Recreational Fishing Initiatives Fund Final Report

Re-establishing recreational prawning in the Swan-Canning Estuary

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This document and the information it presents brings together the work of many individuals of the contributing organizations, who deserve special acknowledgement.

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Non-technical summary of research findings

This project builds on the work of a previous Recreational Fishing Initiatives Fund Project to pilot the culture and of the Western School Prawn (*Metapenaeus dalli*) in to the Swan-Canning Estuary and increase interest in prawning via a citizen science/community engagement project. Having developed, for the first time, successful aquaculture techniques for this species in the former project, the current project utilised these techniques to release ~2 million hatchery-reared post-larval *M. dalli* in to the Swan-Canning Estuary. It also produced good-quality data to inform the management of this iconic species, re-engaged community with the prawns and stewardship of the estuary through a citizen science program (Prawn Watch) and developed a refined citizen science monitoring program for *M. dalli* that could be used in the future.

Between 25th November 2015 and 2nd March 2016, 764 gravid *M. dalli* (*i.e.* broodstock) were collected from the estuary and transported to the culture facility where they produced 11.845 million eggs. Of these, 8.368 million (70.6%) were viable and were cultured resulting in the release of 1,991,800 post-larvae into the Swan-Canning Estuary. The collection of broodstock was aided by a University-led monitoring program, resulting in an average of 127 gravid females being collected compared to between 9 and 73 in previous years.

Monitoring of the prawn population involved sampling 20 sites in the nearshore, shallow waters and 16 sites in the deeper, offshore waters of the estuary, using hand and otter trawls, respectively, every 28 days on the new moon between October 2015 and March 2016. This sampling yielded a total of 4,618 *M. dalli.* Clear temporal patterns of abundance of *M. dalli* in the shallow waters was detected, with densities being low in October, before increasing to a peak in November and declined sequentially thereafter. The low densities recorded in October reflect the fact that most *M. dalli* remained in the deeper waters and did not move in to the cooler shallower areas. However, by November densities of all *M. dalli* and the proportion of gravid females increasing markedly, likely due to increases in water temperature. The subsequent decline in the abundance of *M. dalli* after November/December was thought to be due to mortality of females following the

physiological stresses associated with rapid somatic and reproductive growth that occurs at this time of year.

Two pronounced peaks in the number of gravid prawns in the shallows, *i.e.* November/December (average of 19 mm carapace length) and February/March (average of 25 mm carapace length), indicates that females may spawn twice in a breeding season. Despite the fact that densities of *M. dalli* were always greater in the offshore than nearshore waters, densities of gravid females were typically greater in the nearshore waters. This indicates that the majority of the population reside in the deeper waters, with a 'subset' of individuals moving into the nearshore waters to breed and/or spawn. This movement makes them susceptible to fishing pressure, particularly as the females are much larger and thus more likely to be retained by fishers.

Based on this and other findings four recommendations for management of the recreational fishery for *M. dalli* in the Swan-Canning Estuary were proposed to increase sustainability and prevent the need for future restocking. (i) a reduced daily bag limit per person to 5L; (ii) introduction of a partial closure to hand-trawling between 15 October to 15 December inclusive; (iii) continuation of the existing zone restrictions in relation to throw and hand-trawl nets and (iv) continuation of existing gear prescriptions and expectation of by-catch return.

This project continued to build on the Prawn Watch, which was established in 2012, and sought to continue that work through the delivery of a strategic media campaign. Existing products (*i.e.* logbooks, website, flyers, display boards and the Smartphone App) were updated through this campaign and a series of events and forums were held that enabled the communication of sustainable fishing approaches and Prawn Watch, such as the Blessing of the Rivers Festival, Autumn Rivers Festival, Patterns in Science event and Clean-up days. In addition, community continued to be engaged in sharing their data through Prawn Watch and contributing to broodstock collection events. Information was shared with the community through River Guardians emails, facebook, media events and video and celebrated through feedback forums.

A trial citizen science monitoring project was undertaken in February 2015 and the results compared to a complementary University-led scientific sampling program. Analysis of the results suggested that it would be possible to establish a refined community monitoring program *i.e.* Prawn Patch Watch, which could provide sound quantitative data on prawn populations. It is envisaged that such a program would involve ~20 keen volunteers who would monitor their own site (Prawn Patch) on the closest weekend for the 1st of each month between October to March (*i.e.* the prawn breeding and recreational fishing season). On each sampling occasion, four 50 m trawls would be conducted each of the 10 sites to produce reliable data. Having received training, after each trawl the volunteers would record the total number of *M. dalli* and the number of gravid females, potentially also with the abundance of key predators and salinity and water temperature data. Data could be recorded into existing logbooks, database or the Prawn Watch smartphone app. It is recommended that this focussed citizen science project could sit within the existing Prawn Watch project, which would continue to engage a wide audience. Importantly it should be run alongside a University-led monitoring program for the first year to ensure it provide robust results that can be validated.

Section 1: Background information and aims

Estuaries are among the most productive of all aquatic ecosystems as they receive nutrients from riverine, tidal, atmospheric and waste inputs (Schelske and Odum, 1961; Cloern, 1987; Tweedley et al., 2016c). This high productivity enables an abundance of food sources for the many species that reside in the estuary and thus densities of fish and invertebrates are higher in these systems than in neighbouring nearshore coastal waters (Valesini et al., 2004; Valesini et al., 2014; Tweedley et al., 2015). Moreover, the presence of aquatic macrophytes provides shelter and protection, particularly for smaller individuals (Blaber and Blaber, 1980; Jackson et al., 2001). As a result of these characteristics estuaries are often described as nursery areas and many fish and crustacean species (i.e. marine estuarine-opportunists sensu Potter et al., 2015a; 2015b) actively recruiting to these environments as juveniles. This is partly also due to the fact that individuals living in estuaries undergo more rapid growth, which reduces predation risk and thus increase survival beyond what could be achieved in their natal environment (Potter et al., 2011; Veale et al., 2015). While marine estuarine-opportunists colonise macrotidal estuaries, which have a large tidal range, are turbid and undergo rapid and pronounced changes in salinity over a tidal cycle, these conditions are not suitable environments for successful spawning and larval development (see review in Tweedley et al., 2016c). In contrast, those microtidal estuaries with a tidal range of < 2 m, such as those systems in south-western Australia, are conductive for spawning and thus, in addition to marine estuarine-opportunists, contain numerous species that complete their entire life cycle within the estuary (*i.e.* estuarine-resident species) that can make very large contributions to the fish fauna (Hoeksema et al., 2009; Veale et al., 2014).

The ecological value of estuaries as fish/crustacean habitat is reflected in the contribution that species which utilise these productive and sheltered waters make to commercial and recreational fisheries. For example, Lellis-Dibble et al. (2008) estimated that estuarine species contributed 46% by mass and 68% by value to commercial fish and shellfish landings in the United States between 2000 and 2004, while Creighton et al. (2015) predicted that, in Australia, >75% of commercial fish catch and, in some regions, up to 90% of all recreational angling catch comprised fish that utilise estuaries. In a Western Australian context, fish

species such as the Black Bream *Acanthopagrus butcheri*, (Chaplin et al., 1998; Sarre and Potter, 1999) and Cobbler *Cnidoglanis macrocephalus* (Laurenson et al., 1993; Ayvazian et al., 1994) complete their life cycle within estuaries, while species of flathead, whiting and mullet use estuaries as a nursey areas (Potter et al., 2016). These fish are popular species for recreational fishers, with ~350,000 School Whiting *Sillago* spp., ~250,000 Australian Herring *Arripis georgianus*, ~169,000 King George Whiting *Sillaginodes punctatus*, ~125,000 *A. butcheri* and ~22,000 Southern Bluespotted Flathead *Platycephalus speculator* estimated to be caught by recreational fishers in 2011/12 and 2013/14 (Ryan et al., 2013; 2015). Crustacean species too utilise estuaries in south-western Australia (Potter et al., 2015b) and are also popular amongst recreational fishers, with the 900,000 Blue Swimmer Crab *Portunus armatus* and 136,000 Prawns (likely Western King Prawn *Penaeus latisulcatus* and Western School Prawns *Metapenaeus dalli*) being caught over the same periods (Ryan et al., 2013; 2015).

The genus *Metapenaeus* comprises nearly 30 species that are found exclusively throughout the inshore coastal and estuarine waters of the Indo-West Pacific (De Grave, 2014) where they contribute to important commercial and recreational fisheries (Dichmont et al., 2006; Kompas et al., 2010). For example, in subtropical and temperate New South Wales, Australia, an average of 1,410 tonnes of prawns, valued at more than AUD $18 million, were caught annually between 2004 to 2009, in nearshore and estuarine environments, with *Metapenaeus macleayi* and *M. bennettae* comprising 54% and 32% of the total catch by weight and value, respectively (Montgomery, 2010). Prawns found in the estuaries of this region, predominantly *P. plebejus* and *M. macleayi*, are also exploited by recreational fishers who catch ~4,700 tonnes annually (Montgomery, 2010).

Metapenaeus dalli is the only metapenaeid found in temperate south-western Australia (Racek, 1957). This species typically occurs in shallow, inshore marine waters (< 30 m deep) along the western coast of Australia from Darwin in the north to Cape Naturaliste in the south and also in Java, Indonesia (Grey et al., 1983). However, in latitudes south of 31° S, it is found only in estuaries and completes its entire life cycle within these systems (Potter et al., 1986; 1989; Broadley et al., 2017; Crisp et al., 2017a), with larval development lasting ~12

days (Crisp et al., 2016). *Metapenaeus dalli* is thus classified as a solely estuarine species in this region (Potter et al., 2015a).

Both *M. dalli* and *P. latisulcatus* were the focus of a small commercial and iconic recreational fishery in the Swan-Canning Estuary. The commercial fishery catch peaked at 15 tonnes in 1959, but then declined, leading to its closure in the mid-1970s (Smith, 2006). At its peak, recreational prawning in this estuary involved over 50,000 people and became an iconic pastime, particularly during the Christmas period (Smithwick et al., 2011). However, recreational catch rates also declined, with the last significant catches recorded in the late 1990s. The reasons for the decline are unclear but are likely due to a combination of overfishing, changing environmental conditions and recruitment failure (Smith, 2006; 2007). Smith et al. (2007) concluded that despite the large reduction in fishing pressure, *M. dalli* populations were still low and had not recovered. They attributed this lack of recovery to the small, discrete breeding stock that was not at large enough to rebuild the population through self-replenishment. Thus, given the long-term recruitment failure, restocking was seen as a possible means of increasing the population size of *M. dalli* in the Swan-Canning Estuary by bypassing the recruitment bottleneck during the high mortality stages from larval to young juvenile prawns.

A trial restocking program entitled, "*production and release of Western School Prawns into the Swan-Canning River park over a three year period to enhance the community values of the recreational prawn fishery*" funded through the Recreational Fishing Initiatives Fund, was initiated in 2012. This project developed novel aquaculture techniques for *M. dalli* and released ~1,000, ~600,000 and ~2,000,000 million post-larvae into the Swan-Canning Estuary in 2012/13, 2013/14 and 2014/15, respectively, and established Prawn Watch, a community engagement program to help educate and reconnect fisheries with the prawn fishery and the estuary (Jenkins et al., 2015). Given the success of the trial program, the overall aim of the current project aimed to continue to release prawns and engage recreational prawn fishers. Specifically, the current project had four aims.

1) Culture and release 2 million juvenile Western School Prawns into the Swan-Canning Estuary in 2015/16 (Section 2).

3) Through a biological survey, produce sound, scientific information to help inform the management of Western School Prawns in the Swan-Canning Estuary into the future (Section 3).

2) Evaluate the effectiveness of data collected by recreational prawn fishers to provide low cost monitoring of Western School Prawns into the future (Section 4).

4) Communicate sustainable recreational prawning messages through a strategic media plan (Section 5).

Section 2: Culture and release of Western School Prawns into the Swan-Canning Estuary in 2015/16

Aim

The overall aim of this section of the project was to culture and release 2,000,000 Western School Prawns (*Metapenaeus dalli*) into the Swan-Canning Estuary in 2015/16. Specifically this involved:

- Capture of gravid broodstock from the Swan-Canning Estuary.
- Spawn the captive prawns in the hatchery, to incubate and hatch their eggs.
- Culture the nauplii through the various planktonic larval stages until they become post larvae and settle, thus becoming benthic.
- Grow the post larvae until competent (*i.e.* for 8 to 10 days after reaching the PL). stage; and to
- Release the resultant juveniles into the Swan-Canning Estuary.

Materials and methods

Broodstock collection

Gravid *M. dalli* were collected on six occasions between 25th November 2015 and 2nd March 2016. All collections were carried out after dark and involved several teams of two people dragging a hand trawl net that was 4 m wide, constructed from 25 mm mesh and fished to a depth of 1 m. The net was dragged for between 50 and 200 metres in the shallow (0.3-1.5 m deep) waters of the estuary. At the end of each drag (and sometimes periodically), the net was pulled ashore, the catch was shaken to the cod end of the net and the contents emptied onto a tarpaulin laid flat on to the shore (Fig. 2.1). The catch was sorted and gravid *M. dalli* (Figure 2.2) were placed into an insulated 40 L container holding ~10 L of estuary water, supplied with air bubbled via a battery operated aerator. All non-gravid *M. dalli* and all bycatch (usually fish) were returned alive to the river. Detached plant material (*e.g.* seagrass detritus) was also returned to the river, with any rubbish collected (*e.g.* bottles, plastics etc.) being retained and later placed into a rubbish bin.

Fig. 2.1. A broodstock collection event, in this case, involving students from John Tokin College in Mandurah.

Fig. 2.2. Gravid (pregnant) female *Metapenaeus dalli.*

Spawning

After collection, gravid prawns were transported alive back to the ACAAR hatchery in Fremantle where up to 25 prawns were weighed and slowly acclimated into each of several 300 L cylindro-conical fibreglass tanks (Fig. 2.3). Each tank was fitted with a flat false bottom of plastic mesh, which supported the prawns off the bottom of the tank and allowed any spawned eggs to fall to the bottom of the tank. These tanks were covered with black plastic to exclude light.

The tanks were supplied with gentle central aeration and full-strength seawater at a temperature of 25-27 °C at a flow rate of 2.5 L/min (*i.e.* one tank volume exchange every two hours) that entered the tank at the top and exited through the bottom drain. The water level in the tank was set by the height of the flexible external drain pipe. Water exiting the tank through the bottom carried any eggs that were spawned overnight into a series of egg collection screens contained within a water bath. The screens were firstly a 500 µm screen to collect debris, a 250 µm screen to collect eggs and a 48 µm screen to collect any nauplii that might hatch prior to harvest (Fig. 2.3).

Fig. 2.3. 300 L cylindro-conical fibreglass spawning tanks complete with the egg collection screens.

Egg counting

The following morning, if any prawns had spawned overnight the 250 µm screens would contain eggs and any nauplii that may have hatched early will have passed through to the 48 µm screen. If eggs were observed remaining in the spawning tank, water flow was shut and the water drained through the collectors. Eggs were then gently washed into a clean white bucket using water of the same temperature and the bucket filled to a known volume. The water in the bucket was then gently mixed and a minimum of six subsamples of known volume removed and the eggs counted to provide an accurate estimate of the total number of eggs in the bucket.

Incubation

The water temperature in the 1,000 L incubators tanks was set to the same as the spawning tanks (*i.e.* 25-27 °C). The incubators have a solid stand pipe and gentle aeration (Fig. 2.4a). Eggs were stocked into the incubator tanks at a concentration of between 1,000 and 2,000/L. Tanks were held in complete darkness and received no flow until hatching occurred at ~24 hours after spawning.

The following morning, once the eggs had hatched, the incubator air was turned off and the water flow was turned on to 8 L/min (*i.e.* 50% exchange per hour). The water temperature (at 25 to 27 °C) was similar to that of the newly filled larval tank (see below) to ensure that the nauplii do not suffer thermal shock on transfer. To transfer nauplii, the lid was opened slightly and a siphon hose was placed into the top of the incubator and the incubator and the flow was directed into the nauplii harvester at a gentle rate of 8L/minute. The nauplii harvester consisted of a 150 µm screen over a 100 µm screen in a water bath. The siphon continued for several hours after which time all nauplii were concentrated on the 150 µm screen and could be transferred to a bucket and counted in the same method as the eggs. Note that this step was only done periodically throughout the harvesting stage to ensure the nauplii density in the screen did not get too high.

After harvesting nauplii from the spawning tanks, any adult prawns that did not spawn were

identified, consolidated into a single tank, and the above spawning process repeated for another night. Prawns that had spawned were euthanised and weighed to determine their weight loss. They were then placed into Ziploc bags and labelled with the spawning tank number, the spawn date and frozen for later analysis if deemed necessary. In some cases samples were taken to Murdoch University for genetic analysis.

Larval rearing

The larval rearing tanks used in this project were three 1,000L tall cylindroconical fibreglass tanks (as for the incubators) or a single 5,000 L, 4 metre long by 2 m wide 'parabolic' tank as typically used by the commercial prawn culture industry (Fig. 2.4b). The 1,000 L tanks contained a solid central stand pipe and central air ring with moderate aeration, whereas the 5,000 L tank had two standpipes and aeration down its length.

Fig. 2.4. (a) 1,000 L tank as used for incubation and larval rearing and (b) 5,000 L parabolic prawn culture tank.

Larval tanks were filled with 1 micron filtered 25 °C water, covered to exclude light and not subjected with flow (*i.e.* they were static) until the larvae moulted through the various stages (Fig. 2.5) and reached Mysis 2. At this time, the water flow was commenced with the daily exchange rate gradually increasing from 25% to 100% over 16 days (Table 2.1). A 250 µm surface banjo screen was fitted to the tank when flow through began to retain the larvae within the tank. Prior to this a blank cap blocked the overflow hole. Prawns were passively transferred into a new tank at around PL5 prior to starting the inert feed.

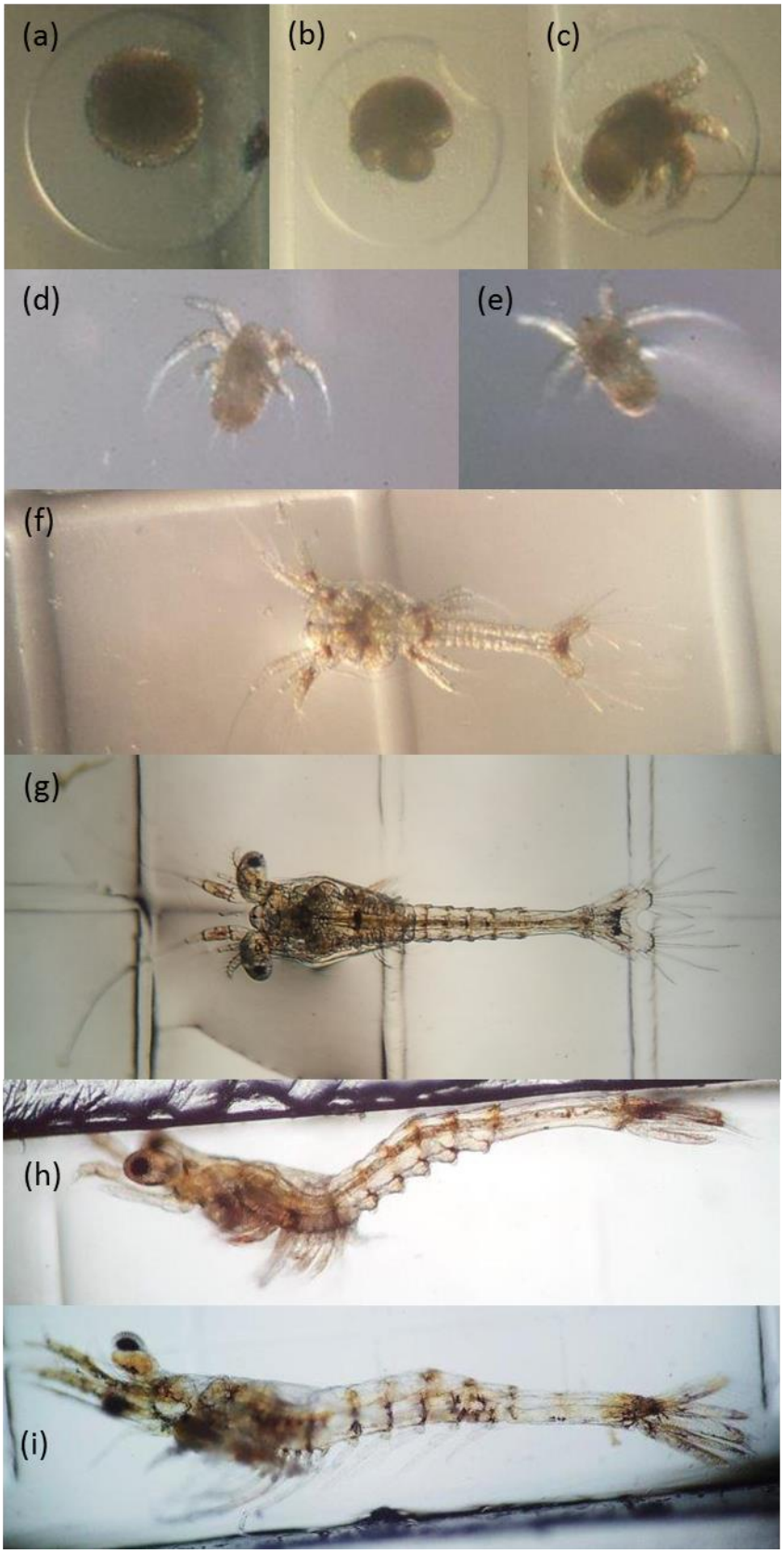


Fig. 2.5. Photos of larval *Metapenaeus dalli* at various stages of development. Egg at (a) ~ 1, (b) 3-4 and (c) 8-10 hours old, (d, e) nauplli at 1-2 days old, (f) Zoea I at 3 days old, (g) Zoea II at 4 days old, (g) Zoea III at 5 days old, (h) Mysis I at 6 days old and (i) post-larvae at 10 days old.

Larval feeding

The *M. dalli* larvae were fed a mix of unicellular diatoms throughout the entire culture period, primarily *Chaetoceros calcitrans* and *Chaetoceros muelerii* as well as some *Tetraselmis suecica* (Table 2.1 and Fig. 2.6). *Chaetoceros muelerii* is excellent nutritionally for prawns and was used as the primary feed, whereas, *T. suecica* (a unicellular green flagellate) was employed mainly for its water conditioning properties, rather than for its nutritional value, during the static culture phase. Specially formulated prawn microdiet was added to the tanks from about day 12 onwards in gradually increasing quantities. The feeding schedule used for the larval *M. dalli* can be seen in Table 2.1 and includes information such as age, life stage, stock numbers, expected mortalities, flow rates, feed types, quantities and composition and weaning diet rates once PL had been achieved. The ratio of the various microalgal species in the feeds did vary daily, depending on the availability and quantities of each species. There was also provision in the table to use Reed Shellfish diet (PAS) if live algae quantities became limiting. All algae was grown axenically in a dedicated and well equipped algal laboratory by dedicated algal staff. As is the case when culturing molluscs, the quality of the algae is arguably the most important element of success for a prawn hatchery.

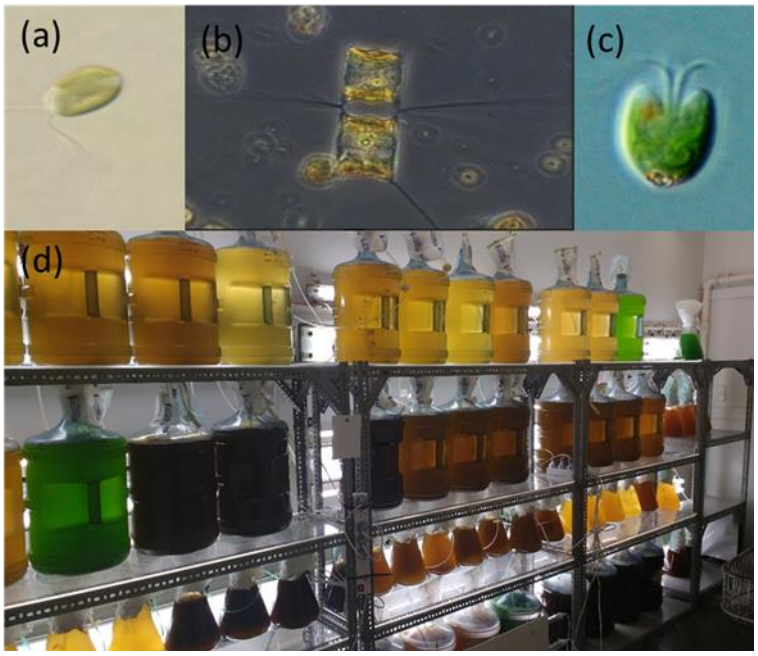


Fig. 2.6. Microalgae larval feeds, *i.e.* (a), *Isochyrsis*, (b) *Chaetoceros* and (c) *Tetraselmis,* used in the culture of *Metapenaeus dalli* and (d) the axenic algal culture room used to produce microalgal feeds.

Table 2.1. The feeding schedule developed for the culture of *Metapenaeus dalli*.

Larval stage	Age (days)	Daily mort %	Stock Number (start)	Daily Mort No.	Stock Number (end)	Water ex. (%)	Flow rate (L/min)	Scrn size (um)	Target Feed Density Total Cells / uL	Algae species % of daily feed (cell volume factor)					Est. cells eaten or w. ex. / day (%)	Est. Total algae cells replaced / ml	Formulated Diet Microelite or FrippaK							
										2.5	1	0.1	*1.0*				ME 50		ME 100		PL+150 or ME 200		PL+300 or ME	
										CC	CM	TS	PAS	Total			g/L	Tot.	g/L	Tot.	g/L	Tot.	g/L	Tot.
	-1								125															
N3/N4	0	4.0%	2,060,000	81,370	1,978,630	0%	0	0	125	15%	40%	20%	25%	100%	0%	0								
N5/Z1	1	4.0%	1,978,630	78,616	1,900,014	0%	0	0	100	15%	40%	20%	25%	100%	15%	-25								
Z1	2	3.5%	1,900,014	65,550	1,834,464	0%	0	0	100	15%	40%	20%	25%	100%	20%	15								
Z2	3	3.5%	1,834,464	64,206	1,770,257	0%	0	0	100	15%	40%	20%	25%	100%	30%	20								
Z3	4	3.5%	1,770,257	61,959	1,708,298	0%	0	0	100	15%	40%	20%	25%	100%	50%	30								
Z3/M1	5	3.5%	1,708,298	59,790	1,648,508	0%	0	0	100	15%	40%	20%	25%	100%	60%	50								
M1	6	4.0%	1,648,508	65,116	1,583,392	0%	0	0	100	10%	35%	15%	40%	100%	70%	60								
M2	7	3.5%	1,583,392	54,627	1,528,765	0%	0.000	0	100	10%	35%	15%	40%	100%	75%	70								
M3	8	3.5%	1,528,765	52,742	1,476,022	0%	0.000	0	100	10%	35%	15%	40%	100%	80%	75								
M3/PL1	9	4.0%	1,476,022	59,041	1,416,982	0%	0.000	0	100	10%	35%	15%	40%	100%	80%	80								
PL1	10	4.0%	1,416,982	56,679	1,360,302	0%	0.000	250	100	10%	35%	15%	40%	100%	80%	80								
PL2	11	4.0%	1,360,302	55,079	1,305,224	50%	1.736	250	100	10%	35%	15%	40%	100%	80%	80								
PL3	12	4.0%	1,305,224	52,849	1,252,375	50%	1.736	250	100	10%	35%	15%	40%	100%	80%	80			0.004	8240				
PL4	13	2.5%	1,252,375	31,309	1,221,066	50%	1.736	250	100	5%	10%	5%	80%	100%	80%	80			0.002	4120	0.002	4120		
PL5	14	2.0%	1,221,066	24,971	1,196,095	50%	1.736	250	100	5%	10%	5%	80%	100%	80%	80					0.005	10300		
PL6	15	1.5%	1,196,095	17,941	1,178,154	55%	1.910	250	100	5%	10%	5%	80%	100%	80%	80					0.006	12360		
PL7	16	1.5%	1,178,154	17,672	1,160,481	60%	2.083	250	100	5%	10%	5%	80%	100%	80%	80					0.007	14420		
PL8	17	1.0%	1,160,481	12,127	1,148,354	65%	2.257	250	100	5%	10%	5%	80%	100%	80%	80					0.008	16480		
PL9	18	1.0%	1,148,354	12,000	1,136,354	70%	2.431	250	100	5%	10%	5%	80%	100%	80%	80					0.009	18540		
PL10	19	1.0%	1,136,354	11,875	1,124,479	75%	2.604	250	100	5%	10%	5%	80%	100%	80%	80					0.01	20600		
PL11	20	1.0%	1,124,479	11,751	1,112,728	80%	2.778	250	100	5%	10%	5%	80%	100%	80%	80					0.015	30900		
PL12	21	1.0%	1,112,728	11,628	1,101,100	90%	3.125	250	100	5%	10%	5%	80%	100%	80%	80					0.015	30900		
PL13	22	1.0%	1,101,100	11,011	1,090,089	100%	3.472	250	100	5%	10%	5%	80%	100%	80%	80					0.020	41200		
PL14	23	1.0%	1,090,089	10,901	1,079,188	100%	3.472	250	100	5%	10%	5%	80%	100%	80%	80								
PL15	24	1.0%	1,079,188	10,792	1,068,396	100%	3.472	250	100	5%	10%	5%	80%	100%	80%	80								

Harvesting

Prior to harvesting, a sample of hatchery-reared post-larvae were removed and sent to the Fish Health Laboratory at the Department of Fisheries Western Australia for analyses. The analysis includes a histological assessment to determine infection by bacteria or viruses which also provides an insight into the general health of the prawns. When a health clearance was issued (which occurred on all occasions), post-larvae prawns were harvested from 8 to 15 days after moulting into this stage. Harvesting was achieved by draining the tank into a submerged concentrator which had a 500um screen on the outlet. The post-larvae were then rinsed in fresh seawater for 20 minutes in the concentrator before being transferred to a bucket and counted using the same method as that for eggs and nauplii.

After counting they were then placed in oxygenated transport bags with 7L of seawater at a maximum rate of 250,000 post-larvae per bag and then transported in a foam container to the designated release site on the Swan-Canning Estuary. Upon arrival, the post-larvae in each bag was acclimated to the water quality conditions in the estuary by slowly mixing the shallow nearshore water into the floating bag, leaving the bag alone for several minutes and then adding more water and finally emptying the contents of the bag into the nearshore waters of the estuary (Fig. 2.7).

Fig. 2.7. (a) Former Minister for Fisheries, Hon. Ken Baston MLA, and (b) Dr James Tweedley (Murdoch University) and James Florisson (Recfishwest) releasing hatchery-reared prawns in 2015 and 2016, respectively.

Results

A total of 764 gravid *M. dalli* were collected during the six broodstock events between November 2015 and March 2016 (Table 2.2). The majority of these were collected from the Canning Bridge region and delivered to the ACAAR hatchery for spawning the same evening. The number of eggs per gravid individual increased markedly over the breeding season, starting from 5,781 and in late November and 7,768 in early December, to ~2.5 times greater in late December/early January (15,702) to a peak of 70,526 eggs per gravid prawn, a 12 times increase from the start of the season, in early March (Table. 2.3). Egg capacity per female is directly linked to body size and this observed increase is due to the rapid growth of the prawns over the warmer months of the spawning season.

The 764 broodstock produced 11.845 million eggs, of which 8.368 million (70.6%) were viable (*i.e.* fertilised and hatched) and resulted in the release of 1,991,800 PL8-PL10 larvae into the Swan-Canning Estuary (Table 2.4 and Fig. 2.8). The survival of viable eggs to the PL8 stage was 28%.

Table 2.2. Date, location and number of gravid *Metapenaeus dalli* collected from the Swan-Canning Estuary during the summer of 2015/16.

Capture date	Location	# of broodstock captured
25/11/2015	Canning Bridge to Deep Water Point	237
01/12/2015	Canning Bridge	168
21/12/2015	Canning Bridge	168
15/01/2016	Canning Bridge	121
09/02/2016	Canning Bridge and Jetty Street, Claremont	32
02/03/2016	Canning Bridge	38

Table 2.3. Number of eggs for each broodstock event and larvae harvested.

Spawning date	# eggs spawned	Mean # eggs per female	Total # larval harvested
11/27/2015	1,370,000	5,781	890,000
12/03/2015	1,305,000	7,768	1,077,500
24/12/2015	2,500,000	14,881	2,200,000
12/01/2016	1,900,000	15,702	1,646,250
12/02/2016	2,090,000	65,313	980,000
04/03/2016	2,680,000	70,526	1,547,800

Table 2.4. Number of *Metapenaeus dalli* released, dates and times of releases.

Release #	Date	Site	Time of day	# prawns released
1	14/12/2015	Hawkins St. to Deepwater Point, Mt. Pleasant	14:30-15:30	709,000
2	21/12/2015	Clive St. to Hawkins St, Mt. Pleasant	13:00	113,000
3	12/01/2016	Killilan Rd. and Canning Bridge, Applecross	12:00-16:00	232,000
4	02/02/2016	Killilan Rd, Applecross	15:00	9,000
5	02/03/2016	Moreau Mews to Riverway Rd, Applecross	13:00	253,000
6	22/03/2016	Como Jetty, Como	13:00-16:00	307,300
7	23/03/2016	Como Jetty, Como	14:00	368,500
Total				**1,991,800**

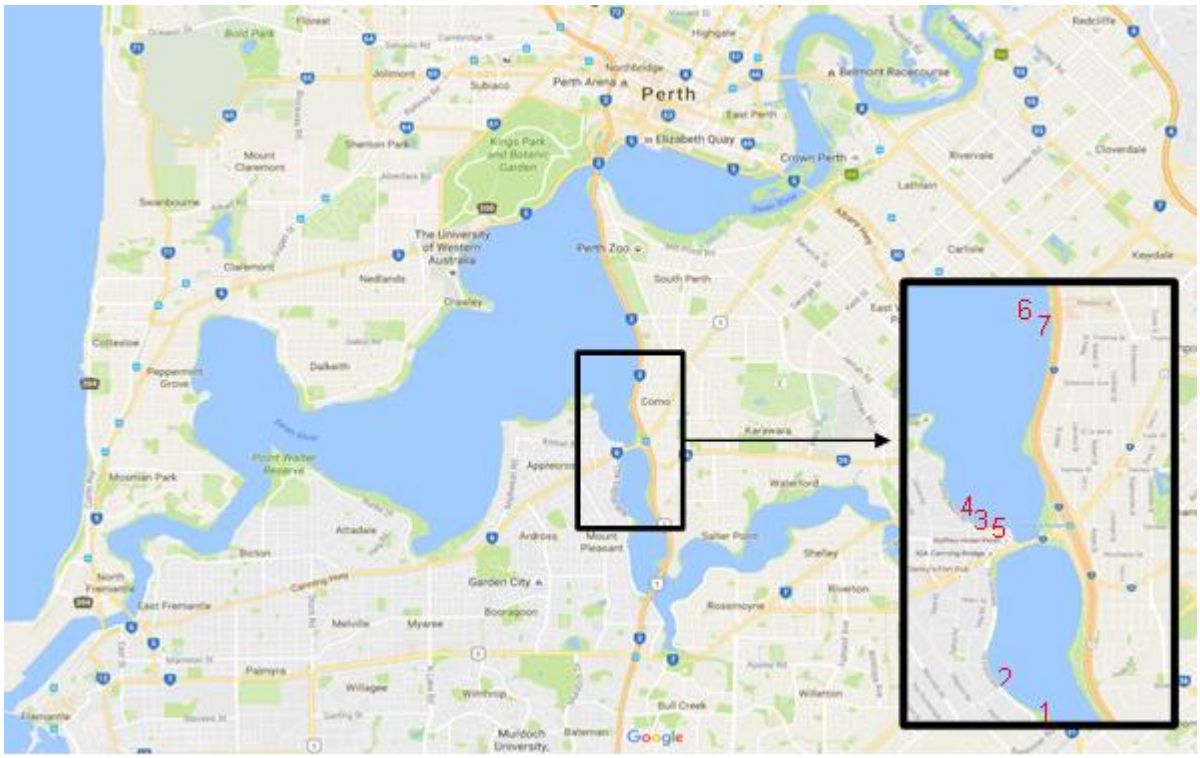


Fig. 2.8. Release locations of prawns in the 2015/2016 breeding season. See Table 2.4 for the number of hatchery-reared prawns.

Discussion

This *Metapenaeus dalli* restocking project commenced in the summer of 2012/2013. The first project was funded for a period of three years with the project reported on here funded for one additional year. This prawn species had not previously been cultured, and new culture technology needed to be developed due to its small size and its inability to catch and consume *Artemia*, the normal prawn live feed for prawn larval stages in hatcheries. A fast learning curve was needed therefore to ensure the hatchery phase of this project was successful and a range of measures were employed to assist in its success.

These measures included:

- Contracting a CSIRO prawn culture specialist, Dr Greg Coman to advise on culture methodology during the initial stages of the project;
- Contracting an experienced prawn hatchery operator, Mr Roger Barnard to assist in the project throughout its duration;
- Contracting specialist algal technicians to ensure a regular and clean supply of algae for the prawn culture:
- Purchase of specialist equipment including a large autoclave, a special 5,000 litre prawn culture tank from Queensland;
- Fitting out a specialist temperature controlled room in the ACAAR hatchery for prawns; and
- Provision of dedicated ACAAR staff to run the culture phase of the project.

The success of the approach taken by ACAAR in this project is evidenced by the rapid improvement from year one of the project to its conclusion four years later. The first season (2012/13) of the project resulted in the release of 1,000 post-larval prawns into the Swan-Canning Estuary, which increased to 635,000 in the second year (2013/14) and 2 million prawns in both 2014/15 and 2015/16 (Figs 10, 11). Other measures of success included the improvement in targeting and collecting gravid prawns and the improvement in survival in the hatchery in each year of the project.

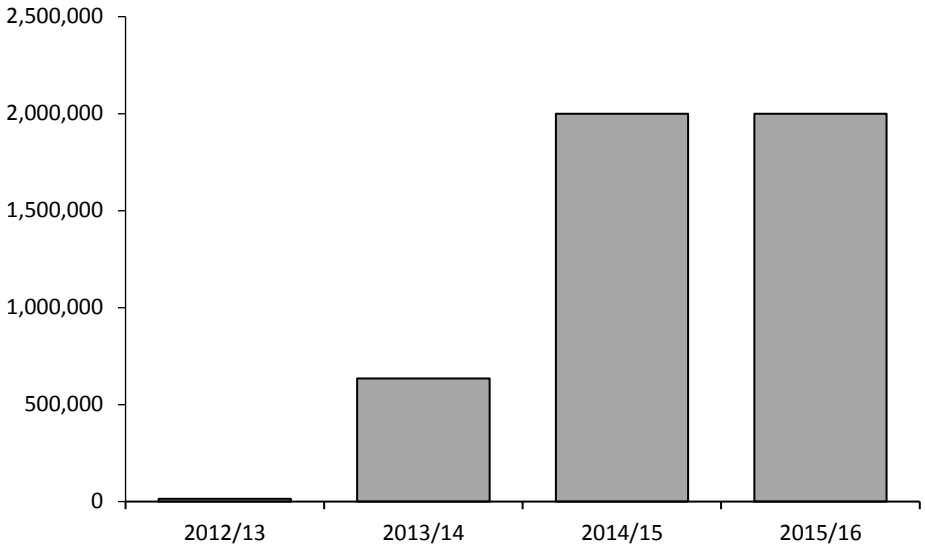


Fig. 2.10. Number of hatchery-reared *Metapenaeus dalli* released into the Swan-Canning Estuary in each year of the project.

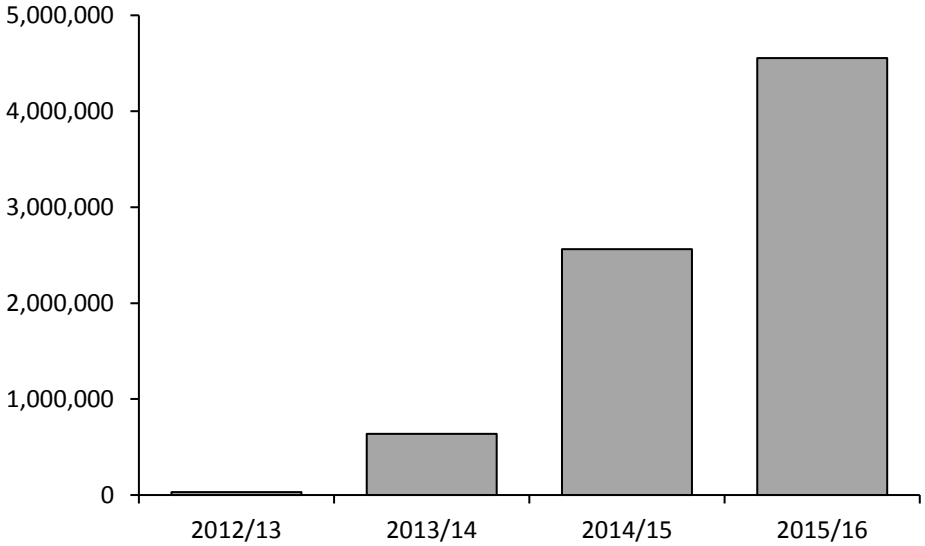


Fig. 2.11. Cumulative number of hatchery-reared *Metapenaeus dalli* released into the Swan-Canning Estuary in each year of the project.

Section 3: Patterns of abundance and distribution of the Western School Prawn in the summer of 2015/16

Aim

This section describes the non-destructive survey of the *Metapenaeus dalli* population the Swan-Canning Estuary for the purpose of achieving two broad aims, (i) to determine when and where breeding was occurring to inform broodstock collection and (ii) to use these data to inform management. Note that the data described in this section were combined with those collected as part of another project (FRDC 2013/221 "*Stock enhancement of the Western School Prawn (*Metapenaeus dalli*) in the Swan-Canning Estuary; evaluating recruitment limitation, environment and release strategies*") and used to information future management of the *M. dalli* fishery in the Swan-Canning Estuary (see Section 6).

Materials and methods

The Swan-Canning Estuary (Fig. 3.1) in south-western Australia, is ~50 km long and covers an area of ~55 km^2 (Valesini et al., 2014). This drowned river valley system is permanently-open to the Indian Ocean via a narrow entrance channel that opens into two basins and the tidal portions of the Swan and Canning Rivers. Although the majority of the estuary is shallow, *i.e.* < 2 m in depth, it reaches a maximum depth of ~20 m in the entrance channel. The region experiences a Mediterranean climate, with hot, dry summers and cool, wet winters (Gentilli, 1971). Approximately 70% of the rainfall occurs between May and September (Hodgkin and Hesp, 1998), leading to marked seasonal variations in environmental conditions in the estuary: salinities are stable and relatively high throughout much of the estuary during the austral summer (December to February), but during winter, may vary markedly along the estuary following substantial freshwater discharge (Tweedley et al., 2016c).

The estuary flows through the capital city of Perth, which supports ~78% of the 2.6 million people in the state of Western Australia (Australian Bureau of Statistics, 2015). Both the estuary and its catchment have been highly modified by anthropogenic activities (Commonwealth of Australia, 2002), which has led to multiple stressors on the system, such

as the increased delivery of sediments and nutrients, in addition to changes to salinity and hydrological regime, including periodic hypoxia (Stephens and Imberger, 1996; Tweedley et al., 2016b). Despite these perturbations, the estuary is valued highly by the Western Australian community for its aesthetic, commercial, environmental and cultural importance and recreational fisheries (Malseed and Sumner, 2001).

Prawns were sampled at night at 20 nearshore (< 2 m deep) sites using a hand trawl net and 16 offshore sites (2-17 m deep) using a small otter trawl net, on each new moon phase (*i.e.* every 28 days when the moon < 10% illumination) between October 2015 and March 2016 (*i.e.* 6 lunar cycles).The sites extended from close to the mouth of the Swan-Canning Estuary to ~34 and ~27 km upstream in the Swan and Canning rivers, respectively (Fig. 3.1), with the total area within the bounds of the sampling sites being 35 km^2, 15.5 km^2 in nearshore waters and 19.6 km^2 in offshore waters.

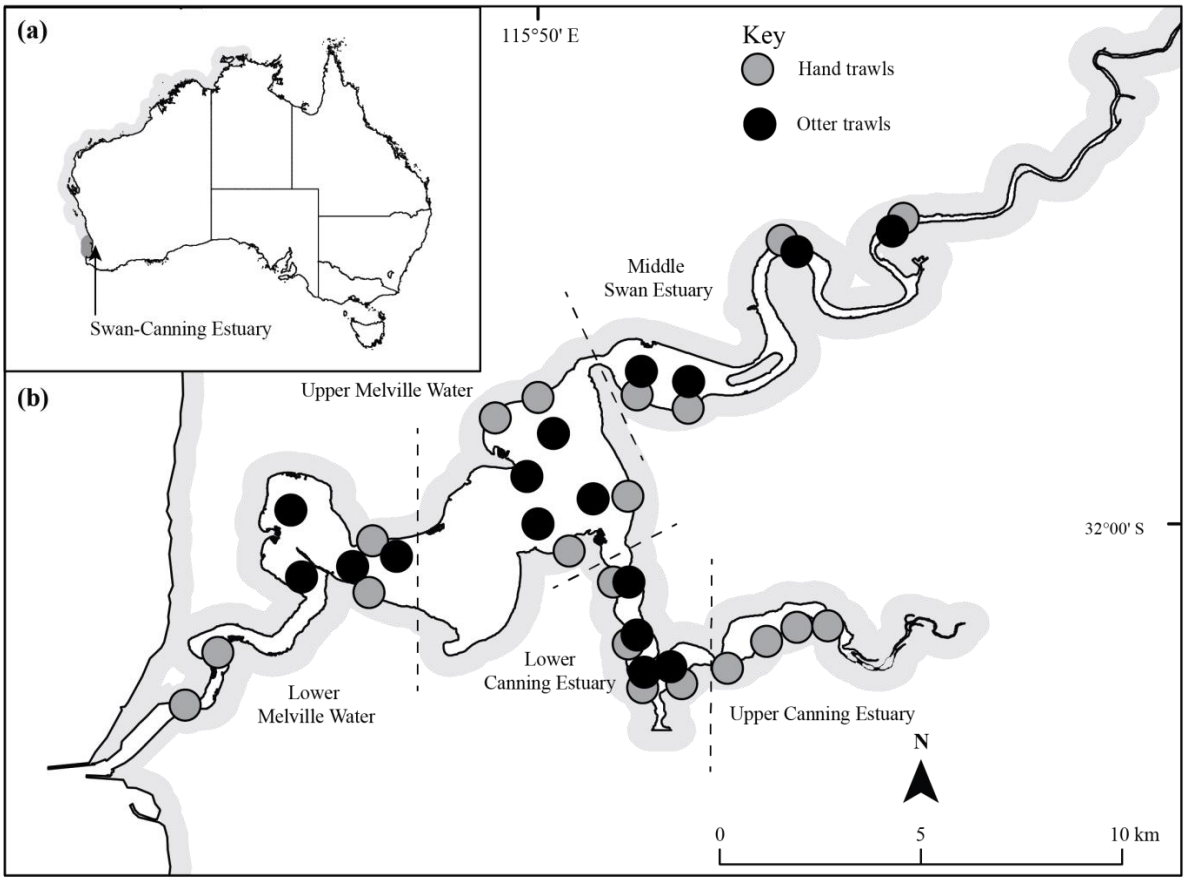


Fig. 3.1. Map showing (a) Australia and the distribution of *Metapenaeus dalli* in inshore marine waters (light grey) and solely in estuaries (dark grey) and (b) location of the 20 nearshore sites and 16 offshore sites in Swan-Canning Estuary sampled over 6 lunar cycles between October 2015 and March 2016. Dotted lines denote the separation among the five broad regions of the estuary. Taken from Broadley *et al*. (2016).

Nearshore sites were sampled using a 4 m wide hand trawl constructed from 9 mm mesh. The width of the hand trawl net during trawling was, on average, ~2.85 m, but varied slightly amongst trawls depending on the condition of the substratum, presence of submerged obstacles and localised wind and wave conditions. Two replicate trawls of 200 m (swept area of ~570 m^2, were carried out at each site on each sampling period and on any single lunar cycle covered a total area of 22,800 m^2. A 2.6 m wide otter trawl net, with 25 mm mesh in the body, and 9 mm mesh in the cod end was employed to sample prawns in the offshore waters. The net was towed at a speed of ~1.6 knots (~3 km h^{-1}) for 5 min, covering a distance of ~250 m. Two replicate trawls of ~650 m^2 were completed at each site on each sampling period covering a total area of 20,800 m^2 at the 16 sites. After each trawl, individuals of *M. dalli* were counted, sexed, measured and returned alive to the water. The carapace length (CL), *i.e.* orbital indent to the posterior edge of the carapace, of each individual was measured (0.01 mm) using digital vernier callipers. Females were identified by presence of a thelycum and males by the presence of a petasma. Individuals without a thelycum or petasma were recorded as juveniles. Female prawns were also inspected to determine if they were gravid, *i.e.* had large green ovaries, as described by Tuma (1967) and Crisp et al. (2017a) and/or possessed a spermatophore.

As the focus of the sampling regime was to identify potential broodstock collection sites to support the aquaculture effort, the data are visualised below and no statistical analyses have been undertaken.

Results

Distribution and abundance of Metapenaeus dalli in the nearshore waters

Temporal trends

A total of 946 *M. dalli* were recorded in the nearshore, shallow waters between October 2015 and March 2016, with catches in a single net ranging from 0 to 49 (individuals 500 m^{-2}). Among the months, pooled across the 20 sites, densities (500 m^{-2}) increased from 2.5 in October to a peak of 7.5 in November, before decreasing sequentially between December (4) and March (0.9; Fig. 3.2). Whereas a clear progression in density was evident when looking at all *M. dalli*, two distinct peaks in the density of gravid individuals were recorded in November/December and February/March (both ~2 individuals 500 m^{-2}; Fig. 3.3). In contrast, very low numbers of gravid prawns were recorded in October (0.01 individuals 500 m^{-2}) and, to a slightly lesser extent, in January (0.5). The proportion of gravid females to the total number of females above the length at 50% maturity (L_{50}) exhibited a similar trend to that of the number of gravid prawns. The proportion of gravid prawns were greatest in March (100%) and also very high in November, December and February (~80%), with low and very low values in January and October (38 and 0.05 %, respectively; Fig. 3.3).

Despite prawns being present in the nearshore waters in October, only a very small minority of prawns were gravid. Breeding activity started in November, coinciding with the peak in total *M. dalli* abundance, and continued into December, before reducing markedly in January and finally increasing again in February and March, despite a reduction in total *M. dalli* abundance. Interestingly, despite the sequential decrease in the total number of prawns from November to March, the number of gravid prawns was relatively consistent during the two breeding peaks (Fig. 3.3).

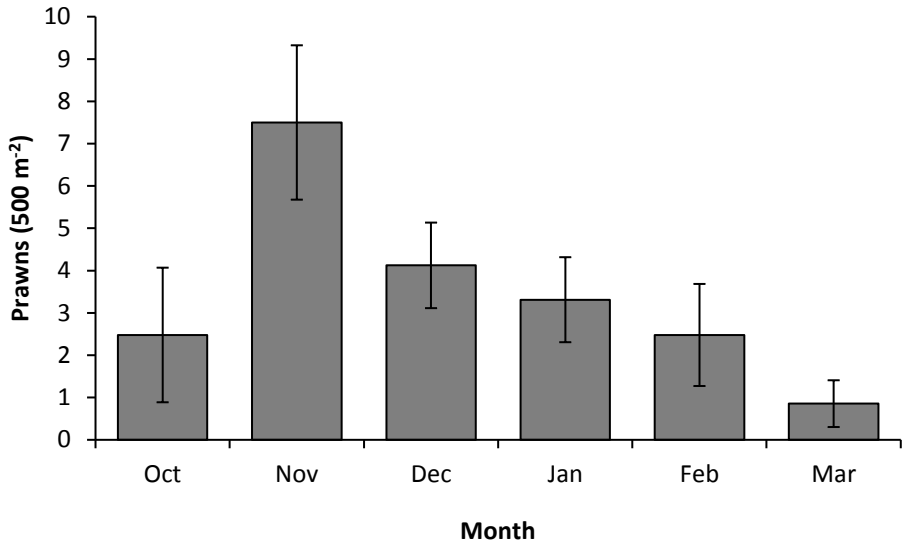


Fig. 3.2. Mean (± standard error) density (500 m^{-2}) of *Metapenaeus dalli* across the 20 sites sampled in the nearshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016.

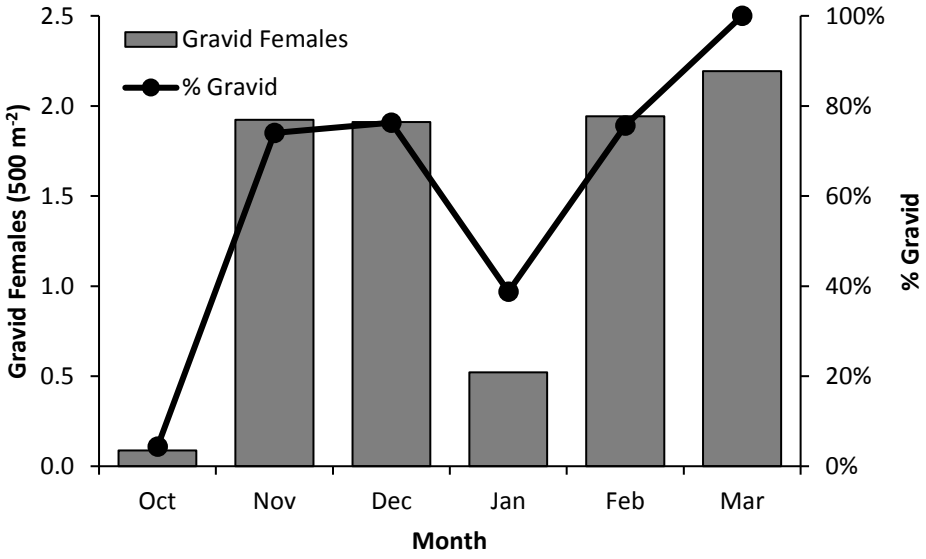


Fig. 3.3. Mean density (500 m^{-2}) of gravid *Metapenaeus dalli* above the length at 50% maturity (L_{50}) across the 20 sites sampled in the nearshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016. Line represents the proportion of females above the L_{50} that are gravid in each month.

Spatial trends

In October 2015, *M. dalli* were concentrated in two parts of the Swan-Canning Estuary; with the majority located on the southern shore of Perth Water (near Coode St.) and a smaller group around Mount Henry Bridge in the Canning Estuary (Fig. 3.4). Very few prawns were recorded in Melville Water. One month later, prawns were still abundant in Perth Water and the lower parts of the Canning Estuary, however, they had spread further upstream in the Swan Estuary to Maylands and Garratt Road Bridge and downstream to sites on the northern shore of Melville Water (Matilda Bay and Dalkeith). This pattern of distribution was maintained into December, albeit at lower densities and particularly so for sites in Perth Water (Fig. 3.4). In January *M. dalli* were typically found on the northern side of Melville Water and at sites in Perth Water and further upstream; with densities being greatest at these more upstream sites. Densities in the Canning Estuary declined between December and January and remained relatively low for the rest of the breeding season. The trend for *M. dalli* to move upstream continued in February, with the majority of individuals caught at Maylands and Garratt Road Bridge, although 'hotspots' of abundance were recorded at Dalkeith and Canning Bridge. By March, densities were at their lowest and *M. dalli* were almost exclusively recorded as sites upstream of Perth Water (Fig. 3.4). In all of the six months, *M. dalli* was never recorded at sites in the Entrance Channel (Stirling Bridge and Leeuwin Barracks) and at Point Walter, although substantial numbers of *P. latisulcatus* were recorded (data no shown).

Very few gravid *M. dalli* were found in October, with only a single individual recorded at Canning Bridge, reflecting the fact that, in this month, only ~0.5% of female prawns were gravid (Figs 3.3, 3.4). However, in the months where gravid prawns were recorded, their spatial pattern of abundance was similar to that of the entire populations. For example, in November and December, gravid *M. dalli* were located in the lower Canning Estuary in both months and also in Perth Water in November and at Dalkeith in December (Fig. 3.5). In January and February, the majority of spawning females were found in the northern side of Melville Water and Maylands and Garratt Road Bridge, with this last site sites being particularly important in February. By March gravid *M. dalli* were only recorded at these two most upstream sites (Fig. 3.5).

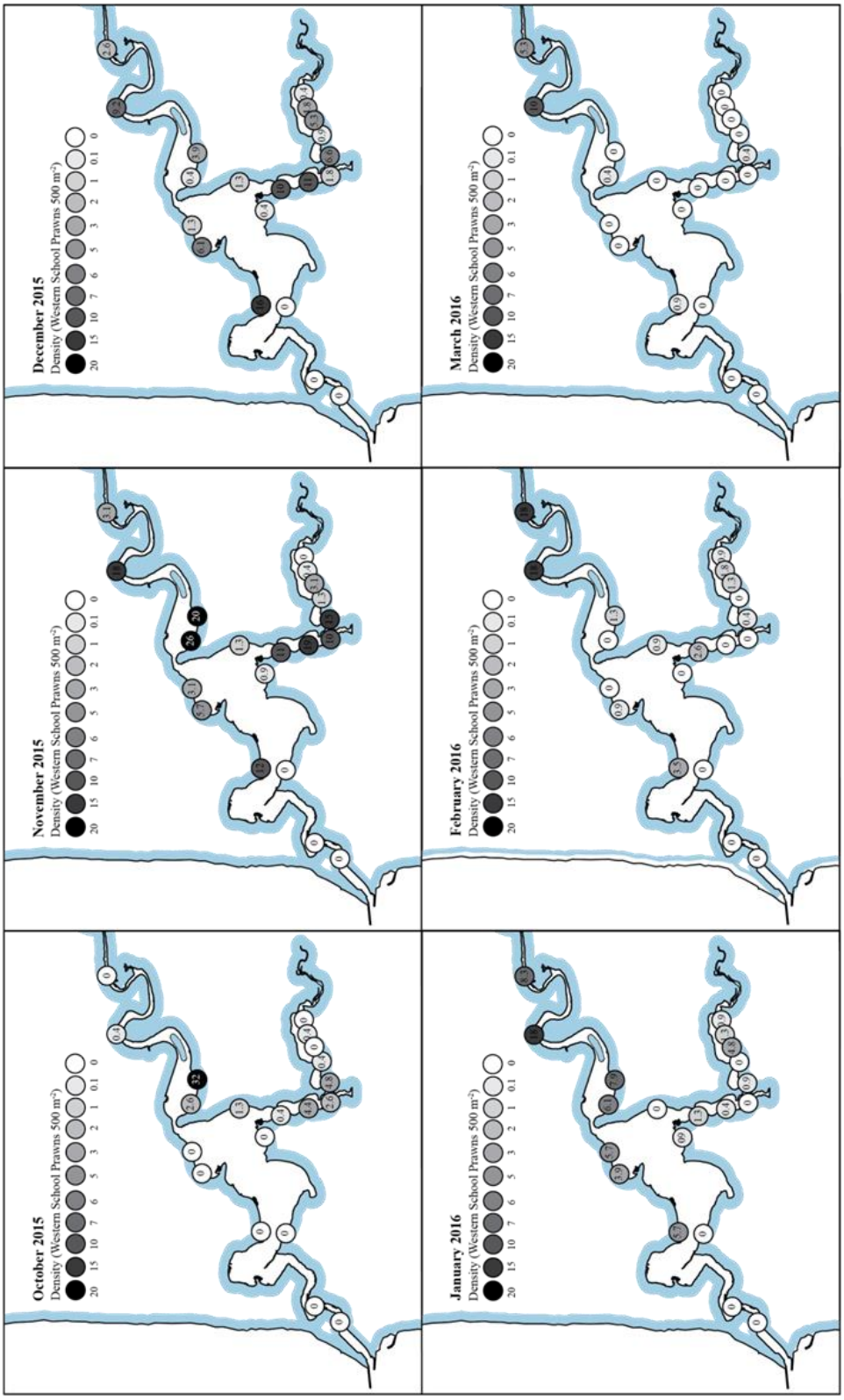


Fig. 3.4. Heat map showing the mean density (500 m^{-2}) of *Metapenaeus dalli* at each of the 20 sites sampled in the nearshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016.

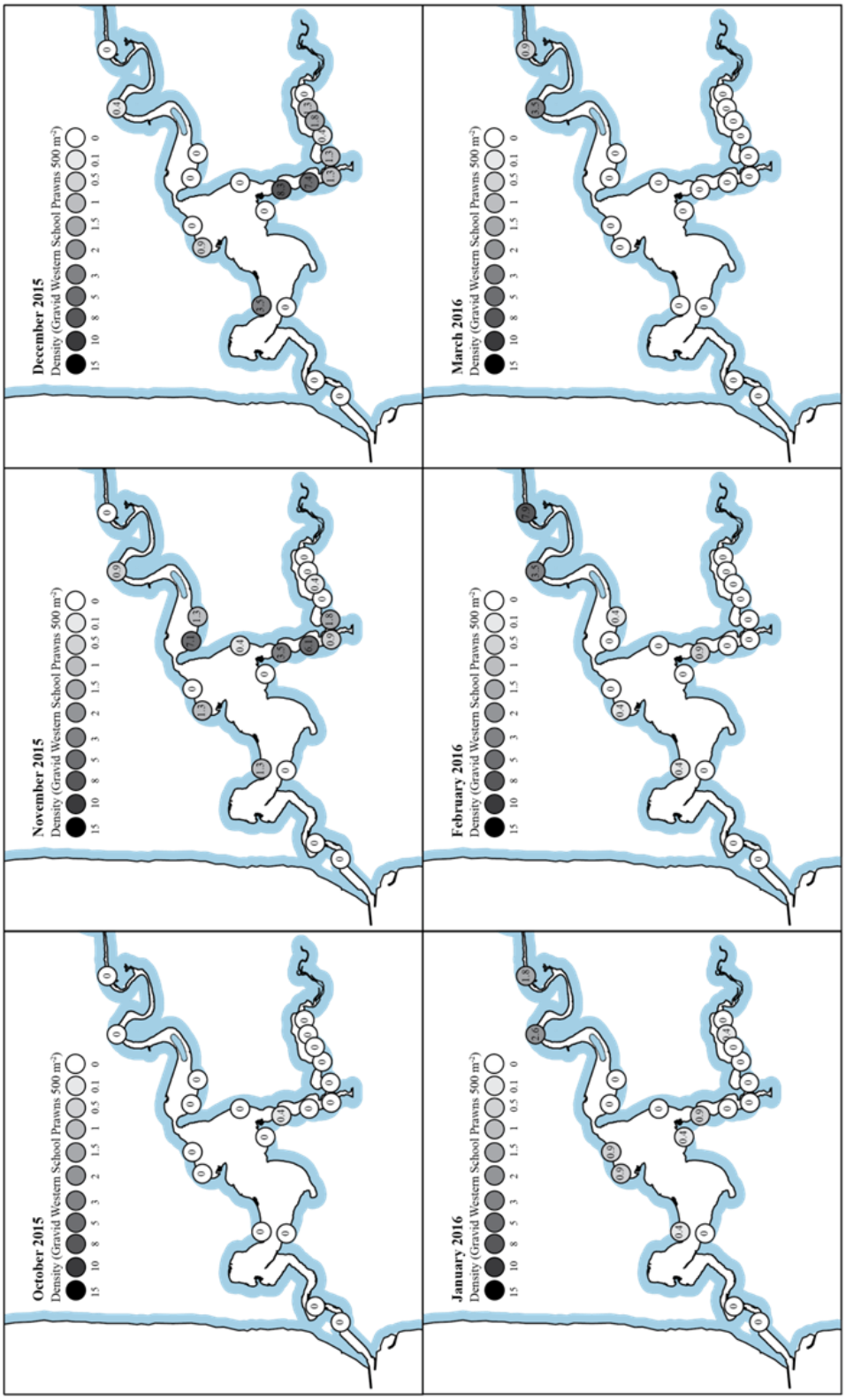


Fig. 3.5. Heat map showing the mean density (500 m^{-2}) of gravid *Metapenaeus dalli* above the length of 50% maturity at each of the 20 sites sampled in the nearshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016.

Distribution and abundance of Metapenaeus dalli in the offshore waters

Temporal trends

A total of 3,672 *M. dalli* were recorded from the 16 sites in the offshore, deeper waters by otter trawl in each month between October 2015 and March 2016, with catches in a single trawl ranging from 0 to 160 (individuals 500 m^{-2}). Density (500 m^{-2}) peaked in November and December (23), with moderately reduced values in January (18) and October (15; Fig. 3.6). These densities (range 4-23) were greater than those recorded in the nearshore waters (range 0.9-4) in all but November (7.5 in nearshore waters), and in each month the densities in the offshore waters exceeded those of the corresponding month in nearshore waters (*cf.* Figs 3.2, 3.6). Despite the differences in the densities between the offshore and nearshore waters in each month, the temporal pattern of abundance among months, but within a water depth, remained similar, *i.e.* peaking in November and then declining. It is worth noting, however, that, in relative terms, *M. dalli* was far more abundant in the deeper waters in October and December than in the shallower, nearshore areas.

As in the nearshore waters the abundance of gravid *M. dalli* peaked twice, albeit at slightly different times; firstly in November and secondly in January/February. Despite the far larger numbers of prawns recorded in November in the offshore (23) compared with the nearshore waters (7.5), the number of gravid *M. dalli* was far greater in the nearshore (2) than offshore waters (0.4) and a similar trend was present in January/February; albeit not as marked due to the pronounced decline in gravid prawns in the nearshore waters in January (*cf.* Figs 3.3, 3.7). The temporal pattern in the proportion of gravid *M. dalli* to the total number of females above the L_{50} followed a comparable trend to that of their abundance, *i.e.* peaking in November (~7%) and February (~50%). However, these values were far lower than those in the nearshore waters, which ranged from 74-100% during November, December, February and March.

The pattern of abundance of all *M. dalli* and those that are gravid in the offshore waters follows a similar pattern to those in the nearshore waters, albeit slightly temporally offset. In general, density of all *M. dalli* is far greater in the offshore waters, however, the reverse is true for gravid prawns and the proportion of mature females that are gravid (*i.e.* greater in nearshore waters).

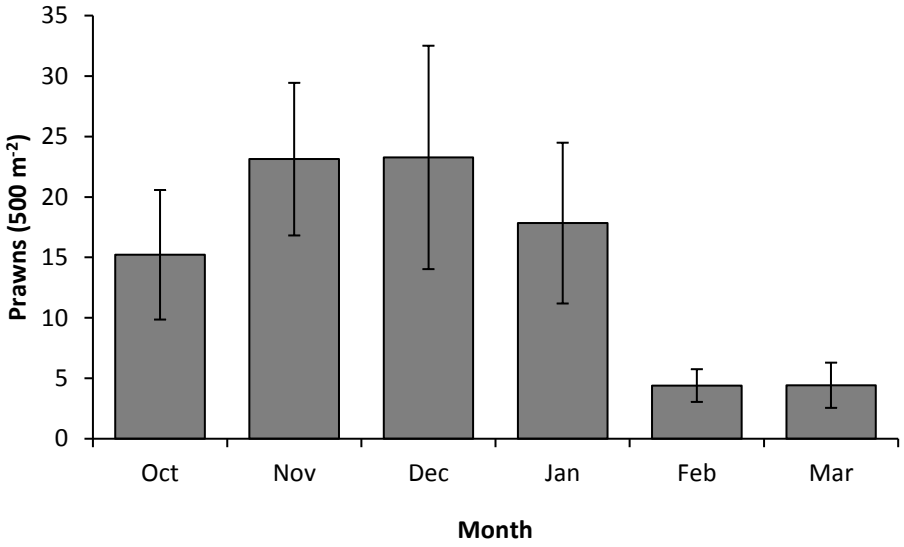


Fig. 3.6. Mean (± standard error) density (500 m^{-2}) of *Metapenaeus dalli* across the 16 sites sampled in the offshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016.

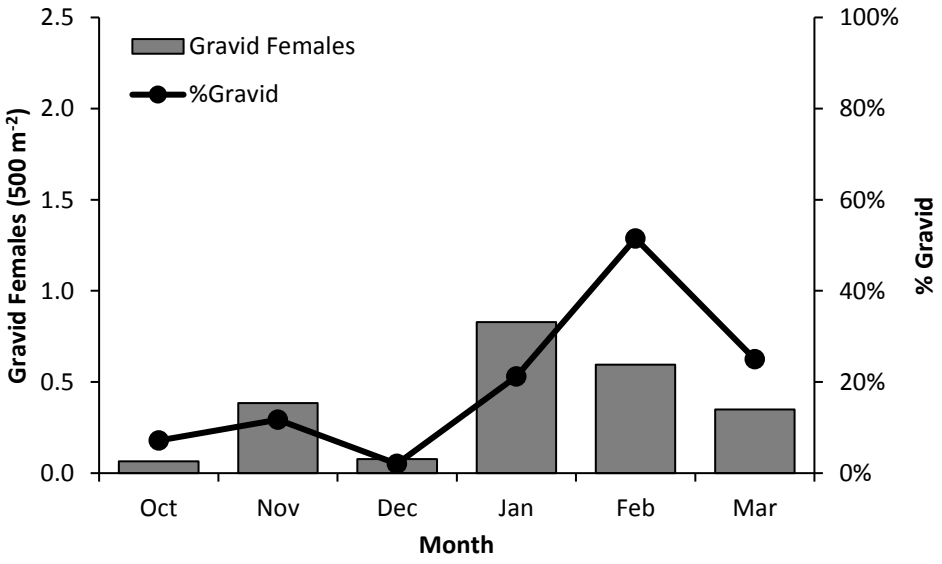


Fig. 3.7. Mean density (500 m^{-2}) of gravid *Metapenaeus dalli* above the length at 50% maturity (L_{50}) across the 16 sites sampled in the offshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016. Line represents the proportion of females above the L_{50} that are gravid in each month.

Spatial trends

In October 2015, *M. dalli* were recorded mainly in the Canning Estuary and sites upstream of the Narrows Bridge and, to a lesser extent, on the northern side of Melville Water (Fig. 3.8). This spatial pattern of distribution was maintained for the duration of the sampling (*i.e.* until March 2016), although the densities at individual sites changed, typically decreasing after December (Fig. 3.8). This relatively constant pattern of distribution was in contrast to that in the nearshore waters where there was a trend for *M. dalli* to move upstream particular in February and March (Fig. 3.4). As with the nearshore waters, however, *M. dalli* were not caught in large densities at any of the three most downstream sites (*i.e.* Mosman Bay, Freshwater Bay or Point Walter and instead substantial numbers of *P. latisulcatus* were recorded (data not shown).

As in the nearshore waters, very few gravid *M. dalli* were found in the offshore waters in October, with only a single individual recorded at South Perth, reflecting the fact that in this month only ~0.06% of female prawns were gravid (Figs 3.7, 3.9). In each of the remaining months, gravid prawns were recorded at sites in the Canning Estuary, with their abundance peaking in January and February. In both of these months gravid individuals were also recorded at locations in Melville Water, particularly Dalkeith. Gravid prawns were also recorded at Maylands and Garratt Road Bridge, but only in February and March (Fig. 3.9).

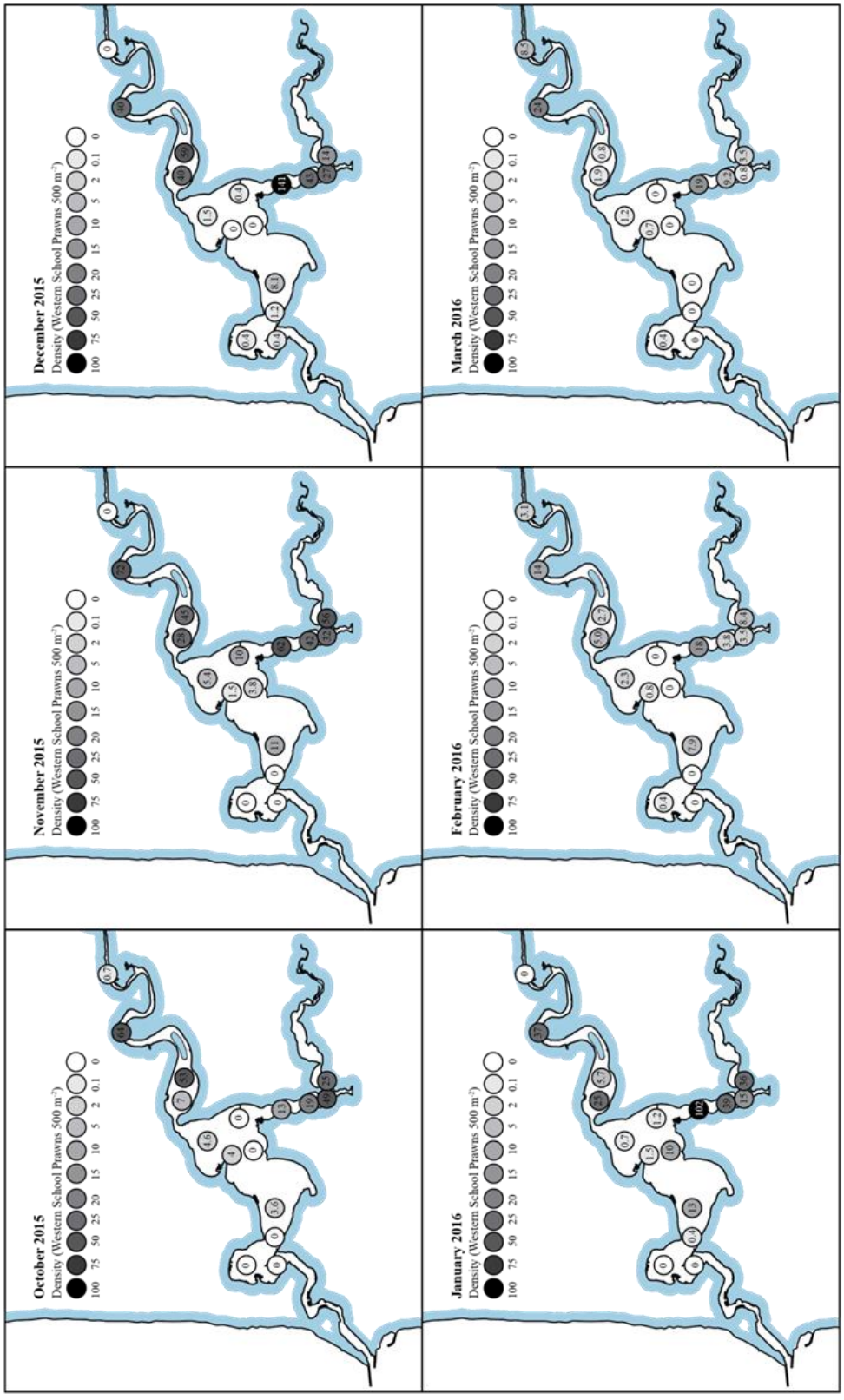


Fig. 3.8. Heat map showing the mean density (500 m^{-2}) of *Metapenaeus dalli* at each of the 16 sites sampled in the offshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016.

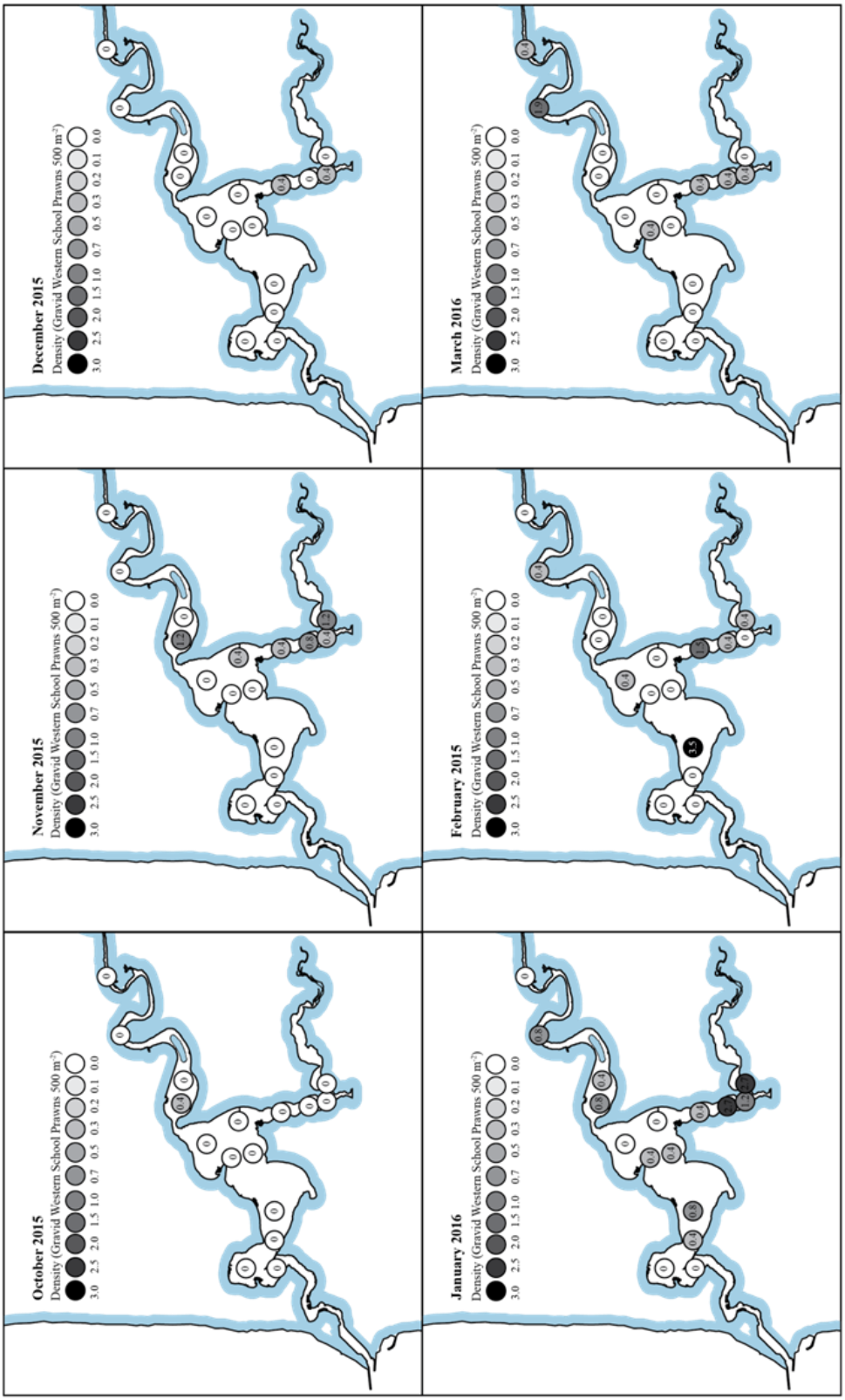


Fig. 3.9. Heat map showing the mean density (500 m^{-2}) of gravid *Metapenaeus dalli* above the length of 50% maturity at each of the 16 sites sampled in the offshore waters of the Swan-Canning Estuary in each month between October 2015 and March 2016.

Informing broodstock collection

One of the aims of the monitoring program was to help (in conjunction the Prawn Watch volunteers) determine suitable (targeted) locations for broodstock collection events. Over the four years of restocking (2012-2016), the largest number of gravid females were collected in 2015-/16, with 764 collected, compared to 115-581 in the preceding years (Fig. 3.10). The greater number of gravid prawns that were collected as the program progressed resulted in fewer number of broodstock collection events being conducted, thus increasing the broodstock efficiency, *i.e.* the average number of gravid prawns retained on each collection event (Fig. 3.10). Collection was most successful in 2015/16 with the most number of gravid prawn collected in the fewest number of collection events.

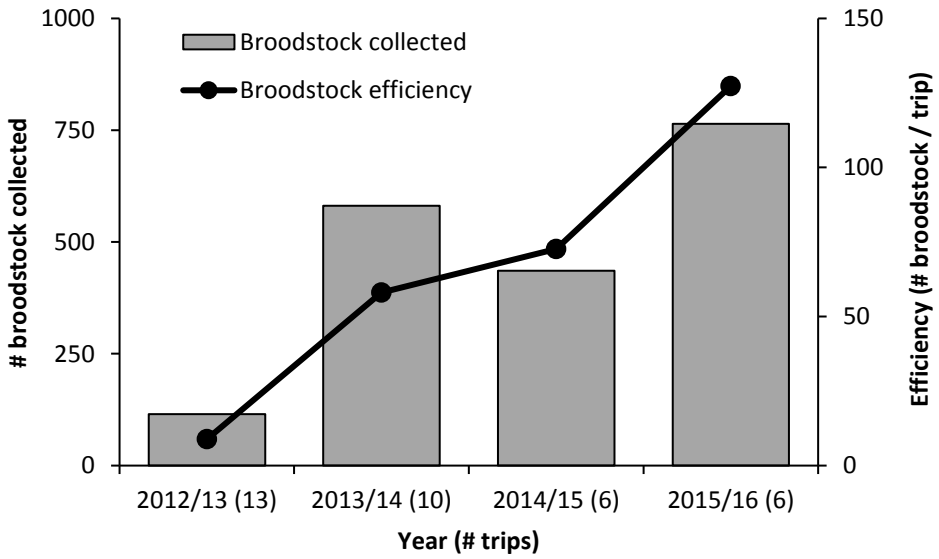


Fig. 3.10. Number of broodstock and broodstock efficiency (*i.e.* the average number of gravid *Metapenaeus dalli* retained on a broodstock collection) in each breeding season between 2012/13 and 2015/16. The number of collection events in each breeding season are given in parentheses on the *x* axis.

Discussion

Temporal trends in abundance

In the case of both the nearshore and offshore waters a clear temporal pattern of abundance of *M. dalli* was detected. Densities in the nearshore waters were low in October, increased to a peak in November and declined sequentially thereafter. Densities of prawns were far higher in the offshore than nearshore waters in all seasons, but particularly so in October, which reflects the fact that most *M. dalli* remained in the deeper waters and did not move in to the cooler shallower, nearshore areas. However, by November, increases in solar radiation and a reduction in freshwater discharge, raised water temperatures in the shallows and thus made these waters more conductive to this essentially 'tropical' species of prawn (Grey et al., 1983). As well as densities increasing markedly in November, the number and proportion, of gravid females increased too. This is likely also due to increases in water temperature, as, in the two preceding years, Broadley et al. (2017) found that gravid *M. dalli* were found only from October to March and spawning activity was greatest from November to February, when surface and bottom water temperatures exceeded 20 °C. Analysis of the data obtained in the current study, with those for the previous two years demonstrates that the peak timing of abundance in the nearshore waters and spawning various among years, reflecting inter-annual changes in rainfall and air temperature, which thus influence salinity and water temperature (Crisp et al., in prep.).

The subsequent decline in the abundance of *M. dalli* in both the nearshore and offshore waters after November and December was likely to due to mortality of females following the physiological stress associated with rapid somatic and reproductive growth that occurs at this time of year. This is reflected in the estimated total instantaneous mortality rates for female *M. dalli* in the Swan-Canning Estuary being 60% greater than that that for males (Broadley et al., 2017). Moreover, there was also an increase in the male:female ratio, indicating that the decline in abundance of *M. dalli* was mainly due to the loss of females (Crisp et al., in prep.).

The two pronounced peaks in the number of gravid prawns in the shallows, *i.e.* (i) November/December and (ii) February/March may reflect the fact that females may spawn twice in a breeding season, but could also be due to those females born towards the

end of the previous spawning season (*i.e.* March) reaching sexual maturity and thus being able to become gravid. These theories are supported by the fact that the average size of gravid female prawns was ~19 mm CL in November/December (range 13-26) and around the size at which 50% of females are mature, but was ~25 CL in February/March (range 19-30). This suggests that some of those prawns that spawned in 19 mm CL in earlier in the season grow and spawn again at a larger size, while others that were too small to breed in November/December obtain maturity later in the season and spawn then (albeit at a smaller size).

Interestingly, despite the fact that densities of *M. dalli* were always greater in the offshore and nearshore waters, densities of gravid females were typically greater in the nearshore waters. This indicates that the majority of the population reside in the deeper waters, with a 'subset' of individuals moving into the nearshore waters to breed and/or spawn. Thus once females become gravid they move into the shallow waters to mate, if they have not already received a spermatophore, and spawn. This movement makes them susceptible to fishing pressure, particularly as the females are almost 50% larger (*i.e.* L_∞ 33.6 mm CL for females and 22.8 mm CL for males; Broadley *et al.* 2016) and thus more likely to be retained by fishers. Given the likely possibility that a portion of the females will spawn twice in a breeding season, and that as they reach a larger size as the season progresses and thus are able to release more eggs (see Table 2.3; Crisp *et al*. in prep), the removal of these prawns has the potential to substantially reduce egg production (see Section 6).

Spatial trends in abundance

In the nearshore, shallow waters *M. dalli* were recorded at sites upstream of the Entrance Channel (*i.e.* in Melville Water and waters above). Densities in the October – December were greatest in the lower Canning Estuary and Perth Water, which likely reflects the presence of warmer water due to the installation of boards on Kent Street Weir on 1st October 2015; preventing the flow of cooler, low salinity water into the Canning Estuary and the shallow depths of Perth Water, which increase in temperature faster than the deeper waters of Melville Water. As water temperatures increase in Melville Water, densities of *M. dalli* increase. Prawns move upstream later in the season, a pattern recorded by Potter et al.

(1986), which these authors put down to an increase in salinity. The spatial pattern of abundance in the deeper waters was far less pronounced than the shallows, which is likely due to the more stable water physico-chemical conditions. Still, the largest densities of *M. dalli* were recorded in the lower Canning Estuary on Perth Water, which again reflects the fact that these waters were warmest throughout all months of the breeding seasons. The reason that very few or no *M. dalli* were recorded at the most downstream sites reflects the fact that although the waters here had the highest salinity, they were often the coolest. Laboratory studies by Crisp et al. (2017b) suggested that water temperature (and not salinity) had the biggest influence on growth, which is presumably the primary aim of prawns at this time of year, with larger individuals being able to produce more eggs.

Informing broodstock collection

The consecutive increases in broodstock efficiency (*i.e.* the number of gravid females collected at a collection event) obtained in each breeding season highlight the importance of obtaining good quality monitoring data. This was particularly important in the current study as each collection event took several days to organise, as the collection was done by community members, and thus being able to select the best available sites resulted in more broodstock being collected and increased volunteer satisfaction. Given that the patterns of abundance of prawns in the estuary changes regularly throughout the breeding season (and also among years) this information is crucial to the success of the broodstock collection. While it is obvious that lower numbers of broodstock would generate fewer eggs and larvae and therefore inhibit the success of the restocking, it also has implications for volunteer engagement. Several studies have highlighted the implications of a lack of engagement on volunteer attrition (Eveleigh et al., 2014; Tweedley et al., 2016a) and thus, if broodstock collection events were conducted without collecting any gravid females fewer community members would be willing to participate, which would be counterintuitive to the success of the community engagement and restocking.

Section 4. Community engagement and stewardship through Prawn Watch

Aims

Prawn Watch is a citizen science - community engagement project initiated by the Swan River Trust and lead by the Department of Parks and Wildlife since the merger of those organisations. Prawn Watch is part of the Department's River Guardians community engagement framework and is funded, through the Recreational Fisheries Initiative Fund (RFIF), as well as the Department itself.

The project was linked to the culture and release of Western School Prawns (*Metapenaeus dalli*) into the Swan-Canning Estuary (which is part of Swan Canning Riverpark).

Prawn Watch was initiated in 2012 and had a number of goals:

- Short-term: facilitate improved understanding of an important iconic species and the river system through data collection, information sharing and awareness raising about river issues, the prawn fishery and its management.
- Intermediate-term: contribute to improved stewardship of the prawn fishery and the Riverpark by: promoting river friendly activities; encouraging sustainable fishing practice; and contributing to improve fishing policy.
- Long-term: Contribute to an improved fishery and Riverpark environment .

These goals were outlined in a communications strategy established at the start of the project and carried through into a strategic media plan developed in 2015. The outcomes of the overall project are reported here as well as deliverables under the media plan (further detail; see also Appendix 1).

Approach

Throughout its development in 2012, Prawn Watch fostered partnerships with universities; technical institutions, government departments and natural resource management

organisations. It was recognised in those partnerships, that Prawn Watch was integral to, and one element of, a much bigger project that included: the culture and release of *M. dalli*; and a university based research and monitoring project (FRDC 2013/221 "Stock enhancement of the Western School Prawn (*Metapenaeus dalli*) in the Swan-Canning Estuary; evaluating recruitment limitation, environment and release strategies").

In 2015, a strategic media campaign set out to update the communication outputs of Prawn Watch and contribute against the overall objectives of that project. Existing products were updated through this campaign and a series of events and forums were held that enabled the communication of sustainable fishing approaches and Prawn Watch. In addition, community continued to be engaged in sharing their data through Prawn Watch and contributing to broodstock collection events.

Prawn Watch worked to engage with community, local businesses, media outlets, scientific and government sectors across four areas of activity that are described further below that include: (i) engagement and awareness raising (ii) communications, (iii) citizen science monitoring and (iv) influencing sustainable management and policy.

Engagement and awareness raising

Prawn Watch was established in November 2012, with a small number of volunteers engaged early in the project to help develop communications tools and to identify prawning sites based on historical catch information to support broodstock collection. These volunteers became part of an on-going Prawn Watch Reference Group . In order to boost volunteer numbers the project was "soft launched" through a range of networks in time for a broodstock collector's workshop on 17 October 2013. The project was later, formally launched by the then Western Australian Minister for Fisheries Hon. Ken Baston on 6 February 2014 (Fig. 4.1).

Four volunteer training workshops were held over the course of this project. The first volunteer induction workshop (held on 17 October 2013 at the Royal Perth Yacht Club) attracted 80 community members. The event was targeted at engaging and training people

interested in helping with broodstock collection. Subsequently, 44 volunteers registered as broodstock collectors. A second event (held on 6 February 2014 at the South Perth Yacht Club) was aimed at engaging the broader community into being involved with Prawn Watch. One hundred people attended this event, with 80 new members signing up, bringing the total number of volunteers to 124.

Fig. 4.1. Photograph of former Western Australian Minister for Fisheries, Hon. Ken Baston MLA (second from right), with some members of the project team from left Kevin Reid (Prawn Watch Reference Group), Dr Kerry Trayler (Parks and Wildlife), Greg Jenkins (ACAAR), Will Smithwick (Prawn Watch Reference Group), Jen Elliot (Parks and Wildlife), Dr James Tweedly, Professor Neil Loneragan (Murdoch University), Mark Pagano (Department of Fisheries) and Dr Andrew Rowland (Recfishwest).

The third training event (held on the 15th October 2014 at Murdoch University) was targeted at engaging and training students interested in helping with broodstock collection and the university based monitoring project. Twelve people were inducted as broodstock collectors following that event bring total volunteers to 135. The fourth and final training event (held at South Perth Yacht Club on November 13th 2014) was again open to the broad community (Figure 4.2). Following this event, membership stood at 179 people. The project maintained over 75% of its members, with 135 still involved two year later in November 2016.

Each of the volunteer workshops included presentations from the Swan River Trust / Department of Parks and Wildlife, Australian Centre for Applied Aquaculture (South Metropolitan TAFE), Murdoch University, with additional presentation and training provided by the Department of Fisheries and community members. Topics included information on the overall project and its aims, river issues, prawn biology and ecology, aquaculture techniques, recreational fisheries regulations, safety issues, how to fish for prawns and broodstock, as well as sustainable fishing and RiverWise messages.

Fig. 4.2. Composite photograph of theory and practical components of training events.

As part of the volunteer workshops, community attitudes and understandings were surveyed both before and after every event. At each of the four training sessions, participants showed an increased understanding of the daily recreational bag limit for prawns after training, with 100% of respondents answering correctly in the last three events (Fig. 4.3). In general, participants also showed increased understanding of prawn ecology, issues facing the river

and of River-wise practices. All participants at the 2015 forum were surveyed after the event and 100% of participants indicated that their understanding of Western School Prawns and/or the Riverpark had been improved.

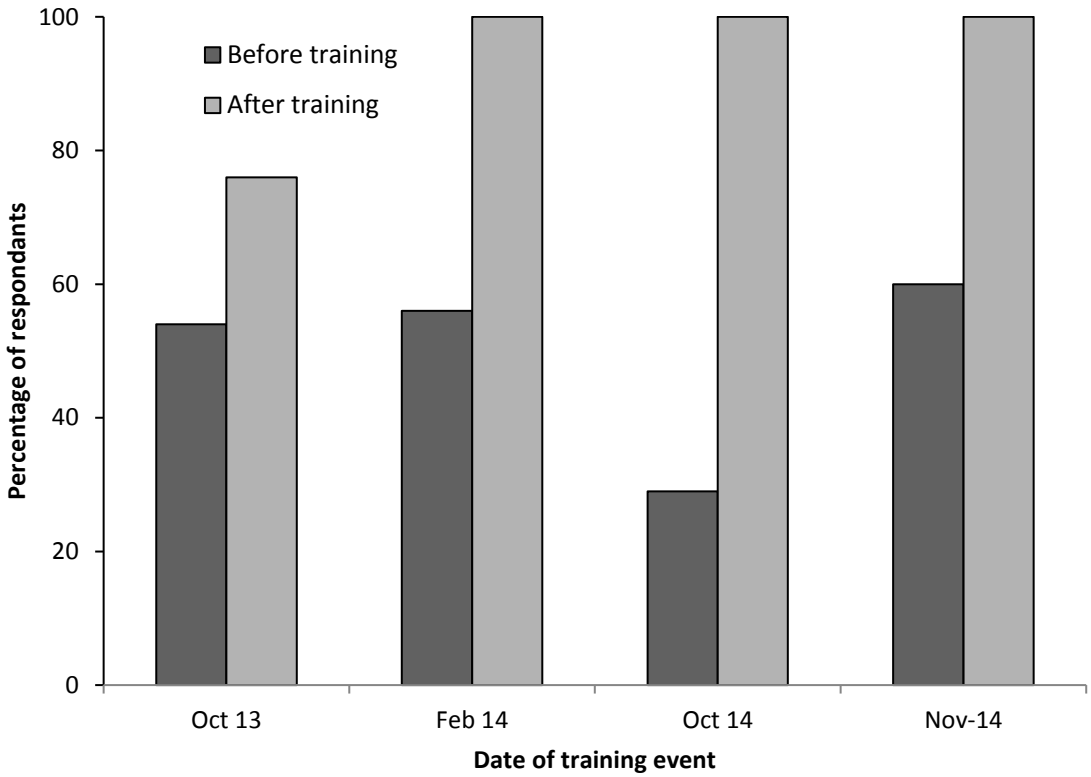


Fig. 4.3. Proportion of participants that knew the correct recreational bag limit for prawns in the Swan-Canning Estuary before and after training events. Return rate 8-30%.

Annual feedback forums were held in September 2014 and 2015 and a final forum, "*The Secret Life of Prawns*", was held in October 2016. These events were intended to celebrate the action of participants in Prawn Watch as well as the associated aquaculture and research and monitoring projects. They enabled researchers and managers to summarise their findings and activities across the year as well as to provide information on community monitoring, aquaculture and restocking results. The forums also provided an avenue to

thank the community for their efforts in broodstock collection and citizen science monitoring and prizes were awarded to members for their efforts. In recognition of the action of the volunteers, awards were presented to the Citizen Scientist of the Year and Prawn Watcher of the Year (Table 4.1).

Table 4.1. Volunteer awards and winners over the course of the project.

Award	Winner	Rationale
2014 Citizen Scientist	Will Smithwick	Awarded to the volunteer who contributed the best citizen scientist observations.
2014 Prawn Watcher of the year	Damien Mansfield	Awarded to the volunteer who contributed the most amount of monitoring time.
2015 Citizen Scientist	Kevin Reid	Awarded for his valuable contribution to Prawn Watch through observation and reporting
2015 Prawn Watcher of the year	Darren Hamley	Awarded for his valuable contribution to Prawn Watch through monitoring and activity
2016 Citizen Scientist	Mel Turner	Awarded for her valuable contribution to Prawn Watch through reporting and extension
2016 Prawn Watcher of the year	Jeevarayan Rao	Awarded for their valuable contribution to Prawn Watch through monitoring and reporting

In December 2015, the Department of Parks and Wildlife held their annual Volunteer of the Year and Outstanding Service Awards. The 2014-15 was a record year, with 4,636 individuals contributing more than 600,000 hours to Parks and Wildlife environmental and recreational projects. Outstanding Service awards were presented by the Minister for the Environment, Hon. Albert Jacob, to Prawn Watch volunteers, Will Smithwick and Kevin Reid for their ongoing contribution to the project (Fig. 4.4).

Fig. 4.4. Western Australian Minister for the Environment, Hon. Albert Jacob MLA (left), to Prawn Watch volunteers, Will Smithwick and Kevin Reid (right).

Communications

Prawn Watch web pages were established in November 2013 as part of the River Guardians site (http://www.riverguardians.com/projects/prawn-watch) to provide information on the project, as well as facts about *M. dalli* and where to catch them. The web pages also tell people how they can get involved and encourages them to share their own stories as well as citizen science data. The content of the pages was updated in 2015 and 2016 in order to ensure information was current based on the on-going research project and to update the data input pages based on feedback and improvements in technology. An evaluation of hits to the River Guardians Website conducted in 2016, showed that between 1 July 2015 and 30 June 2016, the "Catching River Prawns" page had 3,697 hits and was second only in popularity to the landing page for that site.

A fact sheet on the Western School Prawns was made available through the Prawn Watch web pages as well as the Department of Parks and Wildlife website and will be updated based on the findings of this and the FRDC project. The information in that fact sheet also provided the basis for a "Creature Feature" article as part of the Swan River Trust's Riverview magazine (Issue 2, Spring 2013). That magazine issue also contained a feature article on the restocking of prawns. A third article, focussed on the "Communities Role in the River Prawn Comeback" was published in Riverview magazine (Issue 3, Summer 2014). A smaller update to the community on the prawn restocking was provided in Riverview (Issue 4, Autumn/Winter 2014). Community involvement in the project was also highlighted as a feature story in the 2013-14 Annual Report of the Swan River Trust. Restocking successes were reported in the River Protection Strategy Community Update in 2015 and then later in the June 2016 winter edition of the Department of Parks and Wildlife Landscope Magazine (see Appendix 2) and the Parks and Wildlife Annual Report 2015/16.

Prawn Watchers were kept up to date with the project through regular emails as part of the River Guardians mail out. This provided opportunities to promote broodstocking activities they could partake in, share sustainability messages and invite the community to other events where Prawn Watch was showcased. An example of these is provided in Appendix 3. In addition, messages promoting sustainable prawning were posted to the River Guardians Facebook page (Fig. 4.5). The Facebook page also provided an opportunity to engage Prawn

Watchers in other River Guardians events, such as larger community festivals and river clean-up days.

Fig. 4.5. Facebook post encouraging improved prawning practices in the Riverpark.

Prawn Watch was promoted at a range of events on and about the Riverpark, including the Autumn Rivers Festival (a festival held on the banks of the Swan River in Bassendean and Belmont) in April 2014 and March 2015 and March 2016 (Fig. 4.6), SwanFish 2015 and 2016 (a recreational fishers event), and the Science Week – Patterns in Science festival (a celebration of science in the community), August 2015 (Fig. 4.7). At each of these events, a series of storyboards describing Prawn Watch, the culture of prawning in Perth and research

outputs were displayed along with hands on material, such as prawning equipment and aquaria containing different species of prawns. The storyboards were updated in 2016 (Appendix 4). Oral presentations were also provided to audiences at all these events, with the exception of Swanfish. In particular, the Autumn Rivers Festival regularly attracts over 7,000 people and new River Guardians / Prawn Watchers were signed up at these events. Prawn Watch also featured in promotional activity at the 2016 Blessing of the River Festival.

A flyer promoting sustainable fishing was added to suite of the educational materials available at the display stands in 2015 and was updated in 2016 (Appendix 5). A promotional video, prepared in 2014, was used at all events where facilities were available. See: https://www.youtube.com/watch?v=CmHktABVy0A). A new 6 minute video describing the project and its outcomes was developed in time for the 2016 feedback forum (link to video here). In addition a video, demonstrating how to fish for prawns will also be finalized in 2016 and available at tackle fishing stores as part of a Strategic Media Plan.

Fig. 4.6. Sustainable fishing displays and engagement at the Autumn Rivers Festival in 2015.

Fig. 4.7. Community engagement officers and Gaia Resources staff with displays and interacting with community at the Patterns in Science Festival in August 2015.

Print, audio and visual media played a key role in raising awareness of the Prawn Watch project and the wider restocking project. An extensive media campaign was launched in association with the formal launch of Prawn Watch through the Western Australian Minister for Fisheries in February 2014. The campaign was based around a collaborative media statement released by all partner organisations (see acknowledgements) connected to this project. The aim of the release was to informing the public about the project and engaging their interest and involvement. Media analyses (in the period associated with the launch (5 Feb – 18 Mar 2014) indicated that our release was promoted in 26 media items across five different types and reaching a cumulative audience of over 761,000 people with an estimated advertising value of $64,545 (Table 4.2 and see Appendix 6 for full details).

Table 4.2. The number of media articles, audience and advertising space rate for media associated with Prawn Watch launch.

Media Type	Number	Audience	Advertising space rate
AM Radio	6	115,000	$8,505
FM Radio	1	42,000	$255
On-line	10	55	$12,353
Print	7	430,543	$7,393
TV	2	174,000	$36,039
Total	**26**	**761,598**	**$64,535**

The release of the Prawn Watch smartphone application (app) by the then current Western Australian Ministers for Fisheries and Environment in January 2015, generated further media interest with follow-up Channel 9 New 'Special Report', two radio interviews on ABC and 6PR and a number of follow up articles. A further media release by the Fisheries and Environment Ministers in February 2015 announced the news that more than one million prawns had been restocked during the 2014/15 breeding season. Channel 9 then did a second report that resulted in follow up stories. The prawn restocking story was linked to stories about the health of the Swan River on a number of occasions.

The project also sparked other media interest, with project officers being asked to take part in educational documentaries including:

- Destinations WA – Catching Swan River Prawns https://www.youtube.com/watch?v=K0CJKeYRB0M
- Destinations WA - Drunken Prawns https://www.youtube.com/watch?v=WS4jMDb-8Xc
- What's the catch (http://www.sbs.com.au/programs/whats-the-catch) hosted by the Gourmet Farmer Matthew Evans (Fig. 4.8). Note that while video footage about prawning and the restocking project was recorded it was not used in the final series.

Fig 4.8 Project officers Dr Kerry Trayler and Dr James Tweedley discussing sustainability of prawning with "Whats the Catch" presenter Matthew Evans.

In March 2016, a joint media release was made by the former Western Australian Minister for Fisheries Hon. Ken Baston and Minister for Environment Hon. Albert Jacob (Appendix 7). This marked the release of the 4 millionth *M. dalli* into the Swan-Canning estuary since the project began and sparked another flurry of media including video footage on Channel 9, 10 and 7, as well as online at WA today and the Sydney Morning Herald.

https://www.youtube.com/watch?v=C2cV2-7Eziw

http://tenplay.com.au/news/perth/2016/3/2/a-special-prawn

https://au.news.yahoo.com/thewest/video/watch/30996269/swan-river-shrinking-for-stadium-footbridge/#page1

http://www.smh.com.au/video/video-news/video-wa-news/swan-river-is-prawn-again-20160302-4bfas

http://www.watoday.com.au/wa-news/400000-western-school-prawns-released-into-the-swan-and-canning-rivers-20160302-gn8wco.html

Media was also used to promote the findings of the research undertaken from the broader project. The example below was used to breakdown the paradigm that blowies (*Torquigener pleurogramma*) were the major predator of *M. dalli*, presumably as they are abundant in the estuary and are infamous for striping bait from recreational fishers. Research showed that the small apagonid Gobbleguts (*Ostorhinchus rueppellii*) was a more veracious predator; a significant finding in relation to determining appropriate release strategies. Murdoch University released a media statement in March 2016 regarding the findings of the research and this was picked up by ABC online (Fig. 4.9).

http://media.murdoch.edu.au/science-maximises-prawn-restocking-success

http://www.abc.net.au/news/2016-03-08/gobble-guts-potential-threat-to-prawn-stocks-swan-canning-rivers/7231216

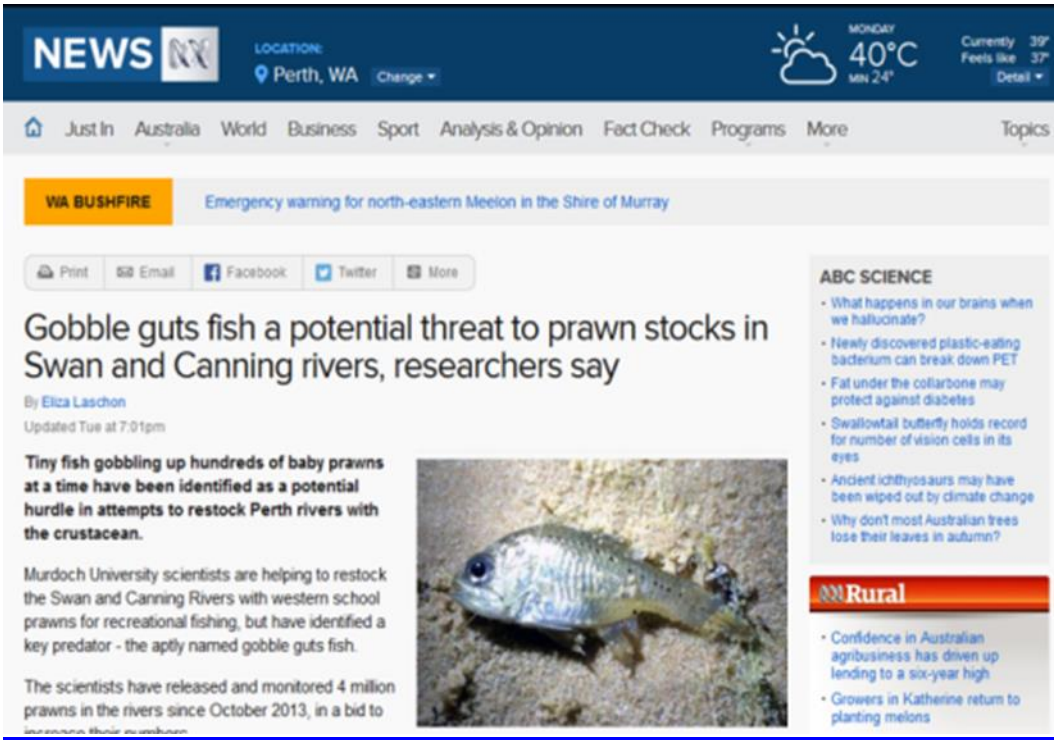


Fig. 4.9. Excerpt from ABC online media about predation on restocked *Metapenaeus dalli* by fish.

Information about Prawn Watch, its findings and associated research were presented at a number of national and international forums including:

2014 Annual Symposium of the Fisheries Society of the British Isles on restocking. "*Assessing the decline in western school prawn (*Metapenaeus dalli*) abundance in a temperature Australian estuary: evaluating the effectiveness of prawn releases and the impacts of environmental change".* (James R. Tweedley, Neil R. Loneragan, Greg Jenkins, Kerry Trayler and Jennifer Chaplin);

2015 National Estuaries Network Forum (Perth): Mini-Workshop on Barriers and Bridges to Citizen Science in Estuaries: Managing volunteers, data, expectations and outcomes. "*Snapshots of Citizen Science in the Swan Canning*". (Kerry Trayler, Kim Onton, Marnie Giroud, and Kim Smith)

2015 Australian Citizen Science Conference: Maximising the Capacity of Citizen Science for Science and Society 23-24 July, 2015 , Canberra. Workshop 4: The social impacts of citizen science. *"Prawn Watch: Engaging fishers in science, restocking and sustainable management of an iconic species that has declined in abundance."* (Kerry M. Trayler, James R. Tweedley, Greg I. Jenkins)

2015 Parks and Wildlife Conference – Engaging Community. 13-16 October. *What makes good citizen science projects* (Kerry Trayler, Marnie Giroud, George Shedwari).

Citizen Science Monitoring

Community members were supported in undertaking monitoring of prawn populations in the Swan-Canning Estuary through the provision of waterproof logbooks, a web based database and the Prawn Watch smartphone app. The Prawn Watch logbook was developed to enable community members to recorded their data in the field and printed in time for the first training workshop in October 2013. This edition was constructed from waterproof paper and the front cover featured former Western Australian Minister for Fisheries Hon. Ken Baston. A further update is in production to ensure the logbook aligns with phone app and to reflect changes in management over time. Once the data is collected, members are able to enter the information from the logbook into a web-based database (URL) or into a smartphone app (see Figure 4.10).

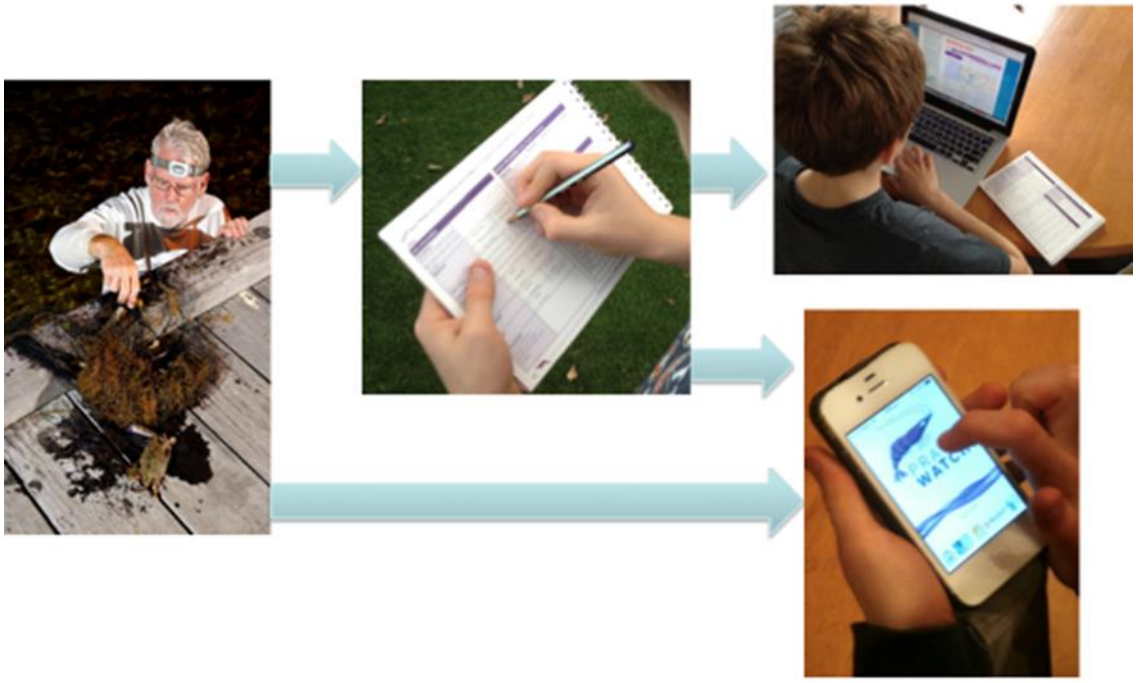


Fig. 4.10. Schematic showing the ways in which Prawn Watchers can collect data using their logbooks and submit data through a web based database and smartphone app. Photos: Stewart Allen and Kerry Trayler.

The Prawn Watch smartphone app was developed by Gaia Resources, for both Apple and Android platforms, to coincide with the November 2014 training and the opening of the prawning season. The app framework was based on the successful Dolphin Watch smartphone app. The approach to logging data on the app follows the same sequence in the logbook, with location data, prawn catch data and by-catch data all being recorded. Version, *i.e.* 1.03, which was released in May 2015, and updated in 2016 enables displays of both individual records and a broad summary of the number of prawns being recorded in different zones of the Swan Canning Riverpark (Figure 4.11). Specific training sessions to support community in the use of the app were provided through the River Guardians program and in collaboration with Gaia Resources. These sessions occurred as part of the Patterns in Science Festival in 2015 and 2016 and targeted special events in 2016 (see Fig 4.7).

Fig. 4.11. Screenshot of the Prawn Watch app showing both individual records (purple prawn) and total number of prawns caught by prawn watchers in four different regions of Riverpark Catch is shown as a heat map overlaid on the regions.

The web based database, which was originally established in November 2013, was brought into line with the smartphone app in May 2015, to allow for sites to be located using a map interface (Fig. 4.12). Data entry boxes were replaced with drop down menus to improve the speed and ease of data entry.

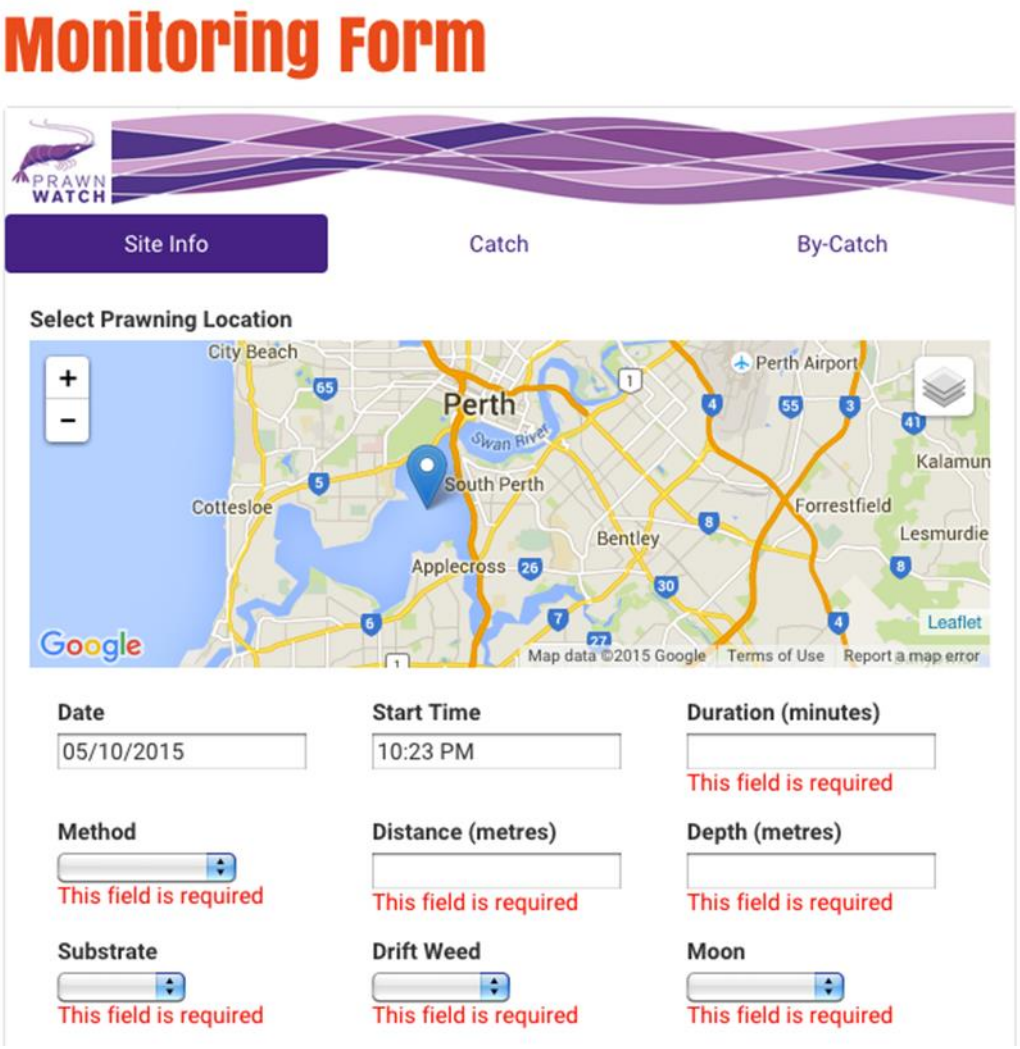


Fig. 4.11. Screenshot of the updated monitoring data entry form on Prawn Watch website.

In addition to independently logging their own catch into a database via a web interface or smartphone app, a group of dedicated volunteers were engaged in the collection of broodstock to support the aquaculture effort (Figs 4.12). Since 2012, these volunteers contributed over 980 hours of time with an additional 300 hours provided by partner organisations in this project. Volunteers were encouraged to log the information collected at the broodstock events on-line. These volunteers were also involved in the evaluation of the effectiveness of citizen science data to provide low-cost monitoring of *M. dalli* (see Section 5). In addition, a plethora of undergraduate students from Murdoch University were also

engaged in this project through Prawn Watch training and promotion via Facebook and have volunteered over 3,600 hours of time to support the university based research and monitoring project connected to this project (see Section 2).

Fig.4.12. Photographs of broodstock collection 2015.

A total of 213 records were logged by Prawn Watchers over the course of the project, with 96 entries in the web based database over the 2013/14 season, 102 in 2014/15, (20 via the web-based database and 82 by the smartphone app) and 15 in 2015/16. Data collected in the 2013/14 season shows the activity of Prawn Watchers across the Melville Water and the lower portions of the Canning Estuary and that most prawners surveyed the shallow, nearshore waters using a hand trawl or scoop net (Fig. 4.14).

In the 2014/15 prawning the 20 records in the web-based database again showed a range of methods being undertaken to record prawns in the river (Figure 4.15. Unfortunately, due to an error in version 1.0 of the Prawn Watch app, the method of survey was not recorded. Data that was recorded using the app in 2014/15 show a spread of survey information across the river with sites at Matilda Bay, Canning Bridge and Freshwater Bay being preferred locations for Prawn Watchers (Figure 4.15).

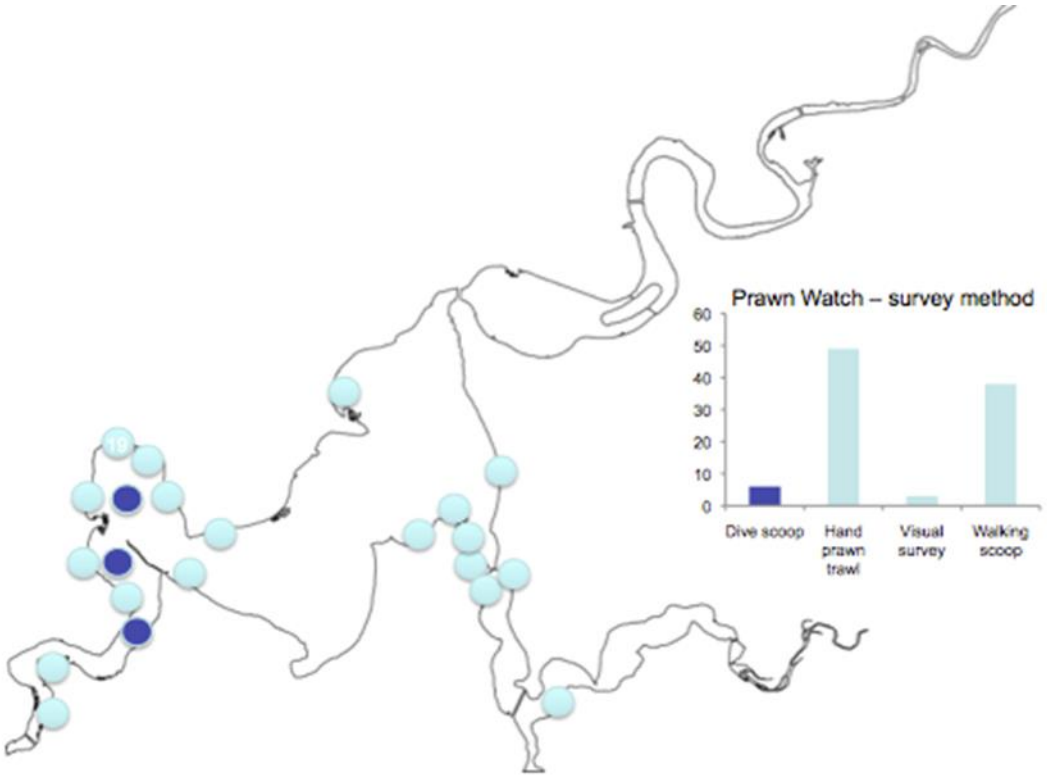


Fig. 4.14. Map showing the locations where Prawn Watchers recorded data between November 2013 and June 2014 and their survey method. ● shore-based prawning methods and ● SCUBA-based methods. n = 96.

Fig. 4.15. Map showing the locations where Prawn Watchers recorded data between November 2014 and June 2015 and their survey method. Data obtained from the web-based database. n = 20.

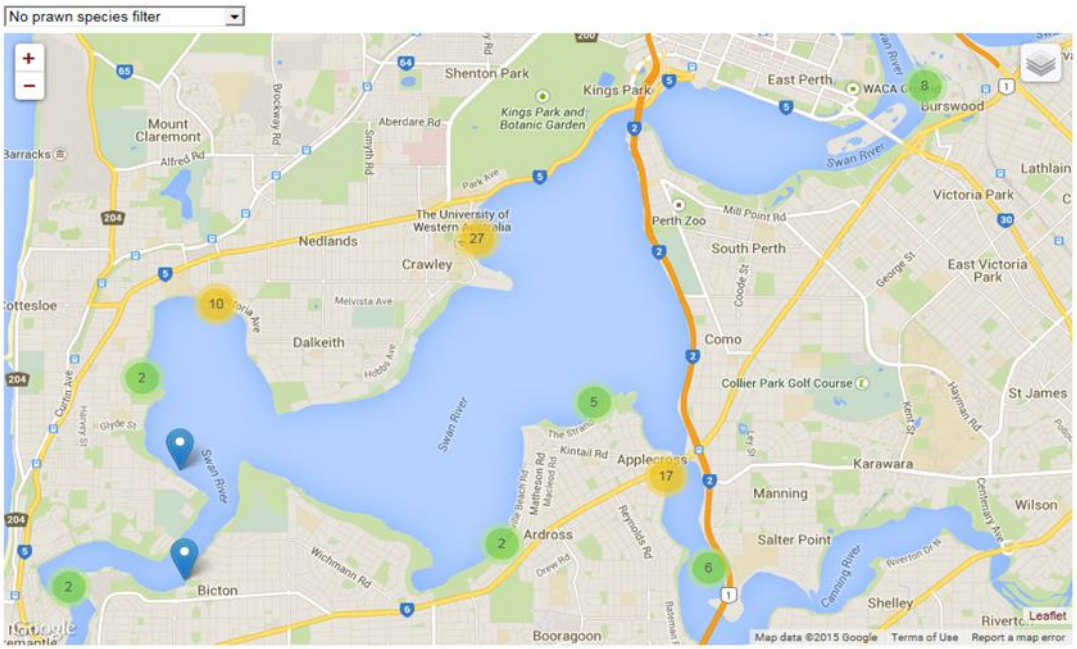


Fig. 4.16. Map showing the locations where Prawn Watchers recorded data between November 2014 and June 2015 and the number recorded at each site. Data obtained from the smartphone app. n = 82.

Entries into the database using the app and the web pages dropped significantly over the prawning season in 2015-16, with only 15 records identified (Fig. 4.16). The decline has been attributed to the cessation of targeted training for community prior to the start of the season.

Fig. 4.17. Map showing the location of Prawn Watch data collection between November 2015 and July 2016. n = 15.

Community monitoring data was never been formally validated as it was intended as an engagement tool in the first instance and not as the prime mechanism for monitoring prawns in the river. The community data was seen as supplementary to an extensive university-led monitoring project, which from 2013-2016, took a similar approach to monitoring to that described in Section 3 of this report. A comparison of species data collected by the community in 2013/14 (Figure 4.18) with data collected by Murdoch University over a period, showed similar patterns of distribution of *M. dalli* and *P. latisulcatus*, with the former species found throughout Melville Water and the lower reaches of the Canning Estuary and the latter species located in the more saline areas further downstream (Fig. 4.17). This improved confidence in the community's capacity to distinguish between the two large penaeid species occurring in the Riverpark. However, some inaccuracies remain in the dataset. Key amongst these were incomplete records and the accuracy of catch/unit effort data. The latter was problematic as it was apparent that many fishers would log their entire effort over an evening (ie: sometimes 3 hours), rather than logging each hand trawl separately. Other issues around the identification of the location of

record were resolved through the mapping interface available on the Smartphone app and database updates. In 2015 it was recommended that if community monitoring was to be used for on-going monitoring purposes then an approach must be standardised and validated against independent data. Subsequently, a comparison of citizen science and university based scientific monitoring was undertaken and described further in Chapter 5.

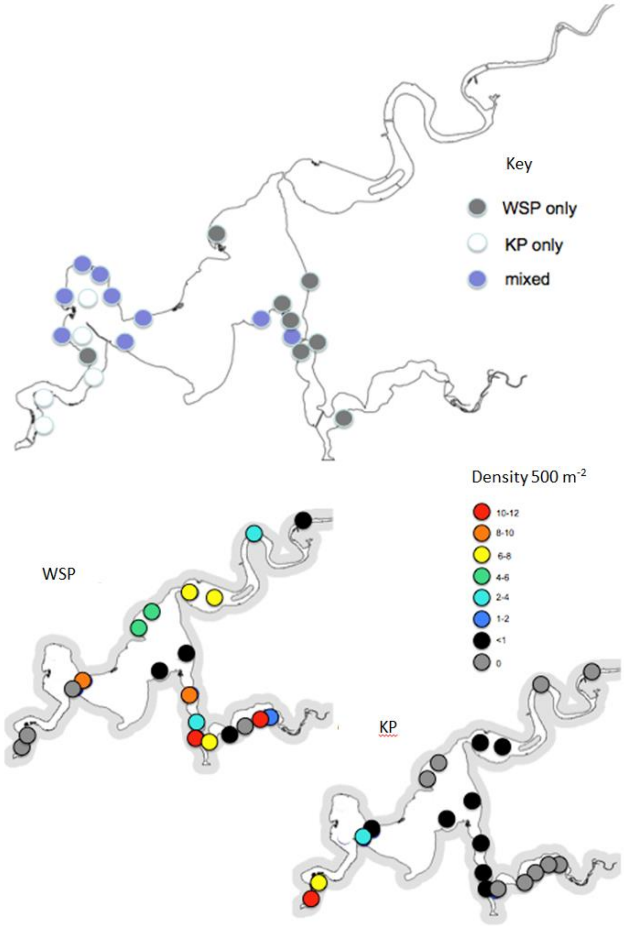


Fig. 4.18. Map showing the sites at which *Metapenaeus dalli* (WSP) and *Peaneus latisulcatus* (KP) were recorded by the Prawn Watchers (top) and University-led monitoring project (bottom) December 2013 and February 2014.

Influencing sustainable management and policy

Through training events, project communications, *i.e.* website, flyers, logbooks, media statements and forums, this project has promoted key messages about sustainability including:

- Returning all by-catch (*e.g.* blowies and jellyfish) to the estuary.
- Returning gravid and/or small prawns in the estuary.
- Taking all rubbish home.
- Abiding by fisheries regulations set by the Western Australian Department of Fisheries.
- Avoiding prawning within 100m of Swan Canning Marine Reserves.
- Avoiding trampling vegetation when assessing prawning sites.

Furthermore, the Department of Parks and Wildlife has continued to raise issues about the sustainability of fishing practices with the Department of Fisheries. In recognition the restocking component of the project was coming to an end and results of associated research were being compiled the Department of Parks and Wildlife initiated discussions with key stakeholders to discuss approaches to manage the fishery moving forward. Details of those discussions are presented further and recommendations made in section 6 of this report.

Discussion

In 2015, a strategic media campaign set out to update the communication outputs of Prawn Watch and contribute against the overall objectives of that project, established in 2012. Existing products (ie: logbooks, website, flyers, display boards and the Smartphone App) were updated through this campaign and a series of events and forums were held that enabled the communication of sustainable fishing approaches and Prawn Watch (ie: Blessing of the Rivers festival, Autumn Rivers Festival, Patterns in Science festival, Clean-up days). In addition, community continued to be engaged in sharing their data through Prawn Watch and contributing to broodstock collection events. Information was shared with the community through River Guardians emails, facebook, media events and video and celebrated through feedback forums. The media campaign is on-going and being delivered through the prawn season of 2016/17 as this is the most appropriate time to connect with fishers.

The Prawn Watch initiative is a good example of a contributory citizen science – community engagement project. The initiative engaged many people from all walks of life including fishers, businessmen and women, local government representatives and children. In part this may have been because many people had a personal connection with the rivers and prawning – typically from childhood experiences that they held dear. Training events provided people with understandings about sustainable fishing and confidence in technique. Many people brought their children along to training events and broodstock collection nights and were keen to share with them their experience and pass of their passion for prawning and connection to the river.

The community were able to demonstrated learnings as part of the project and contribute to a genuine effort to try and improve the prawn population.

The project linked closely with university based monitoring to provide feedback to the community as part of the community engagement program. Community monitoring was reported back to community, along with the learnings from the university based monitoring and research findings.

The benefits of an on-going citizen science approach to monitoring prawns include, but are not limited to:

- A more informed and engaged community;
- An inexpensive monitoring approach;
- Individuals able to share knowledge about prawns, the river and sustainable fishing with their communities;
- Social capital –building on good will for productive purpose;
- Behavior and attitude change;
- Providing connection to the river.

The community based data from Prawn Watch was not used as a primary mechanism for monitoring prawns. However, provided steps are in place to deal with validation and data integrity, the existing tools of the log books, database and smartphone app could be applied to such a purpose.

Recommendations for an improved approach to Prawn Watch are made in Section 5 of this report.

Section 5: Evaluate the effectiveness of data collected by recreational prawn fishers to provide low cost monitoring of Western School Prawns

Aims

The aim of this section is to evaluate the effectiveness of data collected by recreational prawn fishers to provide low cost monitoring of Western School Prawns into the future. This was done by trialling a citizen science monitoring program involving skilled volunteers against that conducted by university-based scientists.

Materials and methods

This section employed two sampling regimes, the first of which was the University-led sampling the second that that designed by University researchers, but operated by citizen scientists. The University-led sampling was that described in detail in Section 3. In brief, it employed a modified recreational prawn net (*i.e.* same dimensions), but with a heavier lead line sowed into the net and constructed from a finer mesh (9 mm). The net was dragged for 200 m twice at each of the 20 sites (Fig. 5.1), with the sampling conducted at least 30 minutes after sunset and over three days of the new moon phase, namely 8, 10 and 11 February 2016. The citizen science sampling regime was carried out by 11 teams of two people at a subset of seven sites (Fig. 5.1). Six of these sites overlapped with the University-led sampling, with the remaining site chosen for a broodstock collection event which occurred on the same night. To reduce temporal bias, the citizen science sampling occurred on 9 February 2016 and thus during the same period as the University-led sampling. Each team of citizen scientists was given a detailed set of instructions and data sheets (Appendix 9, 10) and a recreational hand trawl net. This net was the same dimensions, *i.e.* 4 m wide and 1.5 m tall, as the net used in the University-led sampling, but was constructed from 16 mm mesh, as this is the smallest mesh allowed under the recreational fishing regulations and that used in most prawn nets sold in tackle stores in Perth. At each site, 10 samples hand trawl samples of 50 m in length were conducted and the number of

Western School Prawns (*Metapenaeus dalli*) and Western King Prawns (*Penaeus latisulcatus*) in each sample recorded.

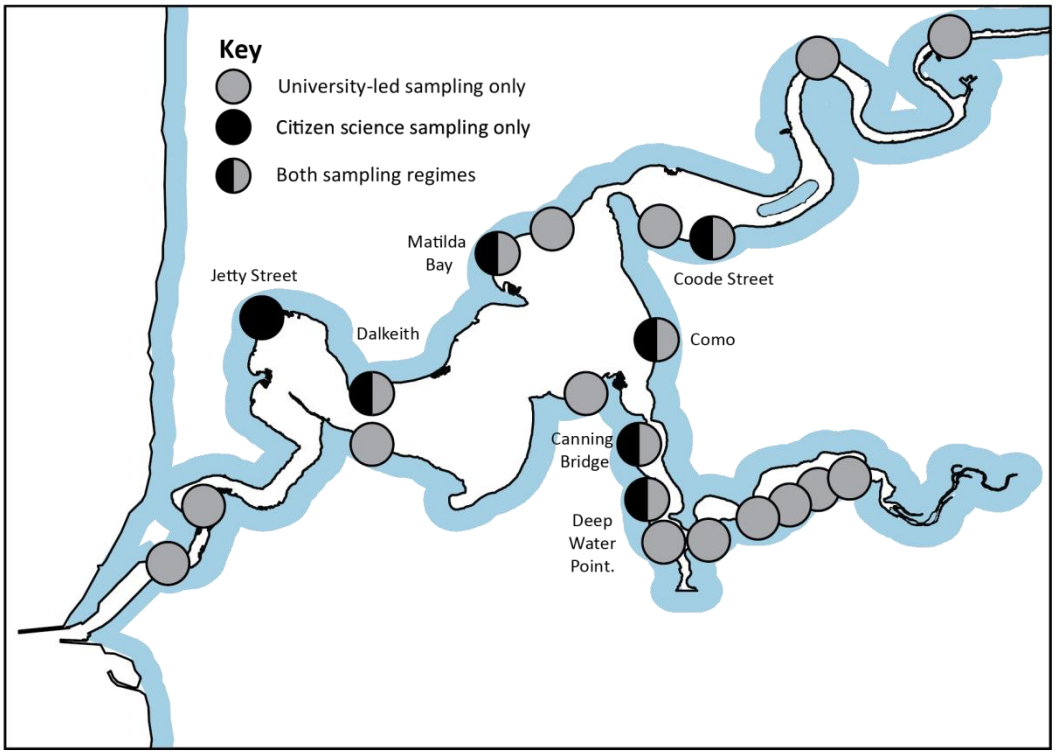


Fig. 5.1. Sites in the Swan-Canning Estuary at which sampling for *Metapenaeus dalli* was conducted by University-based and citizen scientists in February 2016. The names of the sites at which the citizen science sampling occurred at are provided.

Maps denoting the presence and absence of both *M. dalli* and *P. latisulcatus* at each of the sites were produced together with line plots showing the running mean of the abundance against the number of samples to determine how many replicates were needed to produce a reliable result.

Results

A total of 480 *M. dalli* and 204 *P. latisulcatus* were recorded during the citizen science sampling program on 9 February 2016, with the former species being recorded at every site and, in particular, Matilda Bay and Canning Bridge. Individuals of *P. latisulcatus* were recorded at four of the seven sites, being most abundant at Jetty Street in the lower parts of Melville Water (Fig. 5.2).

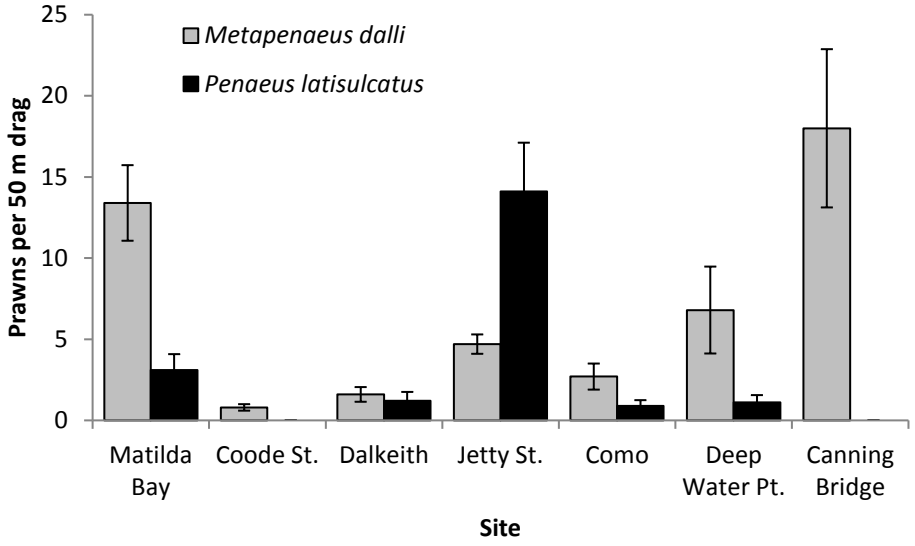


Fig. 5.2. Mean number of Western School Prawns (*Metapenaeus dalli*) and Western King Prawns (*Penaeus latisulcatus*) recorded in a 50 m drag at seven sites in the nearshore waters of the Swan-Canning Estuary in February 2016. Locations of the sites are shown in Fig. 5.1.

The trends exhibited by the running means, at each of the individual sites, showed that the number of *M. dalli* recorded in after each 50 m drag sample was relatively consistent. When the running mean data were expressed as percentage variation away from the final mean, which visually maximises differences, after four samples the running mean was within 50% of the value for the final mean, *i.e.* that after ten drags had been completed (Fig. 5.3). This suggests that four replicates would provide a good measure of the abundance of *M. dalli.* The only exception was Deep Water Point, on the Canning Estuary, where two replicates (numbers 6 and 7), contained far larger number of *M. dalli* (25 and 18, respectively) than the other samples (average of 3). The trend for *P. latisulcatus* was similar with relatively consistent catches at most sites and running mean after four replicates falling within 50% of the final mean at five of the seven sites (Fig. 5.4).

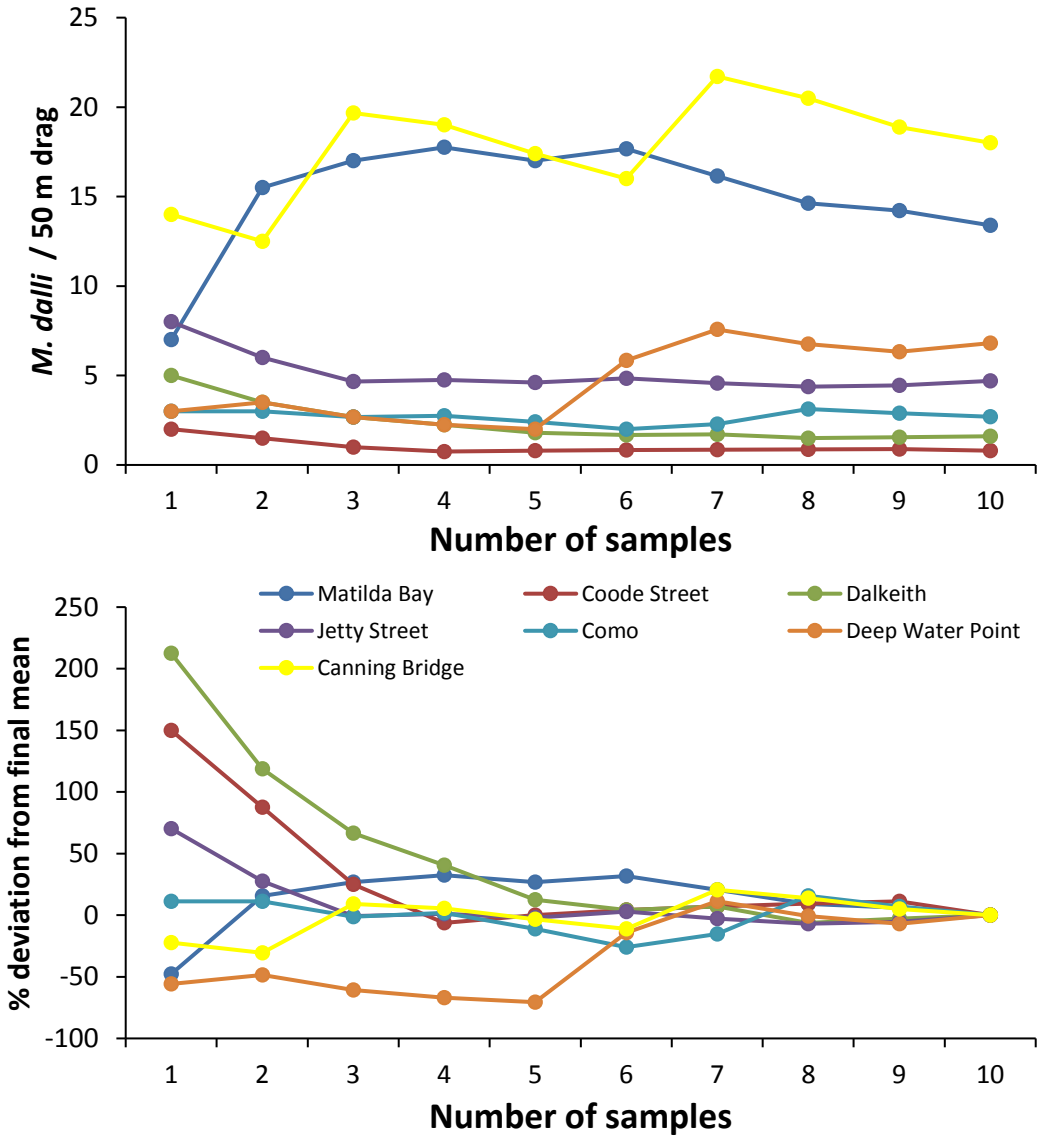


Fig. 5.3. (Top) Running mean of the number of *Metapenaeus dalli* recorded in a 50 m drags at seven sites in the nearshore waters of the Swan-Canning Estuary in February 2016. (Bottom) Percentage deviation of each running mean to the final mean recorded after ten drags at each of the seven sites. Locations of the sites are shown in Fig. 5.1.

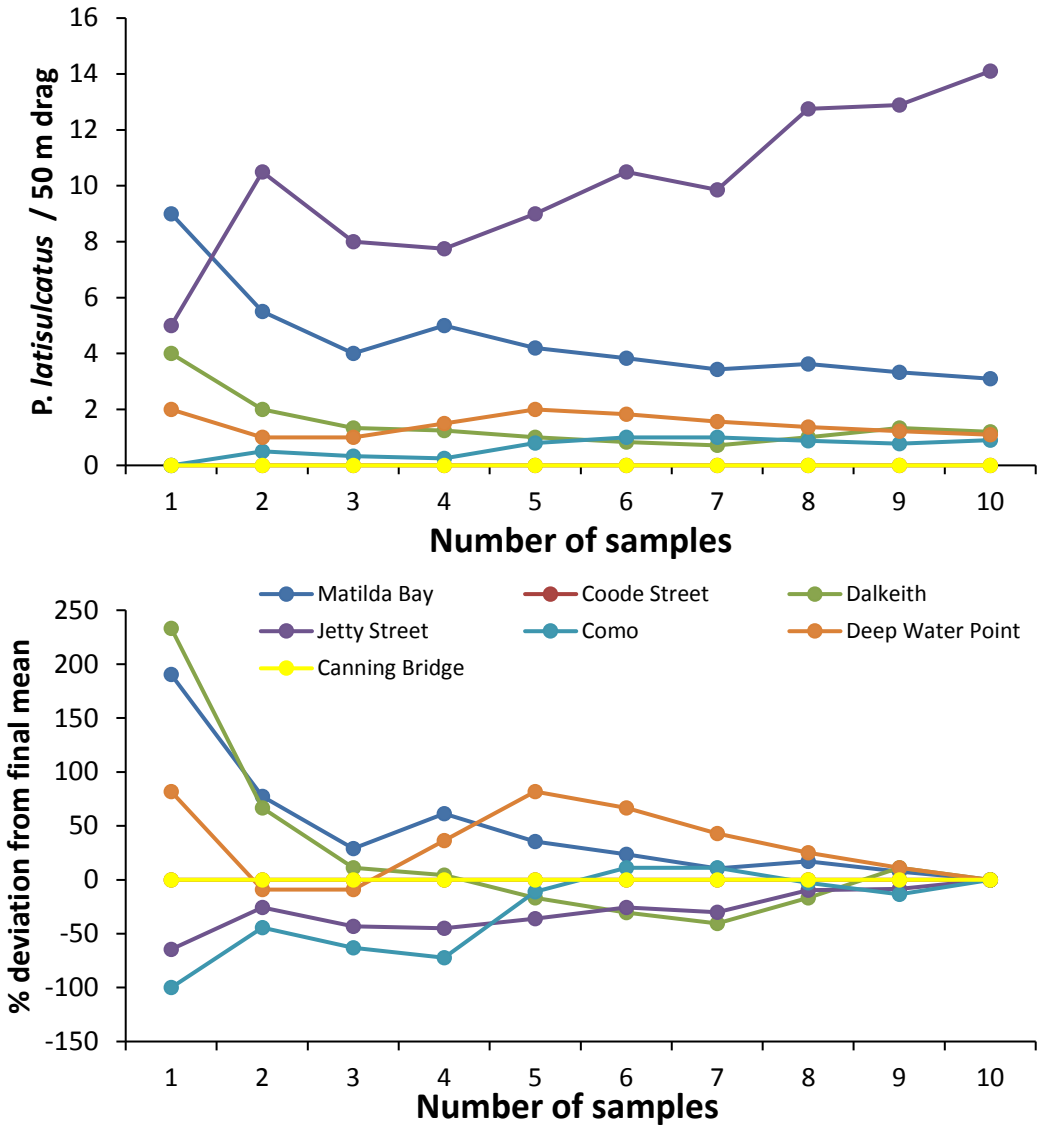


Fig. 5.4. (Top) Running mean of the number of *Penaeus latisulcatus* recorded in a 50 m drags at seven sites in the nearshore waters of the Swan-Canning Estuary in February 2016. (Bottom) Percentage deviation of each running mean to the final mean recorded after ten drags at each of the seven sites. Locations of the sites are shown in Fig. 5.1.

A comparison of the presence/absence of *M. dalli* and *P. latisulcatus* at the sites sampled by University and citizen scientists indicated that the patterns of distribution of each prawn species were broadly similar in both sampling regimes (Fig. 5.5). Generally both species were recorded throughout Melville Water, with the *M. dalli* occurring upstream of the Narrows Bridge. Although it is hard to standardise the two methodologies (*i.e.* 2 x 200 m *vs* 10 x 50 m drags) when the catches were standardised to individuals per 200 m drag far larger number

of prawns were captured using the recreational net. This equated to 18 and 27 times greater catches of *M. dalli* and *P. latisulcatus.*

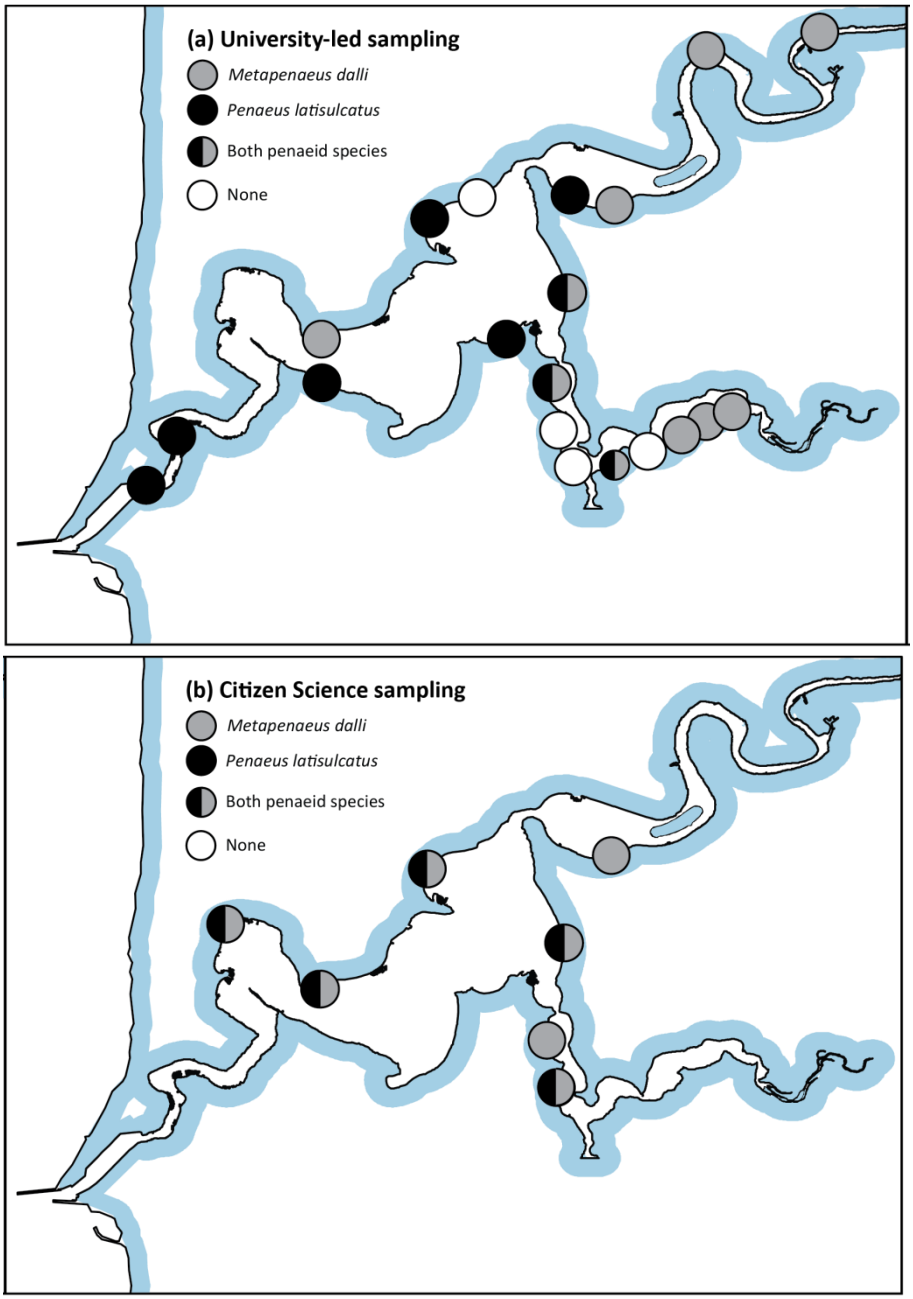


Fig. 5.5. Map comparing the presence/absence of *Metapenaeus dalli* and *Penaeus latisulcatus* at the sites sampled by University-based and citizen scientists in February 2016. Note two replicate 200 m drags were conducted at each site by the University-based scientist, while ten drags of 50 m in length were conducted by the citizen scientists.

Discussion

Comparison between University-led and citizen science monitoring

This section of the report set out to determine whether experienced Prawn Watchers could be utilised as part of a citizen science program to monitor populations of *M. dalli* in the Swan-Canning Estuary into the future. A comparison of the results of the University-led *vs* citizen science monitoring program demonstrated that the community could distinguish between *M. dalli* and *P. latisulcatus* and that both sampling regimes showed similar patterns of distribution for each species across the Swan-Canning Estuary. Where differences did occur, it was generally due to one of the species not being recorded in the scientific monitoring. This reflects the fact that a lower number of replicate samples were collected at each site, on each sampling occasion, during the University (2) than citizen (10) programs, ala the species-area curve relationship (Cain, 1938).

It is interesting that far larger number of prawns were collected using the recreational hand trawl net. Such a finding may be due to the mesh size being larger in the recreational than scientific net (16 *vs* 9 mm), which would enable less debris to be retained in the net thus increasing the speed at which it could be dragged through the water, thereby reducing the chance of prawns escaping or avoiding the net, *i.e.* increasing it fishing efficiency. As such, there would be value in conducting a depletion experiment to determine the catchability of the net (Loneragan et al., 1995). The rationale behind the use of the smaller mesh size in the scientific nets was to allow the potential to detect post-larval and early juvenile *M. dalli* during winter and spring, however, this sampling occurred during summer, at a time when induvial would be at or approaching their maximum size (Broadley et al., 2017), the reduced mesh size afforded no advantage.

The lower catch rates in the scientific net may also reflect the fact that drags were longer, which may also decrease fishing efficiency and that given the increased number of drags it is possible that some of the prawns collected in the recreational net may have been collected in a previous drag. One modification that should be made to the recreational net for any future citizen science monitoring is the addition of weight to the leadline, this was included on the nets used in the current study and, to the best of our knowledge, does increase catches of this benthic species.

Analysis of the running means suggested that four replicate samples would be sufficient to obtain a robust estimate of the density of both *M. dalli* and *P. latisulcatus* (*i.e.* < 50% deviation from the mean). Given our experience with community Prawn Watchers during the current study, four 50 m drags is not seen as too onerous for volunteers, to the point where they would be unwilling to participant in the sampling or drop out of any future monitoring program. While the trends were consistent here it is worth considering that the *M. dalli*, is relatively mobile and thus conducting a lower number of replicates would reduce the quality of the results.

In summary, the results in this section indicate that highly trained citizen scientist could produce sound monitoring results for *M. dalli* and *P. latisulcatus* using a recreational prawn net providing at least four replicate drags of 50 m are conducted at each site on each sampling occasion. Examples of the training materials are provided in Appendix 9 and 10.

Recommendations for a future citizen science prawn monitoring project

The existing Prawn Watch project is a citizen science/community engagement project. The information that community have provided (as outlined in Section 4 of this report) has complemented the University-led monitoring of prawn populations. Monitoring was not the sole purpose of the current Prawn Watch project and, as such, rigour in the methodology of sampling, and data provided, prevents the citizen data being used confidently for the purpose of providing sound information on prawn population size and dynamics.

Prawn Watch (2012-2016) achieved many societal outcomes as outlined in its objectives. Through the associated University-led monitoring it was also able to provide quality information on prawn populations and influence management (see section 6). Moving forward, if it is intended that a citizen science project monitors and provides sound scientific information on prawn population size and dynamics, then it is important to build more rigour into the data collection, validation and quality assurance. In addition, it is important to have clearly articulated goals for this kind of citizen science project (Tweddle et al., 2012). While they were clearly articulated and achieved for Prawn Watch (2012-12016), these may change and may encompass:

- Programmatic outcomes: population information to influence fishery policy/ management;
- Societal outcomes; social capital and engagement; *capacity building; behaviour change*;
- Individual outcomes: skill development; attitude change; learning.

The investigation reported in this section of the report has shown that a comparatively small number (*i.e.* 4) trawl samples of 50 m in length could provide sound data on the abundance of prawns at a range of sites. This gives confidence that it is possible to create a more rigorous monitoring regime with fishers that could complement a broader scale engagement program.

It is, therefore proposed that a small number of fishers (~20) are inducted as Prawn Patch Watchers. These fishers could be engaged to monitor between October and March each year at 10 patches in total across a broad area of the Swan-Canning Estuary, known to support populations of *M. dalli* (Fig. 5.6).

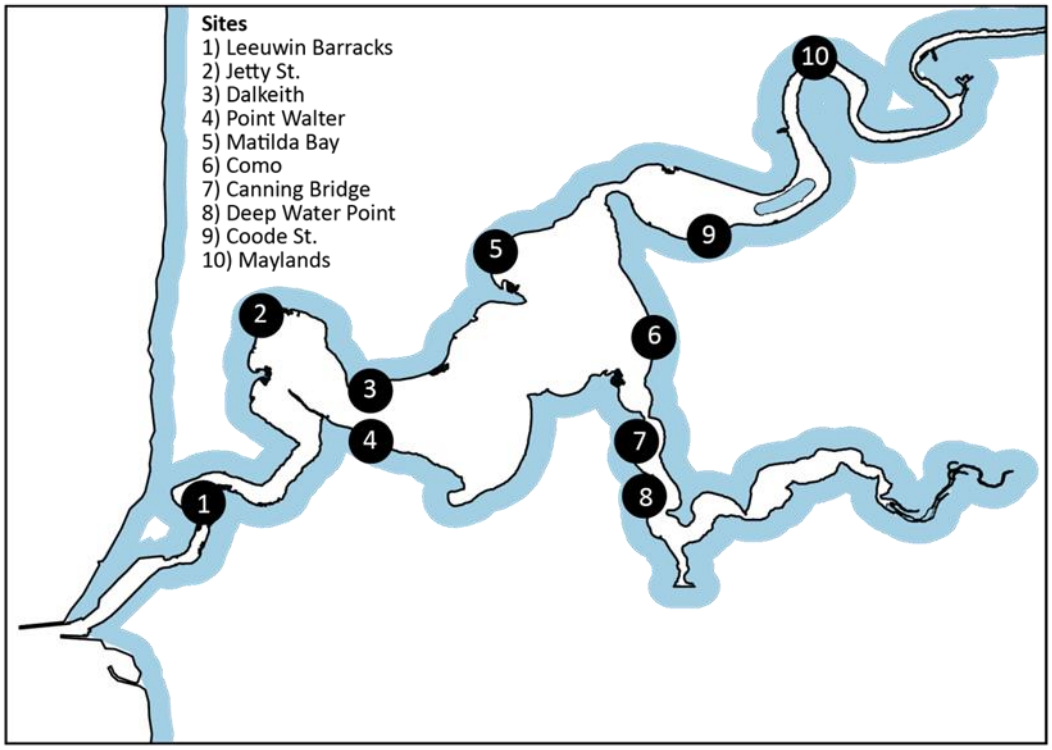


Fig. 5.6. Suggested sites to be sampled in any future citizen science monitoring project for *Metapenaeus dalli* in the Swan-Canning Estuary.

It is recommended that Prawn Patch Watchers are trained to use a standard technique and approach. This should involve taking four independent 50 m trawls at each site (*i.e.* their own patch) using a recreational prawn net. These would be undertaken monthly (on closest weekend to 1st of the month). After each trawl, the number of all *M. dalli* and the number of gravid (stage 4) *M. dalli* would be recorded (Fig. 5.7; Crisp et al., 2017a). Prawn Patch Watchers could also record the number of key predator (*i.e.* Gobbleguts; *Ostorhinchus rueppellii*) in each trawl sample, as well as salinity and temperature using simple, inexpensive equipment (*e.g.* a manual [glass] thermometer and a refractometer). Data could be recorded into existing logbooks, database or the Prawn Watch smartphone app.

Fig. 5.7. Photograph showing a gravid (stage 4) *Metapenaeus dalli* from the Swan-Canning Estuary.

This dedicated citizen science monitoring approach should be complemented in its first year with a University-led monitoring program in order to validate the results of the citizen science monitoring. Thereafter, providing there is proven rigour in the approach, then it could continue. The existing logbooks, database and smartphone app were designed to be flexible and can support this approach as well as broader scale community monitoring, provided Prawn Patch Watchers had a dedicated identifier. The app would need to be updated to enable Prawn Patch Watch data to be provided back to the community in a meaningful way.

Citizen science monitoring of fisheries using targeted volunteers is not without precedent in Western Australia. An example of this type of approach is used by the Department of Fisheries Volunteer Angling program to provide annual recruitment information on juvenile Tailor (*Pomatomus saltatrix)*. However, it must be recognized that, in order to succeed in the longer term such programs must be resourced.

Advice provided by the Department of Fisheries (K. Smith, pers. comm) suggests that the success of maintaining a volunteer base for these kinds of programs hinges on a number of factors including:

- One-on-one engagement; personal connection; sense of belonging; feedback; incentives and celebration;
- Scientist involvement (rigour / engagement); Volunteer coordinators;
- Specialist skills in community engagement and recruitment.

A summary of components of the proposed Prawn Patch Watch *vs* the existing Prawn Watch are provided in Table 5.1.

Table 5.1. Comparison of the components in the existing Prawn Watch and proposed Prawn Patch Watch for a targeted number of participants.

Components of Prawn Watch project	Components of Prawn Patch Watch project
Community engagement strategy	Community engagement strategy and data management plan
Pre-season engagement and training in approaches to sustainable fishing and monitoring	Pre-season engagement and training in specific techniques for patch monitoring and data recording. Provision of equipment.
Ad-hoc in-season app training	One-on-one training on site at start of monitoring period. Complementary university based monitoring for one year.
On-going communications through River Guardians messages	One on one communications through season and incentives
App based display of individual data and composite data across zones	App based display of individual data and composite Prawn Patch data across zones. Additional analyses of datasets for each site and zone. Comparisons to University dataset
Feedback forum	Report development. Feedback forum and celebration bbq.

In order to support a dedicated citizen science monitoring project the project would need to be adequately resourced. Indicative resourcing required for these two components of Prawn Watch would include;

- DPaW principal scientist 0.1 FTE
- DPaW environmental officer 0.2 FTE
- DPaW community engagement officer 0.5 FTE
- DPaW marketing officer 0.1 FTE
- University research scientist (1st year) 0.2 FTE
- University research assistant (1st year) (0.2 FTE
- University sampling budget (*e.g.* car hire and minor equipment)
- App revision to improve data discovery
- 10 nets and associated monitoring equipment for participants
- Incentive resources for volunteers
- Engagement budget (*e.g.* venue hire, travel and catering).

Prawn Watch is currently a contributory citizen science project. Community provided data that was analysed and combined with university results before being provided back to the community via the app and/or feedback forums. A more focussed project, with a smaller number of key contributors involved in the collection of data would enable increased involvement of citizens in the analyses and interpretation of data, and enable volunteers to be involved in the coordination of the project, thereby creating a more collaborative project and enhancing both societal and individual outcomes.

Section 6: Recommendations for a sustainable prawn fishery

Prawning was an integral part of Perth culture in the 1970-1990s, engaging up to 50,000 people each year, however, once the stocks of *Metapenaeus dalli* declined, interest in the fishery waned. Over the course of this project and its predecessor (Jenkins et al., 2015), 4.5 million post-larval *M. dalli* were released into the Swan-Canning Estuary over a four year period (2013-2016). The publicity generated from this study, and particularly the Prawn Watch component, increased interest in prawning. Anecdotal information suggests that this resulted in an increase in recreational fishing effort, with participants reporting their best catches in years and some even decades.

The estimated biomass for *M. dalli* in the Swan-Canning Estuary was calculated by Broadley et al. (2017) is 2.37 tonnes, and is thus only ~16% of the maximum commercial catch for prawns (both *M. dalli* and the Western King Prawn *Penaeus* [= *Melicertus*] *latisculatus*) recorded from the system during the peak of the commercial fishery in the 1950s (Smith, 2006). It is apparent therefore that the current biomass of *M. dalli* is very low and has not recovered since recreational fishing decreased greatly in the late 1990s, over 15 years ago.

This pilot restocking project has likely had a significant positive effect on the populations of *M. dalli* in the Swan-Canning Estuary, with the abundance of this species in the deeper waters of the estuary during the breeding season (Oct-Mar) being 49 and 110% greater in 2014/15 and 2015/16, respectively, than after the first year of restocking in 2013/14 (Appendix 11). Note that monitoring was only initiated in October 2013, which was after the release of 1,000 prawns in May 2013. However, with the restocking now finalised and anecdotal evidence of an increase in fishing pressure, attention must turn to ways to ensure the sustainability of the current *M. dalli* population. A large amount of research and monitoring has been completed through this project, to support management in decision making. The project steering committee therefore sought to engage with stakeholders and policy makers to present the knowledge obtained during the project and discuss ways of improving the sustainability of the fishery in the longer term.

On 9 June 2016, the Department of Parks and Wildlife facilitated a meeting of stakeholders to discuss the sustainable management of this recreational fishery. Representatives of the Department of Parks and Wildlife, Department of Fisheries (both research and policy divisions), Murdoch University, Recfishwest, Australian Centre for Applied Aquaculture Research and two experienced recreational fishers from the Prawn Watch Reference Committee were present. At that meeting, the historical and existing prawning regulations were summarised (see Table 6.1) and it was acknowledged that in the past, fishery regulations had included a 50 mm length limit and seasonal closures and that over time the recreational fishing regulations of the *M. dalli* fishery in the Swan-Canning Estuary had been simplified such that seasonal and size limits had been removed. Presently, the recreational fishery guidelines (2016) permit the taking of prawns year round in the estuary. A daily bag limit of 9L applies. Gear is restricted to hand- dip, scoop and trawl nets. The use of hand-throw net is not permitted. The use of hand-trawls is excluded within 100m of the Pelican Point and Milyu sections of the Swan Estuary Marine Park. This exclusion does not, however, include the Alfred Cove section of the marine park.

Table 6.1. History of fishery regulations for the recreational Western School Prawn fishery in the Swan-Canning Estuary.

	Management regulations				
Year	**Size limit**	**Bag limit**	**Gear**	**Season**	**Location in Swan-Canning Estuary**
1988	50 mm from eye to tip of tail	9L person day^{-1}	Scoop net, hand trawl net or hand dip net. Hand trawl. Nets must not exceed 4 m in width, nor contain any mesh < 16 mm.	Not mentioned	Not mentioned
1990	None	9L person day^{-1}	Scoop net, hand trawl net or hand dip net. Hand trawl. Hand trawl nets must not exceed 4 m in width, contain any mesh < 16 mm and must not be attached to a boat or set.	Swan-Canning Estuary: closed from 31 July to 1 November each year. Serpentine, Murray, Dandalup, and Harvey Rivers are closed from 1 May to a date in November announced each year in the papers.	Not mentioned
2013	None	9L person day^{-1}	Hand dip net, hand scoop net, hand throw net and hand trawl net. Hand trawl nets must not exceed 4 m in width, contain any mesh < 16 mm and must not be attached to a boat or set.	Swan-Canning Estuary: Closed to drag trawl nets 1 August – 31 October Peel-Harvey Estuary and rivers: closed all year to trawl nets	With 100 m of any part of the Pelican Point Nature Reserve or within 100 m of Milyu Nature Reserve
2015	None	9L person day^{-1}	Hand dip net, hand scoop net, hand throw net and hand trawl net. Hand trawl nets must not exceed 4 m in width, contain any mesh < 16 mm and must not be attached to a boat or set.	Swan-Canning Estuary: None. Peel-Harvey Estuary and rivers: closed all year to trawl nets	With 100 m of any part of the Pelican Point Nature Reserve or within 100 m of Milyu Nature Reserve

Information pertaining to the biology and ecology of *M. dalli* was also presented at that meeting (Appendix 9). These demonstrated that individuals of this species in the Swan-Canning Estuary represent an isolated population, as they complete their life cycle with the estuary and are not found in adjacent marine waters (Potter et al., 1986). They are also a relatively small species, with the larger females reaching a maximum size (L_{∞}) of 33.6 mm CL and 23.6 g wet weight, but also suffering a higher natural mortality than males. Although the fecundity of *M. dalli* is similar to that of other metapenaeids in temperate waters, this value is far smaller than for congeners inhabiting tropical environments and *Penaeus* spp. in any environment. Breeding in *M. dalli* occurs in the shallow waters of the estuary between October/November, when water temperature rise to > 20 °C, and March.

These biological characteristics have implications for the management of this because:

(i) There is unlikely to be significant immigration of *M. dalli* individuals into the Swan-Canning Estuary from other nearby estuaries (*e.g.* Peel-Harvey) and/or nearshore marine waters, i.e. the population is isolated.

(ii) Females suffer a higher natural mortality than males with most dying after spawning.

(iii) Females obtain a far larger size and weight and thus may preferentially be the target of recreational fishers.

(iv) Individuals move from offshore water refuges into the nearshore waters to breed.

(v) The breeding and peak recreational fishing seasons co-occur and as such they are subject to fishing pressure throughout the breeding period.

A range of potential management options were discussed to improve the sustainability of the *M. dalli* fishery in the Swan-Canning Estuary. Each option was discussed and comments made on its likelihood of success, feasibility and maintenance of social values (Table 6.2).

Table 6.2. Potential management options to improve the sustainability of the recreational Western School Prawn fishery in the Swan-Canning Estuary.

Options	Comments
Size limits; *e.g.* 50 mm length used in 1980s	Too hard to for fishers to measure each prawn captured. Difficult to enforce. Best to be managed through code on conduct.
Return females or gravid female; *e.g.* as with Blue Swimmer Crabs (*Portunus armatus)*	Most community members are unable to distinguish between male and female prawns and also gravid and non-gravid females. Best to be managed via community education.
Bag limits; currently 9L per person per day (mixed *M. dalli* and *P. latisculatus* limit)	Current bag limit too high, especially as hand trawl nets require two people to operate. However, any reduction needs to consider effects on scuba divers who target *P. latisculatus.* Community find it hard to distinguish prawn species and so separate *M. dalli* and *P. latisculatus* limits unlikely to be successful.
Spatial closure in marine reserves	Currently prawning allowed in two of the three marine reserves in the Swan-Canning Estuary. Banning in all three would simplify regulations and prevent bird disturbance.
Spatial closure in other areas	Confusing for the community and may result in a loss of amenity as fishers may have to travel away from their local area to prawn.
Full closure	Not supported. Would result in the loss of an iconic fishery and pastime.
Temporal closure; *e.g.* closure from 1st August – 31st October as enforced previously.	Potential option that could be used to reduce/prevent fishing pressure at the start of the breeding seasons. However, prawning should be allowed to occur at Christmas to maintain social benefits.
Fishing gear restrictions	Hand scoop only fishery not supported.

Following discussions during the meeting, a number of recommendations were produced.

(i) A code of conduct and/or community education program (*e.g.* Prawn Watch) were best placed to promote sustainable fishing practices, such as the release of sexually immature prawns, female prawns and/or gravid females.

(ii) Any future management should focus on maintaining stocks of *M. dalli* and the social value of the fishery. Thus, full closure, a hand scoop/dip net only fishery and spatial closures outside of marine reserves were not supported.

(iii) A bag limit per person of 5L per day should be considered subject to considerations of the implications for recreational fishing of *P. latisulcatus*. Temporal closures considered at the start of the breeding season to allow a proportion of the population to spawn.

(iv) There is a need for the population of *M. dalli* in the Swan-Canning Estuary to be monitored in the future.

(v) Recreational prawning regulations should be reassessed in the near future if monitoring indicates that stocks are increasing.

Staff from the Department of Parks and Wildlife met again with Recfishwest on 3 August 2016, with the view to trying to reach common agreement around bag limits, partial closure and exclusion zones. Additional information on the fecundity of adult females during breeding seasons between October 2013 and March 2016 was prepared for that meeting and cumulative fecundity plotted (Fig. 6.1) to show the impact of reinstating a season closure on spawning and thereby the future stock.

Estimates of cumulative egg production were variable within a month in each year (Fig. 6.1), reflecting differences in the timing and duration of reproduction (see Crisp et al., in prep. for full details of the methodology) and therefore some caution has to be exercised in using these for policy formation. However, they did at least provide some information for discussion. Without a closed season all gravid females, and thereby future stock, are vulnerable to fishing pressure as they move into the shallow waters to breed. The implementation of a seasonal closure delaying the starting of the prawning season until 1 of

November, 1 December and 1 January would have the potential to protect 0.5%, 4-57 and 17-70% of future stock (measured here as eggs produced by the gravid females; Fig. 6.1).

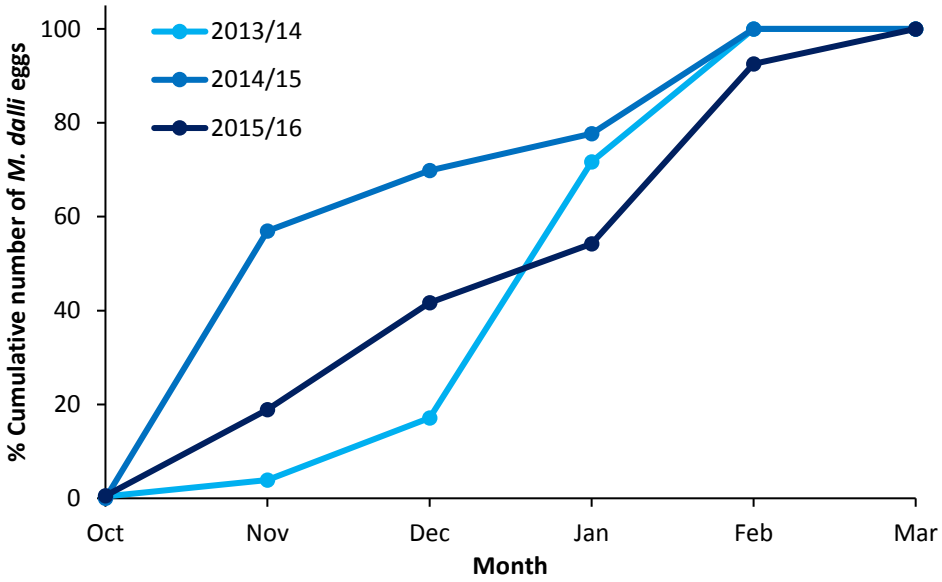


Fig. 6.1. Percentage cumulative number of eggs produced by female *Metapenaeus dalli* in each month between October and March in three breeding seasons, *i.e.* 2013/14, 2014/15 and 2015/16. Note sampling was conducted on the new moon and thus specific dates vary among months and years. Number of eggs was estimated by summing the fecundity of each gravid female recorded in a month, using a length to fecundity relationship (see Crisp et al., in prep.). These data make the assumptions that (i) females spawn once and (ii) that each gravid female will spawn before the next sampling occasion ~ 28 days later.

At the meeting it was agreed that a reduced daily bag limit (from 9 to 5L) and a partial closure between mid-October and mid-December would be beneficial to the sustainability of the school prawn fishery. No agreement was reached regarding exclusion zones.

Based on those discussions the Department of Parks and Wildlife wrote to the Department of Fisheries requesting their consideration for a review of the recreational fisheries guidelines for prawning to include:

(i) a reduced daily bag limit (from 9L to 5L);

(ii) introduction of a partial closure to hand-trawling between 15 October to 15 December inclusive;

(iii) continuation of the existing zone restrictions in relation to throw and hand-trawl nets;

(iv) continuation of existing gear prescriptions and expectation of by-catch return.

In that request, the Department of Parks and Wildlife recognised the importance of prawning as a cultural activity and a community benefit of the Swan-Canning Estuary. It also recognized that the current Recreational Fisheries Guidelines (2016) provided some exclusion zones. These prevent the use of throw nets across the waterway and prevent the use of hand-trawl nets within 100 metres of any part of the Pelican Point and Milyu Nature Reserves. While Parks and Wildlife notes that this regulation does not protect the Alfred Cove Nature Reserve from the potential impact of trawling, it acknowledges that the regulation does provide some protection to habitat values within the Swan Estuary Marine Park, and should therefore remain in place.

Recfishwest has since formally advised the Department of Fisheries that it is supportive of the measures outlined in the Department of Parks and Wildlife letter requesting a review of the regulations relating to prawn fishing. It is understood that changes will now be considered by the Department of Fisheries in the preparation of the Aquatic Resources Management Regulations.

Appendices

Appendix 1. Key Prawn Watch media plan timelines for 2016.

Milestone	Date	Progress
Deliver Prawn Watch education activation at Blessing of the River festival on the Canning River	29 Nov 2015	Completed
Draft Prawn Watch communications plan complete	30 Jan 2016	Completed
New Prawn Watch website content completed and updated	29 Feb - 29 April 2016	Completed
Prawn Watch revised A5 flyer completed	29 Feb 2016	Completed
Swanfish special event activation/education	28 - 29 Feb 2016	Completed
Prawn Watchers receive email update	29 Feb 2016	Completed
Ministerial media event	1 - 15 March 2016	Completed
Autumn Rivers Festival special event	April 2016	Completed
Prawn Watch phone App updates complete	April 2016	Completed
Clean up Day special event education	June 2016	Completed
Prawn Watch brood stock volunteers BBQ	30 May 2016	Completed
Prawn Watch education and promo materials completed and sent to fishing tackle shops, outdoor stores and venue partners.	Nov 2016 - Jan 2017	Ongoing
Proactive media packages sent out to relevant fishing/outdoor magazines, television stations, newspapers, online publications, radio stations etc	Nov 2016 - Jan 2017	Ongoing
Prawn Watch data review	August 2016	Completed
Prawn Watch findings announced/launch event held	Oct/Nov 2016	Completed
Prawn Watch evaluated	Oct/Nov 2016	Completed

Appendix 2. Landscope Magazine (Winter 2016) and Parks and Wildlife Annual Report 2015/16.

Bush telegraph by Karla Graham

READERS' PIC

Argyle cycad *(Cycas pruinosa)*

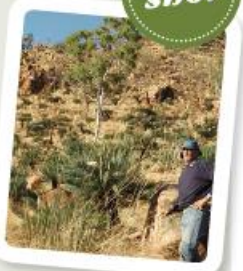
Words and photo by Don Stallard

"Argyle cycad (*Cycas pruinosa*) supposedly represents "the earliest form of plant life" on the Earth's surface.

This particular stand is a fine example of this species distributed throughout the central and north-east Kimberley. For me, the location of this stand thrives at the core of the Kimberley where the mighty King Leopold and Durack ranges meet. Where the higher peaks of Mt Wells, Bedford and King are concentrated. Where the source of the Ord and Fitzroy rivers rise and flow in opposite directions but are separated by few kilometres by what I call the Kimberley Divide. This divide continues north-west to further separate the sources of the Little Fitzroy River from the Durack and Chamberlain rivers. Adding to these attractions are the nearby Teronis Gorge, old Elgee Cliff's homestead and cave paintings, all of which highlight the importance of this location."

Have you got a fantastic nature photograph you would like to see published in *LANDSCOPE*? Send it, along with a 100-word description of the species or how and where you took the shot, to landscope@dpaw.wa.gov.au.

Snap shot



Camera watch program calls on volunteers

People all around the world now have the opportunity to take part in *Western Shield*, the biggest conservation project ever undertaken in Australia, with the launch of an online citizen science program.

Hosted on the collaborative volunteer research website Zooniverse, the *Western Shield Camera Watch* project draws on the help of more than two million volunteers to identify native and introduced animals captured by 90 remote cameras around Western Australia.

Volunteers don't need any scientific knowledge, just a keen eye and a willingness to learn. The website provides a step-by-step guide to correctly identifying the animal by shape, size, colour and markings.

The identifications received will help *Western Shield* scientists at the Department of Parks and Wildlife measure the success of its broadscale feral cat and fox baiting program.

More than 200,000 images are already loaded onto the site for identification. To get involved, visit www.zooniverse.org, register, and search for '*Western Shield Camera Watch*'.

Prawn project boasts 4.5 million milestone

A project to address the decline of western school prawns in the Swan and Canning rivers has seen more than 4.5 million prawns released back into the river system in the past three years.

The restocking project works with the community through the citizen science program *Prawn Watch*, to collect gravid (pregnant) female prawns from the river each year during the November–April breeding season. They are transferred to tanks and allowed to spawn naturally in a carefully controlled environment, where chances of the young's survival are much higher than in the river. The juvenile prawns are later released into the Swan Canning Riverpark, boosting the population and helping to reinstate prawning as a recreational activity for Perth families.

The historically popular activity of drag netting for prawns has all but disappeared as prawn numbers have declined since the 1950s.

Restocking began in 2013, using recreational fishing licence fees to partly fund the project. In March 2016, 674,000 juvenile prawns were released along the Como foreshore to bring the project's total above the 4.5 million mark.

The project is a joint effort between the Department of Parks and Wildlife, the Australian Centre for Applied Aquaculture Research, Murdoch University, Recfishwest, the Department of Fisheries, the WA Fish Foundation and the Fisheries Research and Development Corporation.

Below Discover more about *Prawn Watch*. *Video – Parks and Wildlife*

Case study
Government outcome: The ecological health and community benefit of the Swan and Canning rivers is protected.

Prawn project restocks rivers

2015–16 saw the 4.5 millionth western school prawn (*Metapenaeus dalli*) released into the Swan Canning Riverpark as part of a multi-agency project to increase the species' population.

The western school prawn restocking and monitoring program sees Parks and Wildlife work with six project partners to research, monitor, culture and release western school prawns with the aim of bringing recreational prawning back as a popular pastime for Perth residents.

The project began in 2012, led by the former Swan River Trust, in response to declining numbers of western school prawns in the river since the 1950s. Historically, both commercial and recreational fishers targeted this species. Commercial landings peaked at 14 tonnes in 1959 but declined to three tonnes by 1975. While the commercial fishery no longer targets prawns, recreational fishers continue to take part in drag netting for the crustaceans as a treasured part of river culture.

Environmental factors, and not fishing pressures, are thought to be responsible for the decline in western school prawn abundance. The restocking project aims to re-establish prawning in the Riverpark and encourage people to have a stronger engagement with the river environment.

Three main components make up the project: the production and release of prawns into the Riverpark; engaging the community through stock release and monitoring; and evaluating stock status, release strategies and factors affecting population recruitment and survival.

The restocking aspect of the program began in 2014, with Challenger Institute releasing 635,000 western school prawns. Almost two million were released in 2015 and a further 1.8 million during 2016. By April 2016 the project celebrated a total of 4.5 million western school prawns released.

The project's restocking success was largely made possible by scientists at the Australian Centre for Applied Aquaculture Research (ACAAR) when they successfully cultured school prawns in 2012.

The culturing process involves collecting wild female egg-carrying (gravid) prawns from the river. They are transferred to tanks and allowed to spawn naturally in a carefully controlled environment, where chances of the young's survival are much higher than in the river. The juvenile school prawns are released back into the river when they grow past the main predation stage.

March 2016 also marked another project milestone – the completion of monitoring over three full breeding seasons, allowing researchers to gather a robust data set that can be used to determine the biological characteristics of the prawn population in the Swan Canning Riverpark. Preliminary information has indicated that restocking has had an impact on prawn populations. Monitoring will be extended into the 2016–17 breeding season, promising even more clarity on stock status and changes over time.

Scientists also continued to undertake research into the salinity and temperature tolerance of western school prawns. In addition, a survey into the diets of potential predators revealed one of the prawns' major predators to be the aptly named gobble guts fish. A Murdoch University researcher found about 300 juvenile prawns in the stomach of a single gobble guts that was only 45mm long.

Results of all the research are being processed to determine the best release sites in the Riverpark, taking into account the availability of suitable substrate, the presence of juvenile or adult prawns at the site at the time, the environmental conditions such as prevailing wind, and easy access to the site.

Getting members of the community involved is a vital aspect of the project. Under the Parks and Wildlife *Prawn Watch* project, volunteers take part by helping collect gravid prawns, reporting details of prawning catches to help inform research, and releasing juvenile prawns into the river.

Over the project's three-year history, 179 volunteers formally joined the *Prawn Watch* project, taking part in collection and release events, training sessions and workshops. In addition, university students have contributed more than 3000 hours to support monitoring.

Community members also continued to contribute to citizen science research by logging details of their prawning catches in the *Prawn Watch* logbook, smartphone app and website.

Project partners include Parks and Wildlife, Murdoch University, the Department of Fisheries, the WA Fish Foundation, Recfishwest, ACAAR at Challenger Institute of Technology, and the Fisheries Research and Development Corporation.

Drag netting for prawns. *Photo – Stewart Allen*

A western school prawn. *Photo – Stewart Allen*

Volunteers are an important aspect of the project. *Photo – Stewart Allen*

Returning by-catch to the river alive. *Photo – Stewart Allen*

Gravid (egg-carrying) prawn. *Photo – Mark Thornley/Parks and Wildlife*

Appendix 3. Example of communications sent to community through River Guardians program.

RIVER GUARDIANS

May 2016

Welcome to all our new members who have become River Guardians over the last couple of months.

This newsletter is an update on everything to do with the Swan Canning Riverpark.

If there is anything you would like to see more or less of in this quarterly newsletter please let us know at guardians@dpaw.wa.gov.au.

Prawning in the rivers

With thanks to our Prawn Watch volunteers and world-first prawn culturing techniques, western school prawn numbers in the Swan and Canning rivers have been boosted by another 1.5 million animals across 2015–16.

More than 2.5 million juvenile school prawns were restocked between May 2013 and March 2015 and a further two million school prawns are targeted for release by June 2016 under the current Recreational Fishing Initiatives Fund (RFIF) supported by Recfishwest.

If you're out prawning, please use the Prawn Watch App, online monitoring form or log book to record your catch. Community input is vital to help monitor the western school prawn and to help us plan and re-establish the experience and pleasure of prawning.

iPhone
Android
online monitoring form
or logbook

For more information visit the River Guardians website.
More details on this and other RFIF projects are available on the Recfishwest website.

Warm regards,

Marnie, Rachel and Carol
River Guardians Team
Department of Parks and Wildlife

17 Dick Perry Avenue, Technology Park, Western Precinct, Kensington WA 6151
P: 08 9219 9000

Web: www.swanrivertrust.wa.gov.au |
www.riverguardians.com
CARING FOR THE SWAN CANNING RIVERPARK

Appendix 4. Prawn Watch story boards.

Appendix 5. Sustainable fishing flyer.

Gravid or 'pregnant' western school prawns can be identified by a bright green row of eggs running from the middle of their back to their tail.

Bringing recreational prawning back to the Swan Canning Riverpark

The Department of Parks and Wildlife is working with its project partners to bring western school prawns back to the Swan and Canning rivers.

You can help by adopting sustainable prawning techniques. Recreational fishers are encouraged to return gravid (pregnant) females to the water where they will naturally boost the school prawn population.

The future of prawning in the rivers is in our hands.

Department of Parks and Wildlife
SWAN CANNING RIVERPARK
PRAWN WATCH

Prawning for the future

Sustainable prawning

One of the best ways to prawn sustainably is to return gravid (pregnant) prawns to the river. Each female western school prawn produces between 20,000 and 60,000 eggs. Every gravid prawn returned to the water can lead to many more prawns the next year.

Gravid prawns can easily be identified by the bright green row of eggs running from the middle of their back to their tail.

Sustainable prawning tips

- Please return all by-catch to the river, including all fish, invertebrates and weed. If you sort your catch on a tarpaulin, it is easy to return the by-catch when prawns are removed.
- Take your rubbish home with you and keep off foreshore vegetation.
- Regulations apply to prawning. See the Department of Fisheries website for details - **www.fish.wa.gov.au**.

Prawn Watch

Prawn Watch is a Parks and Wildlife initiative that engages the community to monitor prawns in the Swan Canning Riverpark. It is part of a larger program focused on restocking the Swan and Canning rivers with western school prawns. More than 4.5 million western school prawns have already been released.

Get involved

Parks and Wildlife urges the public to share information on prawn catches by using the Prawn Watch smartphone app or online monitoring form on the River Guardians website. You can also contact us on 9278 0900 to receive a free Prawn Watch logbook. Community input is valuable in helping us monitor the prawn fishery.

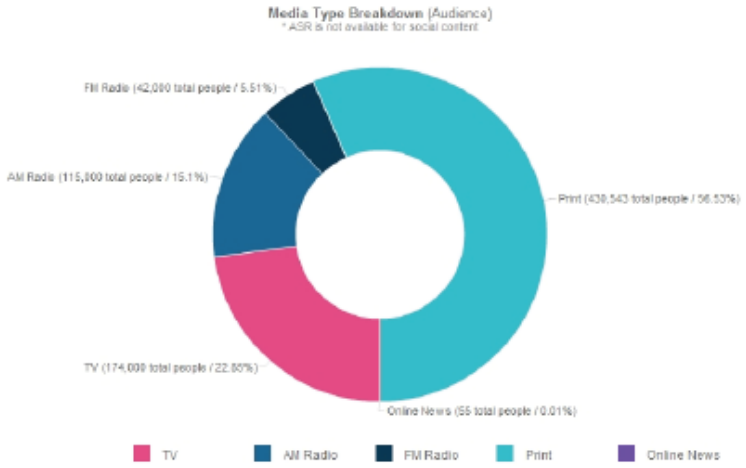
www.riverguardians.com

Project partners

Department of Parks and Wildlife · Murdoch University · Challenger · recfishwest · Recreational Fishing Initiatives Fund · FRDC

Appendix 6. Media analytics associated with Prawn Watch launch.

Total media types	Total items	Total audience	Total ASR (in AUD)
5	26	761,598	$64,545



An analysis of coverage produced in the 42 days between 05 Feb 2014 and 18 Mar 2014 from 1 folders (Prawn Watch) found 26 items. This coverage reached a cumulative audience of 761,598 and had an advertising space rate of AUD 64,545.
* Online News had the highest volume of coverage (10 items or 38% of the total volume of coverage)
* Print reached the highest cumulative audience (430,543 items or 56% of the cumulative audience)
* TV had the highest advertising space rate (AUD 36,039 or 55% of the total advertising space rate)

Media Type	Volume	Audience	ASR (in AUD)
AM Radio	6	115,000	$8,505
FM Radio	1	42,000	$255
Online	10	55	$12,353
Print	7	430,543	$7,393
TV	2	174,000	$36,039

Appendix 7. Joint media statement in March 2016 from the ministers for Fisheries and Environment.

Media Statements

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Four millionth prawn for Swan and Canning rivers

Wednesday, 2 March 2016

- **Fishing licence fees help support restocking projects in WA**
- **Brings to four million the number of juvenile prawns released since 2013**

Hon Ken Baston MLC
Former Minister for Agriculture and Food; Fisheries

Hon Albert Jacob BEnvDes M.Arch JP MLA
Minister for Environment; Heritage

Successful prawn breeding techniques developed in Western Australia are improving restocking efforts in the Swan and Canning rivers, with another 1.5 million juvenile prawns released so far during 2015-16.

The latest release of 400,000 western school prawns occurred today near Canning Bridge and Matilda Bay - all cultured by the Australian Centre for Applied Aquaculture Research (ACAAR) in Fremantle.

The Department of Parks and Wildlife, Department of Fisheries, Recfishwest, the WA Fish Foundation, ACAAR, Murdoch University, Prawn Watch and the Fisheries Research and Development Corporation are working together on the project.

Fisheries Minister Ken Baston said the partnership between government and community groups was helping restore the popular recreational activity of prawning for Perth families.

The historically popular recreational drag netting for prawns had all but disappeared as prawn numbers fell over time. Restocking began in 2013, using fishing licence fees to fund the project.

Between May 2013 and March 2015, 2.5 million juvenile prawns were released into the rivers. Another 1.1 million prawns were released in December 2015. The release this week brings the total number to four million.

"The prawn culture work by ACAAR has stepped up release rates as the staff involved refine their techniques and knowledge," Mr Baston said.

"This is another example of how recreational fishing licence fees are being re-invested in projects to benefit recreational fishing."

Environment Minister Albert Jacob said the restocking work had been run in conjunction with the citizen science Prawn Watch program, to encourage stewardship of the rivers.

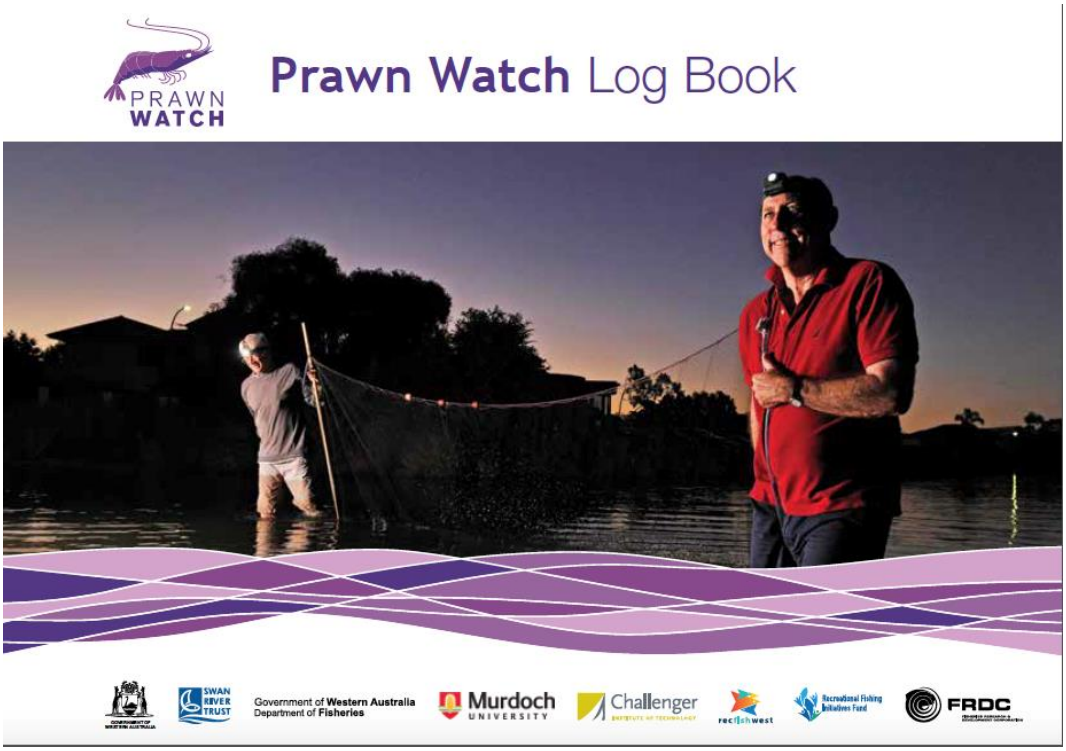
"We are keen to see the community connect with the river and to experience the pleasure of prawning. They can share information on their catch with us by using the Prawn Watch app," Mr Jacob said.

Fact File

- **For more information, visit http://riverguardians.com/projects/prawn-watch or http://recfishwest.org.au/funding-projects/large-grants**

Fisheries Minister's office - 6552 5400
Environment Minister's office - 6552 5800

Appendix 8. Prawn Watch logbook with former Fisheries Minister on cover (top) and most recent version (bottom).



Appendix 9. Instruction sheet provided to the citizen scientists during the citizen science monitoring trial.

Western School Prawn – Citizen Science Monitoring

Overview

Thank you for taking part in this trail to help develop a citizen science methodology suitable for monitoring populations of the Western School Prawn.

The aim of tonight's sampling is to record prawn numbers at a range of sites across the Swan-Canning Estuary.

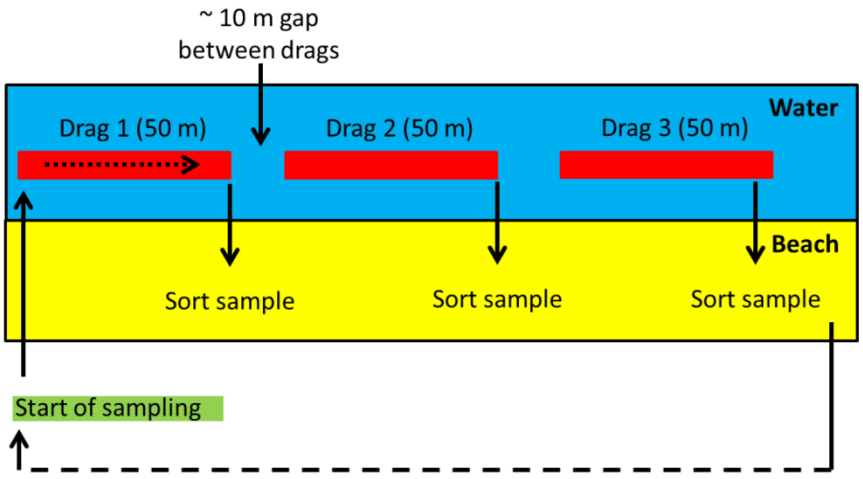
You will be spilt into small teams and assigned to a particular site. At each site, we require **10 drags of 50 m** to be conducted. Note that there may be more than one team of fishers at a site. You will be provided with a data sheet to fill out after each drag, which also includes some information on how to distinguish between the Western School and Western King prawns.

Method

- Start at one end of the beach.
- Together with your partner, enter the water to a depth of ~ 1m (waist deep).
- Drag the net for ~ 50 m (this should be around 80 steps and could be marked out on the beach beforehand).
- Bring net onto shore, shake contents into the cod-end and empty on to a tarp.
- Sort and return all fish to the water alive immediately.
- Count the number of Western School Prawns and Western King Prawns and record on the data sheet.
- Keep gravid female School Prawns for broodstock collection and return other prawns to water.
- Prepare net for next drag (tie net and remove any plant material).
- Repeat up to 10 times for each site (note there may be more than one team per site).
- Please leave ~ 10 m between drags (to avoid overlap/disturbance).
- If you run out of beach, walk back to the beginning and start again.
- See overleaf for diagram.

recfishwest
Recreational Fishing Initiatives Fund
Government of Western Australia Department of Fisheries

Sampling diagram



If you run out of beach return to the start of the first drag and continue

THANK YOU!

Appendix 10. Data sheet provided to the citizen scientists during the citizen science monitoring trial.

Government of Western Australia
Department of Fisheries

Western School Prawn – Citizen Science Monitoring

Site: _____

Date: _____

Start time: _____ **End time:** _____

Drag #	# School Prawns	# King Prawns
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

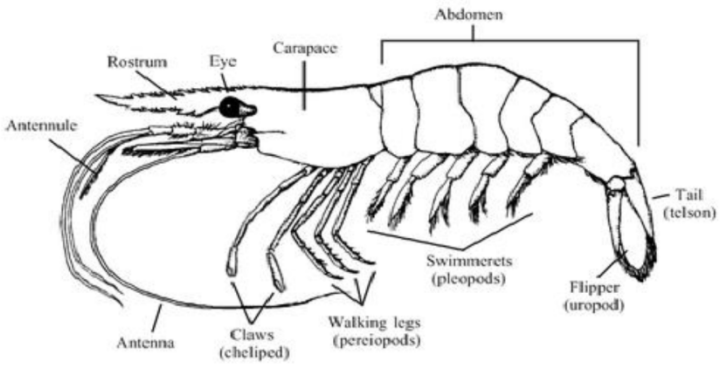
recfishwest
Recreational Fishing Initiatives Fund
Government of Western Australia Department of Fisheries

Useful information

Identification guide

	Western School Prawn	Western King Prawn
		
Size	85 mm total length	200 mm total length
Antennal filaments	Comparatively long and visibly bifurcate (2 tips)	Small and indistinct
Rostrum	Pale and straight. No spine	Ridges are dark brown. Visible spine at base of rostrum
Eyes	Eyes stalks are small and eyes held close to the head. Eyes are rounded and dark in colour	Eye stalks are long. Eyes are somewhat bean shape and appear compound (*i.e.* 'fly-like')
Walking Legs	Pale yellow-green	Light blue
Tail (Telson & Uropod)	Pale yellow-green	Light blue

Prawn anatomy



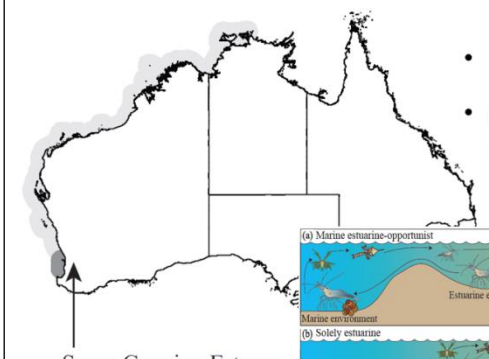
Appendix 11. Slides presented at the Western School Prawns management meeting.

Biology of the Western School Prawn in the Swan-Canning Estuary

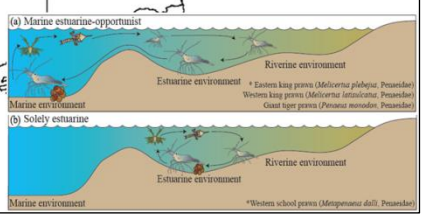
General biology

- **Habitat:** Inshore waters and rivers/estuaries to 33 m. Found over sand or sandy mud
- **Size:** Up to 120 mm TL, but generally 90 mm and 10 g. Live for up to 2 years
- **Diet:** Small invertebrates and detritus
- **Fishery:** Small commercial fishery (closed 1970s) & iconic recreational fishery

Australian distribution



- Estuarine resident
- Self-sustaining population

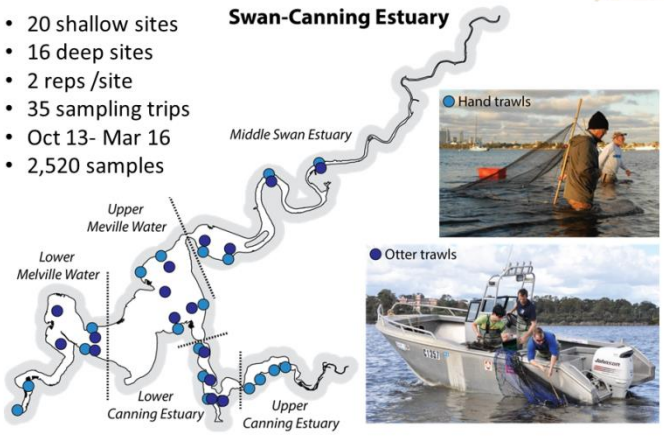


MU Research component

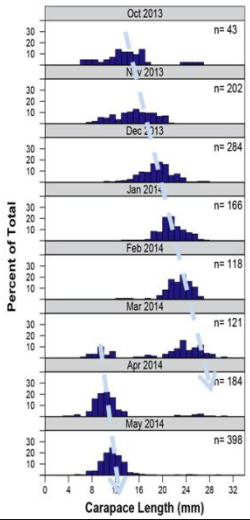
- ***Overall aim: Optimizing the release strategies***
- *Specific aims:*
  - *Larval development and ecology*
  - *Genetic implications of restocking*
  - Biological parameters
  - Spatial and temporal abundance/distributions of prawns
  - *Influence of environmental variables*
  - Impact of predation
  - *Bio-economic model for restocking*

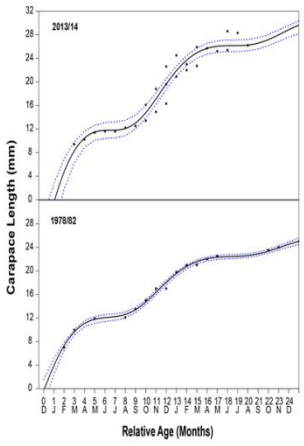
Monitoring regime

- 20 shallow sites
- 16 deep sites
- 2 reps /site
- 35 sampling trips
- Oct 13- Mar 16
- 2,520 samples



Growth

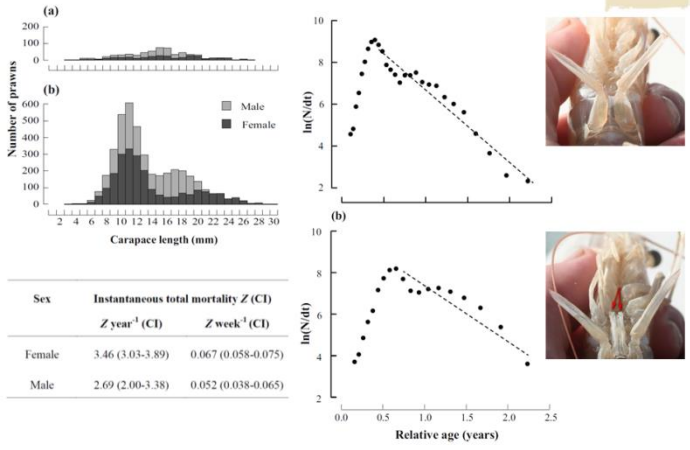




2013/14
- L_{∞} = 33.7 mm
- *k* = 1.06
- T_0 = -0.16

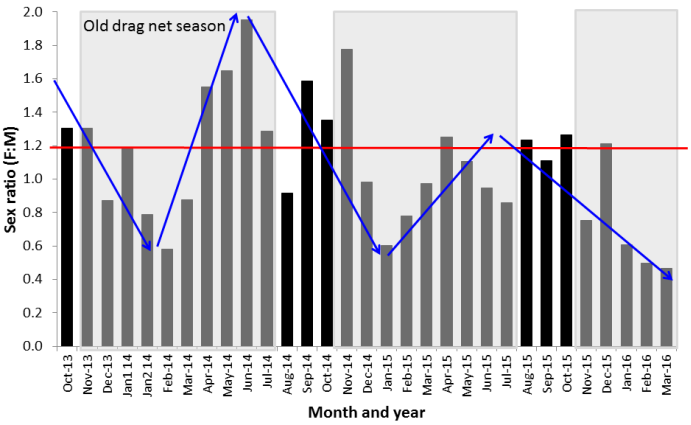
1978/82
- L_{∞} = 28.0 mm
- *K* = 1.05
- T_0 = -0.16

Growth and mortality

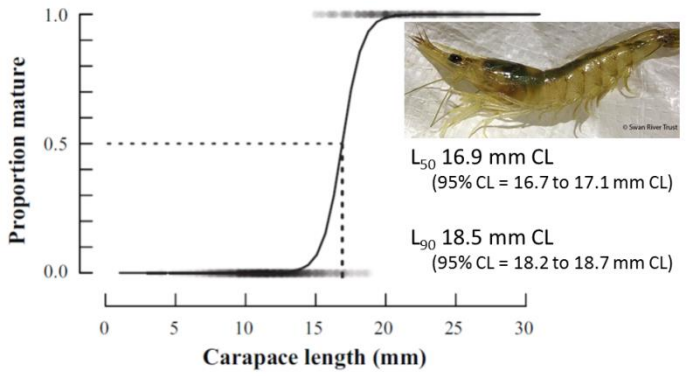


Sex	Instantaneous total mortality Z (CI)	
	Z year^{-1} (CI)	Z week^{-1} (CI)
Female	3.46 (3.03-3.89)	0.067 (0.058-0.075)
Male	2.69 (2.00-3.38)	0.052 (0.038-0.065)

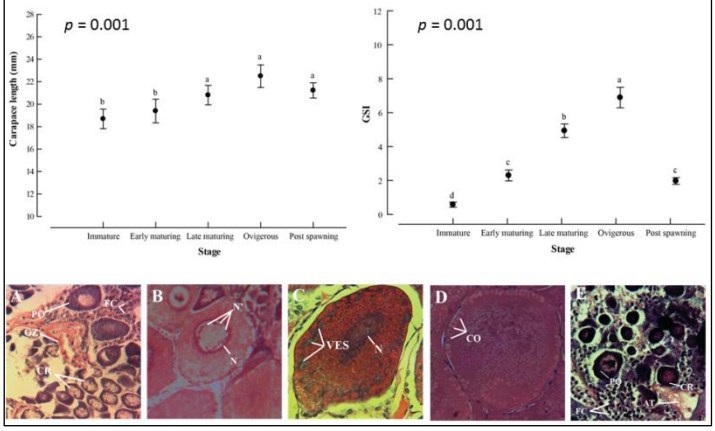
Sex ratio



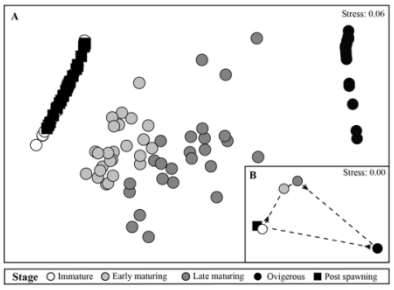
Size at maturity



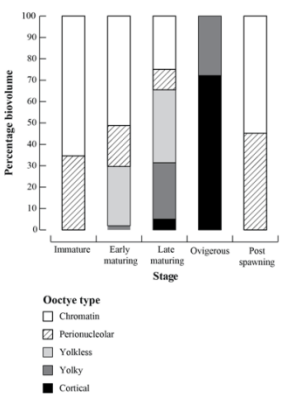
Gonadal development



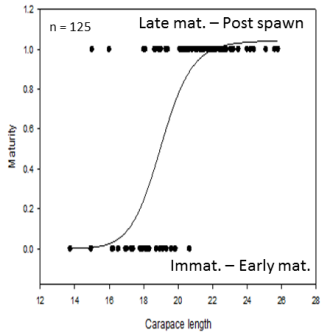
Gonadal development

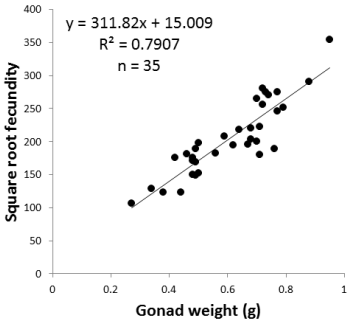


Global $R = 0.787$, $p = 0.001$



Histological size at maturity



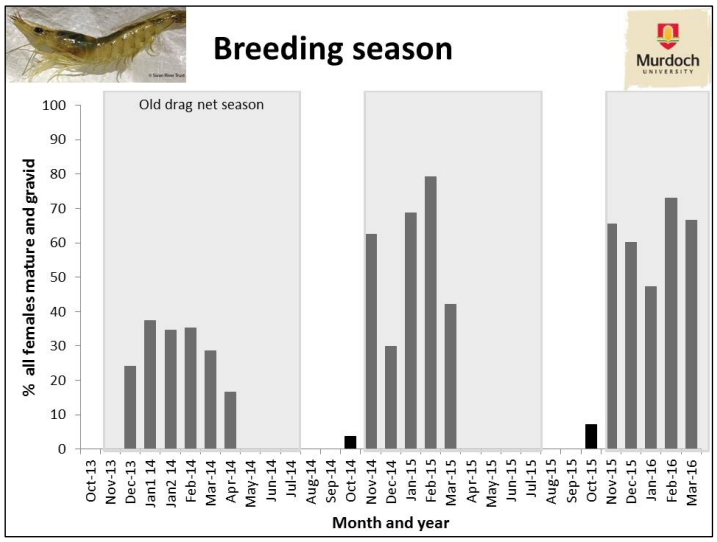


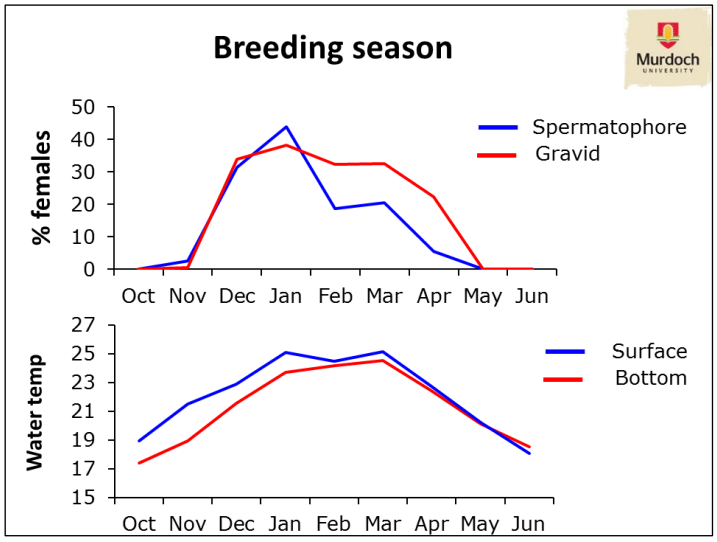
L_{50}

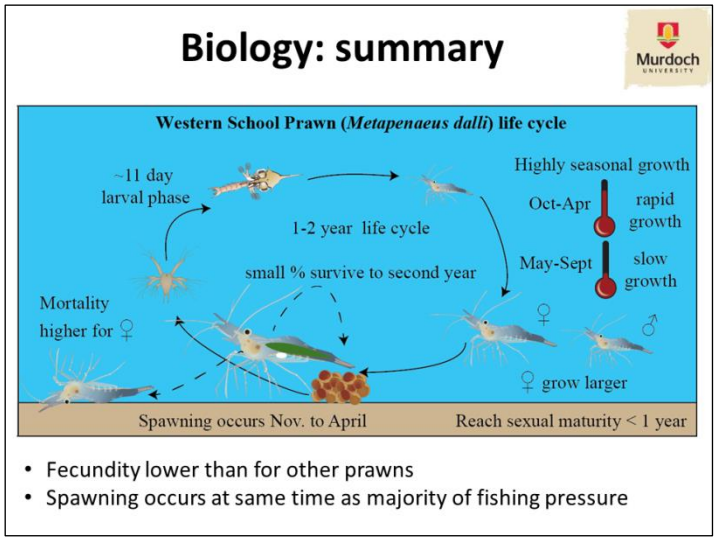
- 18.96 mm CL
- 5.8 g wet weight

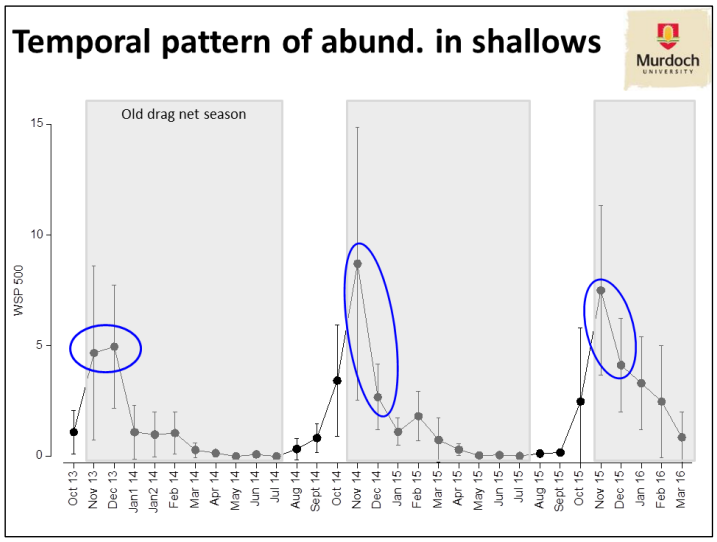
Fecundity

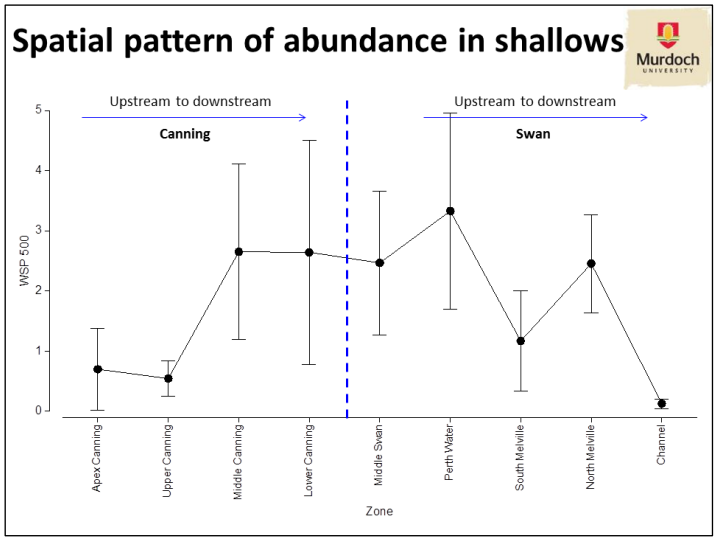
- 11,400 – 125,000 ova

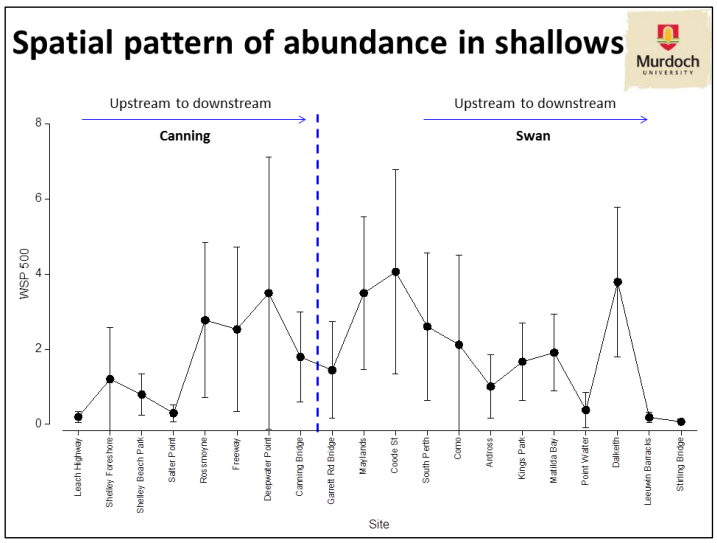

Breeding season
Murdoch
Old drag net season
% all females mature and gravid
100
90
80
70
60
50
40
30
20
10
0
Oct-13
Nov-13
Dec-13
Jan1 14
Jan2 14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Sep-15
Oct-15
Nov-15
Dec-15
Jan-16
Feb-16
Mar-16
Month and year


Breeding season
Murdoch
% females
50
40
30
20
10
0
Spermatophore
Gravid
Oct Nov Dec Jan Feb Mar Apr May Jun
Water temp
27
25
23
21
19
17
15
Surface
Bottom
Oct Nov Dec Jan Feb Mar Apr May Jun


Biology: summary
Murdoch
Western School Prawn (Metapenaeus dalli) life cycle
~11 day larval phase
1-2 year life cycle
small % survive to second year
Mortality higher for ♀
Highly seasonal growth
Oct-Apr rapid growth
May-Sept slow growth
♀ grow larger
Spawning occurs Nov. to April
Reach sexual maturity < 1 year
• Fecundity lower than for other prawns
• Spawning occurs at same time as majority of fishing pressure


Temporal pattern of abund. in shallows
Murdoch University
Old drag net season
WSP 500
0
5
10
15
Oct 13
Nov 13
Dec 13
Jan1 14
Jan2 14
Feb 14
Mar 14
Apr 14
May 14
Jun 14
Jul 14
Aug 14
Sept 14
Oct 14
Nov 14
Dec 14
Jan 15
Feb 15
Mar 15
Apr 15
May 15
Jun 15
Jul 15
Aug 15
Sept 15
Oct 15
Nov 15
Dec 15
Jan 16
Feb 16
Mar 16

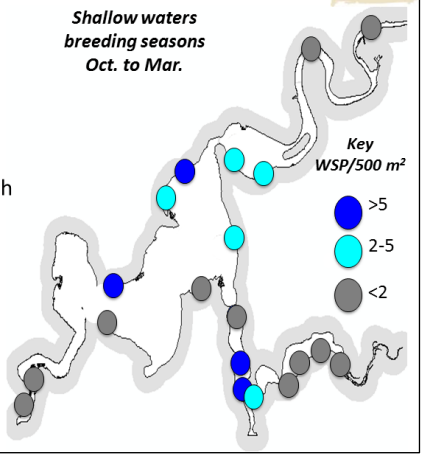

Spatial pattern of abundance in shallows
Murdoch University
Upstream to downstream
Canning
Upstream to downstream
Swan
WSP 500
0
1
2
3
4
5
Apex Canning
Upper Canning
Middle Canning
Lower Canning
Middle Swan
Perth Water
South Melville
North Melville
Channel
Zone


Spatial pattern of abundance in shallows
Murdoch University
Upstream to downstream
Canning
Upstream to downstream
Swan
WSP 500
0
2
4
6
8
Leach Highway
Shelley Foreshore
Shelley Beach Park
Salter Point
Rossmoyne
Freeway
Deepwater Point
Canning Bridge
Garrett Rd Bridge
Maylands
Coode St
South Perth
Como
Ardross
Kings Park
Matilda Bay
Point Walter
Dalkeith
Leeuwin Barracks
Stirling Bridge
Site

Spatial patterns in prawn abundance

Murdoch University

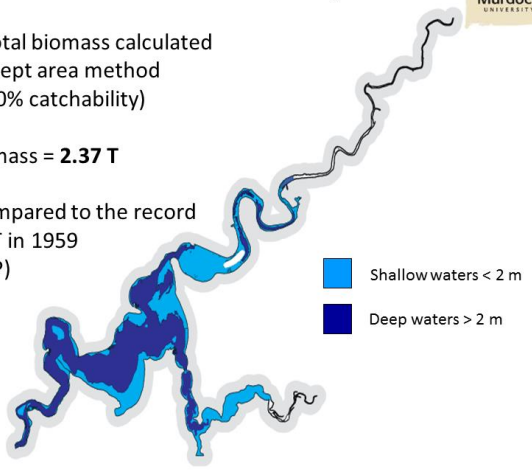
- Most numerous in middle reaches of estuary
- 'Hotspots' of abundance
- Highest densities occur with accumulations of (live) macroalgal drift
- Highly mobile
- Spatial patterns different from Western King Prawn *Melicertus latisculatus*



Population biomass in 13/14

Murdoch University

- Estimated total biomass calculated using the swept area method (assuming 40% catchability)
- Current biomass = **2.37 T**
- Very low compared to the record catch of 15 T in 1959 (WKP & WSP)

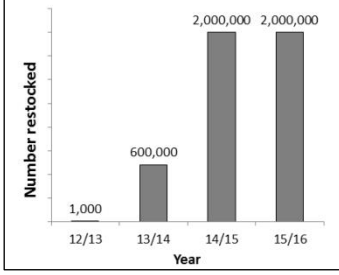


Restocking program

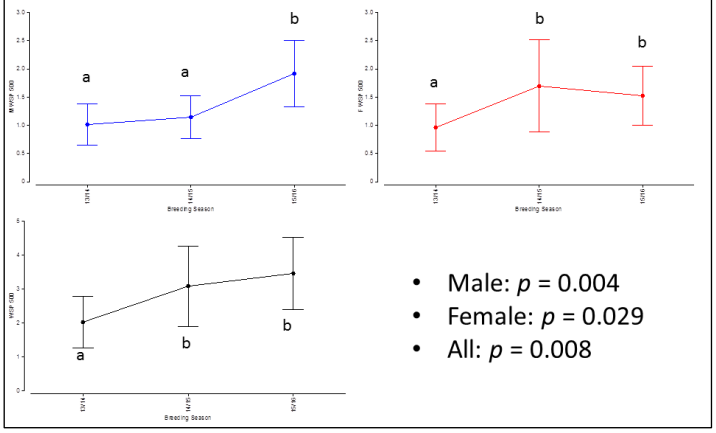
Murdoch University

Australian Centre for Applied Aquaculture Research

- Developed culture methods
- Gravid females collected in the wild
- Post-larvae (PL10 to PL15) released

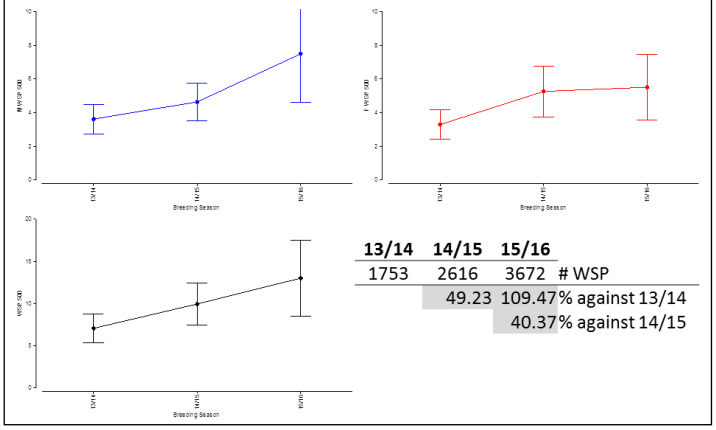


Abundance during breeding season shallows



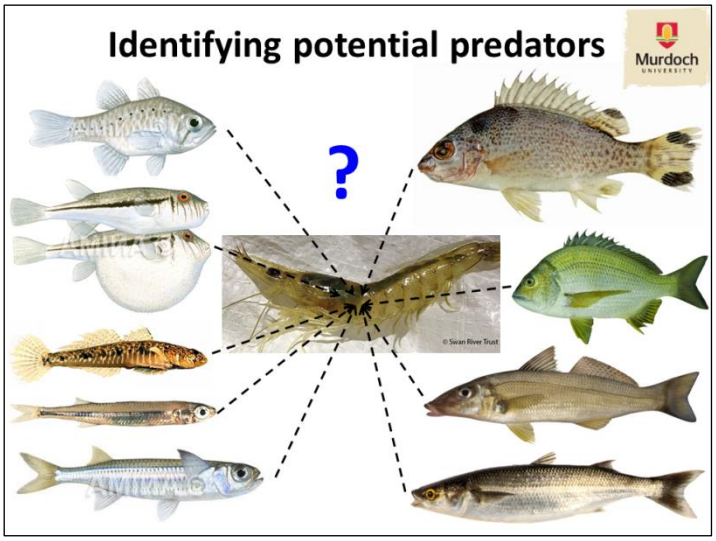
- Male: $p = 0.004$
- Female: $p = 0.029$
- All: $p = 0.008$

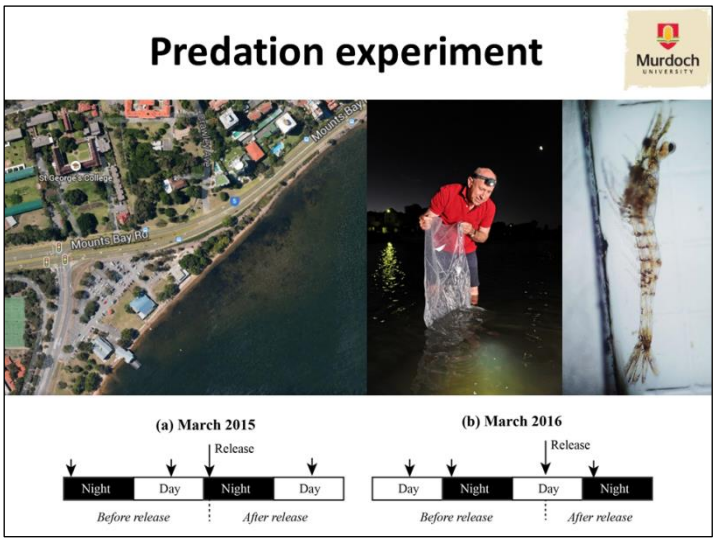
Abundance during breeding season deeper waters

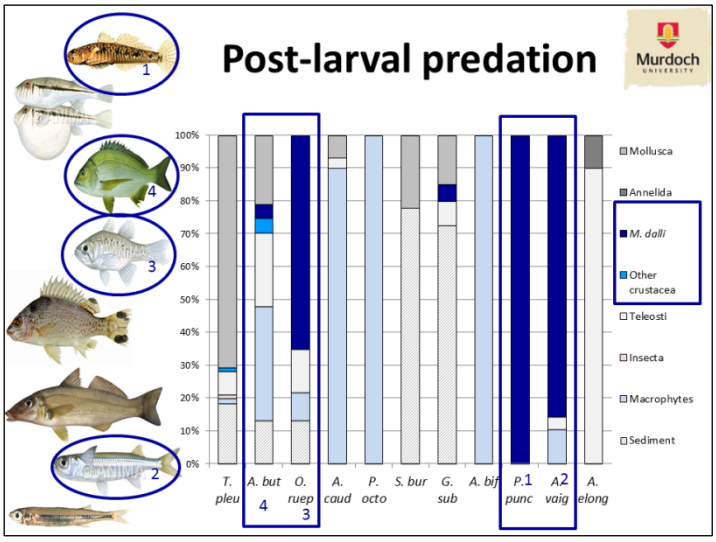


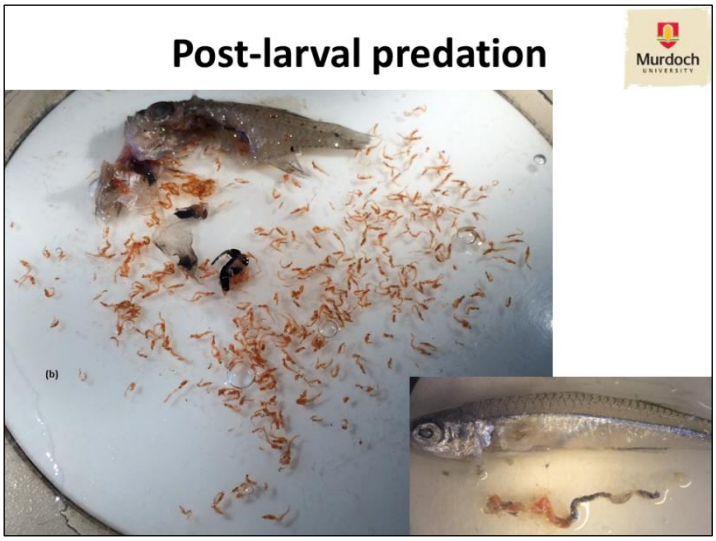
13/14	14/15	15/16	
1753	2616	3672	# WSP
	49.23	109.47%	against 13/14
		40.37%	against 14/15

Identifying potential predators




Predation experiment
Murdoch
Mounts Bay Rd
(a) March 2015
Release
Night
Day
Night
Day
Before release
After release
(b) March 2016
Release
Day
Night
Day
Night
Before release
After release


Post-larval predation
Murdoch
1
4
3
2
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
T. pleu
A. but 4
O. ruep 3
A. caud
P. octo
S. bur
G. sub
A. bif
P.1 punc
A2 vaig
A. elong
Mollusca
Annelida
M. dalli
Other crustacea
Teleosti
Insecta
Macrophytes
Sediment


Post-larval predation
Murdoch
(b)

Summary: Fishery implications

- **Prawn biology**
  - Estuarine species so no recruitment from outside
  - Small species (12 cm long & 16 g)
  - Short-lived, but relatively low fecundity
  - Females larger and suffer higher natural mortality
  - Move into shallows to spawn between Oct and April
- **Potential issues for discussion**
  - Fishing activity occurs during breeding season
  - Fishers select larger prawns (females)
  - Project exposure has increased fishing activity

Where to from here?

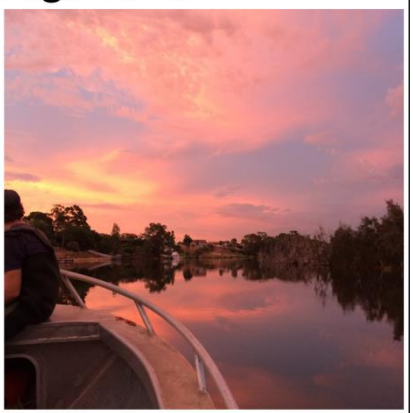
Acknowledgements

Funding bodies

- Swan River Trust, FRDC, RFIF/Recfishwest & Murdoch Uni.

Support

- Greg Jenkins and team at Challenger Institute of Tech. Dr Kerry Trayler and colleagues (DPaW)
- Recreational prawners
- The many volunteers who assisted with sampling
- WAFF (Ian Stagles)



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