systems depends upon the physiological requirements of the species (for example space, water quality and nutrition), the site (for example offshore, estuarine or land based) and operational criteria (for example proximity to transport, processing facilities and markets). Depending on these requirements the aquaculture will then be intensive, semi-intensive or extensive production; depending on the level of input and output per farming area and the stocking density.

Marine aquaculture typically uses floating sea cages with suspended nets for the farming of finfish. Shellfish production is carried out on longlines (suspending cultivation) or using post and rail infrastructure in estuarine areas. Land based farming systems for finfish, crustaceans, algae and ornamental species use earthen and lined ponds, dams, tanks and aquariums. The fundamental aspect of any suitable aquaculture development is a reliable supply of high quality water.

The history of aquaculture in Australia

In Australia, aquaculture has been practiced for approximately 40,000 years by Aboriginal communities. The Aboriginal fish weirs and dam systems in the Brewarrina region of NSW still exist today and stand as a testament to Aboriginal knowledge of engineering and fish migration. Fish and eel weirs are also found in Victoria, in the Lake Condah region. These weirs supported a settled Aboriginal community that farmed eels for food and trade. This is considered to be the earliest and possibly largest land based aquaculture venture in Australia, and possibly the world. Archaeological evidence of purpose designed tools for fishing and shell middens can be found all over the Australian continent. This illustrates the deep connection and prominent place in Aboriginal lifestyle and culture of aquaculture production. Fishing has always been an important part of the cultural and economic life of Aboriginal communities. For Aboriginal people fishing was

Figure 1 Aboriginal fish traps made from rocks, Darling River, 1938; Source: LaTrobe Picture Collection, State Library of Victoria

and still is an integral component of connection to their traditional country (Roberts, 2016). Read more on Aboriginal aquaculture at "The detective work behind the Budj Bim eel traps World Heritage bid".

The modern Australian aquaculture industry occurs in marine, estuarine and freshwater locations. The industry is mostly based in regional Australia on land based systems and makes a significant and positive contribution to the economy.

Australian commercial aquaculture and fisheries, is the fastest growing primary industry in Australia, even if it is relatively new. This is due to increasing demand for high quality, disease-free seafood and aquaculture products.

Aquaculture in Australia learning activities

1. **Define aquaculture.**

_____

_____

2. **List the 7 plants and animals farmed for aquaculture from paragraph three. Use the internet to research an Australian example for each.**

_____

_____

_____

_____

_____

_____

3. **List four different uses for Australian aquaculture products.**

_____

_____

4. **Identify three factors that determine which aquaculture system can be used.**

_____

_____

_____

5. **For one of the factors above explain why it will determine the type of system. For example, physical requirements of the species.**

_____

_____

_____

_____

_____

_____

Use the internet to investigate the Australian Aboriginal fish weirs and dams at Brewarrina in NSW to complete 6-13. (A helpful site to assist your investigation is Brewarrina Aboriginal Fish Traps / Baiame's Ngunnhu')

6. **Identify the river system and Aboriginal name for the Brewarrina fish weirs.**

_____

_____

7. **Identify the traditional custodians and engineers of the site.**

_____

_____

8. **How old are the fish traps?**

9. **Summarise the creation or dreaming story behind the fish traps.**

10. **Describe the design and size of the fish weirs.**

11. **List the materials used to make the fish weirs.**

12. **Describe how the fish weirs worked.**

13. **Do you think the fish traps were effective? Explain your answer.**

The value of aquaculture in NSW

NSW boasts a large and diverse range of primary industries. The State's total production value can be measured through the Gross Value Production (GVP). Figure 2 illustrates the industries contributing to NSW Primary Industries estimated $15,442 million GVP.

Figure 2 NSW Primary Industry GVP. Source NSW DPI, 2017

Fisheries and aquaculture make a significant contribution to the NSW economy and supply produce for both domestic and export markets. In 2016-17 fish and crustacean species made up 71% of our aquaculture exports. Fisheries produce includes both sustainably farmed aquaculture products as well as produce harvested from the wild.

NSW is a relatively small exporter of aquaculture products, with shipments in 2016-17 totalling $10.9 million. Australia, however, does have a competitive advantage in seafood export because of its closeness to Asian markets, and our producers' ability to transport high quality, fresh, disease free seafood into those markets.

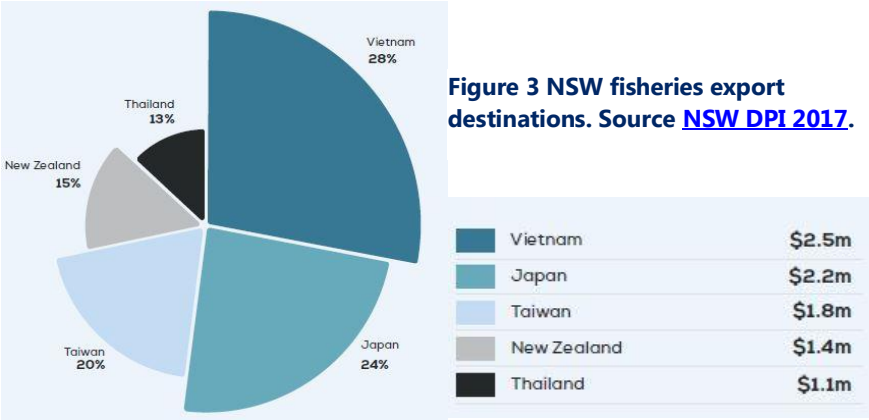

Figure 3 NSW fisheries export destinations. Source NSW DPI 2017.

We do not produce or wild harvest enough aquatic products to meet our domestic demand, so imported produce comes to us from Thailand, New Zealand, Vietnam and China. These imports usually consist of lower-value products such as frozen fillets, frozen prawns and canned fish. More aquaculture products are imported into NSW than we export.

Major aquaculture species farmed in NSW include: oysters (Sydney Rock, Pacific, and Native Oysters), farmed Tiger Prawns, Silver Perch, Yellow-tail Kingfish, Rainbow Trout, Murray Cod, Mulloway and Barramundi. There is also a well-developed freshwater finfish hatchery sector, worth more than $3 million annually. See Figure 4 for the land based aquaculture snapshot; note it does not include marine aquaculture production.

Grouping	Common Name	Scientific Name	Production		Value ($)
			Kilograms	Dozens	
Crustaceans	Black tiger prawn	Penaeus monodon	360,386		$7,868,532
	Yabby	Cherax destructor	4,019		$132,766
	Yabby (bait)	Cherax destructor	2,330		$247,731
Subtotal					**$8,249,029**
Freshwater Fish	Barramundi	Lates calcarifer	43,683		$653,595
	Golden Perch	Macquaria ambigua	1,218		$15,461
	Murray Cod	Maccullochella peelii	264,750		$4,386,824
	Rainbow Trout	Oncorhynchus mykiss	211,047		$2,623,377
	Silver Perch	Bidyanus bidyanus	193,597		$2,397,682
Hatchery	Hatchery Species				$3,826,235
Molluscs	Sydney Rock Oyster	Saccostrea glomerata		5,517,866	$40,682,269
	Pacific Oyster	Crassostrea gigas		287,359	$4,640,844
	Native Oyster	Ostrea angasi		7,546	$89,961
	Oyster Spat				$1,840,849
Total Value ($)					**$70,014,462**

Figure 4 Snapshot of total NSW land based aquaculture production for 2016/17; Source: NSW DPI, 2018

The value of aquaculture in NSW learning activities

1. **List the top 5 contributors to NSW Primary Industries GVP.**

   _____

   _____

2. **According to Figure 2; how much did Aquaculture contribute to NSW primary Industries; and what is its rank?**

   _____

   _____

3. **List the two countries NSW imports aquaculture products from.**

   _____

   _____

4. **Complete the table to list the five main export destinations and the value of product exported for NSW fisheries.**

Export destination	Export value

Freshwater crayfish production in Australia

Australia hosts one of the world's most diverse crayfish fauna. In 2018 there were 143 different species of freshwater crayfish species native to Australia. There has traditionally been little research put into native crayfish and their habitats and new species are continually discovered.

Many Australian crayfish species are unfortunately threatened due to habitat loss, pollution, predation and competition from invasive species and human exploitation. Many species are on the endangered or critically endangered list. Follow this link to further investigate the 143 Australian Freshwater crayfish species; Full Australian Freshwater Crayfish List 2018.

Not all species of freshwater crayfish are suitable to commercial aquaculture production. There are three main species farmed in Australia. These include the Yabby (*Cherax destructor*), the Redclaw (*Cherax quadricarinatus*) and the Marron (*Cherax cainii*). The yabby is smaller and not as high yielding as the redclaw, while the marron is usually larger but slower growing.

Cherax destructor (yabby) are native to the Murray Darling drainage basin of Australia and thrive throughout the whole basin. The Murray Darling Basin reaches from Queensland through New South Wales, Victoria and into South Australia. As well as being native to these areas the *destructor* was introduced to Western Australia in the 1930s where it has become a biosecurity pest, causing havoc to native Western Australian crayfish species. Translocated *Cherax destructor* is also a problem in eastern NSW where it out-competes native species. *Cherax destructor* is the most commonly and widespread yabby farmed in Australia.

Figure 5 *Cherax destructor* (Yabby). Source Rob McCormack, Australian Aquatic Biological

Redclaw are a tropical freshwater crayfish that originated from rivers in the Gulf country of northern Queensland and Northern Territory. Redclaw farming occurs throughout Northern Australian states and in warmer coastal areas of NSW and WA. Freshwater crayfish are grown overseas using Australian redclaw and *destructor* in China, Indonesia, Israel, Spain and the United States of America.

Figure 6 *Cherax quadricarinatus* (Redclaw). Source Rob McCormack, Australian Aquatic Biological

Marron are native to the southern-west tip of Western Australia. Humans have, however, introduced and established them in a larger area from Geraldton to Esperance, WA by stocking dams and waterways. Marron are farmed in all states with the majority of production occurring in Western Australia.

Figure 7 *Cherax cainii* (Marron). Source Rob McCormack, Australian Aquatic Biological

Freshwater crayfish (yabby) production is carried out in either existing dams, ponds or in the last 15 years, in purpose-built semi-intensive ponds and tank systems. Yabby ponds are an ideal use for heavy clay based soils that can otherwise be unproductive. Yabbies can present an opportunity for diversification for farmers who have access to good quality water and spare land. A correctly designed yabby pond system will allow water to be recycled for irrigating other crops after it has been used for yabby production. The biggest limitation to crayfish production is water availability caused by drought.

Crayfish production - fast facts

- *Cherax* refers to crayfish belonging to the smooth-shelled genus.
- Australia's main farmed smooth-shelled crayfish species are the yabby (*Cherax destructor*), marron (*Cherax cainii*) and redclaw (*Cherax quadricarinatus*)
- While *Cherax destructor* is commonly referred to as the yabby, all three species are known to be referred to as yabbies
- Yabby production is predominantly undertaken in farm dams in Australia
- Marron and redclaw production is almost entirely based on semi-intensive aquaculture using purpose built ponds
- While highest prices are paid for marron, they can take more than four years to mature to their legal or market size
- Freshwater crayfish are usually sold live to customers
- Australia's freshwater crayfish production is free of major diseases, giving it a marketing advantage in export markets
- While production has been increasing since the 1990s, the challenge exists to consistently supply crayfish to maintain our export markets
- State governments strongly regulate the location of, and species used, in aquaculture enterprises. (AgriFutures Australia, 2017)

Freshwater crayfish production learning activities

1. **Use the internet and other sources to investigate one of the three freshwater crayfish species commercially produced in Australia. For your chosen species research and include the following:**

- Common Name
- Scientific Name
- An image of your chosen species
- A physical description of your species including:
    - Adult size (length and weight)
    - Colour
- Identify the common diet
- Identify the main predators
- Describe the species natural habitat
- Identify the main markets for your species

Unfortunately many Australian crayfish species are threatened by habitat loss and invasive species.

2. **Use the internet and other sources to investigate a native freshwater crayfish species not farmed. For your chosen species investigate and provide:**
    - An image of the species
    - A physical description of the species
    - A map or description of the distribution of the species
    - A description of the natural habitat
    - A list of reasons why the species is threatened or endangered
    - A description of how we can conserve this species

Ideas include:

- **The endangered, Giant Tasmanian Freshwater Lobster (*Astacopsis gouldi*). This crayfish is the largest freshwater crayfish species in the world**
- **Critically endangered, Hairy marron (*Cherax tenuimans)***
- **The critically endangered Fitzroy falls spiny crayfish (*Euastacus dharawalus)***
- **The Leckies crayfish (*Cherax leckii*)**
- **Vulnerable species, the Murray crayfish (*Euastacus armatus*)**
- **Threatened species, the Burrowing crayfish *(Engaewa pseudoreducta)***

Some helpful sites to start your investigation:

- **the Australian Government site Threatened species & ecological communities**
- **Australian Aquatic Biological's site Australian Crayfish Project (ACP)**

Yabby biology and behaviours

Anatomy

A crayfish's body is made up of a head and thorax protected by a hard shell (called a carapace) and a muscular abdomen and tail. Freshwater crayfish are decapod crustaceans, which mean they have 10 legs.

These include large claws called chelepids for grasping food, fighting and moving. The next pair of legs consists of two small pincers for picking up food particles, they are used to feed themselves and for walking movement. The last pair of legs are used for walking movement.

Underneath their abdomen crayfish have pleopods, also called swimmerettes which are thin leg-like structures used to swim, move water over the gills and hold eggs and larvae. Crayfish have two eyes on the end of their eyestalks but also rely heavily on touch and taste, using one pair of large antennae and smaller antennules.

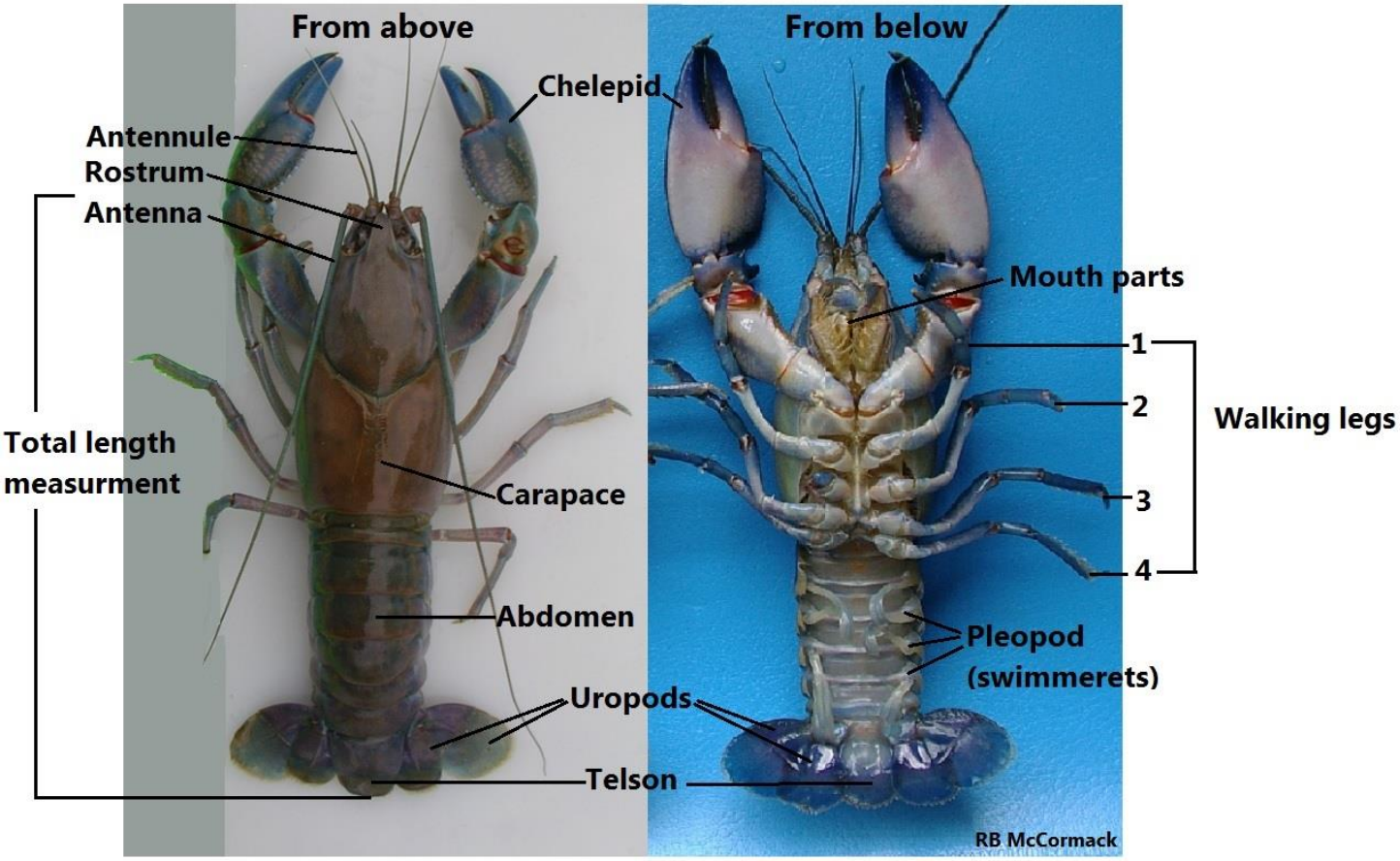

Figure 8 Yabby anatomy. Source: Rob McCormack, Australian Aquatic Biological

Gender of yabbies and freshwater crayfish may be determined by looking at the underside of the animal as seen in Figure 9. Male crayfish have 'genital papillae' or protrusions at the base of their last pair of walking legs. Females have oviducts, observed as small, round, disc shaped openings located on the second pair of walking legs (from the head).

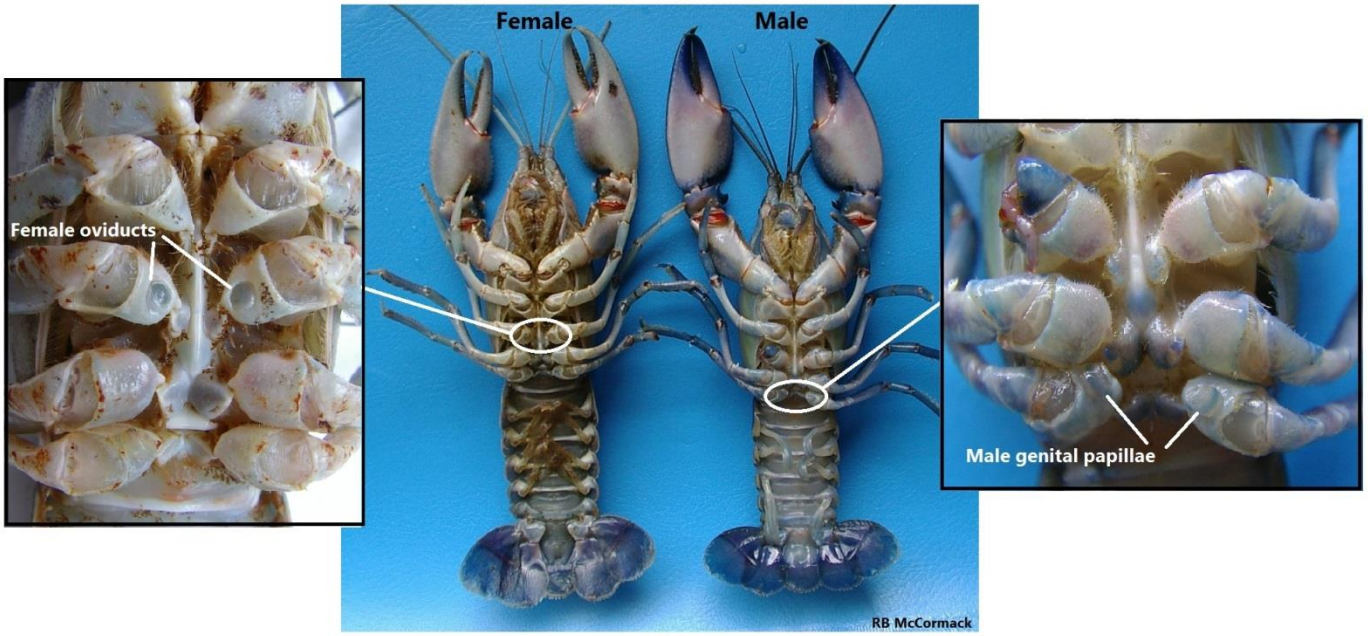

Figure 9 Male and female yabby anatomy. Source: Rob McCormack, Australian Aquatic Biological

Practical -Observe the parts of a freshwater crayfish practical

The following practical investigation is a dissection or observation designed to maximise and challenge student learning through real life observation.

This activity should be used as a guide and must be modified to suit individual teacher personal preference and on individual students' needs, facilities and personal skills. Modifications for this observation activity may include:

- Observing images or examples of freshwater crayfish using YouTube and the internet,
- Non-invasive observation with NO handling of live specimens in an aquarium,
- Purchasing whole crayfish specimens for human consumption to carry out a dissection. Crayfish should be sourced from a licenced supermarket, fish market or a similarly licenced distributor.

Warnings:

- **DO NOT use live animals for this practical activity as it could cause harm and distress to the animals.**
- **Dissection of animals is not mandated by any NESA syllabus.**
- **Refer to the NSW Animals in Schools page to learn more about the use of animals in schools for research purposes.**
- **Dispose of all waste from the dissection into human waste disposal.**
- **DO NOT feed any animal refuse to other animals or allow aquatic animal waste to contaminate waterways or aquatic species.**

Key Word	Definition
Abdomen	The abdomen made up of strong muscles which aid in movement. It is the part consumed by humans.
Antennae	The long thin anterior structures used to touch and taste food and maintain balance.
Antennule	The short thin anterior structure used to taste food.
Carapace	The exoskeleton covering the fused head and thorax region.
Chelepid	The large anterior claws used for grasping food, fighting and movement.
Exoskeleton	The hard external encasement providing the animal with protection and a place for muscles to attach.
Gills	External structures and a part of the animals' respiratory tract. Gills allow exchange of oxygen and carbon dioxide directly between the animal and water.
Mandible	The mouth structure used to grind food. It is surrounded by structures called maxillipeds which push food into the mouth.
Reproductive openings	Male yabbies have protruding genital papillae at the base of their fourth set of walking legs and females have oviducts at the base of their second pair of walking legs.
Swimmerettes	Also called pleopods, these are thin leg-like structures used to swim, move water over the gills and hold eggs and larva.
Tail	The tail is made up of the central telson and outer uropods which aid the animal in swimming and movement. When threatened, the crayfish propels itself backward quickly with strong flips of the telson, located at the tip of the abdomen.
Thorax	The region between the head and abdomen (in humans it is the chest area). It contains the organs for the respiratory, circulation, digestive and nervous systems.
Walking Legs	The legs used for walking, food gathering and moving water over gills. There are four sets of walking legs.

Students are to complete the following activities as they observe a freshwater crayfish. Tick the box when you have completed the activity.

Method:

The head (Tick each box on completion)	
☐	Place the crayfish ventral (belly) side up so you can observe the mouthparts.
☐	Locate the sets of 'leg-like' structures surrounding the mouth or mandible. These are called maxillipeds and are used for handling and breaking apart food for eating.
☐	Locate the mandible which lies underneath the maxillipeds. This structure should be hard and difficult to move.
☐	Locate the two large antennae and the smaller antennules that branch from the base. The antennae are sense organs (touch, taste, and balance).
☐	Locate the eyes, which extend from two stalks called pedicles.

The body	
☐	The body of the crayfish consists of a fused head and thorax. It is covered by thick armour called a carapace. Extending from the carapace between the eyes is a pointy structure called the rostrum. Locate the carapace and rostrum.
☐	The abdomen of the crayfish is segmented and flexible. Gently bend the abdomen back and forth and observe how each segment moves.
☐	Count the number of segments on the abdomen. Hint: bending it will show you where the segments are separated. How many segments are on your crayfish? _____ Compare this number to other crayfish. Are they all the same? _____
The appendages	
☐	Locate the chelipeds (the claws). Gently move the cheliped to determine the range of movement and directions which the chelepid can bend.
☐	Remove a cheliped and use the forceps to find the connective tissue inside. Pulling on this tissue will make the claw open and close. Try it.
☐	Behind the cheliped, find the four pairs of walking legs.
☐	Locate the swimmerettes (appendages attached to each segment of the abdomen). Are the swimmerets jointed? _____ How many pairs of swimmerettes are there? _____
☐	The last segment of the abdomen (tail) is called the telson, and it is specialised for swimming. Locate the two uropods which extend from either side of the telson.
Determining the sex of your crayfish	
☐	Locate the second and fourth pair of walking legs from the crayfish head.
☐	If the base of the second pair of walking legs from the head have an oviduct (oval disc) your crayfish is female. If at the base of the fourth legs there are protrusions called 'genital papillae', your crayfish is male. What is the sex of your crayfish?_____
Apply your knowledge	
☐	Label the crayfish in Figure 10 using the Glossary above.

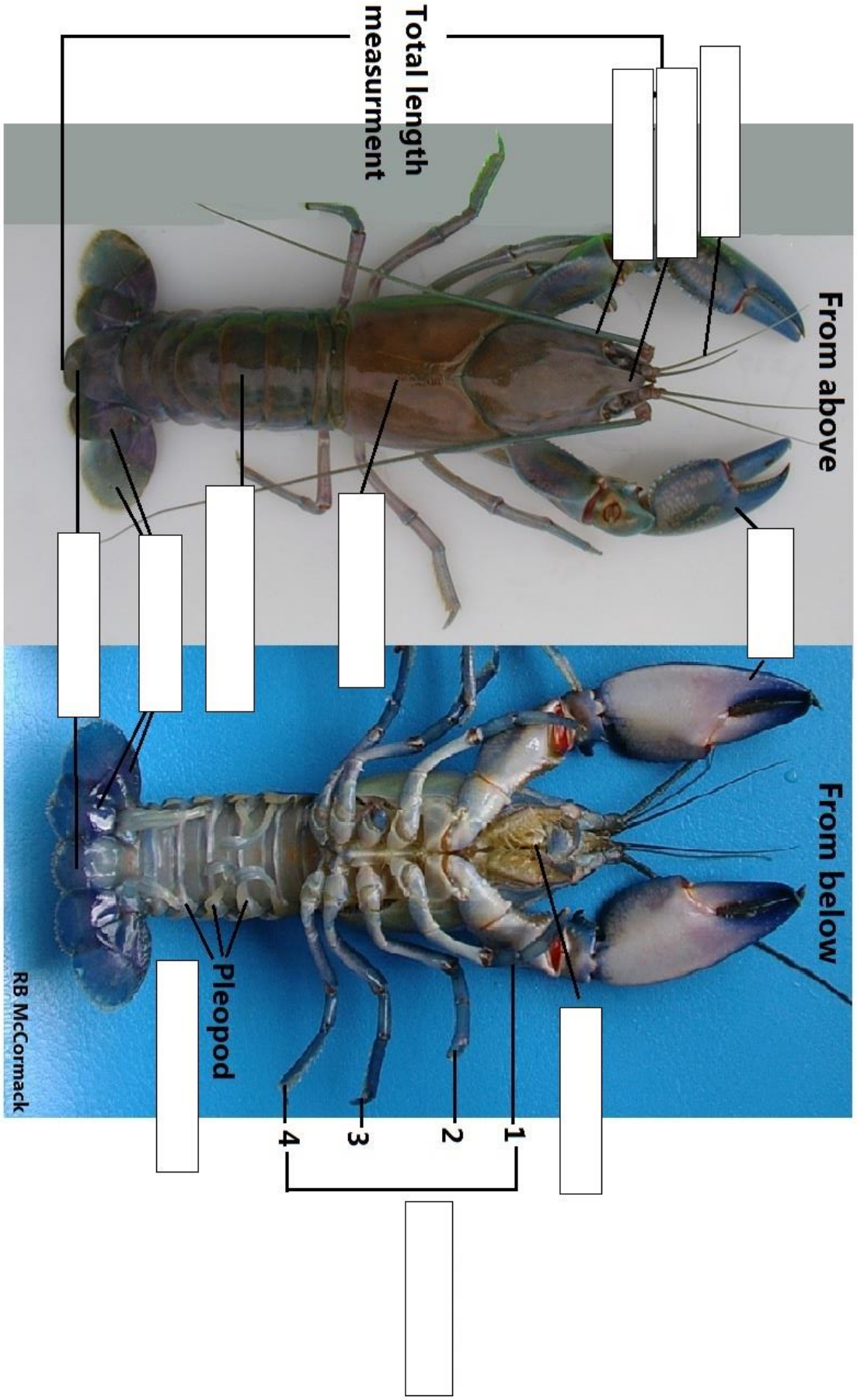

Figure 10 Label the parts of the crayfish

Diet

Yabbies are omnivores and detritivores. This means they will consume both fresh and decaying plant and animal proteins, however they selectively are herbivores. Their feeding style is described as being opportunistic, which means that they will consume any food available within the waterway or pond system. This includes:

- Plant material, for example, aquatic plants, flooded crops, Lucerne, phytoplankton (tiny algae cells) and algae.
- Animal material, for example, aquatic insects and zooplankton (tiny aquatic organisms), free swimming animals such as small fish, insect larvae, snails, other yabbies and tadpoles, animal faeces and material from dead animals. Animal material provides a good source of protein to the yabbies diet.
- Detritus is decomposing plant matter which is colonised by bacteria and fungi. Detritus is a major component of the yabbies' diet and a high protein source.

Why is meat used as bait to catch yabbies?

Yabbies as a solely carnivorous animal is a misconception. Yabbies are very susceptible to low quality or contaminated water. As meat decays it releases substances into a water system that reduce water quality. Yabbies therefore are very attracted to meat and consume it to remove it from the water system before it decays and fouls their habitat.

Reproduction

The sex of yabbies is easily observed through locating the female or male reproductive openings on the underside of the animal. Females have oviducts on the second pair of walking legs from the head and males have papillae growths on the base of the last pair of walking legs.

Yabbies reach sexual maturity at less than one year old and can be as small as 20 grams. The female yabby reaches sexual maturity when about 9 to 10 centimetres long; the male when slightly smaller. Length is measured from the tip of the rostrum which is the spine between the eyes, to the end of telson.

Figure 11 Female yabby in berry. Source, Rob McCormack, Australian Aquatic Biological

Yabbies are fertile and productive breeders and females commonly produce eggs up to five times a year depending on climatic conditions. Mature females can produce between 100-500 eggs per brood depending on her size. Larger females produce a greater number of eggs.

When freshwater crayfish mate, the male deposits a small packet of sperm gel on the female, near the reproductive openings. The female then passes the eggs out through the openings and across the sperm packet; this process results in fertilisation and is called spawning. The fertilised eggs are then guided by the swimmerets to the underside of the tail, where they are fastened on to the swimmerettes and carried until they hatch. The eggs are incubated underneath the tail of the female and hatch between 8 to 10 weeks. When a yabby female is carrying eggs she is termed as 'in berry'.

Hatched young are called 'juveniles'. Juveniles have special hooks on their legs to allow them to cling to the hairs of the female's swimmerettes; they moult several times before leaving and being independent of the parent. Juvenile independence can take up to 25 days dependent on warm water temperature.

Breeding begins in spring when the water temperature reaches 15 to 16◦C. The first batch of eggs hatches 8 to 10 weeks later in early summer. As soon as the young have left (approximately 3 weeks later), the female is ready to breed again. Because of the higher water temperatures in summer, the second brood takes approximately 3 to 4 weeks to incubate. Some females will breed three or more times during the breeding season. If the temperature remains high enough, the breeding season can extend into autumn. In the warmer water in the west of the State, the breeding season may continue almost year around.

Growth

Like all crustaceans, the yabby must periodically moult its exoskeleton to grow in size. The moulting frequency depends upon day length and temperature, which stimulate the release of moult-inducing hormones. The frequency of moults decreases with age.

Newly hatched juveniles moult every few days or so, yearling yabbies moult two to three times a year, and a 3 or 4-year-old perhaps only once a year. The new shell is very soft for a short time. When the yabbies shell is soft, they are very vulnerable to attack by other yabbies, fish and other predators. The clean, pink shell of the new moult contrasts vividly with the dirty, algae-coated shell of the pre-moult animal, especially in older animals.

Growth depends mainly on water temperature, available food and population density. Within limits, the warmer the water the faster a crayfish grows. This is because, like most cold-blooded animals, yabbies cannot regulate their own body temperature. *Cherax destructor* can tolerate temperatures up to 35◦C, however growth appears to suffer over about 28◦C.

After maturity is reached, the female grows more slowly than the male, because they direct more energy into reproduction and producing eggs. A female never grows to the size of an old male, which can weigh 300 grams.

If a yabby loses a limb (claw, walking leg or antenna) it will grow back, starting at the next moult. However, unless the lost part is small, total regeneration is not immediate and usually three or four moults are needed to restore the limb completely. In Figure 9, the males second walking leg is regenerating.

Figure 12 Yabby shell. Source NSW DPI

Learning activity - develop a calendar of operations for yabby management

Develop a calendar of operations for yabby management by completing the table below.

Specific management operations which must be included are:

- Summer feeding and frequency
- Winter feeding and frequency
- Yabby joining
- Juvenile separation from adults
- Breeding season (when you would expect juveniles and berried females)
- Harvesting of yabbies

Season	Time of Year	Management Operation
Summer	January	
	February	
Autumn	March	
	April	
	May	
Winter	June	
	July	
	August	
Spring	September	
	October	
	November	

Summer	December

Practical activity – Monitor crayfish growth

Measure and record growth rates of crayfish over a period of time. Use your data to make observations on how management influences growth rate in yabbies.

Investigation questions could surround:

- Male vs female growth on the same diet
- Growth differences in response to different diets- e.g. *ad.lib* feeding vs. controlled feeding
- Growth rates in response to light manipulation
- Growth rates in response to temperature manipulation

Go to the NSW Animals in Schools website to learn more about welfare, handling and legislation for keeping crayfish in schools for scientific purposes.

Figure 13 *Cherax destructor*. Source, Rob McCormack, Australian Aquatic Biological

Aquaculture production of yabbies

Regulations

Establishing and operating an aquaculture enterprise requires a licence from the relevant state government authority, or department of fisheries. Departments of planning, environment and local government authorities may also need to approve development applications for aquaculture enterprises (AgriFutures Australia, 2017).

Requirements differ between states, but general factors that need approval include:

- Site and species selection approval that minimise environmental impact.
- Producers must have relevant safeguards in place to ensure there is no nutrient contamination into natural waterways.
- Producers must have adequate safeguards to ensure farmed species do not escape into the surrounding environment.
- Aquaculture operators may be required to lodge production figures with the state government and accept inspections by fisheries officers to ensure compliance with licence provisions.
- Live freshwater crayfish may not be moved interstate without certification, licencing and approval (AgriFutures Australia, 2017).

Biosecurity

Biosecurity involves preventing the introduction and spread of diseases, pests and contaminants. Prevention is the target outcome. Unfortunately, biosecurity breaches do occur and new diseases can be introduced via various pathways.

Biosecurity laws have been put in place to protect Australian native crayfish species and protect the crayfish and fisheries production industry. These include:

- Restrictions on movement and fishing. The legislation prohibits the movement of live crayfish between any Australian State or Territory without certification and licensing. These laws have been put in place to reduce and prevent pest and disease spread and to minimise introduced yabbies outcompeting native populations.
- Farmed yabbies, yabbies kept for the aquarium trade, yabbies used for bait or yabby products and waste must never be released or allowed to contaminate streams, rivers and waterways.
- Crayfish may only be fished in water ways in certain areas and at certain times of year.
- Specific trapping equipment must be used for recreational fishing, to prevent trapping and drowning non target aquatic species such as platypus.

Diseases which threaten Australian freshwater crayfish native populations and fisheries industry include:

- Crayfish Plague caused by an exotic fungus (Aphanomyces astaci), is a fatal disease a freshwater crayfish species not present in Australia.
- White spot a highly contagious virus which affects all fresh water and marine decapod crustaceans and some species of marine worms. An outbreak occurred in Australia in 2018 from prawns imported for human consumption which were used as bait.
- Porcelein Disease also known as white tail or white muscle disease, is usually a fatal disease caused by the parasite Thelohania. It is transmitted by marron or yabbies feeding on an infected, dead or dying crayfish.

Learning activity - regulations and welfare

Follow the link to the NSW Department of Primary Industries Starting up in Aquaculture page. Investigate the page to complete activity 7.1

1. **List 5 legal responsibilities a NSW aquaculture producer must carry out to hold a NSW aquaculture permit.**
   - _____
   - _____
   - _____
   - _____
   - _____

2. **Use research to explain the ethical issues why farmed yabbies *(Cherax destructor)* cannot be released into native waterways.**

   _____
   _____
   _____
   _____

Pond design

The success of an aquaculture enterprise is dependent on many factors including the selection of a suitable site and the design and construction of facilities that enable efficient and economic operation. Crayfish and yabby ponds are usually built on relatively flat or slightly sloping land which allows water to be supplied and drained to and from the dams or ponds by gravitation.

Factors to consider for pond and dam set-up:

- If using earthen ponds or dams the pond floor should be compacted and impenetrable to eliminate water loss through seepage and escape of yabbies through burrowing. Clay or clay loam soils are ideal.
- A dependable drought-proof supply of good quality water is essential which is free of contaminants and pathogens.
- Water must be aerated to maximise oxygen content which will improve water quality and production.
- Dams must have a specific water inlet and outlet source. These should both be filtered to stop undesirable aquatic species entering the pond system and yabbies exiting the system.
- Ponds should have a definite deep and shallow end with sloping sides to allow for gravitational drainage of water and crayfish.
- Ponds must have some sort of protection and shelter for yabbies from predators such as birds, fish, turtles, frogs, platypus and other yabbies. Protection could be a bird netting system over the top of the ponds, hessian sacks, branches and pipes in the water to provide the territorial yabbies shelter. Ponds should also be fenced to keep fauna out and prevent farmed crayfish escaping the system into natural waterways.

- Pond systems should be designed with multiple ponds, dams or tanks to allow for different grow-out areas for the different yabby sizes, growth stages or sexes. Grow-out is a term used to describe a crayfish management technique when juvenile and young growing crayfish are separated from mature adults and grouped together according to sex or size to allow them to grow out to a specific size without risk of predation from other yabbies.
- Crayfish systems must include a water recycling system. Most commercial operations continually filter and recycle all water, pumping it between ponds, dams and tanks. When ponds are drained, organic waste and nutrients are collected and this, along with any excess water, is used to grow crops that can be used to grow feed for crayfish. Crayfish production is a very self-sufficient and sustainable system.
  Follow this link to investigate how to DIY build a small scale aquaponics system to grow vegetables and crayfish 'Build a large aquaponics system farm crayfish and vegetables'.
- Ponds are frequently built in a block which reduces building costs, land area and infrastructure costs such as water piping, aeration, fencing and netting.
  Follow this link to the Fisheries and Aquaculture Department page Cultured aquatic species information- *Cherax quadricantus* to investigate crayfish pond set ups and harvesting methods.

Figure 14 Yabby aquaculture, grow out tank system. Source, NSW DPI

Supplementary feeding

Yabby farmers provide feed to supplement natural food sources in the grow-out pond system. The most common types of supplementary feed sources provided include:

- Lupins which are a legume grain high in protein and calcium.
- Cereal grains including wheat, barley and oats which are high in protein and calcium.
- Lucerne hay which is a high protein and fibre source
- Vegetable scraps and grass clippings
- Specifically manufactured crayfish pellets formulated for yabbies' nutritional requirements.

Yabbies are fed around twice per week during the summer months when they are actively growing and breeding. Crayfish will stop feeding just before moulting but will continue feeding soon after the moult. In the winter their activity and metabolism slows down due to lower winter temperatures. In the winter, yabbies are routinely fed once per fortnight.

The amount of supplementary feed required is dependent on water temperature, stock density and the type of food given. Feeding rate must be monitored, because:

- Overfeeding yabbies can result with increased pest and disease burdens and reduced water quality. This happens because the food is not being consumed, so it decays and contaminates the pond system.
- Underfeeding yabbies will result with too much competition between the yabbies for the food and nutrient resources. As a result yabbies will fight and turn to cannibalism.

Harvesting

Yabbies in commercial farms can be harvested using several techniques. Three techniques will be discussed.

- Bait trapping. Baited traps are placed in ponds up to 12 hours and crayfish are collected from the traps. Disadvantages of this harvesting technique are that it is slow, time consuming and not all yabbies are trapped.
- Drain harvesting. Ponds are completely drained and crayfish are either manually collected or collected in a filtering cage around the pond drainage pipe. Disadvantages of this harvesting technique involve loss of yabbies in natural ponds and dams as they burrow in response to dropping water levels. Marron and redclaw do not burrow as much as *destructor* yabbies.
- Flow trapping. The flow trap consists of a large open box with a ramp attached to one side. The trap is set up on the edge of the water in the pond with the ramp going down into the water. A steady water stream from a pump is directed into the box. When the box is full, the water flows down the ramp and into the pond. The crayfish detect this water flow, walk up the ramp and fall into the box. If the pond is slowly drained at the same time, virtually all the crayfish in the pond find their way into the trap.

The flow trapping method allows large quantities to be harvested with minimal stress on both the animal and the farmer. Flow trapping utilises the animal's natural behaviour. Crayfish instinctively travel upstream, so the flowing water triggers a natural response from the crayfish and they move into the current, up the ramp and into the harvest box.

Figure 15 *Cherax destructor* yabbies. Source NSW DPI

In order to effectively manage the pond environment and the stock of crayfish within the pond, it is essential to drain and dry every pond at least once each year. After harvesting the best crayfish are selected as breeding stock (broodstock), with the majority of the production being sold. Broodstock selection ensures that individuals displaying desirable characteristics, such as fast growth rate, are able to contribute their genes to the successive generations (Queensland Government, 2018)

Yabbies being harvested for human consumption must be 'gill flushed' on removal from the pond system. Gill flushing is carried out for food safety. It involves the yabbies being sat in clean water to allow them to flush their gills from any bacteria or fungi that could be present in the pond system. They should be gill flushed for at least an hour after harvesting to meet market requirements. Following gill flushing yabbies are purged which involves yabbies passing all waste. Purged yabbies have a marketing advantage over wild caught yabbies which require the chef to remove the full waste line.

Aquaculture production of yabbies learning activity

Follow this link to watch '[Farming and handling of yabbies]' produced by Fisheries research AU, 2012. This clip investigates management, marketing and harvesting of yabbies in Western Australia. As you watch the clip, complete the activities.

1. **Successful farming means getting the maximum _____ for your_____.**
2. **What percent of farm dams produce yabbies in WA.? _____.**
3. **Western Australia is the leading producer of farmed _____ in Australia, and demand for yabbies is _____ steadily.**
4. **What 3 things do you need to have to start up a yabby farm?**

- _____
- _____
- _____

5. **What are the weights for the five yabby markets?**
   - _____
   - _____
   - _____
   - _____
   - _____
6. **What sizes of yabbies does the market prefer?**

   _____
7. **List three physical characteristics that indicate poor quality yabbies:**
   - _____
   - _____
   - _____
8. **Explain why clear water is not essential for yabby production.**

   _____
9. **List three conditions yabbies don't like:**
   - _____
   - _____
   - _____
10. **What times of year will yabbies reproduce? _____**
11. **What feedstock is recommended to feed yabbies?**

    _____

    _____
12. **How can you tell that yabbies are being underfed?**

    _____

    _____
13. **List things to avoid when feeding yabbies:**

    _____

    _____
14. **In Western Australia, how often should you harvest yabbies?**

    _____

    _____

15. **Once the yabbies have been removed from their nets identify how they should be stored in preparation for transport?**

    _____
    _____
    _____
    _____

16. **List some of the factors that will result with a harvested yabby being returned back to the dam.**

    _____
    _____

17. **Explain why you cannot introduce any yabbies into streams, rivers and waterways.**

    _____
    _____
    _____
    _____

18. **Name and explain three areas that research has identified as important factors to increase yabby production.**
    - _____
    - _____
    - _____

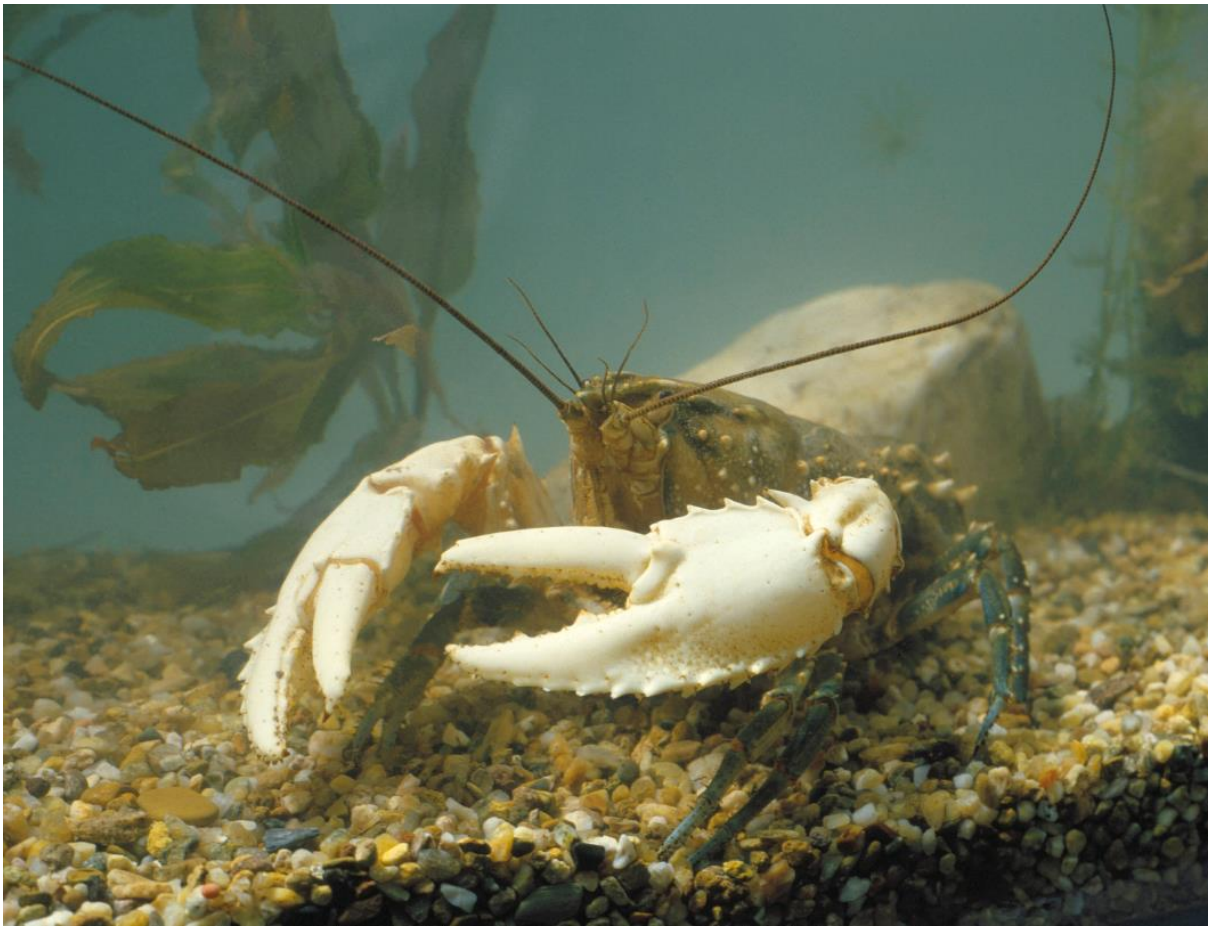

Figure 16 Vulnerable species, Murray crayfish. Source NSW DPI

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Figure 17 *Cherax destructor*. Source NSW DPI

NSW syllabus outcomes

Technology Mandatory 2017 Stage 4

Outcomes	Content
Agriculture and Food Technologies	
TE4-1DP designs, communicates and evaluates innovative ideas and creative solutions to authentic problems or opportunities **TE4-2DP plans and manages the production of designed solutions** **TE4-3DP selects and safely applies a broad range of tools, materials and processes in the production of quality projects** **TE4-5AG investigates how food and fibre are produced in managed environments** **TE4-6FO explains how the characteristics and properties of food determine preparation techniques for healthy eating** **TE4-10TS explains how people in technology related professions contribute to society now and into the future**	**Identifying and defining** • investigate the importance of food and fibre production to Australia's food security and economy including Asia's imports and exports (ACTDEK029) • investigate how food and fibre production is managed in environments as a system and how sustainability can be improved, for example: (ACTDEK032) **ST** – plants and/or animal species grown in managed environments – land management by Aboriginal and/or Torres Strait Islander Peoples – boundaries, inputs, outputs, processes and feedback occurring in a managed environment • evaluate environments that have been designed in consultation with community groups, for example: • develop criteria to evaluate design ideas, processes and solutions, the functionality, aesthetics and a range of constraints, eg accessibility, cultural, economic, resources, safety, social, sustainability, technical (ACTDEP038, ACTDIP027, ACTDIP031) **DT ST** **Researching and planning** • design and plan a product associated with agricultural production (ACTDEP036) **DT ST** • research legal and ethical requirements associated with agricultural production, e.g. keeping animals • investigate ideal conditions for growth and development of an agricultural plant or animal (ACTDEK032) **ST** • develop a schedule or calendar for ongoing care of a plant or animal species associated with an agricultural project (ACTDEP039) **ST** • acquire and interpret data, for example: (ACTDIP025, ACTDIP026) **CT ST** – local environmental and/or physical conditions, eg rainfall, temperature – nutrition information panels, eg saturated fat, sugar content **Producing and implementing** • produce and implement an agricultural project and/or produce nutritious food (ACTDEP039) **DT** • select, justify and use a range of appropriate tools and techniques in an agricultural project and/or food preparation (ACTDEK037) **DT ST** • identify and apply safe and ethical work practices, for example: **DT** – correct use of tools and equipment – food safety and hygiene practices **Testing and evaluating** • evaluate the effectiveness and suitability of choices made during the development and production of the solution • assess the solution against the predetermined criteria
Engineered Systems	
TE4-1DP designs, communicates and evaluates innovative ideas and creative solutions to authentic problems or opportunities	• investigate the way Aboriginal and/or Torres Strait Islander Peoples use engineered solutions to serve community needs including those of cultural identity,