Biology and life cycles of prawns

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Commercial fishing for prawns in Australia is thought to have commenced in Sydney in the early 1800s and has over the intervening period developed from a local cottage industry to one that is equipped with the latest technology and that encompasses most of the coast of Australia. In New South Wales (NSW), fishing for prawns is done in many estuaries and in ocean waters from the border with Queensland in the north to that with Victoria in the south. Average landings in NSW over the five year period to 2008–09 were 1410 tonnes, worth in excess of $18 million. In addition, in more recent times an aquaculture industry for prawns has developed in NSW which in 2008–09 produced 164 tonnes, worth $3.2 million. Taking into account the value of boats, land (for aquaculture), gear and associated industries the humble prawn has a significant effect on this State's economy.

Scooping prawns.

The fisheries

The common species in the NSW commercial catch are the eastern king, school, royal red and inshore greasyback prawns (Figure 1). There are three commercial fisheries that target prawns; namely the ocean trawl, estuary prawn trawl and estuary general fisheries. As their names imply, the ocean trawl and estuary prawn trawl fisheries use one type of gear

A commercial prawn trawler.

known as a trawl net to catch eastern king, school and royal red (ocean trawl only) prawns. In contrast, the estuary general fishery uses a suite of gears to catch eastern king, school and inshore greasyback prawns.

The recreational fishery operates only in estuaries and uses hand haul and scoop nets. For any given estuary, it catches on average 30% (by weight) of the commercial catch from the same estuary and overall its catches are predominantly eastern king prawns. However, school prawns may make up a substantial part of the catch of the recreational fishery in some estuaries.

In 2008–09 there were 12 permits for prawn farms in NSW. In recent years these farms have been growing almost exclusively the black tiger prawns.

Just what is a prawn, what do we know about them and what steps are we taking to further understand these animals?

The basic prawn

Prawns are invertebrates that live in the sediment, emerging from it for such activities as feeding, moulting and reproducing. These swimming crustaceans have a head, tail, five pairs of swimming legs (pleopods), five pairs of walking legs (pereopods) and numerous pairs of head appendages (see Figure 2). The front three pairs of pereopods have claws. Prawns have an external skeleton or shell which must be shed periodically to enable them to grow. The front part of this shell is called the carapace. It covers the head and protects the vital organs such as the heart, brain, gills and stomach. On top of the carapace is a long, serrated spike called the rostrum. The prawn can use the muscular tail or abdomen as an escape mechanism in sudden backwards-directed flicks, but the usual method of propulsion is via the swimming legs.

Because prawns spend quite a large percentage of their time buried in the bottom sediments, some of the head appendages can be joined together to form a funnel. Water, containing oxygen, can then be drawn down this funnel and over the gills so the prawn can continue to breathe while buried in the sediments.

Colour changes

Prawns, like most other crustaceans, are able to change colour, depending upon growth, background colouration and time of day. This colouration is due to the colour of the pigment in minute, special cells called chromatophores found in the prawn's skin beneath the external shell. Common colours found in these chromatophores are sepia-brown, red, yellow, yellow-white and blue. The overall colour of the prawn depends upon the relative proportion of each pigment in the cell and the number and arrangement of these cells over the prawn.

Thus the colour bands on tiger prawns when viewed under the microscope appear as thousands of pigment cells, close together in bands and full of colour pigments. On the other hand, school prawns have pigment cells more widely spaced and the pigment is contracted to the centre of each cell, giving the prawn a pale-spotted appearance. Deepwater prawns have a large number of red chromatophores and appear scarlet or bright red in colour.

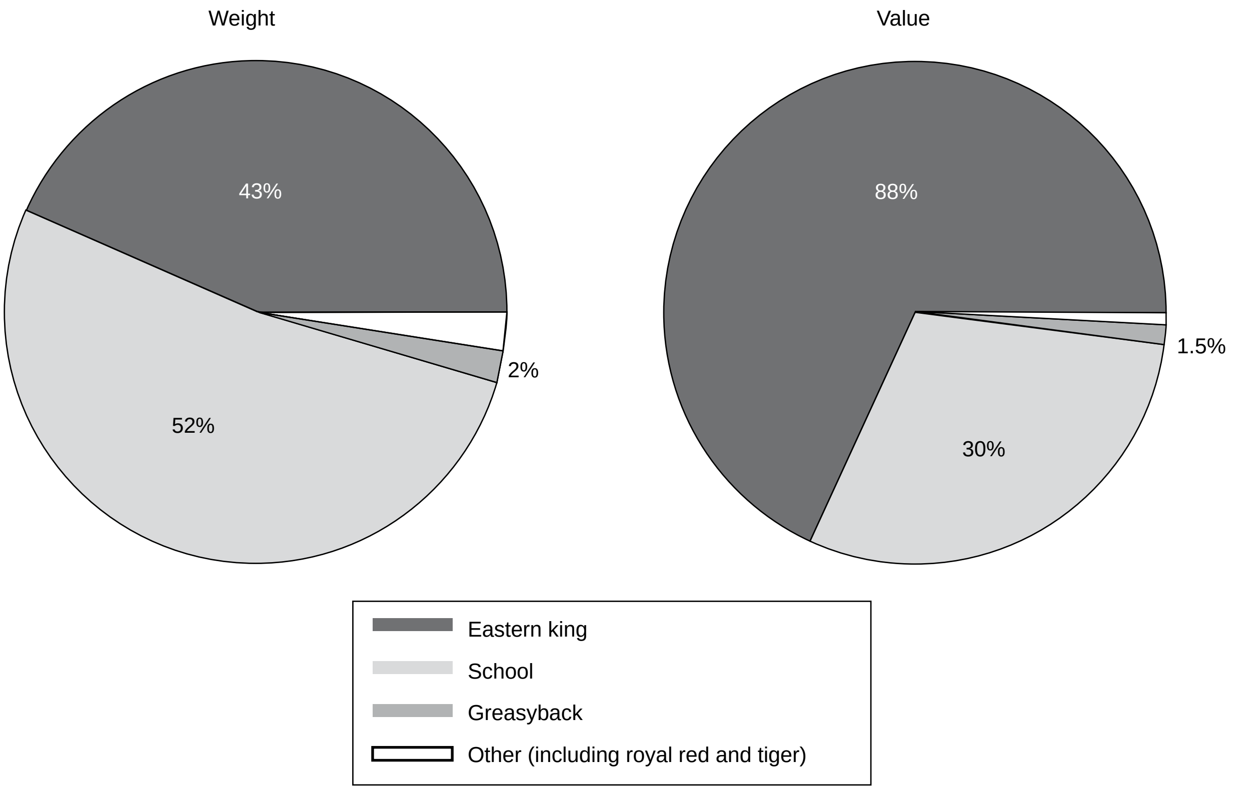

Figure 1. Contribution of main species to the production by the commercial fisheries for the five-year period to 2008–09

This ability to change colour to suit different backgrounds helps the prawns to conceal themselves. In the case of red deepwater prawns such as the royal red prawn, the deep water acts as a filter to remove the red component of light leaving the blue component to reach the bottom. The combination of the red colouration and blue light in this depth of water makes the prawn appear black and therefore more difficult to see.

Moulting

The hard external shell of prawns is incapable of expanding, so to grow, prawns must periodically shed their entire shell. The shell is composed mainly of protein, calcium carbonate and a stiffening agent, called chitin. Prior to shedding its shell, the prawn re-absorbs most of the protein and chitin from the old shell as the new one forms underneath, and increases its water intake to create a space between the body and the new shell. At moulting, the soft-shelled prawn emerges from the old shell via a split between the carapace and tail. During this process the entire shell including the part covering the long feelers or antennae, eyes, legs, gut and associated structures is renewed. After moulting the new shell hardens and the prawn grows into the space between the body and the shell.

The frequency of moulting is dependant upon many factors including size, gender and species of prawn and water temperature. The process is controlled by hormones which are released by glands located in the eyestalks. Small prawns grow more rapidly and hence need to moult more frequently than larger ones and these growth rates are usually highest during the warm, summer months. Numbers of soft-shelled individuals of some species peak around the time of the full moon. Moulting may be inhibited by low water temperatures, whilst higher temperatures may stimulate its onset.

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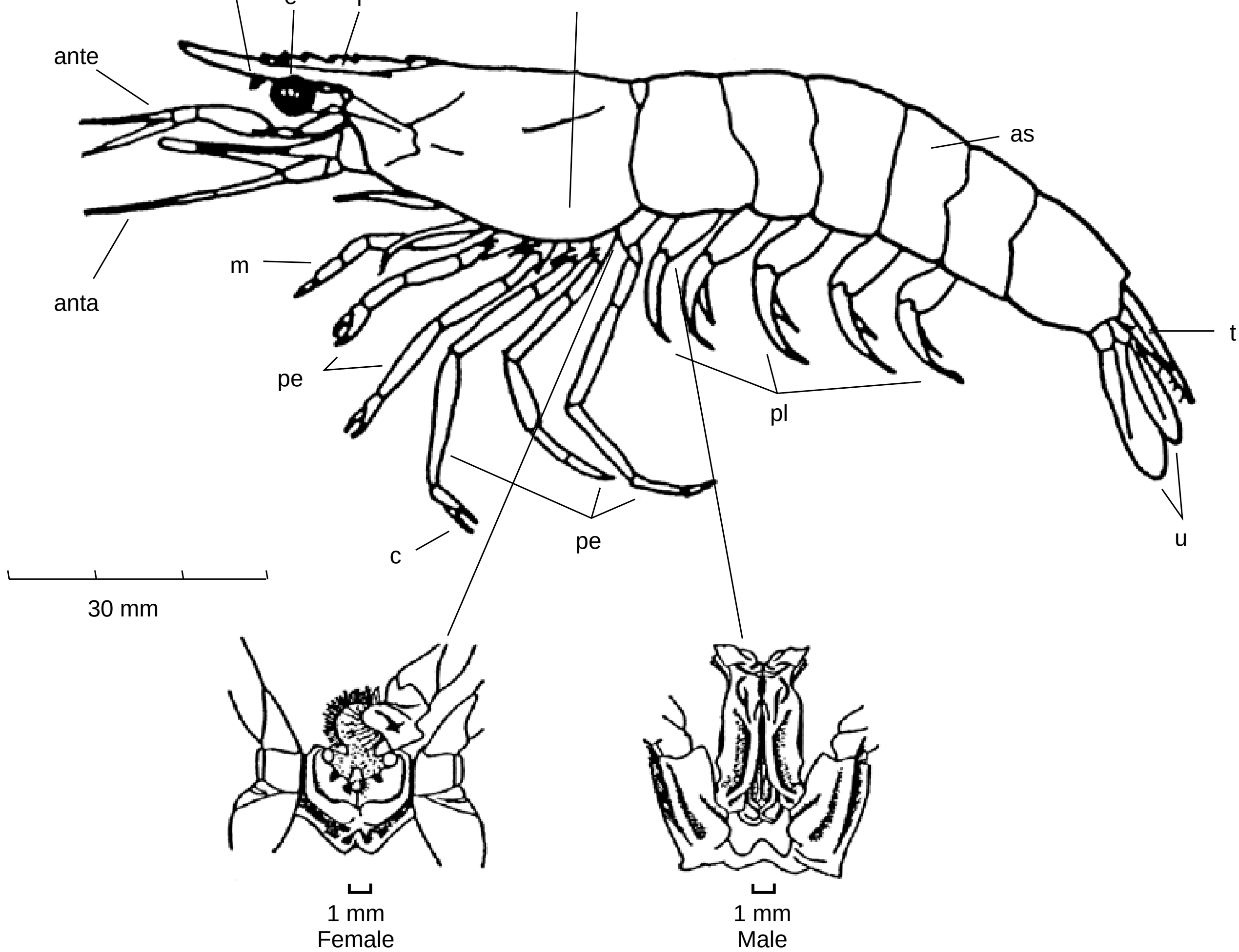

Ventral surfaces of reproductive organs

anta	antenna	m	3rd maxilliped
ante	antennule	pe	pereopods
as	4th abdominal segment	pl	pleopods
br	branchial region of carapace	r	rostrum
c	chela	t	telson
e	eye	te	rostral teeth
		u	uropods

Figure 2. Anatomical parts of the prawn (after Dall 1957)

An eastern king prawn

An inshore greasyback prawn

A royal red prawn

A school prawn

Food and feeding

Almost all crustaceans have the same basic mouthparts although the diversity in form and function is enormous. The main part of the prawn diet is made up of plant material, microorganisms, small shellfish and worms. In aquaculture, prawns are fed artificial diets. Most digestion is rapid and completed in about six hours.

Prawns search the bottom for food with their pereopods which have chemo-sensory hairs attached. Any food that is found is held by those head appendages known as maxillipeds and the teeth or mandibles are used to bite or tear pieces off. The maxillipeds can be used to push large pieces of food away as the mandibles grasp it, thus tearing the food into manageable portions.

Reproduction

The prawn species which are commercially fished are bisexual, that is, the genders are separate, with the mature female being larger than the male. For example, a mature female eastern king prawn could be several times heavier than a mature male.

Male prawns are readily identified by the large copulatory organ, known as the petasma, found between the foremost pair of swimming legs (see Figure 2). Corresponding structures are not present in the female and the foremost pair of pleopods is identical with the other four pairs. Females possess a structure known as the thelycum between the last pair of pereopods which provides an anchor site for the male sperm packet received during copulation (see Figure 2). Males and females can thus be readily identified on the presence or absence of a petasma or a thelycum.

Ovaries containing eggs can often be seen through the shell in the head and tail of mature female prawns. The colour of ovaries changes from pale yellow to olive or orange-brown as they mature. The mature female needs to be in the soft-shelled or newly moulted stage just prior to copulation while the male must be in the hard-shelled condition.

Fertilisation of eggs is internal and spawning is thought to occur soon afterwards. Females are capable of spawning more than once in a season. The number of eggs carried by a female varies with size and between species. The seasonality of spawning varies between species and between stocks of the same species. For instance, eastern king prawns spawn year around in waters off Queensland, whereas they do not spawn in winter off NSW.

Life cycles and age

Prawn life cycles in NSW waters can be considered to be of three types:

A. Estuarine – the entire life cycle is completed in waters of less than sea water salinity. An example of this type would be the inshore greasyback prawn;

B. Marine – the entire life cycle is completed in oceanic waters. An example of this type would be the royal red prawn

C. Mixed – postlarval and juvenile stages of the prawn's life cycle occur in estuarine waters of less than sea water salinity whilst the adolescent, adult, egg and larval stages occur offshore in oceanic waters. Examples of this most common type include eastern king and school prawns.

The 'mixed' life cycle is diagrammatically represented in Figure 3. Fertilized eggs are shed onto the bottom in oceanic waters where they remain for a short period until they hatch. The first larval stage called a nauplius emerges from the spherical egg and starts swimming up towards the surface. This naupliar stage goes through several moults, getting larger with each moult, and ultimately changes to a protozoea. The prawn similarly moults and grows through several protozoea then mysis stages before developing into a postlarva. The mysis stage is the first stage that somewhat resembles the appearance of the adult prawn.

The development time from spawning to postlarva for prawn species with 'estuarine' or 'mixed' life cycles is between two and three weeks. Hatching success and larval survival are affected by water temperature and salinity and are greatest in waters of the same temperature and salinity as that where spawning took place.

Up to the mysis stage the larvae are free swimming and form part of the zooplankton found in the open sea. Zooplankton together with phytoplankton is eaten by a multitude of other animals, including larval prawns, and is a vital part of the ocean's food system. After the free swimming, planktonic mysis stage, postlarva adopt a bottom existence, reach the shore and enter the rivers and coastal lakes In the estuaries and lakes, the juvenile prawns have to adapt to wide fluctuations in, among other things, salinity and temperature. School prawns appear to be more tolerant of these fluctuations than eastern king prawns.

After over-wintering in the estuaries and lakes the juvenile prawns grow rapidly and upon some cue, start to migrate back to the ocean. These migrations rise to a peak in the 'dark' period of the summer, lunar cycles and are fished enthusiastically by both amateur and professional fishermen. The physiology of prawns with a 'mixed' life cycle is such that the prawns require the conditions found in the deeper ocean waters to reach maturity. Once they reach oceanic waters, the prawns rapidly mature, mate and spawn – thus completing the life cycle.

The life cycle of prawns is rather short with species such as school prawns living, for the most part, a little over a year while larger species such as eastern king prawns are probably up to two years old, with some individuals perhaps entering a third year of life.

Prawns have specific habitat preferences which differ between species and between life stages for the same species. For instance, eastern king prawns are less tolerant of low salinity than school or inshore greasyback prawns and so whilst in estuaries will be found in the 'marine dominated' area of the estuary. Generally, prawns prefer a substrate with high mud content. School prawns though are found in muddy substrate in estuaries but in ocean waters prefer fine sand. Eastern king, school and inshore greasyback prawns prefer a vegetated to an unvegetated substrate.

In terms of movements during their life times, inshore greasyback prawns would be confined to their 'home' estuary or coastal lake. Tagged school prawns on the other hand have been reported to have moved up to 120 km from their 'home' estuary, whilst tagged eastern king prawns have been recorded as moving northwards over distances of up to 1333 km (Figure 4).

Total prawn catch in any one season therefore depends upon a complicated interaction of many factors including the success of spawning, the effects of environmental fluctuations, the success of larval stages in finding suitable habitat and, the effects of predators and diseases on all stages of prawn's life cycle.

Diseases and parasites

As is common with all other animals including humans, prawns may suffer from a range of diseases and parasites. Some of these kill the prawn whilst others result in changes in appearance and behaviour. One common symptom of stress in a prawn is opaque and white segments in the tail. This can be caused by viruses, bacteria, protozoans or physical trauma. The incidence of disease or parasitic infection is low in the wild but increases under aquaculture conditions when the prawns are in high densities and transmission is thereby enhanced. Viral diseases including taura syndrome, 'white-spot' disease, and 'yellow-head' disease are major health problems with prawn farming worldwide, but Australia remains free of these exotic diseases. However, infections caused by indigenous prawn viruses such as gill-associated virus do affect the industry.

Species descriptions

What follows is a guide to identifying the main prawn species contributing to production in NSW.

Eastern king prawn – *Melicertus plebejus* – Body is cream to yellow in colour. The rostrum is straight, extends to the back edge of the carapace and has one 'tooth' on the under side. The tips of the uropods are blue.

School prawn – *Metapenaeus macleayi* – Body is translucent with tinges of brown to green. The rostrum is curved upwards, does not extend to the back of the carapace and does not have any 'teeth' on the under side. The tips of the uropods may be blue.

Inshore greasyback prawn – *Metapenaeus bennettae* – Body is translucent with speckles of brown. There are fine hairs in patches over the body that give the animal a 'rough' or 'greasy' feel. The rostrum is straight, does not extend to the back of the carapace and does not have any 'teeth' on the under side. The tips of the uropods may be brown.

Royal red prawn – *Haliporoides sibogae* – Body is uniformly red to pink in colour. The rostrum is short and at the front edge of the carapace.

Black tiger prawn – *Penaeus monodon* – Body is pigmented dark brown to blue-black and has distinct white saddles. The rostrum extends to the back of the carapace and has two or three teeth on its under side.

Research

The NSW Government has a history dating back to around 1926 in providing funding to explore for prawn resources, develop fisheries for these, and then to monitor and assess the impact of this fishing. Current prawn research by the NSW Government is directed towards doing research either through its own scientific resources or by contractual arrangements with external service providers to collect the information necessary to satisfy the requirements of

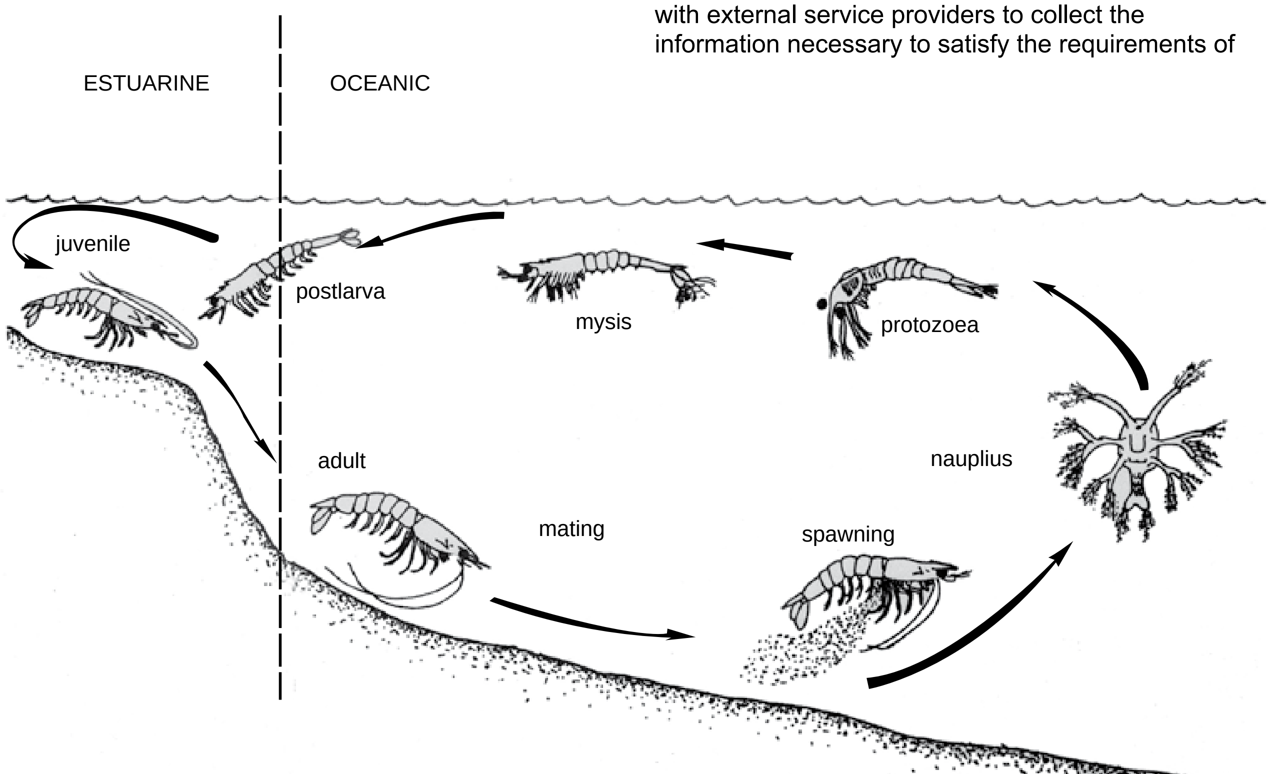

Figure 3. Generalised 'mixed' life cycle of a prawn

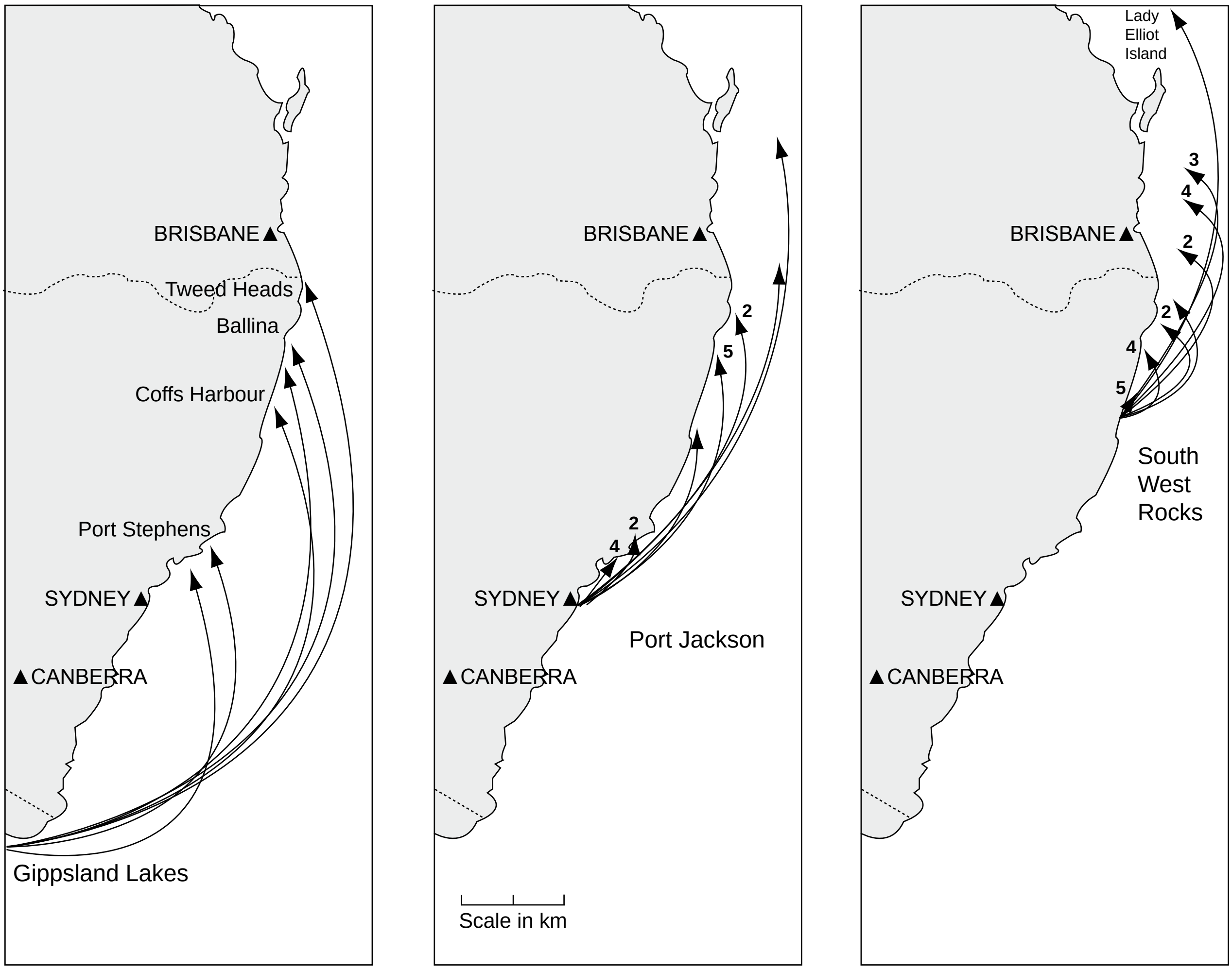

Figure 4. Inferred movements of tagged eastern king prawns. Each map is labelled with the point of release. Where more than one recapture occurred at a location, the appropriate number is recorded next to the pathway (after Montgomery 1990).

the fisheries management strategies for the prawn fisheries. This includes (i) providing the information to assess the status of prawn stocks that are important to the commercial and recreational fishers of NSW, (ii) minimizing the catch of unwanted animals (bycatch) in the fishing gear and maximizing the survival of discards, and (iii) minimizing the impact of fishing gear upon aquatic habitat.

Further, the NSW government was amongst the pioneers of prawn farming research in Australia and developed many of the techniques used by industry today. More recently, research on prawn aquaculture has focused upon prawn farm health management and the use of inland, saline water to culture prawns.

Management

The fisheries of NSW are managed under the *Fisheries Management Act (1994)*. Fisheries management strategies and environmental assessments have been completed for the estuary general, estuary prawn trawl and ocean trawl fisheries in accordance with NSW and Commonwealth law. The management strategies contain goals and objectives for each fishery and a detailed description of the fishing arrangements and new environmental requirements to ensure conservation of biodiversity and sustainable fishing. Like wise the aquaculture industry must follow strict development guidelines and is subject to the process of environmental assessment.

Details of the research and management of the prawn resources of NSW can be found on the Industry & Investment NSW website at www.industry.nsw.gov.au

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