Fish and crayfish fauna of Ellen Brook, Cowaramup Brook and Gunyulgup Brook in the Cape to Cape Region of Western Australia

Report to Ribbons of Blue/Waterwatch WA

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Project summary

During September 2004 a total of 25 sites were sampled for fish and freshwater crayfish in Ellen Brook, Cowaramup Brook and Gunyulgup Brook. This included 11 sites on Ellen Brook, six sites on Cowaramup Brook and eight sites on Gunyulgup Brook. A total of 1270, 720 and 1450 m^2 were sampled on Ellen, Cowaramup and Gunyulgup Brooks, respectively.

Five species of fish were captured in the 11 sites sampled in Ellen Brook. These included two freshwater species that are endemic to south-western Australia, i.e. the Western Pygmy Perch and the Nightfish, the marine-estuarine opportunistic Sea Mullet, the marine Zebra Fish and the introduced Mosquitofish. The only fish species captured in the six sites sampled in Cowaramup Brook was the introduced Mosquitofish. Three species of fish were captured in the eight sites sampled in Gunyulgup Brook. These include the estuarine Swan River Goby and Black Bream and the marine/estuarine opportunistic Sea Mullet. All three species were found at the mouth of the brook, with the Black Bream (1 specimen, 43 mm TL) and Sea Mullet (5 individuals, 34-43 mm TL) being small juveniles. In contrast, the 60 Sea Mullet captured at Caves Rd were much larger and ranged in length from 204 to 261 mm TL.

The largest Western Pygmy Perch captured in Ellen Brook was 78 mm TL, a size considerably longer than previously reported for the species (i.e. 68 mm TL, from almost 3000 individuals measured) (see Pen and Potter (1991) in the Collie River. Furthermore, 13 of the 268 individuals captured and measured in Ellen Brook were larger than the largest reported from the Collie River. This high proportion of large individuals is unusual in that most populations of Western Pygmy Perch are represented by the 0+, 1+ and 2+ cohorts, which comprised 99% of all fish examined in the Collie River. In the Collie River, Western Pygmy Perch attain lengths of ~42 and 51 mm TL at the end of their first and second year of life, respectively (Pen and Potter

1992). Based on this length at age data, almost 43% of Western Pygmy Perch in Ellen Brook would have been in their fourth, fifth or sixth year of life. The population of Nightfish in Ellen Brook is similarly dominated by larger, older fish. For example, in the Collie River 98.5% of the population is < than three years old (<85 mm TL), whereas in Ellen Brook, over 70% of the population is > three years old (i.e. >85 mm TL) (see Pen and Potter 1990). These dramatically contrasting population demographics are important, particularly in terms of ensuring the survival of what may be an aging population. It is possible that either predation is high on juvenile fish or that the high degree of water extraction is impacting on the fishes. The considerable number of new dams in the catchment, increased land clearing and long term drought experienced in the region again may be affecting environmental flows to the degree that only the few larger fish are surviving, possibly as they are more capable of competing for habitat as it becomes limited.

Four species of endemic freshwater crayfish were captured in Ellen Brook, including the widespread smooth Marron (*Cherax cainii*), the common Gilgie (*Cherax quinquecarinatus*), the restricted Gilgie (*Cherax crassimanus*) and the widespread Koonac (*Cherax preissii*). While only two, eight and four individuals of the Marron, the restricted Gilgie and the Koonac were captured, respectively, over 500 Gilgies were found throughout Ellen Brook, with densities peaking at 3.0 Gilgies m^{-2} at site 10 (Garstone Rd, the second uppermost site). Only one Gilgie was found at the uppermost site (site 11) which offered little habitat or shade. The restricted gilgie in Ellen Brook represents the northern-most extent of its range and reflects its preference for small waterbodies. The overall mean density of common Gilgies throughout Ellen Brook was high, with approximately every 2 m^2 of stream bed being occupied by one animal. The densities of the widespread Gilgie were highest in Cowaramup Brook, with an average mean abundance of 1.62 Gilgies m^{-2}. A total of 963 Gilgies were captured in Cowaramup Brook and they were found in all sites, including the mouth of the brook. A total of six Marron was also captured in three of the six sites sampled. 41 Yabbies were captured in Gunyulgup Brook. There appeared to be three age cohorts (year classes) present including newly released (0+) individuals, indicating that this species was a self-maintaining population. In Gunyulgup Brook Gilgies were captured in all sites with the exception of the mouth, while Marron were only found in the large dam at site 7, where they were probably introduced. The presence of a Yabbie below this dam (site 6) suggests that this is also the most likely avenue of their introduction into this part of the brook. The fact that the majority of Yabbies were caught on another branch of the brook implies that there have been multiple introductions to the system. A wild population of Yabbies in the Hutt River (near Geraldton) has recently been found to have the serious porcelain disease caused by the microsporidian *Thelohania parastaci*, a disease that has also impacted on

the aquaculture industry in this State. This disease is contracted by a crayfish consuming infected tissue. It is possible that the endemic crayfish may be able to contract this disease by consuming infected Yabbie tissue. Therefore, the potential accompanying spread of this and other diseases by Yabbie introductions is of considerable concern in this region. The identification of this, and other diseases, in the yabbies of Gunyulgup Brook should be assessed.

The high abundance and success of Gilgies in these streams is no doubt a reflection of their adaptive life history strategy adapted to these water bodies which includes: the ability to burrow into the water table in temporary waterbodies, a relatively small size at first maturity reproducing after the first year of life, and being able to spawn multiple times over the annual breeding period (spring-summer). Therefore, the wide distribution and large abundance in all three streams in the current study reflects this species adaptiveness to such small lotic systems, subject to low summer water levels.

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1. Introduction

The Cape to Cape region of Western Australia includes the streams flowing west into the Indian Ocean on the Leeuwin-Naturaliste Ridge between Cape Leeuwin and Cape Naturaliste. Surprisingly, the only recent ichthyological studies of the region include those for Margaret River (Morgan *et al*. 1998, Morgan and Beatty 2003, 2004) and Boodjidup Brook (Morgan *et al*. 1998). However, the fish fauna of adjacent streams outside the Cape to Cape region, including the Vasse River (Morgan and Beatty 2004), Carbunup River and Blackwood River (Morgan *et al*. 1998, Thorburn 1999, Morgan *et al*. 2003) have received some attention. It is noteworthy that a number of rare endemic fishes and the lamprey (*Geotria australis*) are found in Margaret River and may also exist in other small streams of the capes.

Although not rich in the number of species, south-western Western Australia houses a highly endemic assemblage of both freshwater fish and crayfish with eight of the 10 species of fish and all 11 freshwater crayfish being found nowhere else. Of the freshwater crayfish, six species belong to *Cherax* and five to *Engaewa* (the obligate burrowing genus unique to the south-west) (Austin and Knott, 1996; Horwitz and Adams, 2000; Austin and Ryan, 2002). The Cape to Cape region is particularly important as all six species of *Cherax* and three *Engaewa* species are found there (Austin and Knott, 1996; Horwitz and Adams, 2000; Austin and Ryan, 2002). This importance is further highlighted by the presence of the critically endangered *Cherax tenuimanus* (the Hairy Marron) only being found in the Margaret River (Austin and Ryan, 2002) and with *Cherax glaber* (shiny gilgies) and *Cherax crassimanus* being present in the region, also having restricted distributions (Austin and Knott, 1996). Furthermore, *Engaewa reducta* and *Engaewa pseudoreducta* are restricted to the northern section of the Cape to Cape region, occupying swampy areas (Horwitz and Adams, 2000). The upper reaches of Margaret River not only house the restricted Hairy Marron, but also two species of rare, endemic freshwater fish, i.e. Balston's Pygmy Perch (*Nannatherina balstoni*) and the Mud Minnow (*Galaxiella munda*) (Morgan *et al*. 1998, Morgan and Beatty 2003, 2004). The Mud Minnow has also been found within the Cape to Cape region in Boodjidup Brook (Morgan *et al*. 1998).

The streams of the Cape to Cape region are under ever increasing pressure due largely to urban and rural encroachment and the associated land clearing, water extraction and damming of the small tributaries that feed the streams. Hunt *et al*. (2002) identified the dominance of degraded riparian zones throughout these streams and that water quality is deteriorating as a result of the landuse (i.e. grazing and pasture). Habitat destruction is probably the process that is causing severe declines in native freshwater fishes in Western Australia, and this is particularly relevant

when considering catchments that are extremely small. For example, the catchment of Ellen Brook is only 29 km^2, while Cowaramup Brook is 24 km^2 and Gunyulgup Brook is 47km^2 (Hunt *et al*. 2002).

Aims of the study

This main aims of this study were to:

- determine the freshwater fish and crayfish fauna of three streams in the Cape to Cape region, i.e. Ellen Brook, Cowaramup Brook and Gunyulgup Brook,
- compare and contrast the associated faunas of each stream,
- identify any feral species and their relative threat,
- make suggestions regarding the conservation of the regions aquatic fauna.

2. Methodology

Sampling equipment

As each stream was relatively clear, shallow and in parts had a high degree of instream habitat that would have inhibited the use of seine nets, each site was sampled using a back-pack electrofisher (*Smith-Root model 12-A*) and scoop net. The electrofisher momentarily stuns the fish and freshwater crayfish allowing the operator to catch the animals in the scoop net and confirm their identity. Furthermore, the electrofisher brings cryptic species of fish and freshwater crayfish out from under snags and burrows. At each site between 30 and 400 m^2 was sampled.

Sample sites and data analysis

During September 2004 a total of 25 sites were sampled for fish and freshwater crayfish in Ellen Brook, Cowaramup Brook and Gunyulgup Brook (Figures 1-3, Plates 1-3). This included 11 sites on Ellen Brook (Figure 1, Plate 1), six sites on Cowaramup Brook (Figure 2, Plate 2) and eight sites on Gunyulgup Brook (Figure 3, Plate 3). A total of 1270, 720 and 1450 m^2 were sampled on Ellen, Cowaramup and Gunyulgup Brooks, respectively.

At each site the longitude and latitude was recorded using a GPS. These data were used to construct maps in *MapInfo* and were then transferred to aerial photographs purchased from DOLA.

On capture, the fish and freshwater crayfish were identified and the native species were released immediately, with introduced species placed in an ice slurry and transferred to 100% ethanol. The total number of each species captured was recorded and their relative abundance determined. The total length (TL) of a sample each fish and crayfish captured was measured to the nearest 1 mm. Length-frequency histograms were illustrated graphically using *Sigma Plot*.

Environmental variables

On each sampling occasion water temperature, conductivity and salinity were recorded. Three replicates were taken at each site with the mean determined. These data were plotted using *Sigma Plot*.

Figure 1 The sites sampled on Ellen Brook for fish and freshwater crayfish.

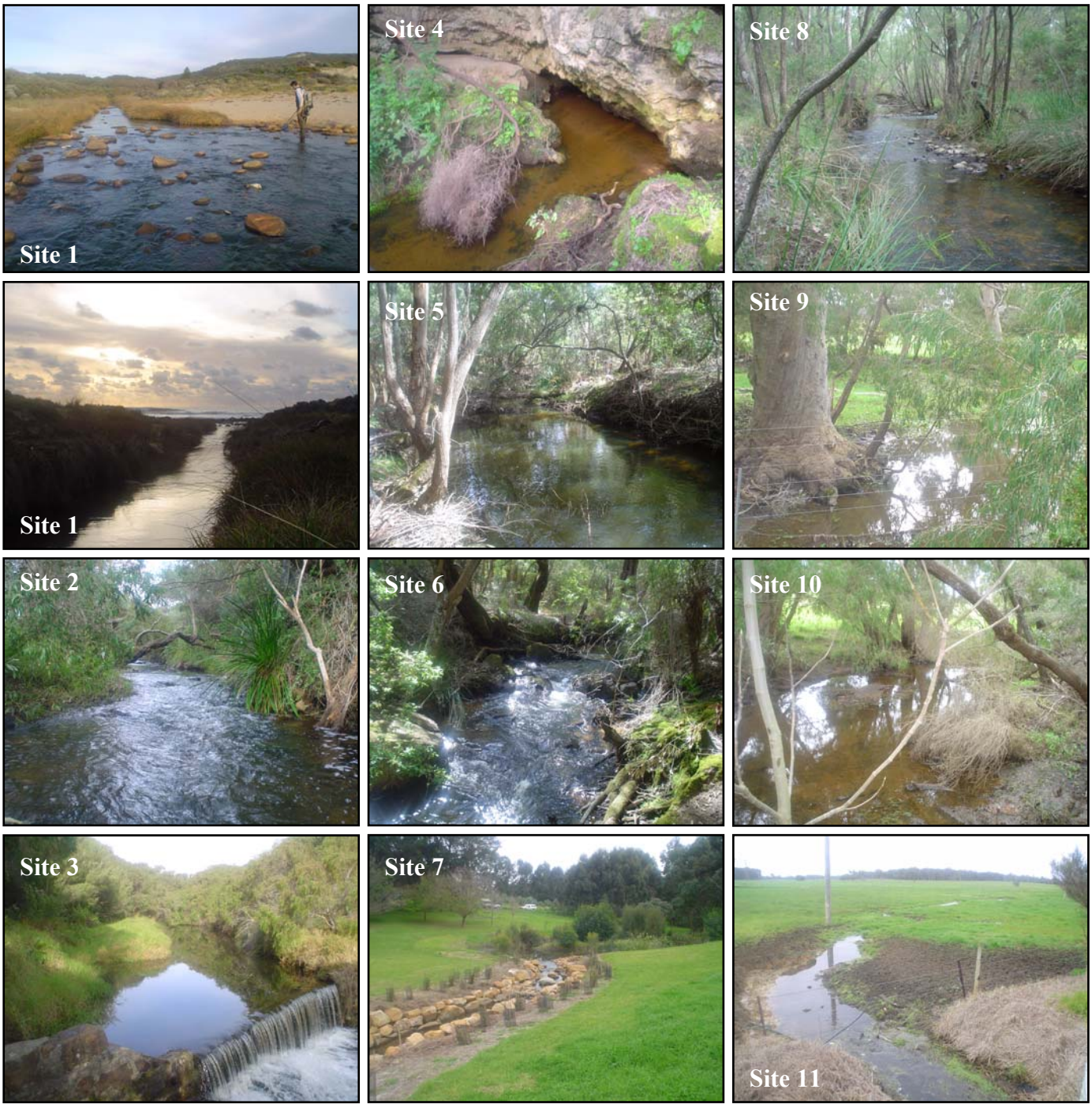

Plate 1 The sites sampled for fish and freshwater crayfish on Ellen Brook. The site numbers are given and correspond to those in Table 1.

Figure 2 The sites sampled on Cowaramup Brook for fish and freshwater crayfish.

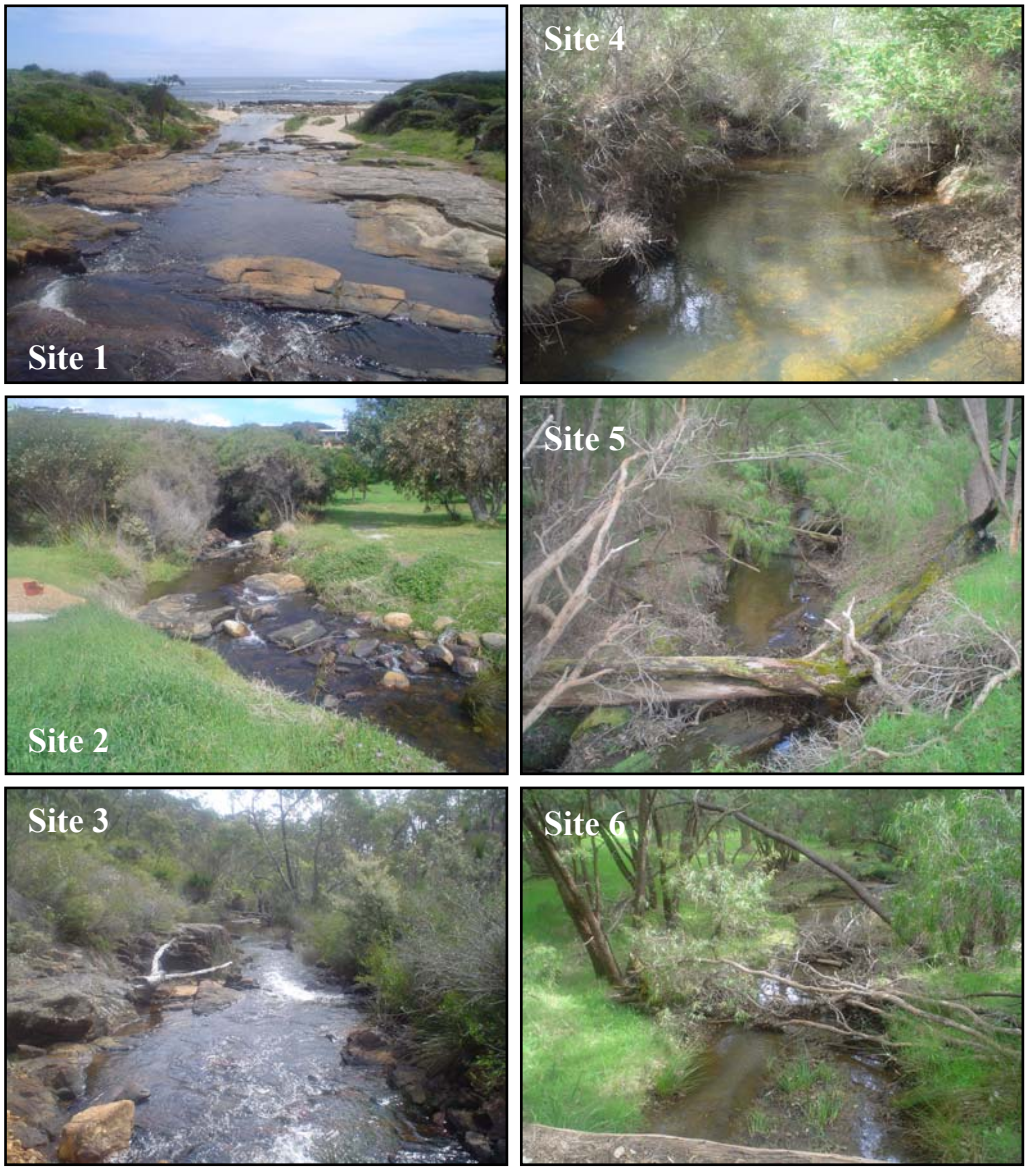

Plate 2 The sites sampled for fish and freshwater crayfish on Cowaramup Brook. The site numbers are given and correspond to those in Table 4.

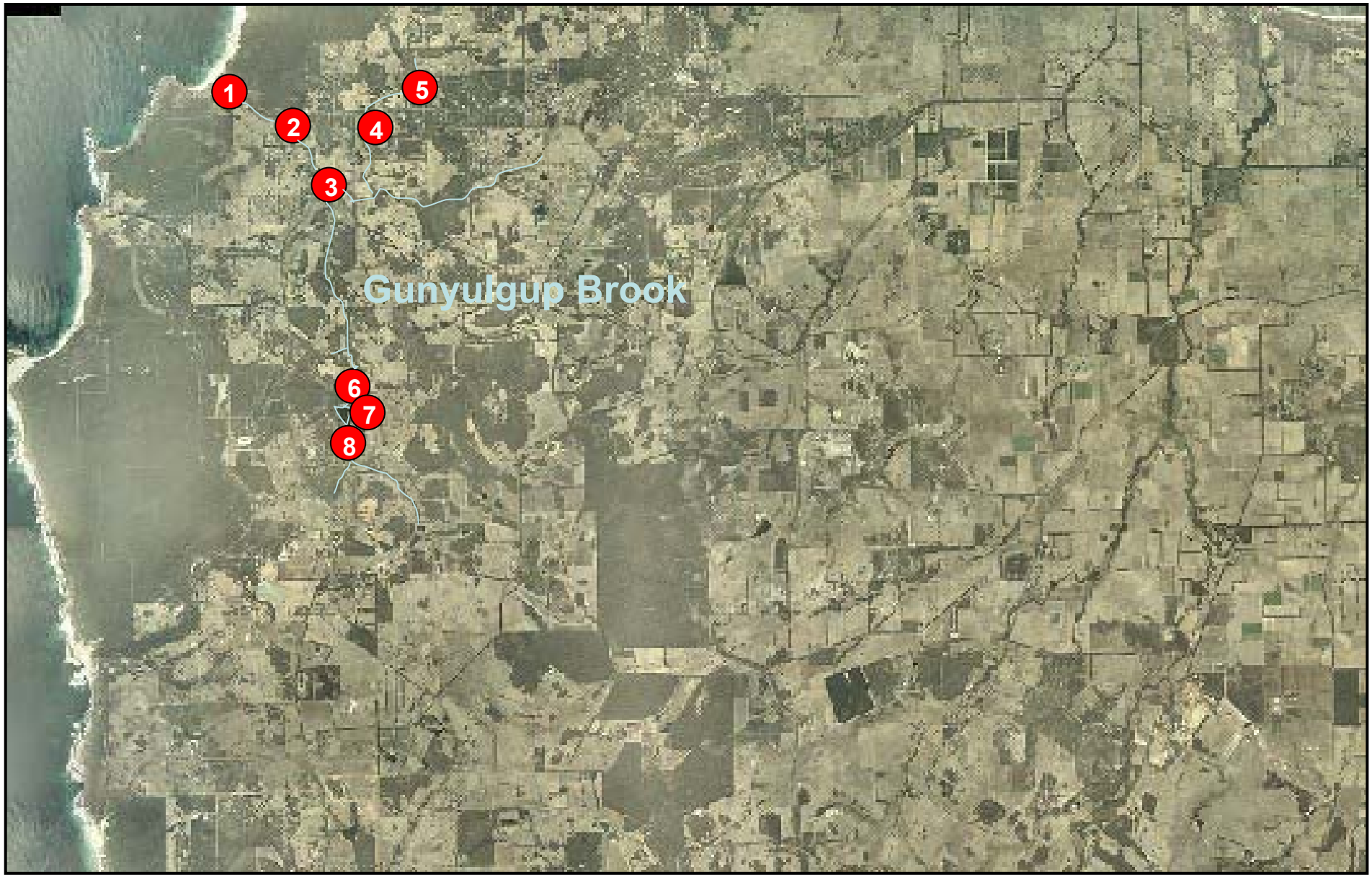

Figure 3 The sites sampled on Gunyulgup Brook for fish and freshwater crayfish.

Plate 2 The sites sampled for fish and freshwater crayfish on Gunyulgup Brook. The site numbers are given and correspond to those in Table 2.

3. Results

3.1 Fish species captured

A key to the freshwater fishes of south-western Australia has been included in an Appendix.

Ellen Brook (Table 1, Figures 1, 4 and 5)

Five species of fish were captured in the 11 sites sampled in Ellen Brook (Table 1, Figure 1, Plate 1). These included two freshwater species that are endemic to south-western Australia, i.e. the Western Pygmy Perch and the Nightfish, the Sea Mullet, a marine-estuarine opportunistic species, the marine Zebra Fish and the introduced Mosquitofish.

Western Pygmy Perch

Nightfish

Sea Mullet

Zebra Fish

Mosquitofish

Photographs: D. Morgan

Juvenile Sea Mullet (length range 27-32 mm TL) and Zebra Fish (~100 mm TL) were only captured at the mouth of Ellen Brook, the latter only within the rock pools at the confluence of the ocean and the former to approximately 100 m upstream of the mouth (Figure 4). Introduced Mosquitofish were only found in three sites and the only substantial infestation recorded was in Herons Brook where densities were ~2 m^{-2}. (Table 1, Figure 5)

The Western Pygmy Perch and Nightfish, however, were widespread and were captured in six and nine sites, respectively (Table 1, Figure 1). Nightfish generally occurred in low numbers at most sites but was represented by a high proportion of large fish (i.e. 76% > 80 mm TL) (Table 1, Figure 4 - *see Discussion*). Although Western Pygmy Perch were widely distributed throughout Ellen Brook, over 80% were captured downstream of the impassable weir (site 3),

which occurs only a few hundred metres upstream of the mouth (Table 1, Figure 4). Furthermore, the sites upstream of the weir were generally only represented by larger, older fish, with the largest fish captured being 78 mm TL (*see Discussion for rationale*).

In general, Ellen Brook superficially offered excellent habitat for fish (i.e. shade, deeper pools, riffle zones and instream habitat), the exception being the most upstream site sampled (Site 11, Ellensbrook Rd) (see Plate 1) which provided no shade and had no woody debris, features often associated with the presence of Nightfish and Western Pygmy Perch.

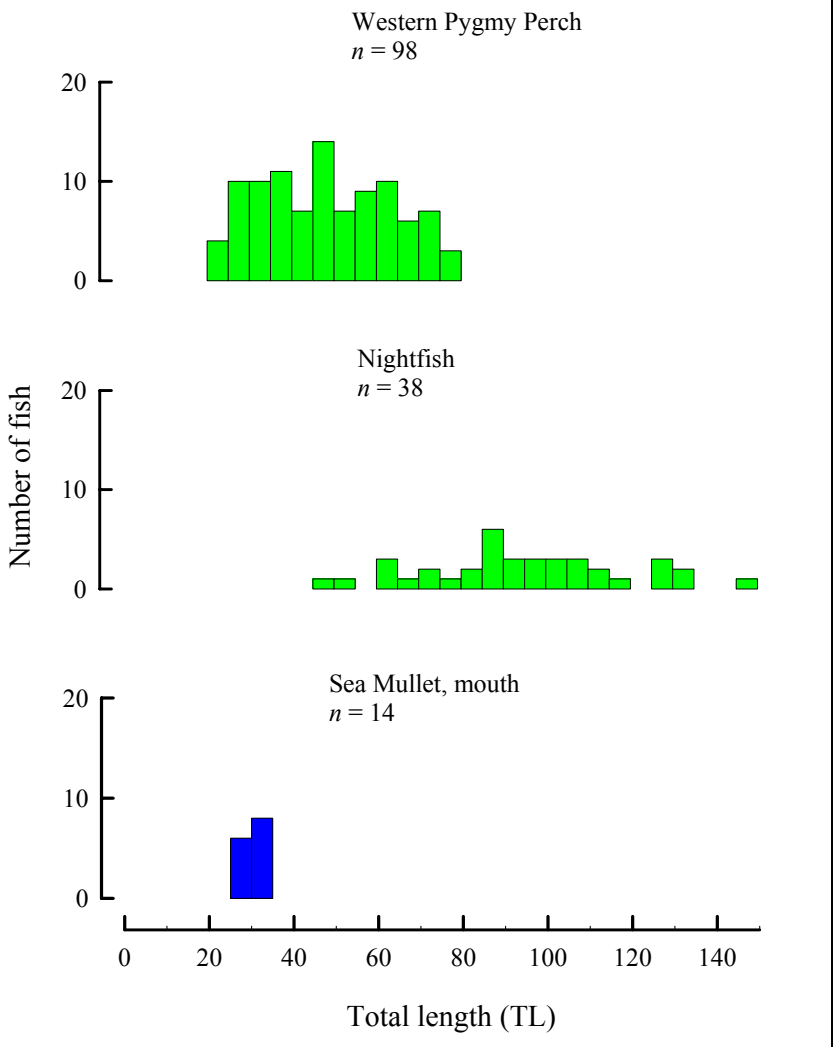

Figure 4 Length-frequency histograms of fishes captured in Ellen Brook during September 2003.

Table 1 The total number and abundance (m^{-2}) (in parenthesis) of each fish species captured at each site sampled in Ellen Brook. See Figure 1 for site locations and Plate 1 for site photographs. N.B. The mosquitofish is an introduced species.

			Fish species				
Site #	**Site name**	**Area sampled (m^2)**	Western Pygmy Perch (*Edelia vittata*)	Nightfish (*Bostockia porosa*)	Sea Mullet (*Mugil cephalus*)	Zebra Fish (*Girella zebra*)	Mosquitofish (*Gambusia holbrooki*)
1	Mouth	200	10 (0.05)	8 (0.04)	200 (1.0)	15 (0.08)	-
2	Homestead	30	145 (4.83)	1 (0.03)	-	-	-
3	Ellen Brook Weir	110	62 (0.56)	5 (0.05)	-	-	2 (0.02)
4	Meekadarribee	30	21 (0.7)	7 (0.23)	-	-	3 (0.1)
5	Glenbourne 1	200	-	6 (0.03)	-	-	-
6	Glenbourne 2	200	5 (0.025)	2 (0.01)	-	-	-
7	Herons Bk	100	-	-	-	-	200 (2.0)
8	Caves Rd	100	-	3 (0.03)	-	-	-
9	Basewood	100	25 (0.25)	8 (0.08)	-	-	-
10	Garstone Rd	100	-	8 (0.08)	-	-	-
11	Ellensbrook Rd	100	-	-	-	-	-
	TOTAL	1270m^2	268 (0.58)	48 (0.05)	200 (0.09)	15 (0.007)	205 (0.19)

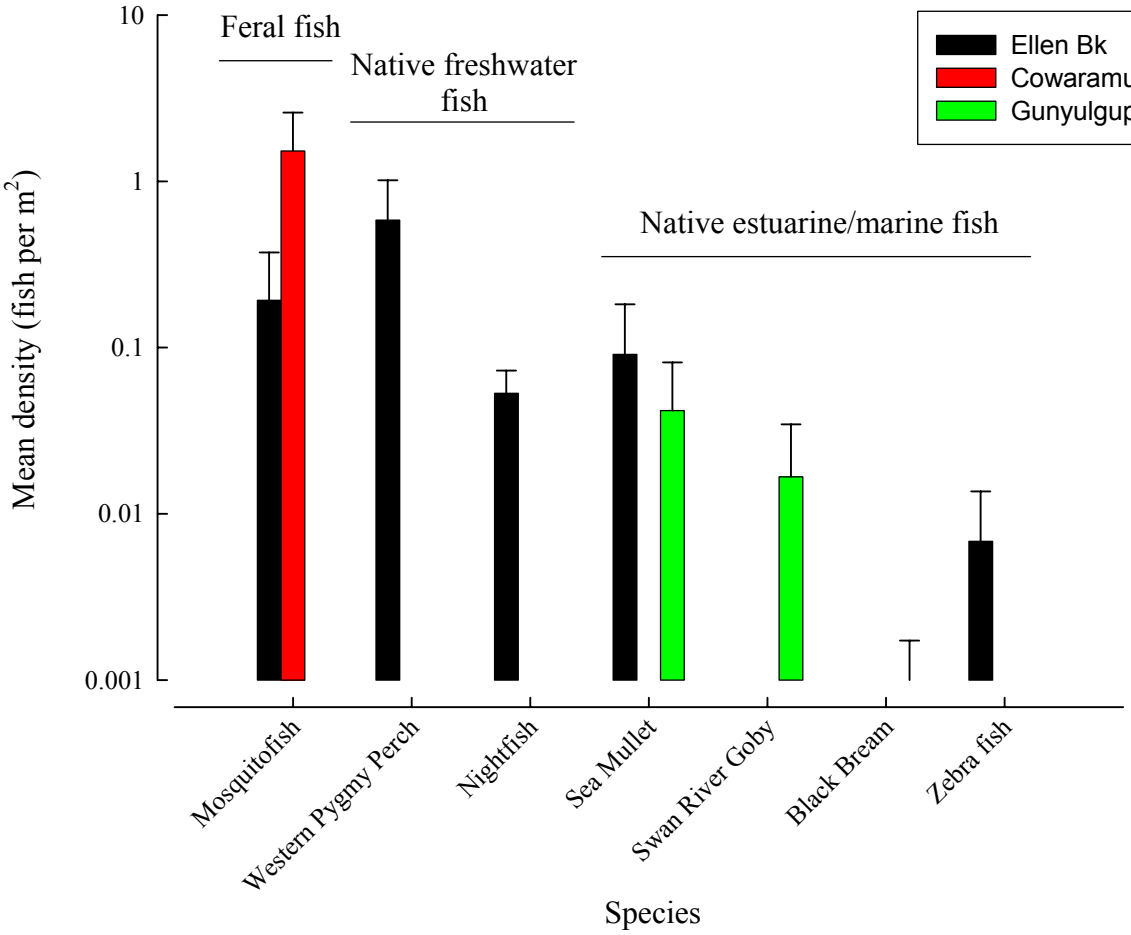

Figure 5 Mean density (+ 1 S.E.) of each fish species in Ellen Brook, Cowaramup Brook and Gunyulgup Brook in September 2003.

Cowaramup Brook (Figures 2 and 5)

The only fish species captured in the six sites sampled in Cowaramup Brook was the introduced Mosquitofish (Figures 2, 5). A total of 1280 Mosquitofish were captured from three sites (sites 3, 5 and 6 – see Table 4 for site names and Figure 2 for site localities), with densities ranging from 0.8 fish m^{-2} at the boundary of the National Park (site 3) to 5.0 fish m^{-2} above the large dam at Merribrook (site 6). (*See Discussion for the impact that Mosquitofish has on native fishes*.)

Mosquitofish

Gunyulgup Brook (Table 2, Figures 3, 5 and 6)

Three species of fish were captured in the eight sites sampled in Gunyulgup Brook (Table 2, Figures 3 and 5). These include the estuarine Swan River Goby and Black Bream and the marine/estuarine opportunistic Sea Mullet. All three species were found at the mouth of the brook, with the Black Bream (1 specimen, 43 mm TL) and Sea Mullet (5 individuals, 34-43 mm TL) being small juveniles. In contrast, the 60 Sea Mullet captured at Caves Rd were much larger and ranged in length from 204 to 261 mm TL (Figure 6, Table 2).

Swan River Goby *Sea Mullet* *Black Bream*

Photographs: D. Morgan

No other sites were found to house fish (see Table 2).

Table 2 The total number and abundance (m^{-2}) (in parenthesis) of each fish species captured at each site sampled in Gunyulgup Brook. See Figure 3 for site locations and Plate 3 for site photographs.

			Fish species		
Site #	**Site name**	**Area sampled (m^2)**	Swan River Goby (*Pseudogobius olorum*)	Black Bream (*Acanthopagrus butcheri*)	Sea Mullet (*Mugil cephalus*)
1	Mouth	150	20 (0.13)	1 (0.007)	5 (0.03)
2	Caves Rd	200	-	-	60 (0.3)
3	Wildwood Rd	200	-	-	-
4	Below Lamonts Dam	100	-	-	-
5	Upper north branch	100	-	-	-
6	Abbeys Farm Rd (below dam)	200	-	-	-
7	Abbeys Farm Rd (in proposed Hilton Dam)	400	-	-	-
8	Abbeys Farm Rd (stream above dam)	100	-	-	-
	TOTAL	$1450m^2$	20 (0.02)	1 (0.0008)	65 (0.04)

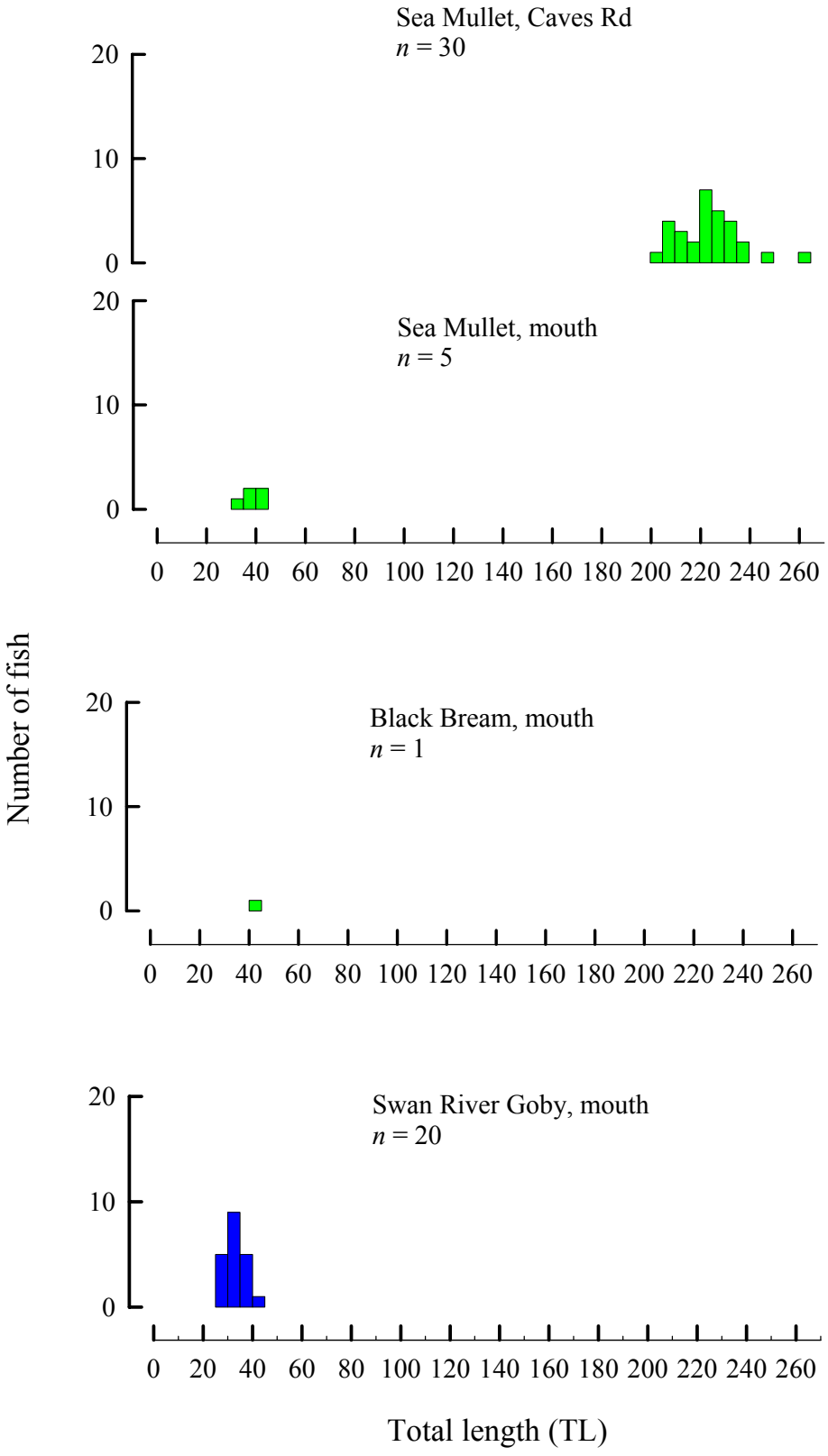

Figure 6 Length-frequency distributions of fishes captured in Gunyulgup Brook during September 2003.

3.2 Freshwater crayfish species captured

A key to the freshwater crayfishes of south-western Australia has been included in an Appendix.

Ellen Brook (Table 3, Figures 1 and 7)

Four species of endemic freshwater crayfish were captured in Ellen Brook, including the widespread smooth Marron (*Cherax cainii*), the common Gilgie (*Cherax quinquecarinatus*), the restricted Gilgie (*Cherax crassimanus*) and the widespread Koonac (*Cherax preissii*) (Table 3, Figures 1, 7-9). While only two, eight and four individuals of the Marron, the restricted Gilgie and the Koonac were captured, respectively, over 500 Gilgies were found throughout Ellen Brook, with densities peaking at 3.0 Gilgies m^{-2} at site 10 (Garstone Rd, the second uppermost site) (Table 3, Figure 7). Only one Gilgie was found at the uppermost site (site 11) which offered little habitat or shade (see Plate 3). The overall mean density of Gilgies throughout Ellen Brook was high, with approximately every 2 m^2 of stream bed being occupied by one animal.

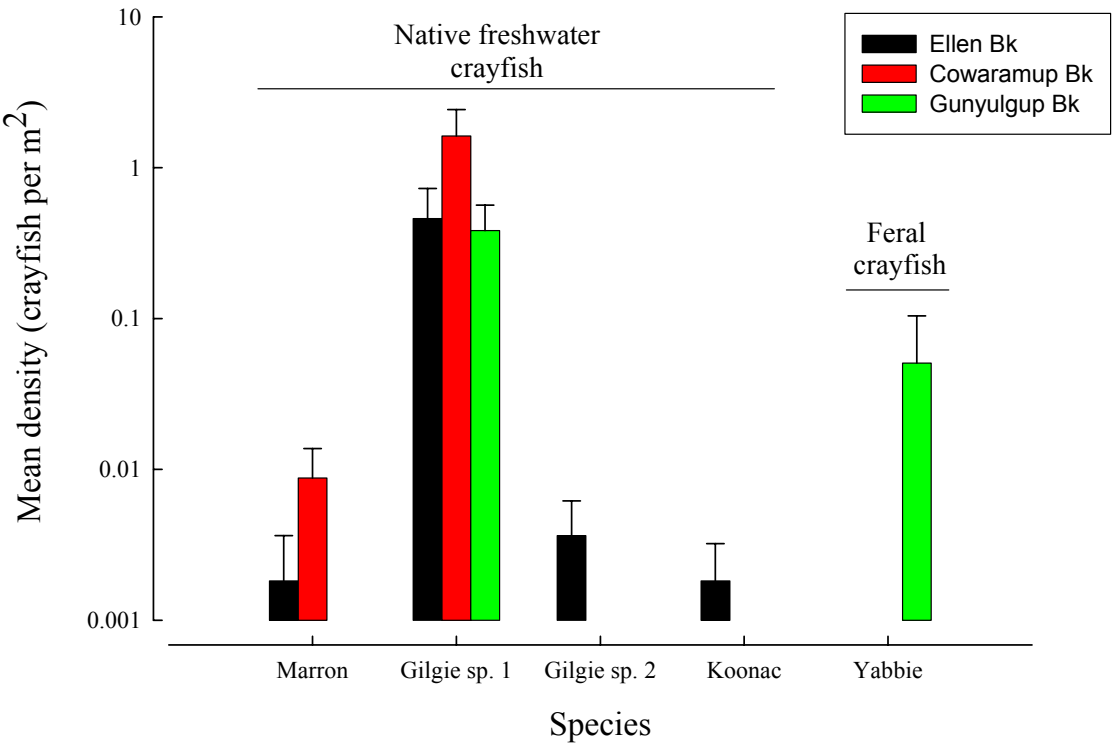

Figure 7 Mean density (+ 1 S.E.) of each freshwater crayfish species captured in Ellen Brook, Cowaramup Brook and Gunyulgup Brook in September 2003.

Table 3 The total number and abundance (m^{-2}) (in parenthesis) of each freshwater crayfish species captured at each site sampled in Ellen Brook. See Figure 1 for site locations.

Site #	Site name	Area sampled (m^2)	Freshwater crayfish species			
			Marron (*Cherax cainii*)	Gilgie sp. 1 (*Cherax quinquecarinatus*)	Gilgie sp. 2 (*Cherax crassimanus*)	Koonac (*Cherax preissii*)
1	Mouth	200	-	-	-	3 (0.015)
2	Homestead	30	-	-	-	-
3	Ellen Brook Weir	110	-	-	-	-
4	Meekadarribee	30	-	-	-	-
5	Glenbourne 1	200	-	50 (0.25)	5 (0.025)	-
6	Glenbourne 2	200	-	30 (0.15)	3 (0.015)	1 (0.005)
7	Herons Bk	100	2 (0.02)	35 (0.35)	-	-
8	Caves Rd	100	-	80 (0.8)	-	-
9	Basewood	100	-	50 (0.5)	-	-
10	Garstone Rd	100	-	300 (3.0)	-	-
11	Ellensbrook Rd	100	-	1 (0.01)	-	-
	TOTAL	1270m^2	2 (0.002)	546 (0.46)	8 (0.004)	4 (0.002)

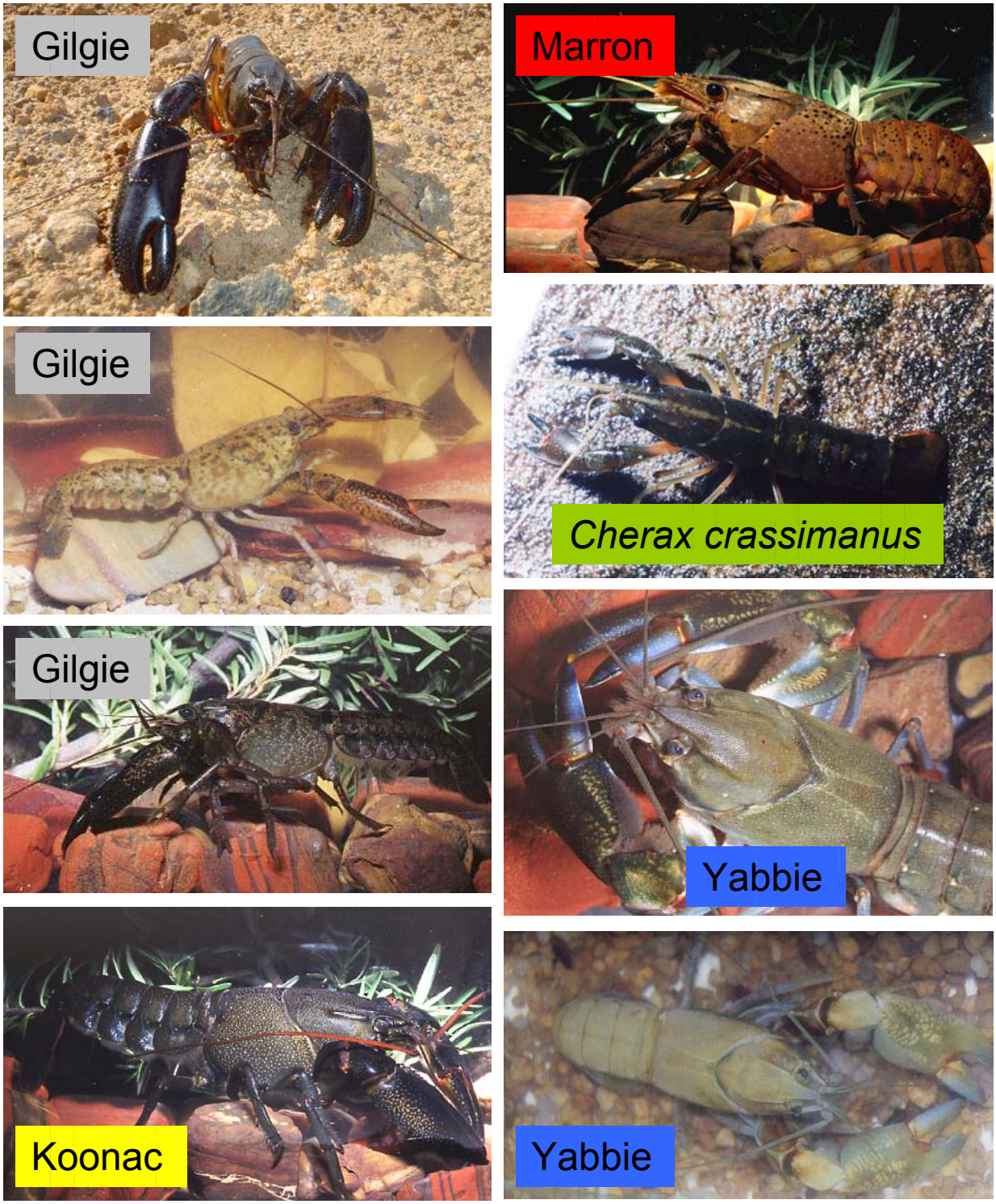

Figure 8 The freshwater crayfish captured during this study, including the common Gilgie *Cherax quinquecarinatus*, the Koonac *Cherax preissii*, the widespread smooth Marron *Cherax tenuimanus* and the restricted Gilgie *Cherax crassimanus*. Note the variation in coloration of the gilgie. Also included is the introduced yabbie *Cherax destructor*. With the exception of the Yabbie, which during this study was only captured in Gunyulgup Brook, all species were found in Ellen Brook. The Marron and widespread Gilgie were also both captured in Gunyulgup Brook and Cowaramup Brook.

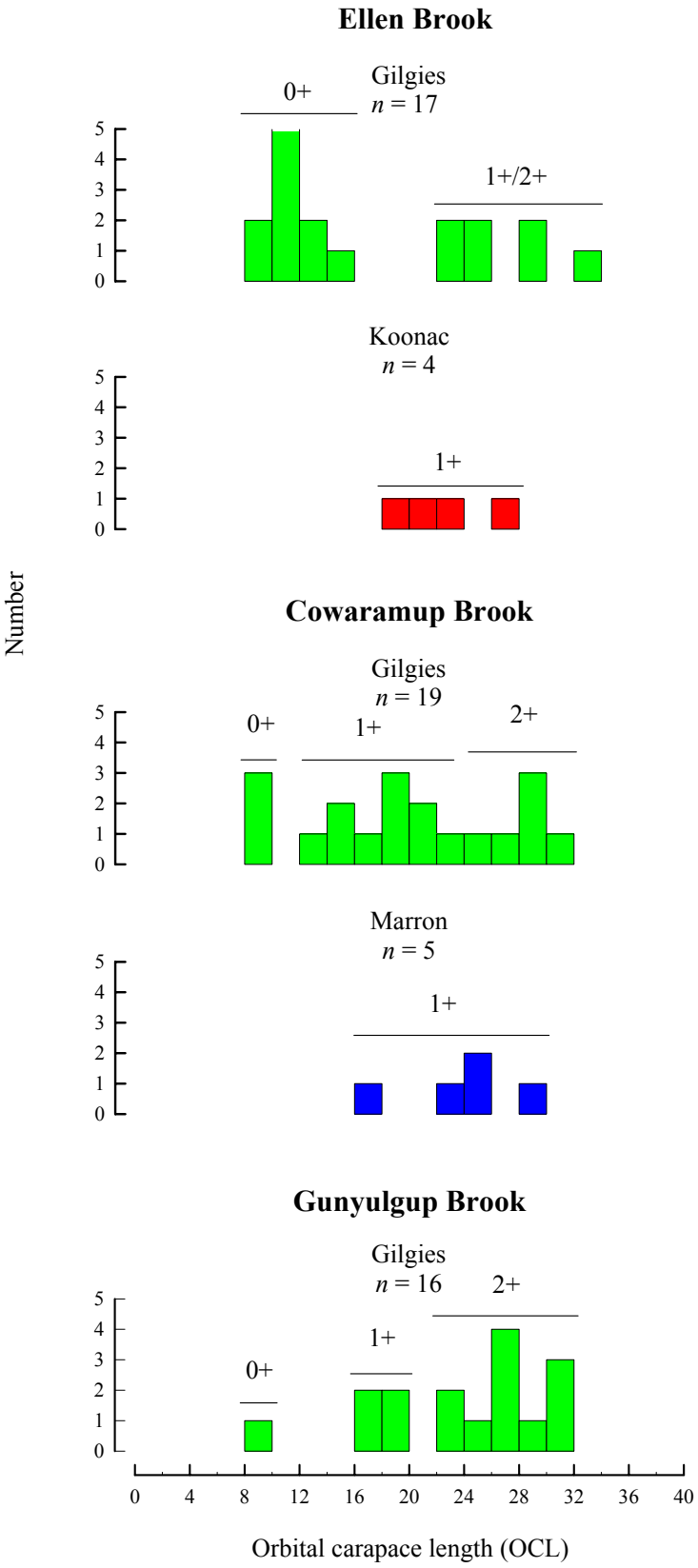

Figure 9 Length-frequencies distributions of freshwater crayfish species captured in Ellen Brook, Cowaramup Brook and Gunyulgup Brook in September, 2004. N.B. Likely age cohorts are provided, see text for explanation.

Cowaramup Brook (Table 3, Figures 1 and 7)

The densities of the widespread Gilgie were highest in Cowaramup Brook, with an average mean abundance of 1.62 Gilgies m^{-2} (Table 4, Figures 7 and 8). A total of 963 Gilgies were captured in Cowaramup Brook and they were found in all sites, including the mouth of the brook (Table 4). Densities of Gilgies were highest at sites 5 (Merribrook) and 2 (Gracetown Bridge), where approximately 4.2 and 3.0 individuals were found in each m^2. A total of six Marron were also captured in three of the six sites sampled (Table 4). All of the Marron captured were small and were probably in their first or second year of life.

All sites sampled in Cowaramup Brook offered excellent in stream habitat and shade for freshwater crayfish.

Table 4 The total number and abundance (m^{-2}) (in parenthesis) of each freshwater crayfish species captured at each site sampled in Cowaramup Brook. See Figure 2 for site locations.

			Freshwater crayfish species	
Site #	**Site name**	**Area sampled (m^2)**	Marron (*Cherax cainii*)	Gilgie sp. 1 (*Cherax quinquecarinatus*)
1	Mouth	100	2 (0.02)	3 (0.03)
2	Gracetown Bridge	100	2 (0.02)	300 (3.0)
3	National Park boundary	100	-	60 (0.6)
4	Caves Rd	160	2 (0.0125)	150 (0.94)
5	Merribrook	60	-	250 (4.17)
6	Merribrook (above dam)	200	-	200 (1.0)
	TOTAL	720m^2	6 (0.009)	963 (1.62)

Gunyulgup Brook

A total of 41 Yabbies were captured in Gunyulgup Brook, with 40 and one captured at sites 4 and 6, respectively (Table 5, Figure 8). The length-frequency distribution of a sub-sample of those captured is shown in Figure 10. There appeared to be three age cohorts (year classes) present (based on age and growth data for the Hutt River by Beatty *et al.* (in press)), including newly released (0+) individuals, indicating that this species was a self-maintaining population. Gilgies were captured in all sites with the exception of the mouth (Table 5), while Marron were only found in the large dam at site 7, where they were probably introduced. The presence of a Yabbie below this dam (site 6) suggests that this is also the most likely avenue of their introduction into this part of the brook. The fact that the majority of Yabbies were caught on another branch of the brook implies that there has been multiple introductions to the system.

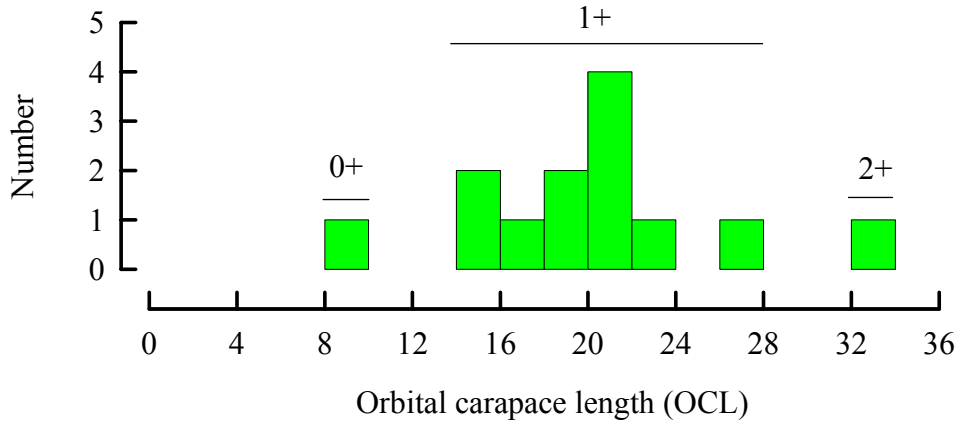

Figure 10 Length-frequency distributions of the feral Yabbie *Cherax destructor* captured in Gunyulgup Brook during September 2003. N.B. Likely age classes are shown.

Table 5 The total number and abundance (m^{-2}) (in parenthesis) of each freshwater crayfish species captured at each site sampled in Gunyulgup Brook. See Figure 3 for site locations. N.B. The Yabbie is an introduced species.

Site #	Site name	Area sampled (m^2)	Freshwater crayfish species: Marron (*Cherax cainii*)	Gilgie sp. 1 (*Cherax quinquecarinatus*)	Yabbie (*Cherax destructor*)
1	Mouth	150	-	-	-
2	Caves Rd	200	-	250 (1.25)	-
3	Wildwood Rd	200	-	200 (1.0)	-
4	Below Lamonts Dam	100		40 (0.4)	40 (0.4)
5	Upper north branch	100	-	15 (0.15)	-
6	Abbeys Farm Rd (below dam)	200	-	18 (0.09)	1 (0.005)
7	Abbeys Farm Rd (in proposed Hilton Dam)	400	1 (0.0025)	8 (0.02)	-
8	Abbeys Farm Rd (stream above dam)	100		15 (0.15)	-
	TOTAL	$1450m^2$	1 (0.0003)	546 (0.38)	41 (0.051)

3.3 Physico-chemical properties

There was a general increase in water temperatures and decrease in conductivity upstream in all three streams sampled during the current study (Figure 11). The generally higher water temperatures recorded at upstream sites was likely due to the reduced size of the streams at those sites, coupled with reduced shading due to degraded riparian vegetation associated with the largely agricultural land use.

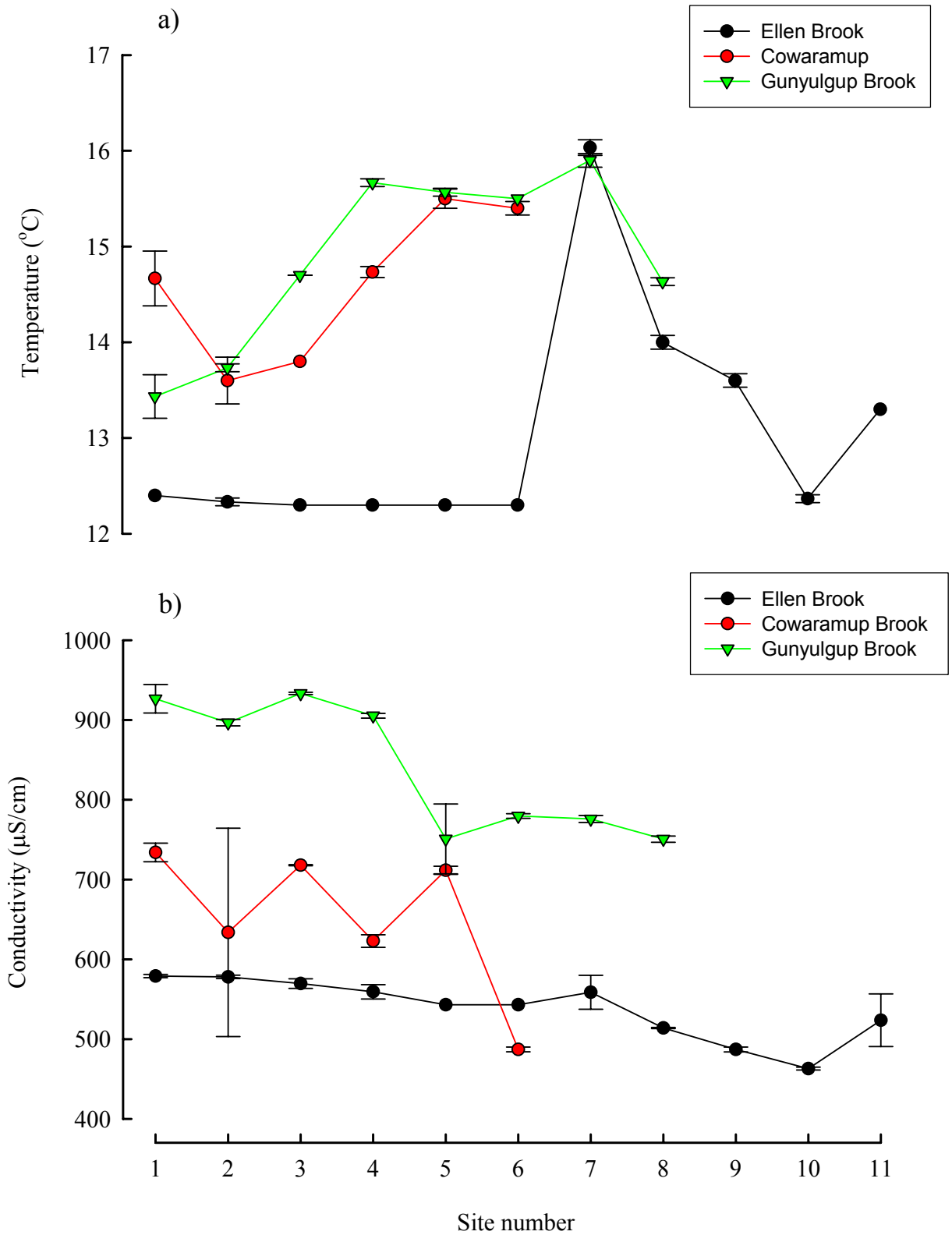

Figure 11 The temperature (a) and conductivity (b) of the sites sampled in Ellen Brook, Cowaramup Brook and Gunyulgup Brook during September 200.

4. Discussion

Fishes of Ellen, Cowaramup and Gunyulgup Brooks

The fish fauna of the three streams sampled during this study was found to be depauperate, with only two endemic freshwater fishes captured (i.e. Western Pygmy Perch and Nightfish), both of these being found in Ellen Brook. Juvenile marine/estuarine Sea Mullet were found in the mouth of Ellen Brook and Gunyulgup Brook, with larger Sea Mullet captured in Gunyulgup Brook as far upstream as Caves Rd. The estuarine Black Bream and Swan River Goby were only captured in the lower section of Gunyulgup Brook. The marine Zebra Fish was captured in the rock pools at the mouth of Ellen Brook. The introduced Mosquitofish was the only fish species found in Cowaramup Brook, and was also found in three sites in Ellen Brook.

Western Pygmy Perch

The largest Western Pygmy Perch captured in Ellen Brook was 78 mm TL, a size considerably longer than previously reported for the species (i.e. 68 mm TL, from almost 3000 individuals measured) (see Pen and Potter (1991) in the Collie River and Figure 4). Furthermore, 13 of the 268 individuals captured and measured in Ellen Brook were larger than the largest reported from the Collie River. According to Pen and Potter (1991), these larger fish would most likely have been in the fifth or even sixth year of life. This high proportion of large individuals is unusual in that most populations of Western Pygmy Perch are represented by the 0+, 1+ and 2+ cohorts, which comprised 99% of all fish examined in the Collie River. In the Collie River, Western Pygmy Perch attain lengths of ~42 and 51 mm TL at the end of their first and second year of life, respectively (Pen and Potter 1992). Based on this length at age data, almost 43% of Western Pygmy Perch in Ellen Brook would have been in their fourth, fifth or sixth year of life. Why does Ellen Brook posses such a high proportion of older fish (i.e. 43%>3 years old, cf. 1%>3 years old in the Collie River)? A number of possible explanations are outlined below:

Is predation on large Western Pygmy Perch higher in the Collie River? Possibly. The Collie River is plagued by feral Redfin Perch (*Perca fluviatilis*), a known predator of Western Pygmy Perch (Morgan *et al*. 2002). However, the large size of these pygmy perch is unusual even compared to other rivers that do not contain Redfin Perch (Morgan *et al*. 1998, unpublished data). It may be that either the high abundance of Gilgies in the stream predate heavily on newly-hatched and juvenile pygmy perch, particularly if water levels during the breeding period in late Spring and Summer become substantially reduced as a result of water extraction, land-

clearing and the long-term drought experienced in the region. Nightfish also have the potential to predate on small pygmy perch.

Nightfish

The population of Nightfish in Ellen Brook is similarly dominated by larger, older fish. For example, in the Collie River 98.5% of the population is < than three years old (<85 mm TL), whereas in Ellen Brook, over 70% of the population is > three years old (i.e. >85 mm TL) (see Pen and Potter 1990). These dramatically contrasting population demographics are important, particularly in terms of ensuring the survival of what may be an aging population. It is possible that either predation is high on juvenile fish or that the high degree of water extraction is impacting on the fishes. The considerable number of new dams in the catchment, increased land clearing and long term drought experienced in the region again may be affecting environmental flows to the degree that only the few larger fish are surviving, possibly as they are more capable of competing for habitat as it becomes limited. Surveys of the fish fauna in the dry period could aid in evaluating the degree of habitat available to fishes during this period.

Sea Mullet

In Western Australia Sea Mullet are believed to spawn at sea in deep water (Thomson 1963), with new recruits moving into estuaries. In the mouths of Ellen Brook and Gunyulgup Brook these recruits were 27-43 mm TL, a size almost identical to that reported by Orr (2000) for new recruited Sea Mullet in Wilson Inlet (south-western Australia) in June 1989. Based on length-frequencies of new recruits in the Swan River Estuary and Wilson Inlet, respectively, Orr (2000) and Chubb *et al*. (1981) estimated that the spawning period extends from April to September. A protracted spawning period from mid-Autumn to Spring allows the juveniles of this species to enter these typically closed rivers at the time that they are connected to the sea. The slightly greater size of new recruits in Gunyulgup Brook (34-43 mm TL) compared to Ellen Brook (27-32 mm TL) may reflect differences in time taken to enter the brooks from offshore spawning grounds. Based on length at age and maturity data provided by Orr (2000) for Sea Mullet in Wilson Inlet, the larger Sea Mullet captured at Caves Rd on Gunyulgup Brook would most likely have been immature individuals at the end of their second year of life.

Black Bream

Based on known spawning periods, size compositions and growth rates of Black Bream in the south-west, the capture of a single juvenile 43 mm TL Black Bream from Gunyulgup Brook is interesting in that, compared to other populations studied (see Sarre and Potter 1999, 2000)), the

size of this fish is not representative. For example, spawning usually occurs in late spring, which would put the Ellen Brook fish at 10 months old, however, in the Swan River, fish range in length from ~45-115 mm TL by just four months of age. It is possible that spawning may have occurred outside the 'normal' spawning period in Autumn 2004 as a consequence of conditions being favourable, a phenomenon that has occurred with Black Bream held in captivity (G. Sarre pers. com.).

Swan River Goby

The Swan River Goby is extremely tolerant of salinity and is an extremely successful estuarine species that is often found large distances from the coast (Morgan *et al*. 2003). This species was only captured near the mouth of Gunyulgup Brook. Barriers in this and the others streams studied probably have prevented their upstream migration.

Mosquitofish

Mosquitofish were introduced by health authorities from the 1930s, is extremely abundant in the south-west (Hill River to Pallinup River) and southern Pilbara (Hutt, Chapman, and Greenough rivers), with an isolated population reported in the Kimberley (Morgan *et al*. 2004). This species is extremely tolerant of many conditions, including highly degraded waters with salinities at least up to 58.2 parts per thousand (ppt). The species dominates the fish fauna of nearby rivers including the Vasse, Blackwood and Margaret (Morgan and Beatty 2003, 2004, Morgan *et al*. 2003).

The impact of Mosquitofish on the endemic fishes of south-western Australia was highlighted by Gill *et al*. (1999). Those workers demonstrated in tank experiments that the degree of caudal fin damage to Western Pygmy Perch and death, caused by Mosquitofish was directly related to the density of Mosquitofish. The relative degree of caudal fin damage in wild populations of the south-west Australian endemic Western Pygmy Perch, Nightfish, and Western Minnow (*Galaxias occidentalis*), was found to be most severe in 0+ (< 1 year old) fish for all species, but was also relatively high in older Western Pygmy Perch (Gill *et al*. 1999). Of 1322 fish examined for caudal fin damage, c. 17 % showed no sign of attack, c. 38 % had minor damage, c. 25 % had moderate damage and c. 20 % had major damage. Evidence was also provided to suggest that in lentic habitats lacking cover and containing Mosquitofish, native fishes were seldom captured. In contrast, habitats that provided cover and also contained Mosquitofish often (63%) also contained native fishes. Griffiths (1972) reported fin-nipping attacks on native fishes in south-western Australia during aquarium trials, and found 100% mortality for the small endemic Black-stripe Minnow (*Galaxiella nigrostriata*) that were

exposed to Mosquitofish (from Morgan *et al.* 2004). In light of these findings it is likely that the high degree of instream habitat in Ellen Brook would assist native fishes in avoiding Mosquitofish attack, however, when water levels become substantially reduced during late summer the level of exposure would increase substantially.

Freshwater crayfishes of Ellen, Cowaramup and Gunyulgup Brooks

Marron

Marron (Figure 9) occupy permanent waterbodies being unable to burrow to escape drought in temporary systems, breed only once a year (during spring, releasing juveniles in late spring/early summer), and grow relatively rapidly to a large size (Riek, 1967; Austin and Knott, 1996; Beatty *et al.* 2003). The widespread Smooth Marron was captured in very low abundances in: Cowaramup Brook at the Caves Rd site and the two sites in Gracetown; in Gunyulgup Brook within the large Abbey Farm dam; and in Ellen Brook at the Herons Brook site (Tables 3-5). The Marron captured in these streams appeared to be approximately 1 year of age (e.g. Cowaramup Brook (Beatty *et al.* 2004).

Given that the abundance of Marron in these three small streams was very low with no mature individuals being recorded (i.e. >~30 mm OCL, the approximate minimum size at maturity, Beatty *et al.* (2003)), it appears that they are not self-maintaining populations and have either been deliberately stocked into the streams at easily accessed sites for recreational fishing, or have escaped from nearby farm dams into the streams. Therefore, it is likely that the Marron captured at the mouth of Cowaramup Brook were deliberately stocked in the past two years as there are no farm dams in the close vicinity and they were not captured at the site immediately upstream from the mouth.

Water levels and quality appeared to be adequate to sustain the Marron populations at the time of sampling (i.e. near the period of peak flow), however, it is likely that these would decline (particularly via increased water temperatures and decreased dissolved oxygen levels in small pools) in remnant pools during summer resulting in high marron mortality. Furthermore, fishing mortality and natural predation (e.g. avian), would also be exacerbated during periods of low water levels.

It is likely that these three streams historically contained self-sustaining populations of Marron with recent relatively dry climate and increased water attenuation (e.g. dam construction)

resulting in reduced stream-flows and subsequent population decline. It is also possible that the Marron populations continue to be self-maintaining with a very low rate of spawning and recruitment due to large rates of juvenile mortality. Sampling should occur in the remnant pools of these streams in late summer in order to assess whether Marron survive during periods of low flow.

Gilgies

Gilgies *C. quinquecarinatus* (Figure 9) are found in a wide variety of permanent and temporary aquatic systems in south-western Western Australia (Riek, 1967; Austin and Knott, 1996). They have a life history strategy adapted to these water bodies which includes: the ability to burrow into the water table in temporary waterbodies, a relatively small size at first maturity reproducing after the first year of life, and being able to spawn multiple times over the annual breeding period (spring-summer) (Austin Knott, 1996; Beatty *et al.* 2005). Therefore, this species had a wide distribution and large abundance in all three streams in the current study reflects this species adaptiveness to such small lotic systems, subject to low summer water levels (Tables 3-5). Furthermore, the omnivorous nature of freshwater crayfish, would result in this being likely being the dominant species in terms of structuring the aquatic food web in these streams.

The restricted gilgie, *C. crassimanus* is found in the extreme corner of south-western Australia from approximately Margaret River to Denmark (Austin 1986; Horwitz and Adams, 2000). It too has been shown to have considerable genetic variability between populations (Austin and Knott, 1996). It is a relatively small species and little is known about its biology. The population in Ellen Brook therefore represents the northern-most extent of its range and reflects its preference for small waterbodies.

Yabbies in Gunyulgup Brook

Yabbies were introduced into W.A. in 1932 for the purpose of aquaculture in wheat-belt farm dams, and support a valuable industry. However, they have recently been recorded from a number of wild systems in south-western Western Australia and pose a serious threat to the endemic freshwater crayfish species and the overall function and structure of the ecosystems into which they are becoming established (Morrissy and Cassells, 1992; Beatty *et al.* in press). In recognition of the threat that they pose, the Department of Fisheries, W.A. only allow the culture of Yabbies East of the Albany Hwy. This study represents the first record of Yabbies in the wild aquatic systems of the unique Cape to Cape region and is of serious concern. Their presence is

likely a result of natural or deliberate release from farm dams in the region. They have also recently been found in the nearby Vasse River (Morgan and Beatty 2004).

Yabbies may spawn up to three times a year from late winter to late summer (cf. once for marron) and thus can rapidly increase in number when introduced into a system. Furthermore, as with other freshwater crayfish species, they consume a wide variety of food sources (omnivorous) and thus may have considerable impact on the ecosystem (Beatty *et al.* in press). A wild population of Yabbies in the Hutt River (near Geraldton) has recently been found to have the serious porcelain disease caused by the microsporidian *Thelohania parastaci*, a disease that has also impacted on the aquaculture industry in this State (Beatty *et al*. in press). This disease is contracted by a crayfish consuming infected tissue. It is possible that the endemic crayfish may be able to contract this disease by consuming infected Yabbie tissue. Therefore, the potential accompanying spread of this and other diseases by Yabbie introductions is of considerable concern in this region. The identification of this, and other diseases, in the yabbies of Gunyulgup Brook should be assessed.

Recommendations

- Dry season sampling is required to assess the available habitat for fishes during periods of little or no flow.
- Monitor the aging populations of Western Pygmy Perch and Nightfish to ensure these populations are maintained.
- Assess the potential for spread of disease from Yabbies to native crayfishes.
- Compare historical flow regimes with current environmental flows.
- Determine the potential for Mosquitofish and Yabbie control.
- Reintroduce native fishes to areas they may have been lost.

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APPENDIX I

Key to the native inland fishes of south-western Australia

(feral fishes not included)

1a. Four pairs of barbels ('whiskers') present..... **Freshwater Cobbler**

1b. Barbels absent .....Go to 2

2a. Scales absent and body fusiform (galaxiids).....Go to 3

2b. Scales present.....Go to 7

3a. Caudal (tail) fin forked and dorsal fin origin above or slightly in front of anal fin origin.....Go to 5

3b. Caudal (tail) fin rounded and dorsal fin origin well behind anal fin origin.....Go to 4

4a. Live coloration consists of two lateral black stripes separated by an orange stripe and dorsal fin originates anterior to the vertical that passes through the fifth anal ray.....**Black-stripe Minnow**

4b. Live coloration consists of a lateral copper coloured band and dorsal fin originates posterior to the vertical that passes through the fifth anal ray.....**Mud Minnow**

5a. Live coloration consists of large, ocellated, non-uniformly spaced lateral spots, fins orange and vertical dark band below eye and behind operculum.....**Trout Minnow**

5b. not as above.....Go to 6

6a. Live coloration consists of vertical banding on sides, lower jaw protrudes and has canine teeth and fangs at the mandibular symphysis.....**Western Minnow**

6b. No vertical banding on sides, jaws equal and lacks canine teeth and fangs at the mandibular symphysis.....**Spotted Minnow**

7a. Two separate dorsal fins present, or if fin single, consists of pronounced spiny front portion and rear soft portion..... .....Go to 8

7b. One dorsal fin composed of five or six distinct fin rays and body long and slender.....**Salamanderfish**

8a. Two dorsal fins well separated.....Go to 9

8b. Two dorsal fins joined and consist of spiny anterior portion and soft, rounded posterior portion.....Go to 10

9a. Two dorsal fins well separated and caudal fin rounded, benthic species.....**Swan River Goby**

9b. Two dorsal fins well separated and caudal fin distinctly forked.....**Western Hardyhead**

10a. Mouth large, reaching beyond anterior margin of eye.....Go to 11

10b. Mouth small, terminal, never reaches eye.....**Western Pygmy Perch**

11a. A series of large conspicuous pores below eyes and on snout, coloration olive-purple, 16-17 soft rays on 2nd dorsal fin, scales small, lateral line continuous, caudal fin distinctly rounded.....**Nightfish**

11b. 9-11 soft rays on 2nd dorsal fin, scales moderate size, lateral line not obvious.....**Balston's Pygmy Perch**

Key to the freshwater crayfishes of south-western Australia

(Engaewa species not included)

1a. Very short, rounded rostrum usually spineless, post orbital ridges absent or greatly reduced, tail entirely calcified.....**Obligate borrowing crayfish *Engaewa* spp.**

1b. Post orbital ridges present, posterior half of telson membranous.....***Cherax* spp**. Go to 2

2a. Setae present on arm (merus) and wrist (carpus).....**Yabbie *C. destructor***

2b. Setae absent on arm and wrist, setae may be present on the edge of propodal palm….....Go to 3

3a. Spines present on the dorsal surface of telson…….....…….....Go to 4

3b. Spines absent on the dorsal surface of telson…….....Go to 5

4a. Obvious setae present on the cephalothorax (head region) of larger individuals, central longitudinal ridge extending to cervical groove…….....**Margaret River Hairy Marron *C. tenuimanus***

4b. Obvious setae absent on the cephalothorax of larger individuals, central longitudinal ridge not extending to cervical groove…….....**common smooth Marron *C. cainii***

5a. Five longitudinal ridges present (central ridge may be reduced) on head (cephalon) (*C. crassimanus* sometimes has these ridges but are more reduced), relatively well developed rostrum and the spine on inner edge of wrist moderately curved and relatively blunt (compared to *C. crassimanus*).....**Gilgie *C. quinquecarinatus***

5b. Post-orbital ridges and rostral carinae on dorsal side of head reduced and central longitudinal ridge usually absent or greatly reduced such that usually two ridges present on head, relatively short rostrum.....Go to 6

6a. Dorsal surface of head lacks fine punctuations to give a shiny appearance …….....***C. glaber***

6b. Fine punctations present on dorsal surface of head to give a 'mat' appearance.....Go to 7

7a. Similar appearance to the gilgie and may have reduced central longitudinal ridge present on head, however, has a small, sharply curving spine on inner edge of wrist (gilgie and koonac moderately curved and relatively blunt) and relatively small maximum size (usually <30 mm OCL)….....***C. crassimanus***

7b. Central longitudinal ridge usually completely absent, short rostrum, large maximum size (>30 mm OCL), relatively large, spade-like claws……..…….....**Koonac *C. preissii***

References to crayfish key

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