Canning River
– freshwater fishes and barriers to migrations

Prepared for

Department of Water & South East Regional Centre for Urban Landcare (SERCUL)

January 2007

Centre for Fish and Fisheries Research
MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

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Citation:

Morgan, DL, Beatty, SJ & McAleer (2007). Canning River – freshwater fishes and barriers to migrations. Centre for Fish & Fisheries Research, Murdoch University report to Department of Water and South East Regional Centre for Urban Landcare (SERCUL).

Acknowledgements
We would like to acknowledge the financial support of the Department of Water and SERCUL. Thanks particularly to Laurence Radin, Tom Atkinson, Michael Whiting and Antonietta Torre for their efforts. Thanks also to Andrew Rowland, Mark Allen, Howard Gill and Simon Visser for field help.

Front cover: Fyke nets set upstream of the Seaforth Gauging Station to determine species movements

Summary

The Canning River is a highly regulated river system. Despite this, a total of 12 species of fish are recognised from the fresh waters of the Canning River catchment, i.e. upstream of Kent Street Weir. This fauna consists of four native freshwater fishes (all of which are endemic to south-western Western Australia), four fishes that are generally considered estuarine species and four introduced or feral fish species. A further species of native freshwater fish is reported in the Western Australian Museum Records. The Canning River also contains three species of freshwater crayfish, including the south-western Australian endemic Smooth Marron (*Cherax cainii*) and Gilgie (*Cherax quinquecarinatus*) and the introduced Yabby (*Cherax destructor*). It therefore remains an important river in terms of its fish assemblage.

The main focus of this study was to determine the extent of the impediment to fish movement of one of the barriers in the main channel of the Canning River: the Seaforth Gauging Station weir.

Monitoring of upstream and downstream fish movement over the Seaforth weir took place on four occasions (three replicate samples) between June and November 2006. The Western Minnow was the most abundant native species captured readily moving upstream and downstream over the weir on all sampling occasions; including its main spawning period that commences in winter.

Limited numbers of Western Pygmy Perch and Nightfish were recorded moving upstream over the weir in November; corresponding with their spring spawning period. The Freshwater Cobbler was also found to move upstream over the Seaforth weir predominantly in September and November, prior to its known summer spawning period.

This study therefore found little evidence of this structure impeding native fish migration during the study period and fishway construction would not be warranted based on these results. However, the study did not incorporate the summer spawning period of the relatively large Freshwater Cobbler and it may act as a barrier to its movement during those dry months.

It is recommended that an assessment be made of the degree of impediment to Freshwater Cobbler movement that this structure represents during summer. It is also recommended that similar seasonal investigations be undertaken at the weir ~500 m upstream of the Seaforth Gauging Station and the Kent St Weir which are likely to impede fish migrations in the Canning River.

Contents

Introduction

The catchment of the Swan-Avon River system, which includes the Canning River, is the largest in the South West Drainage Division of Western Australia and encompasses over 120,000 km^2. While the fish fauna associated with estuary of these systems is well recognised and has been the focus of numerous extensive studies (e.g. Chubb *et al*. 1981, Prince *et al*. 1982, Prince & Potter 1983, Chubb & Potter 1984, 1986, Loneragan *et al*. 1989, Loneragan & Potter 1990, Humphries & Potter 1993, Potter *et al*. 1994, Gill *et al*. 1996, Sarre & Potter 1999, 2000, Kanandjembo *et al*. 2001, Smith 2006), there is little published information with regard to the fish fauna associated with the fresh waters of the Canning or Swan-Avon River. Furthermore, the proximity of these systems to the Western Australian capital city, Perth, has lead to each being highly regulated and much of the hydrological regimes substantially modified.

The major tributaries of the Canning River include the Southern River, Bickley Brook, Yule Brook, Churchman Brook and Bull Creek, with much of the original streams modified to some extent. A number of studies have examined the fishes and/or freshwater crayfishes of the various tributaries, e.g. Aquatic Research Laboratory (1988) reported on the fish fauna of nine sites on the Canning River main channel between Canning Dam and the Bickley Brook confluence; Morrison (1988) and Hewitt (1992) examined the biology of Freshwater Cobbler (*Tandanus bostocki*) in Wungong Reservoir; Morgan & Sarre (1995) surveyed Bickley Brook Reservoir; Maddern (2003) examined the biology of a feral fish in Bull Creek; Beatty *et al*. (2005a) studied the growth and reproduction in the Gilgie (*Cherax quinquecarinatus*) in Bull Creek; Morgan & Beatty (2006) conducted a control programme for feral fish and subsequent restocking of native fish in Bull Creek; Beatty *et al*. (2005b) examined the fish and freshwater crayfish fauna of Southern River; Beatty *et al*. (2003) surveyed the fish and crayfish fauna of Churchman Brook Reservoir and Beatty *et al*. (2006) relocated Marron from Churchman Brook Reservoir during draining of the dam and subsequently restocked the reservoir; Tay (2005) and Beatty *et al*. (2006) report on the diet of a self-maintaining population of introduced Rainbow Trout from Churchman Brook Reservoir; and Morgan *et al*. (2004) provide a compilation of the introduced freshwater fishes in Western Australia, including some of those in the Canning River.

The current study had two main aims, the first of which was to provide an overview of the freshwater fishes in the Canning River and the second was to provide an assessment of the extent to which barriers, in particular the Seaforth Gauging Station, inhibit the migration of fishes in the highly regulated system. This study was initiated and funded by the Department of Water and the South East Regional Centre for Urban Landcare (SERCUL).

Methodology

Historical and contemporary collections of fish in the Canning River

As mentioned in the **Introduction**, a number of studies, many of which are considered grey literature, provide information regarding specific aspects of the fishes of the Canning River and its tributaries. Utilising GPS co-ordinates and the species occurrences provided in the relevant studies listed below, from the authors unpublished data, and from a number of additional sites sampled during this study (see Appendix 1), a series of species distributional maps were created using MapInfo. Relevant studies include those by Aquatic Research Laboratory (1988), Morrison (1988), Hewitt (1992), Morgan & Sarre (1995), Maddern (2003), Beatty *et al*. (2003, 2005a, 2005b, 2006), Morgan *et* al. (2004) and Tay (2005) (see Figure 1).

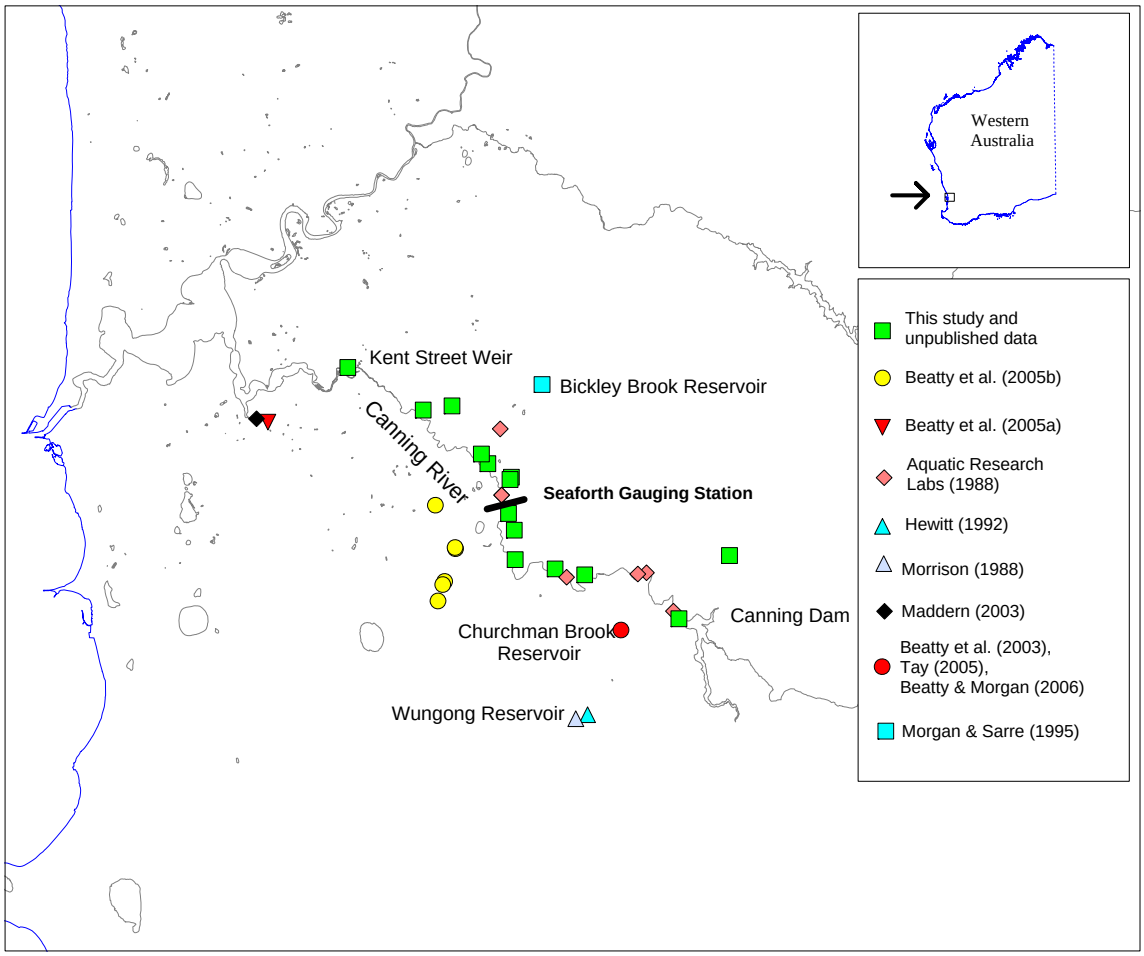

Figure 1 Ichthyological studies in the fresh waters of the Canning River catchment.

Species migrations above and below the Seaforth Gauging Station

During June, July, September and November 2006, fyke nets (composed of 2 mm woven mesh) were utilised to examine the movement of fishes at the Seaforth Gauging Station. Two fyke nets were set upstream of the structure; one of which faced downstream and caught fish moving upstream, and another set facing upstream to capture fish moving downstream. In each month, each net was set for a period of 72 h (i.e. three days) and checked every 24 h to allow for daily movements and for the calculation of a mean daily upstream and downstream movement of fish (and freshwater decapods). The mean number of fish and decapods moving upstream or downstream on each sampling month was calculated and illustrated using SigmaPlot (v. 9). The total length (TL) of each fish captured was measured to the nearest 1 mm, while the orbital carapace length (OCL) of each freshwater crayfish was also measured to the nearest 1 mm. Fish and freshwater decapods were released immediately after identification and length measurements.

Length-frequency histograms were generated using SigmaPlot (v. 9) for each species captured during each sampling event.

Discharge data for the Seaforth Gauging Station was provided by the Department of Water. These data were graphed using SigmaPlot (v. 9).

Flow rates, dissolved oxygen, temperature, pH and conductivity were recorded during each sampling month.

Results

Historical and contemporary collections of fish and freshwater crayfish in the Canning River

A total of 12 species of fish are recognised from the fresh waters of the Canning River catchment. This consisted of four native freshwater fishes (all of which are endemic to south-western Western Australia), four fishes that are generally considered estuarine species and four introduced or feral fish species. A further species of native freshwater fish is reported in the Western Australian Museum Records. The Canning River also contains three species of freshwater crayfish, including the south-western Australian endemic Marron (*Cherax cainii*) and Gilgie (*Cherax quinquecarinatus*) and the introduced Yabby (*Cherax destructor*).

Below is an account of each of the above species found in the Canning River and their distribution.

Native freshwater fishes of the Canning River

The four species of freshwater fish that are endemic to south-western WA that are found in the Canning River and its tributaries include the Freshwater Cobbler (*Tandanus bostocki*), the Western Minnow (*Galaxias occidentalis*), the Western Pygmy Perch (*Edelia vittata*) and the Nightfish (*Bostockia porosa*) (Plate 1, Figures 2, 3, 4 and 5). The Freshwater Cobbler and Nightfish are essentially restricted to the main channel of the Canning River and Wungong Reservoir. The Western Minnow and Western Pygmy Perch are more widespread being found within both the tributaries and main channel.

Plate 1 The four endemic freshwater fishes found in the fresh waters of the Canning River catchment. Photographs: D Morgan and M Allen (Freshwater Cobbler).

Details on the migratory patterns of each of these species are presented in the section entitled ***Species captured using fyke nets at the Seaforth Gauging Station: upstream and downstream migrations***.

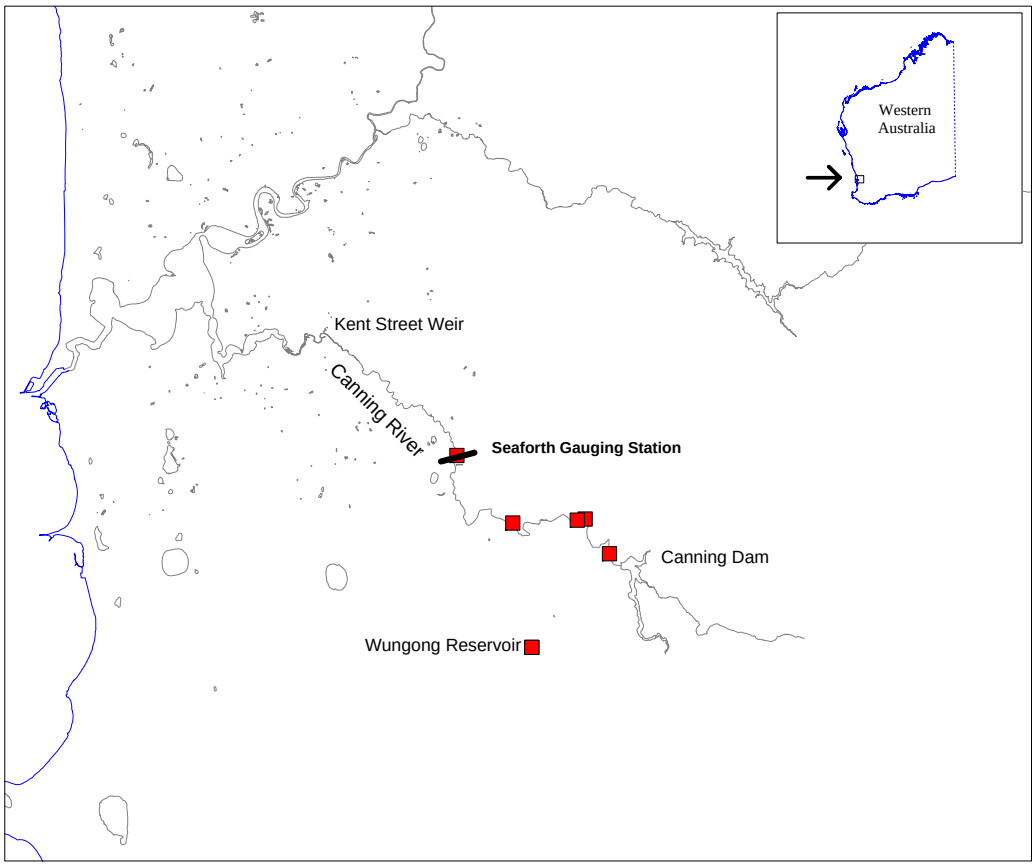

Figure 2 Records of Freshwater Cobbler within the Canning River catchment.

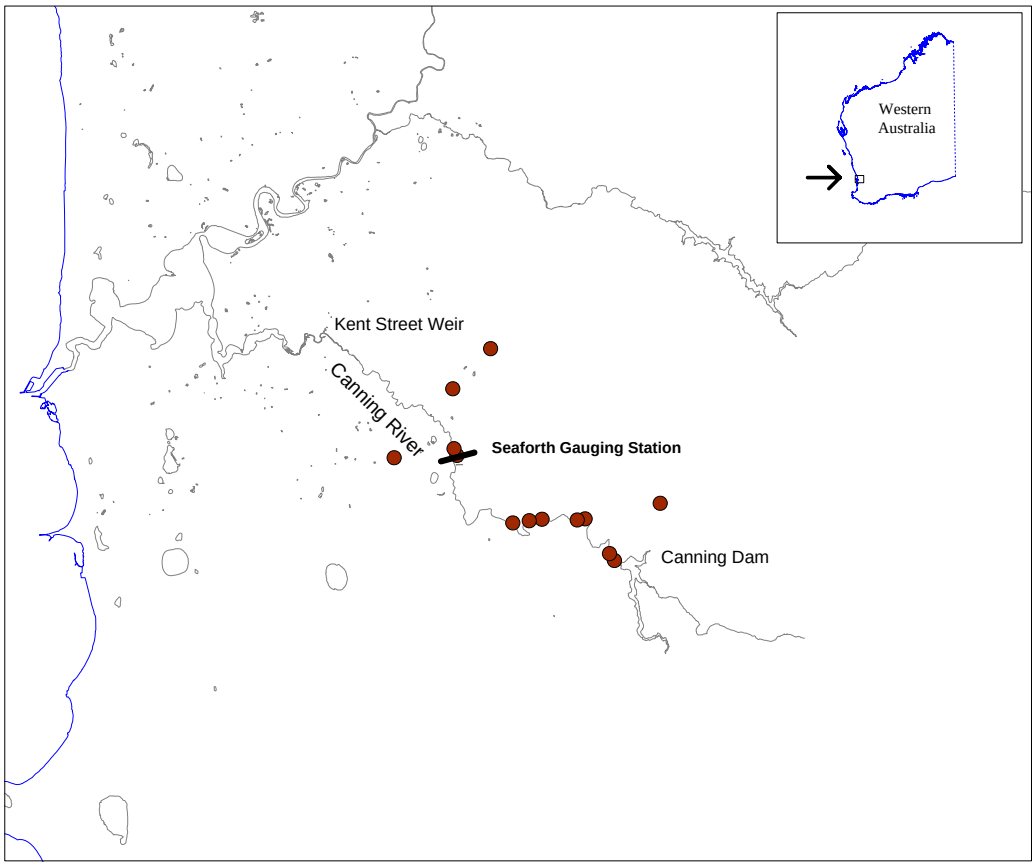

Figure 3 Records of the Western Minnow within the Canning River catchment.

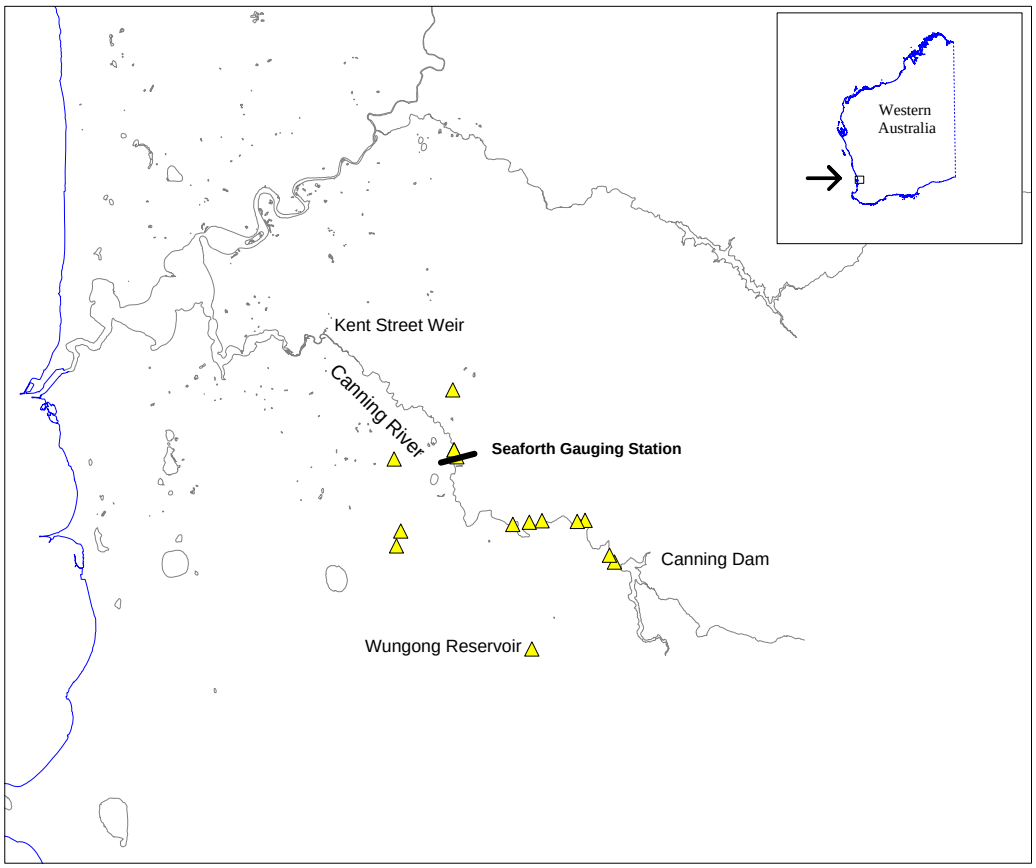

Figure 4 Records of the Western Pygmy Perch within the Canning River catchment.

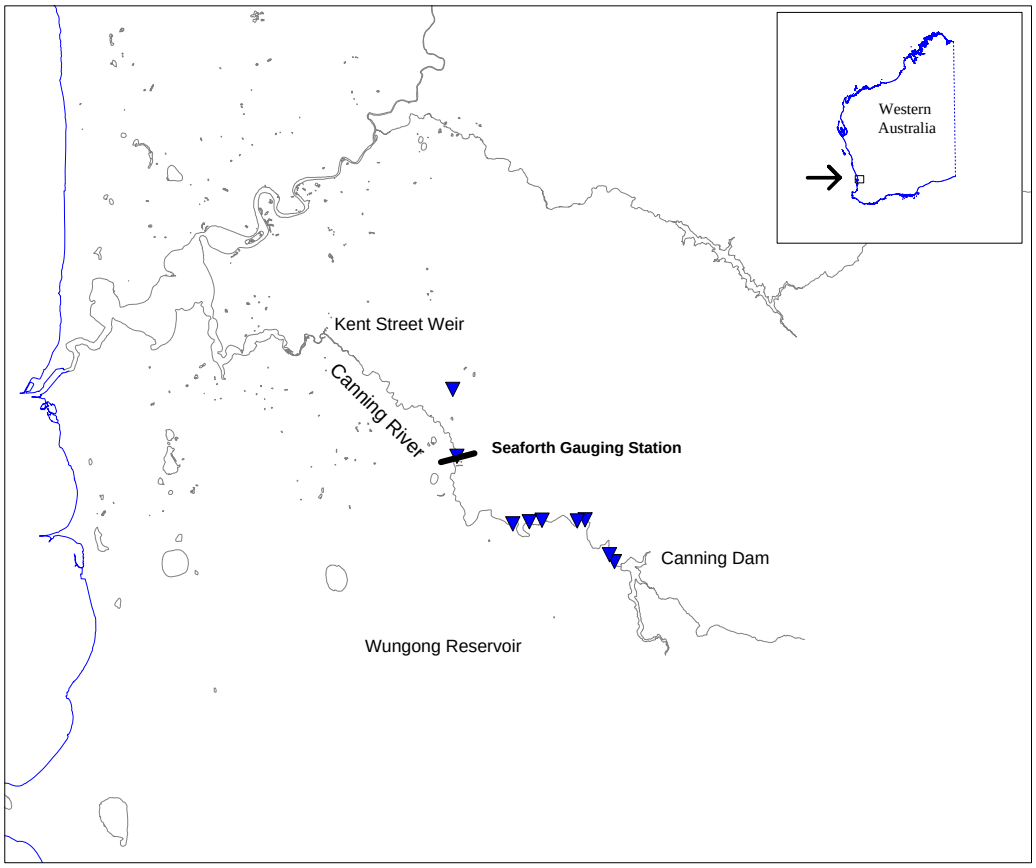

Figure 5 Records of the Nightfish within the Canning River catchment.

The Western Australian Museum has records from the Canning River of a single specimen of another native species of freshwater fish, i.e. the Common Jollytail (*Galaxias maculatus*) (Plate 2, Figure 6), which in some populations has a marine larval stage (Morgan *et al*. 2006). The occurrence of the species within the Canning River Estuary is probably the result of larval drift rather than from a translocation or self-maintaining population in this river (see Morgan *et al*. 2006). Within Australia the species is generally restricted to the south coast of WA and is also found in south-eastern Australia. The species was also recently found within the Harvey River system and Walpole River (see Morgan *et al*. 2006).

Plate 2 The Common Jollytail. Photograph: D Morgan.

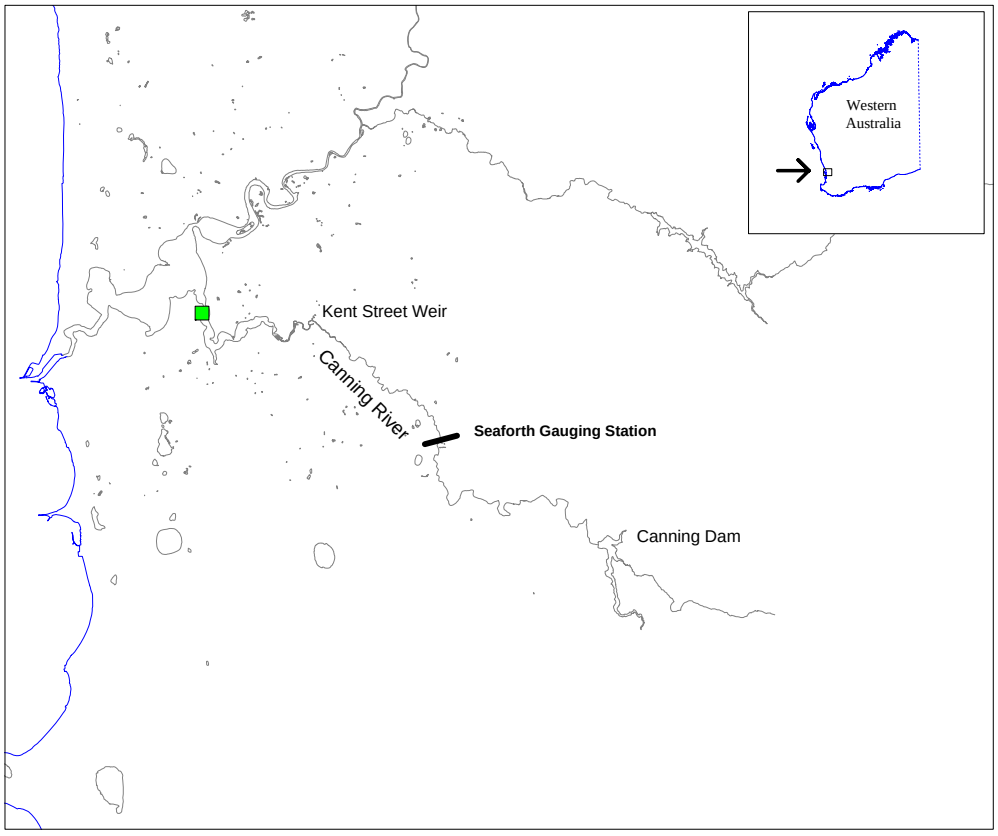

Figure 6 Western Australian Museum records of the Common Jollytail from the Canning River catchment.

Estuarine fishes of the Canning River

The four species of estuarine fishes that are that are found within the freshwaters of the Canning River, i.e. upstream of Kent Street Weir, includes two species that are endemic to the South West Drainage Division, the Western Hardyhead (*Leptatherina wallacei*) and South-west Goby (*Afurcagobius suppositus*), as well as the Swan River Goby (*Pseudogobius olorum*) and during this study a single Sea Mullet (*Mugil cephalus*) (47 mm TL) was recorded at Station St crossing (Plate 3, Figure 7). Each of the first three species is known to breed within the freshwater environment and their presence within the Canning River, upstream of the Kent Street Weir, supports the notion that each has self-maintaining populations in this part of the system. Sea Mullet on the other hand spawn at sea in deep water, migrate into estuaries and freshwaters as juveniles and utilise these habitats as a nursery (Thomson 1963). Based on length-frequencies of new recruits of Sea Mullet in the Swan River Estuary 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 small size of the sole Sea Mullet captured upstream of Kent Street Weir suggests that it is a new recruit to the river, i.e it migrated over/through the weir during winter or spring 2006.

Plate 3 The estuarine fishes found in the freshwaters of the Canning River, i.e. upstream of Kent Street Weir. Photographs: D Morgan and M Allen (Western Hardyhead).

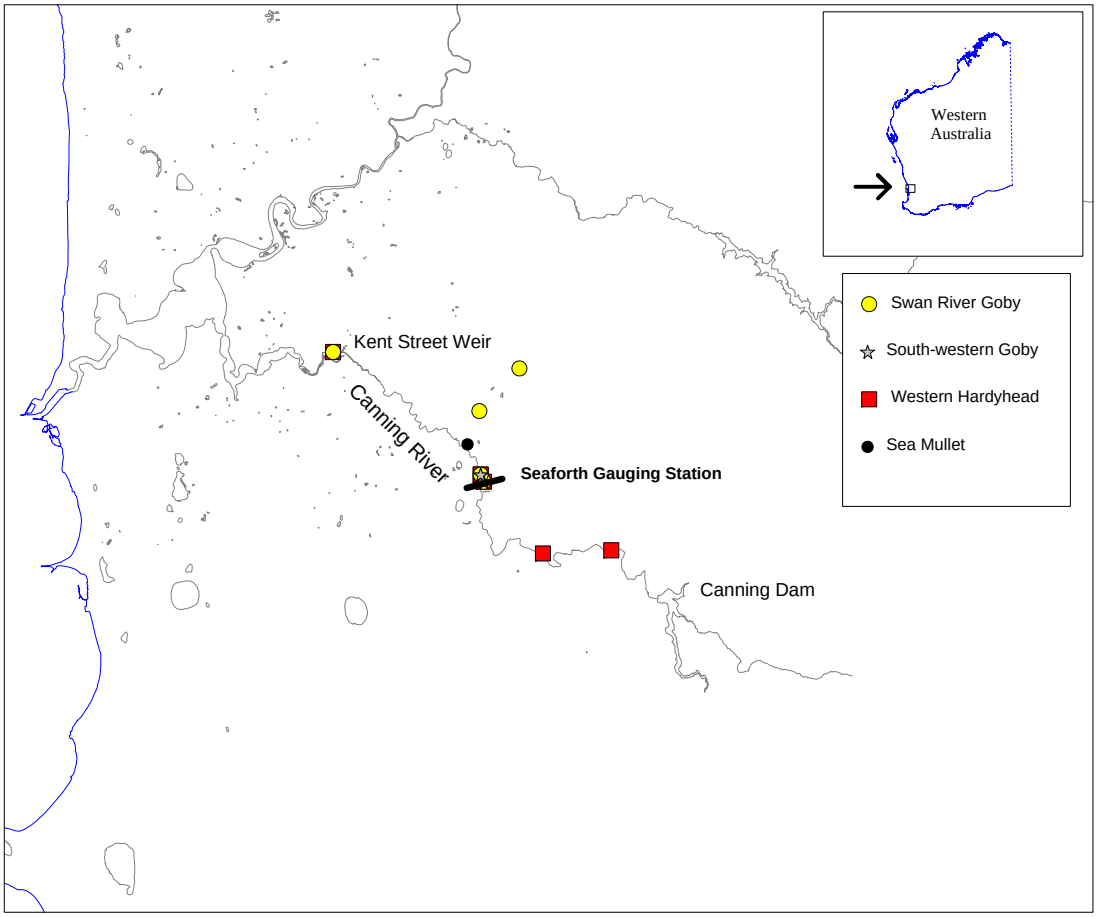

Figure 7 The capture locations of the typically estuarine species within the Canning River.

Introduced fishes of the Canning River

The four species of introduced fishes found within the freshwaters of the Canning River include: two live-bearing poeciliids, the One-spot Livebearer or Leopardfish (*Phalloceros caudimaculatus*) and the Eastern Mosquitofish (*Gambusia holbrooki*); Goldfish (*Carassius auratus*) and Rainbow Trout (*Oncorhynchus mykiss*) (Plate 4, Figure 8).

Each of these species poses a serious threat to the freshwater fishes of south-western Australia. For example, while each of the species compete with native fishes for habitat, particularly when it becomes limited during dry periods, Tay (2005) demonstrated that Rainbow Trout in Churchman Brook Reservoir prey heavily on Marron (*Cherax cainii*) and they are known to predate on native fishes (see Morgan *et al.* 2004); Goldfish have the potential to fuel algal blooms (see Morgan & Beatty 2006b); Eastern Mosquitofish are aggressive towards south-western Australian native fishes and fin-nip (Gill *et al*. 1999); and One-spot Livebearers have an extremely protracted breeding period and can occur in extremely high abundances in this system, specifically in Bull Creek (Maddern 2003, Morgan & Beatty 2006a).

Plate 4 The introduced fishes found in the freshwaters of the Canning River, i.e. upstream of Kent Street Weir. Photographs: D Morgan.

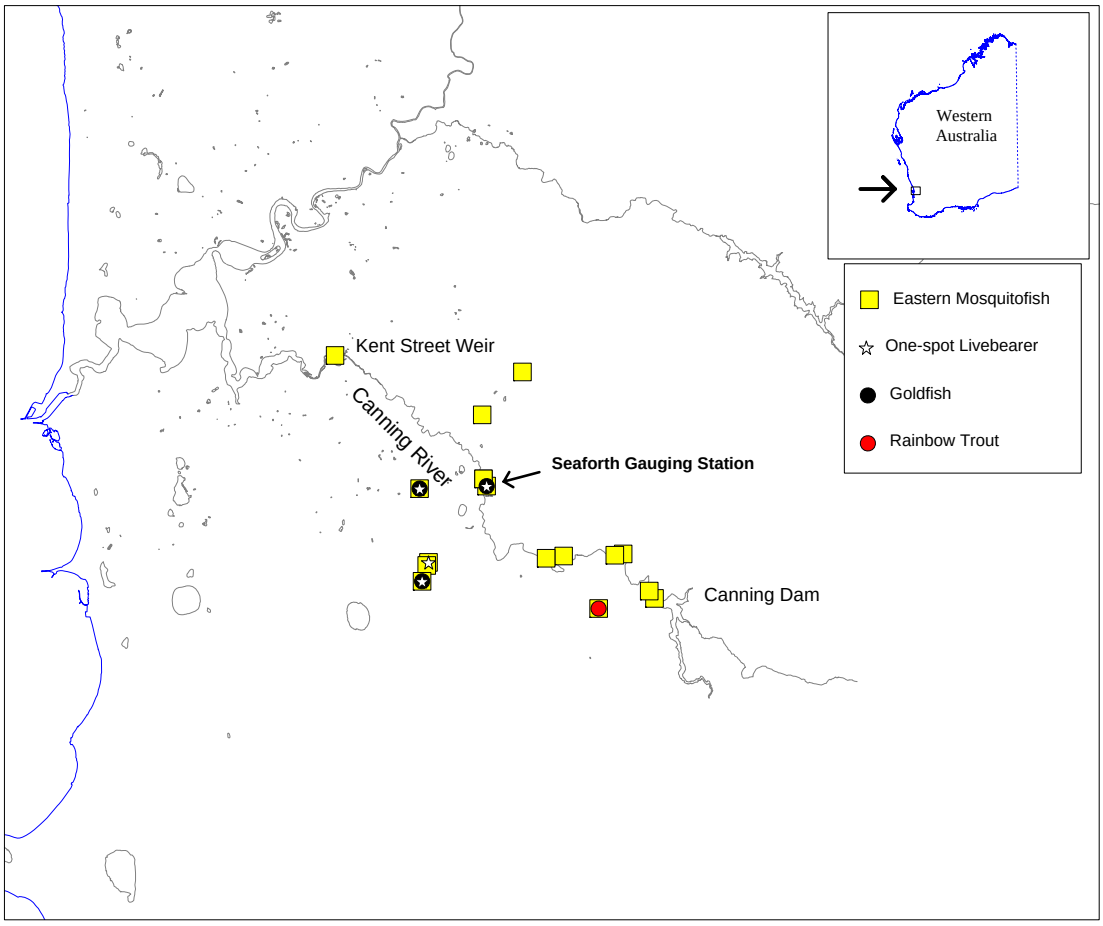

Figure 8 The capture locations of the introduced fishes within the freshwaters of the Canning River.

Furthermore, introduced fishes, particularly those that are 'escapees' from aquariums, pose a genuine and significant threat to native fishes in the form of the introduction of parasites and disease. During this study an introduced anchor worm (*Lernea* sp.) was found on Freshwater Cobbler, Western Pygmy Perch and Nightfish. The most likely vector for the introduction of this species was from Goldfish.

Plate 5 *Lernea* sp. on the dorsal fin of a Freshwater Cobbler from the Canning River. Photograph: S Visser.

Seaforth Gauging Station

Sampling times and discharge

As mentioned in the **Methodology**, the Seaforth Gauging Station was monitored using fyke nets over three 24 h periods in June, July, September and November 2006 (see Figure 9). Sampling events in June and July occurred when the fifth and eighth highest daily discharges were recorded for 2006 (Figure 9). Discharge during the November sampling event was low. Discharge was strongly correlated to rainfall events within the catchment with rapid increases and precipitous declines evident. Discharge was highest between June and October. The Stage Heights (AHD) at the gauging station during the sampling times are shown in Table 1 and highlight the daily variability in discharge and hydrological conditions at the gauging station.

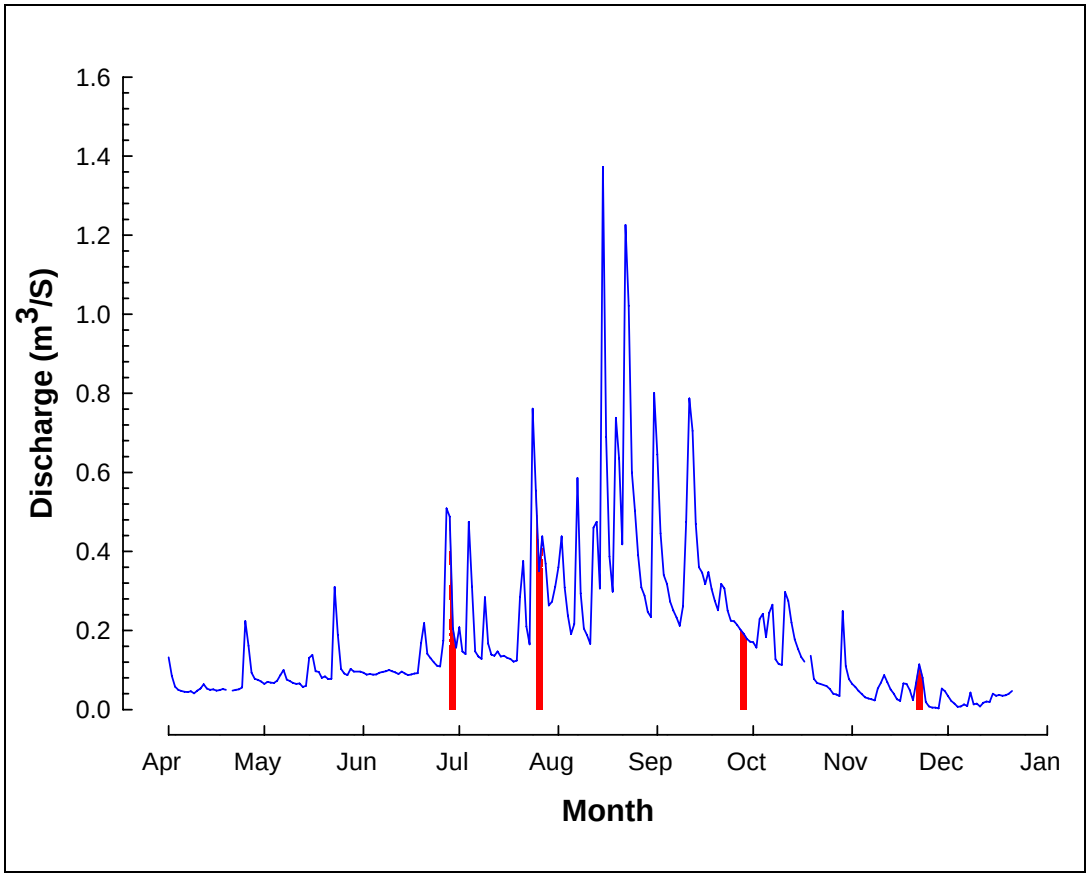

Figure 9 Discharge at the Seaforth Gauging Station between April 2006 and December 2006. The sampling events in June, July, September and November are shaded red.

Table 1: Stage heights above the Seaforth Gauging Station weir on the Canning River at the times of sampling.

Month	Sampling dates	Stage Height (m) above Weir (AHD)
June	28/6/2006	0.26
	29/6/2006	0.2
	30/6/2006	0.18
July	25/7/2006	0.28
	26/7/2006	0.25
	27/7/2006	0.36
September	27/9/2006	0.2
	28/9/2006	0.18
	29/9/2006	0.18
November	21/11/2006	0.16
	22/11/2006	0.175
	23/11/2006	0.16

Conductivity was generally low at the Seaforth Gauging Station during the sampling period and was lowest during July following a rainfall event (Figure 10). Water temperature increased from a low in July of ~12°C to a high of ~24°C in November (Figure 10).

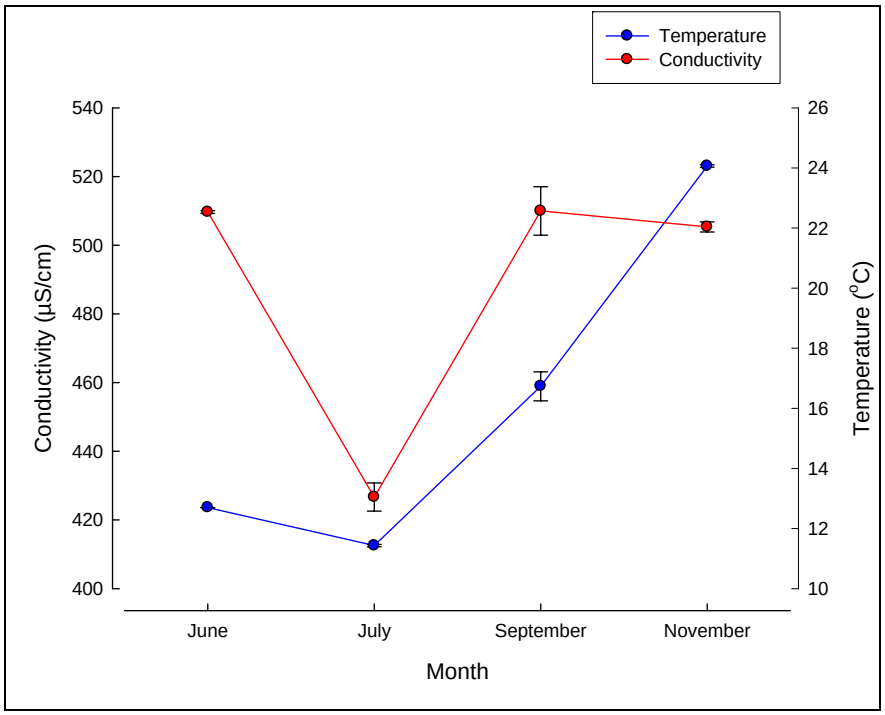

Figure 10 Mean water temperature and conductivity (± 1 SE) at the Seaforth Gauging Station during the sampling events in June, July, September and November.

Figure 11 shows a typical depth-flow profile on a cross-section taken at the middle of the weir and Figure 12 shows a preliminary relationship between the Stage Height (AHD) above the weir and the width of the flooded out water column moving over the weir (i.e. at the 'drop').

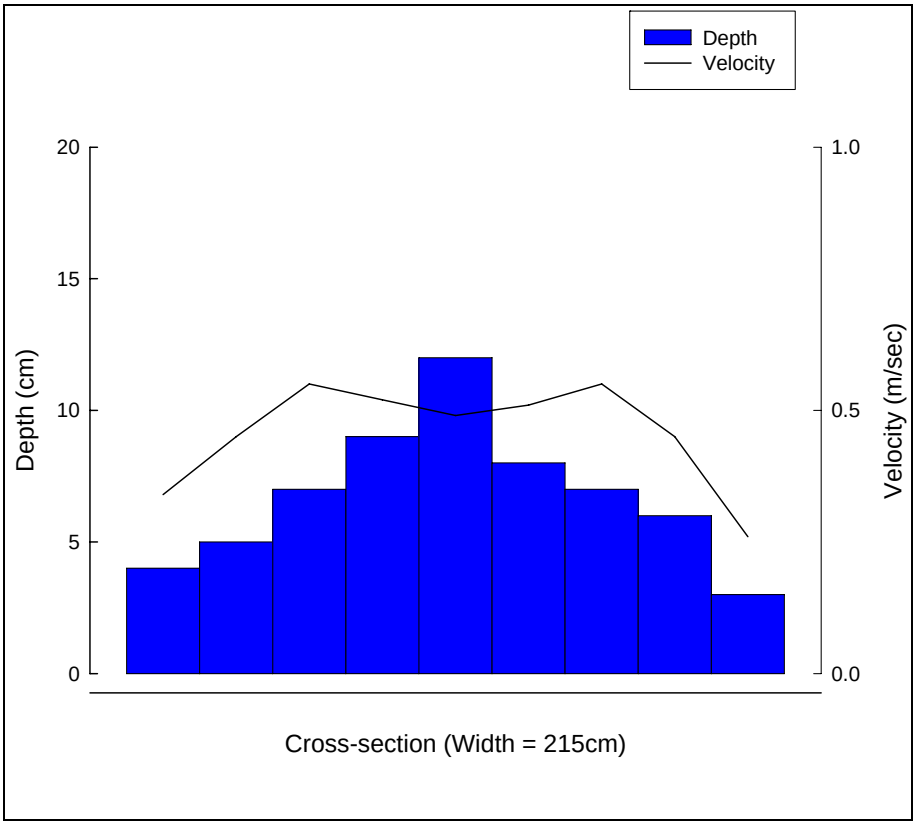

Figure 11 Flow velocities and depth profiles on the cross-section of the Seaforth Gauging Station, 23rd November 2006. N.B. the cross-section was taken from the middle of the v-notch on the weir.

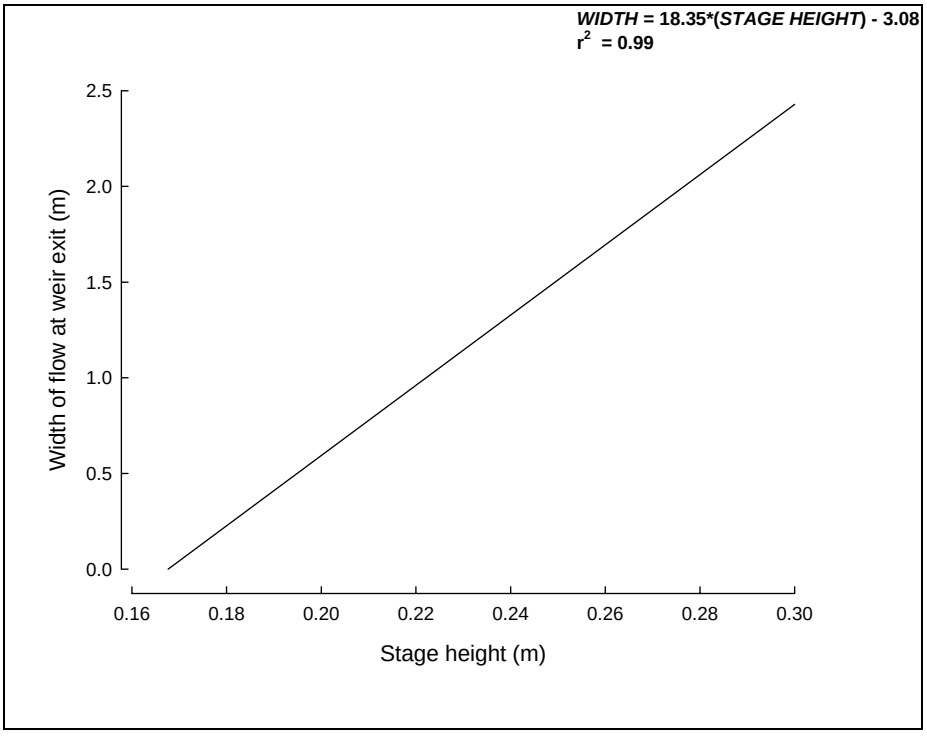

Figure 12 Relationship between the stage height above the Seaforth Gauging Station and the width of the flow column at the fall over the weir. N.B. additional data points are required to further validate this model.

Species captured using fyke nets at the Seaforth Gauging Station: upstream and downstream migrations

Five native and three introduced species of fish were captured in the fyke nets set at the Seaforth Gauging Station (Figures 13, 14). The endemic freshwater Western Minnow was the only species of fish that was captured during all sampling months. Western Minnows were found to move both upstream and downstream over the gauging station on each occasion, however, greater upstream movements were detected on each occasion. For example, on average, ~35 Western Minnows moved upstream over the gauging station each day compared to ~7 fish moving downstream over the structure per day. While many of these individuals were mature animals in most months, during November a large number of individuals were offspring (new recruits) (Figure 15).

Western Pygmy Perch and Nightfish were only captured in fyke nets during November with both species found moving mostly upstream over the weir. However, the Western Pygmy Perch was only captured in very low numbers (i.e. four fish moving upstream) (Figure 13). Freshwater Cobbler were mostly recorded in September and November and were only captured moving upstream over the Seaforth Weir (Figure 13).

Although three species of introduced fishes were recorded moving over the Seaforth Gauging Station, the One-spot Livebearer dominated catches (Figure 14). The majority of these fish were recorded moving downstream during June and July (Figures 14, 16).

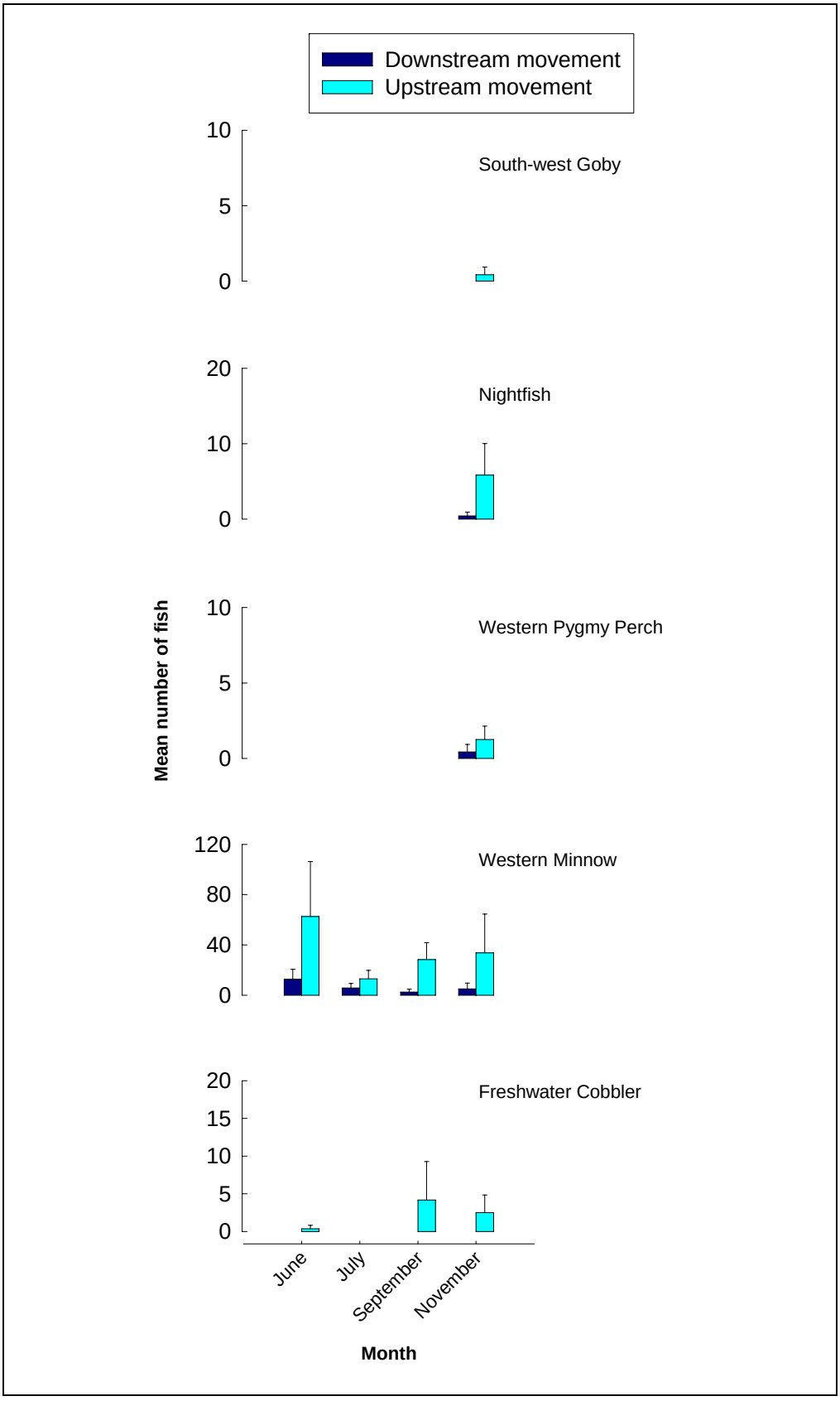

Figure 13 Mean number (± 1 S.E.) of each of the native fish species (24 h^{-1}) captured moving upstream and downstream over the Seaforth Gauging Station during sampling in June, July, September and November 2006.

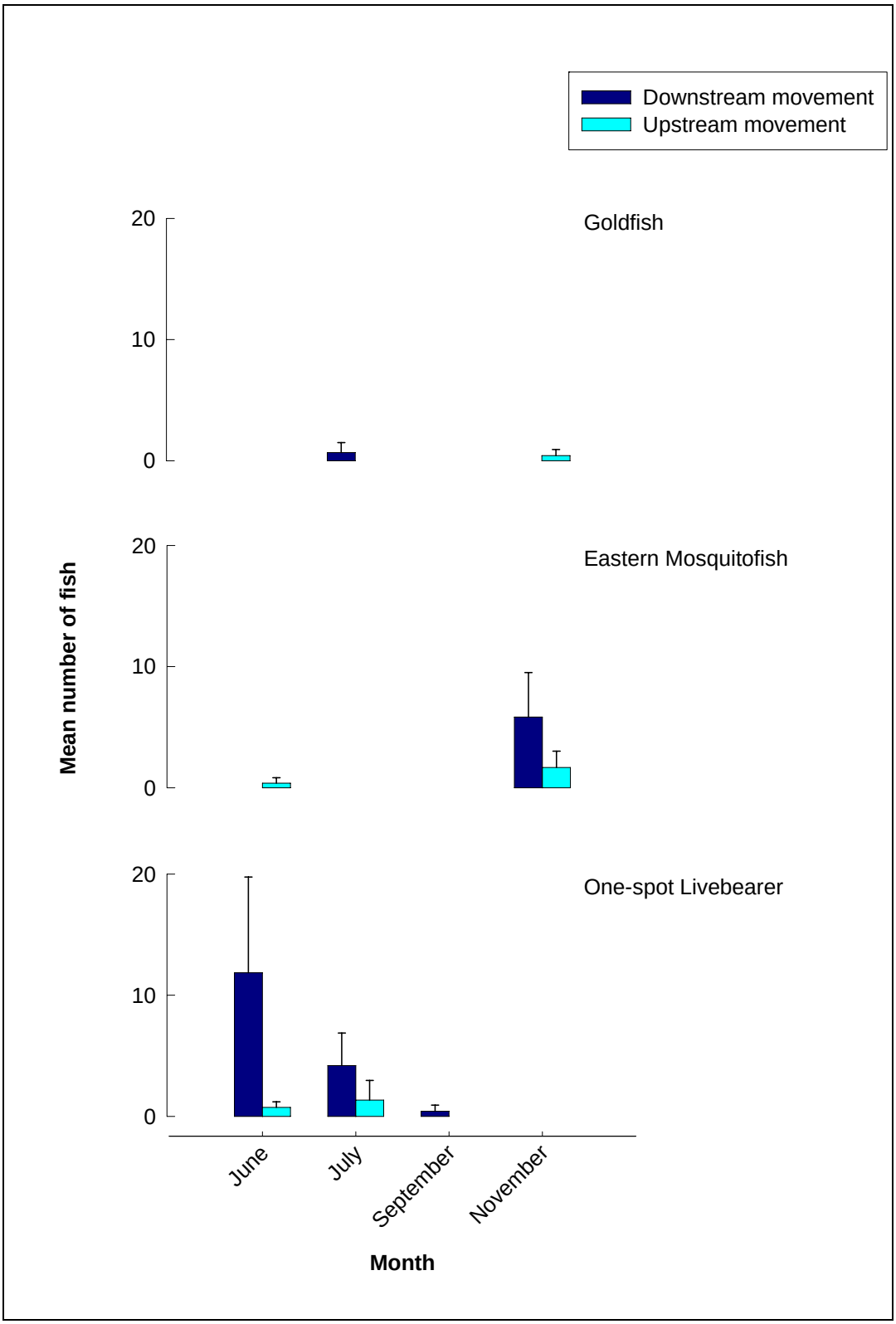

Figure 14 Mean number (±1 S.E.) of each of the introduced fish species ($24h^{-1}$) captured moving upstream and downstream over the Seaforth Gauging Station during sampling in June, July, September and November 2006.

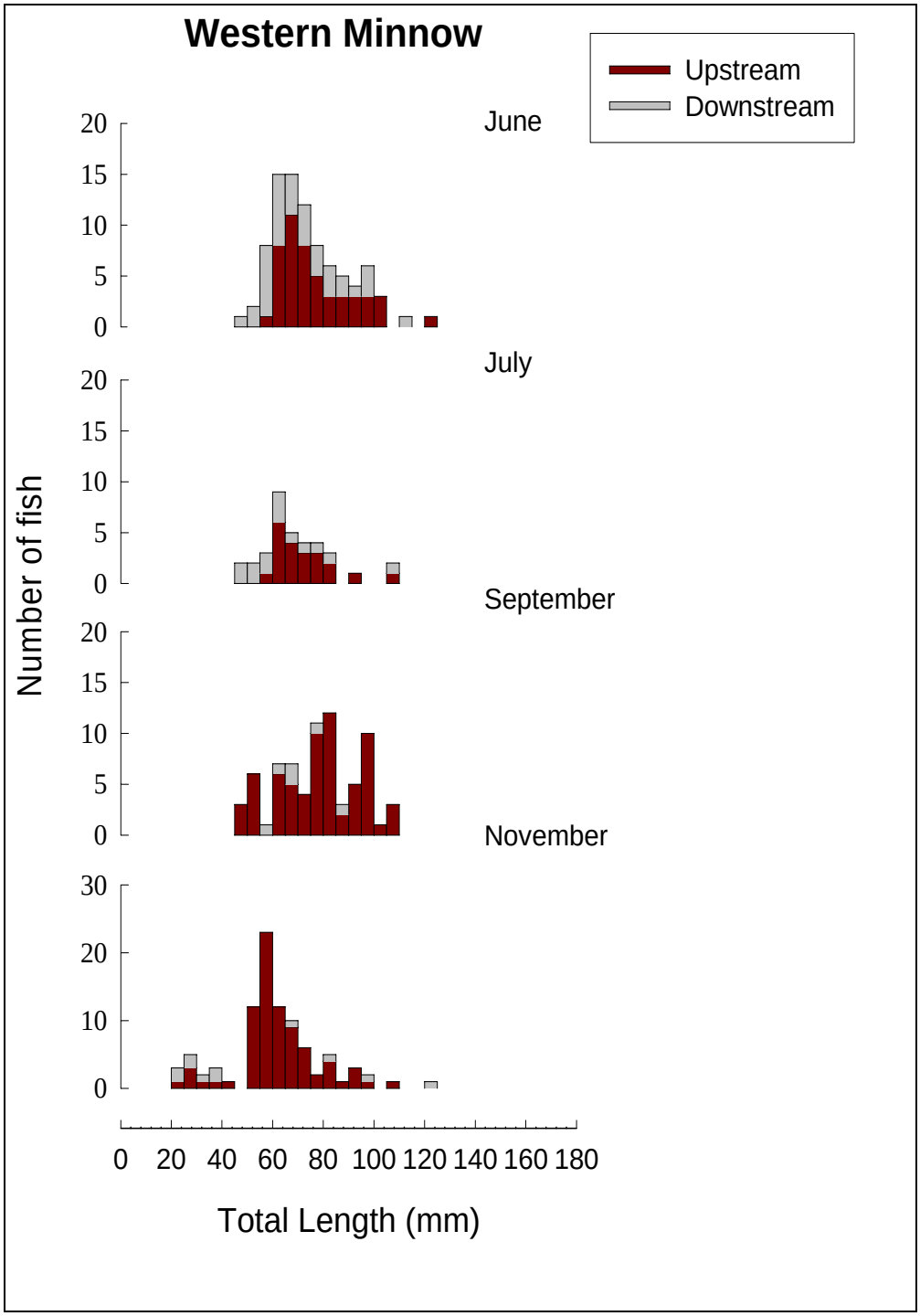

Figure 15 Length-frequency histograms of Western Minnows captured in fyke nets that were moving either upstream or downstream over the Seaforth Gauging Station.

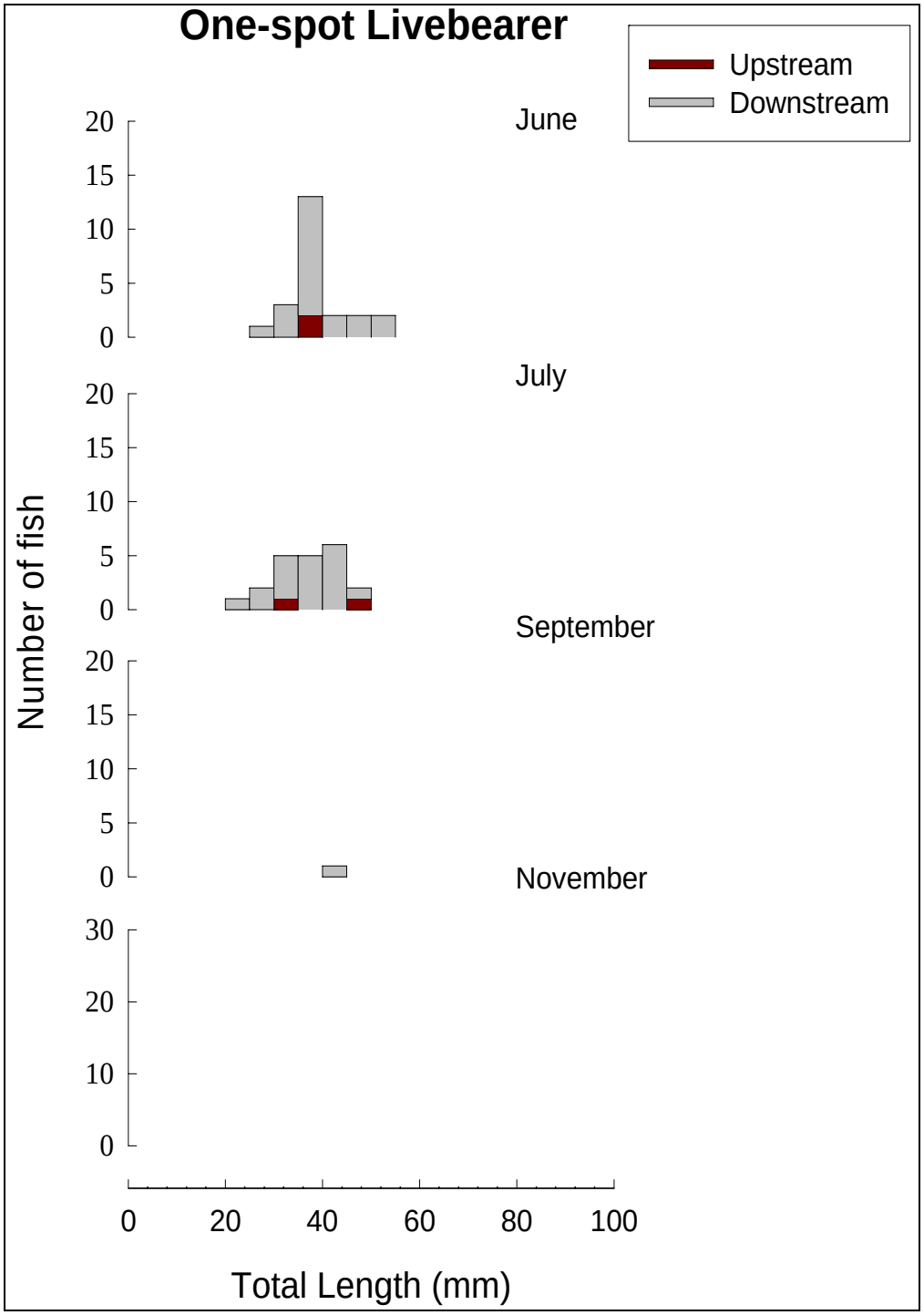

Figure 16 Length-frequency histograms of the One-spot Livebearer captured in fyke nets that were moving either upstream or downstream over the Seaforth Gauging Station.

There were two species of freshwater crayfish recorded moving over the Seaforth Gauging Station, the Marron (*Cherax cainii*) and the Gilgie (*Cherax quinquecarinatus*) (Figure 17). Marron were recorded in far greater numbers at this site and there was an increase in upstream movement during the two spring months (Figure 17). The length-frequency distribution of Marron showed that there were multiple age cohorts present indicative of a reproducing (i.e. self-maintaining) population with no clear relationship existing between the upstream or downstream movement and crayfish size (Figure 18). Shrimp (*Palaemonetes australis*) movements were essentially passive, i.e. downstream with flows.

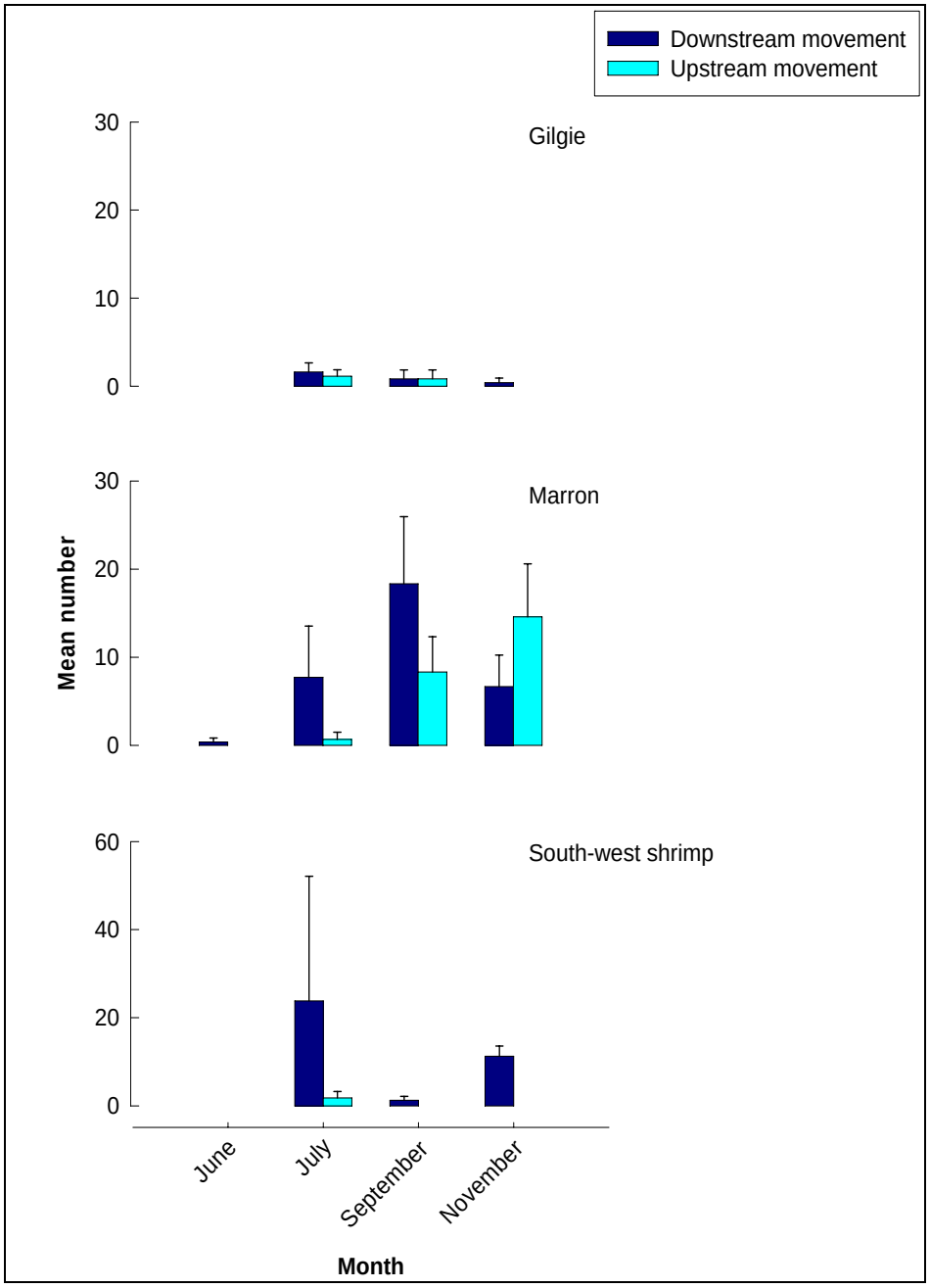

Figure 17 Mean number (±1 S.E.) of crustaceans moving upstream and downstream over the Seaforth Gauging Station ($24h^{-1}$) during the sampling in June, July, September and November 2006.

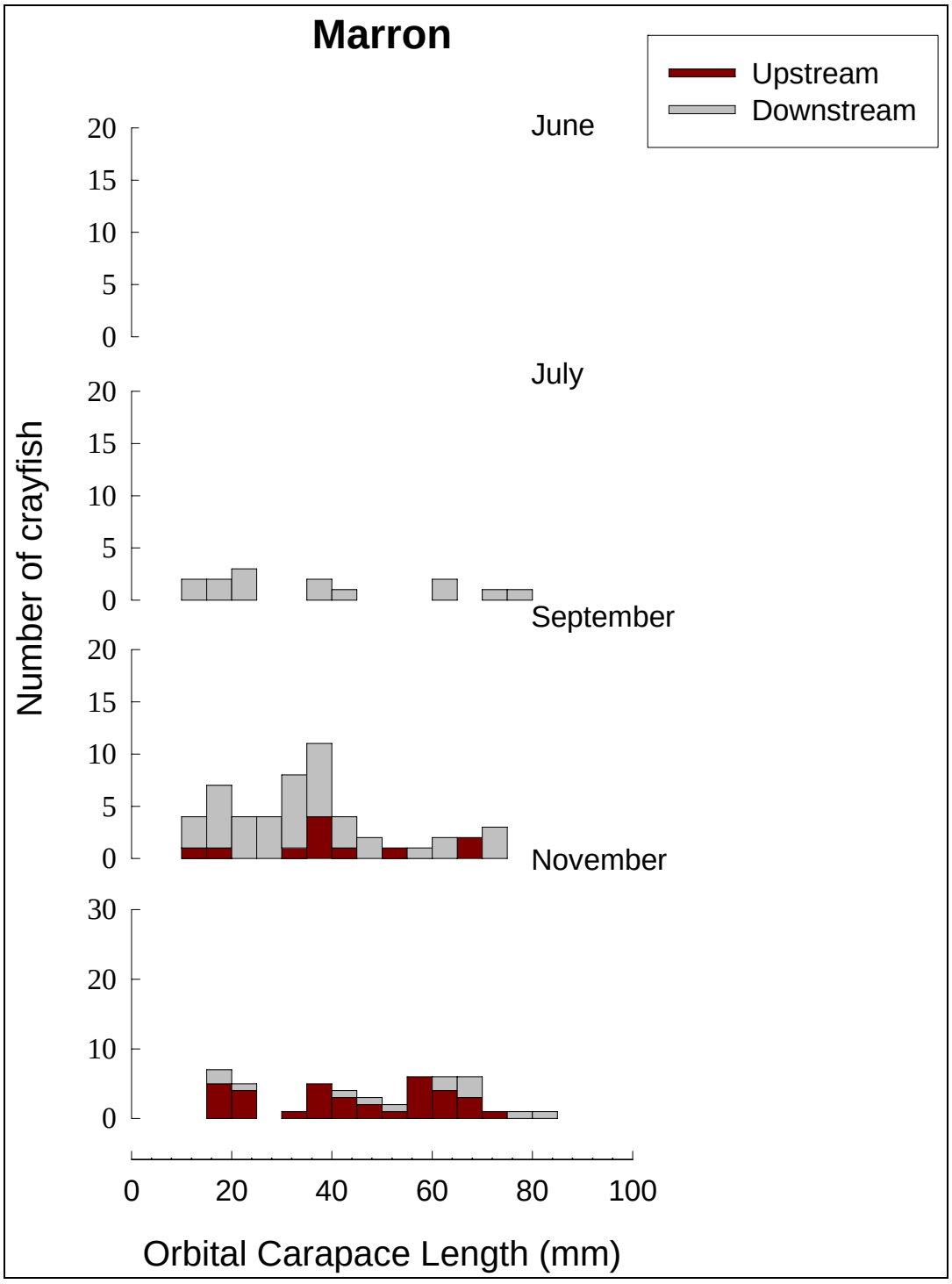

Figure 18 Length-frequency histograms of Marron captured moving upstream and downstream the Seaforth Gauging Station.

Discussion

Fish and freshwater crayfish in the Canning River

Native freshwater fishes

The current suite (i.e. diversity) of native freshwater fishes within the Canning River system is likely to be unchanged since the colonisation of the region. However, the loss of wetland habitats, through dewatering, damming and eutrophication, combined with the effects of introducing four species of exotic fish (and associated parasites) within the system, is likely to have caused substantial declines in overall abundances. Furthermore, the high number of impediments, subsequent modification of habitat and the release of environmental flows from larger dams would have altered the degree to which each species contributes to the faunal composition of the system. Each of the native freshwater fishes that are found within the Canning River undertake migrations to some extent, and generally at different times of the year. Migrations are not restricted to breeding or are only upstream in nature, but may be for feeding or as downstream recruitment of juveniles.

Estuarine fishes

Although the Kent Street Weir appears to restrict the upstream migrations of fishes, the capture of Sea Mullet suggests that at least some fish are able to negotiate this barrier. Ongoing monitoring within the system should investigate the migrations of species below the Kent Street Weir and determine the degree to which it prohibits the upstream movement of estuarine fishes. The link between the estuary and freshwaters is vital to the recruitment of a number of species, including Sea Mullet. *The extent to which the Kent Street Weir impedes fish migration requires examination.*

Introduced fishes

The Eastern Mosquitofish is extremely widespread throughout the Canning River system and is similarly found throughout much of south-western Australia (see Morgan *et al*. 2004). It has probably been in the Canning River since it was first introduced in WA in the 1930s and often occurs in greatest numbers in degraded environments. In contrast, Goldfish and One-spot Livebearers may be relatively recent additions (i.e. last 20 years) to the Canning River. Evidence for this assumption lays in the fact that neither species were captured during the study by the Aquatic Research Laboratory (1988) during their monitoring of nine sites between 1984 and 1987. The One-spot Livebearer has also recently been found within Bull Creek where the population has 'exploded' and it has eliminated the Eastern Mosquitofish through some form of competitive advantage, such as early maturation, prolonged breeding period, non-specialised diet or potential hybridisation (see Maddern 2003, Morgan & Beatty 2006). The dominance of this species

over the Eastern Mosquitofish within our fyke net captures may be indicative of an early stage of transition, from a system that was dominated by Eastern Mosquitofish to one that is dominated by One-spot Livebearers. *The ecology of these species within the Canning River should be examined.*

Freshwater crayfishes

All naturally occurring freshwater crayfishes in south-western Australia are endemic to the region (a total of 11 species from two genera). The Yabbie has been introduced and is now found in a number of wild aquatic systems in the south-west (Beatty *et al.* 2005). As mentioned, this study recorded three species in the Canning River, the wide spread Marron, the common Gilgie and the introduced Yabbie. These species are successfully self-maintaining in this system. Although previously thought to be relatively sedentary, Marron has recently been found to undertake upstream and downstream movements, particularly downstream movement in high flow periods (possibly in search of less habitat competition with larger crayfish). This appeared to occur at the Seaforth Gauging Station with a dominance of smaller (<40 mm OCL) Marron being recorded moving downstream during July and September (Figure 18). *As Marron were found to be readily moving both upstream and downstream over the Seaforth Gauging Station, it is therefore presumably not significantly impacting on the movement species*.

Is the Seaforth Gauging Station weir posing a significant impediment to native fish migrations?

The major focus of this study was to examine the potential for the Seaforth Gauging Station weir to impede fish migrations. However, it should be stressed that there exists a considerable impediment downstream of the Seaforth Gauging Station weir (i.e. the Kent St Weir) which would likely pose a more considerable barrier to fish movement; particularly to estuarine fishes such as Black Bream (*Acanthopagrus butcheri*) and Sea Mullet. Furthermore, the weir approximately 500 m upstream from the Seaforth Gauging Station also probably acts as a barrier to upstream fish movements as reflected by the high densities of fishes found below this structure and absence of fish immediately above (Appendix 1). *These impediments warrant further investigation using methodologies employed in the current study.*

The species regarded as having the strongest swimming ability, the Western Minnow, were found to be moving over the weir during periods of high or low flows throughout the months sampled (Figures 9 and 13, Table 1). This species is known to spawn earlier than the other native species in this study (i.e. from winter) and therefore *the weir is posing no significant impediment to its spawning migration.*

The weir readily flooded out during times of high flows experienced during this study (Figure 9, Table 1). This would generally aid the movement over the weir of species with weaker swimming abilities should those events coincide with their migratory periods. However within the main spawning periods of the Nightfish and Western Pygmy Perch (i.e. November), these species were also able to move over the weir at a relatively low stage height (for the study) of 0.175 m (Figure 13, Table 1). Therefore, it appears that although the weir may pose an additional obstacle to negotiate during their spawning periods (which may have been reflected in the very low numbers of Western Pygmy Perch recorded moving upstream over the weir in November i.e. four fish) *the weir appeared to be negotiable by these two species at the discharge rates experienced at the time of sampling.*

The Freshwater Cobbler is a summer spawner and recent work in the Blackwood River by the authors has revealed very strong upstream migrations during spring and summer with fish being able to move over relatively shallow sections of rapids, despite having a relatively large body size (up to ~450 mm) and being typically benthic (the authors, unpub. data). In the current study, it was also recorded moving upstream over the relatively shallow Seaforth Gauging Station in both September and November. However, the strongest movement of the species was recorded at the peak stage height in September (0.2 m) (Table 1, Figure 13) and was not recorded when it dropped to 0.18 and 0.175 m on the subsequent days in that month (Table 1).

It would be expected that the strongest migration movements of this species would occur during summer (as found in the Blackwood River) when the Seaforth Gauging Station may be more of a barrier should flows be reduced. Although this study found that the Freshwater Cobbler was able to negotiate the weir during spring, *its ability to pass over this structure during its known peak period of movement in summer should be investigated.*

Feral fish species, particularly One-spot Livebearers and Eastern Mosquitofish were generally captured moving downstream over the Seaforth Gauging Station (Figure 14). This probably reflected passive movement associated with high discharge events. A degree of upstream movement over the weir by these species was also recorded indicating that it was generally not impeding their movement (Figure 14).

Conclusions and recommendations

The Canning River is a highly regulated river system; however it still houses four of the eight endemic freshwater fishes of south-western Australia, four native estuarine fishes (two of which are endemic) and two endemic

freshwater crayfish species. It therefore remains an important river in terms of its fish assemblage.

A primary focus of this study was to determine the extent of the impediment to fish movements of one of the barriers in the main channel of the Canning River, the Seaforth Gauging Station. *This study found little evidence of this structure impeding native fish migration during the study period and fishway construction would not be warranted based on these results*. However, the structure still has the potential to limit the upstream movements of Freshwater Cobbler during summer and, although they were found to move over the structure, may also be a partial barrier to the free movement of the Nightfish and Western Pygmy Perch during spring.

It is recommended that an assessment be made of the degree of impediment to Freshwater Cobbler movement that this structure represents during summer. It is also recommended that an assessment be made to examine the degree that the weir ~500 m upstream of the Seaforth Gauging Station and the Kent St Weir impede fish migrations.

References

Aquatic Research Laboratories (1988). *Lower Canning River stream fauna study results and recommendations. Report 11 June 1988, University of Western Australia*.

Beatty, S., Morgan, D. & Gill, H. (2003). *Fish resource survey of Churchman Brook Reservoir*. Report to the Water Corporation of Western Australia.

Beatty, S.J., Morgan, D.L. & Gill, H.S. (2005a). Life history and reproductive biology of the gilgie *Cherax quinquecarinatus*, a freshwater crayfish endemic to south-western Australia *Journal of Crustacean Biology* 25(2): 251-262.

Beatty, S., Morgan, D. & Tay, M. (2006). *Management of aquatic fauna during the refurbishment of Churchman Brook Reservoir*. Murdoch University, Centre for Fish & Fisheries Research report to the Water Corporation of Western Australia.

Beatty, S., Wild, S. & Morgan, D. (2005b). *Impact of culvert construction on the aquatic macroinvertebrate and fish fauna of the Wungong River: preliminary report*. Report to the Main Roads Department.

Beatty, S.J., Morgan, D.L. & Gill, H.S. (2005c). Role of life history strategy in the colonisation of Western Australian aquatic systems by the introduced crayfish *Cherax destructor* Clark, 1936. *Hydrobiologia* 549: 219-237.

Chubb, C.F., Potter, I.C., Grant, C.J., Lenanton, R.C.J. & Wallace, J. (1981). Age structure, growth rates and movements of sea mullet, *Mugil cephalus* L., and yellow-eye mullet, *Aldrichetta forsteri* (Valenciennes), in the Swan-Avon River system, Western Australia. *Australian Journal of Marine and Freshwater Research* 32: 605-628.

Chubb, C.F. & Potter, I.C. (1984). The reproductive biology and estuarine movements of the gizzard shad, *Nematalosa vlaminghi* (Munro). *Journal of Fish Biology* 25: 527-543.

Chubb, C.F. & Potter, I.C. (1986). Age, growth and condition of the Perth Herring, *Nematalosa vlaminghi* (Munro) (Dorosomatinae), in the Swan Estuary, south-western Australia. *Australian Journal of Freshwater Research* 37: 105-112.

Gill, H.S., Hambleton, S.J. & Morgan, D.L. (1999). Is *Gambusia holbrooki* a major threat to the native freshwater fishes of south-western Australia? In Seret, B. & Sire, J.-Y., (eds). Proceedings 5th Indo-Pacific Fish Conference (Noumea, 3-8 November1997). pp. 79-87. Paris: Societe Francaise d'Ichtyologie & Institut de Recherche pour le Development.

Gill, H.S., Wise, B.S., Potter, I.C. & Chaplin, J.A. (1996). Biannual spawning periods and resultant divergent patterns of growth in the estuarine goby *Pseudogobius olorum*: temperature-induced? *Marine Biology* 125: 453-466.

Hewitt, M.A. (1992). *The biology of the south-western Australian catfish Tandanus bostocki Whitley (Plotosidae).* Honours Thesis, Murdoch University, Perth, Western Australia.

Humphries, P. & Potter, I.C. (1993). Relationship between the habitat and diet of three species of atherinids and three species of gobies in a temperate Australian estuary. *Marine Biology* 116: 193-204.

Kanandjembo, A.N., Potter, I.C. & Platell, M.E. (2001). Abrupt shifts in the fish community of the hydrologically variable upper estuary of the Swan River. *Hydrological Processes* 15: 2503-2517.

Loneragan, N.R., Potter, I.C. & Lenanton, R.C.J. (1989). Influence of site, season and year on contributions made by marine, estuarine, diadromous and freshwater species to the fish fauna of a temperate Australian estuary. *Marine Biology* 103: 461-479.

Loneragan, N.R. & Potter, I.C. (1990). Factors influencing community structure and distribution of different life-cycle categories of fishes in shallow waters of a large Australian estuary. *Marine Biology* 106: 25-37.

Maddern, M. (2003). *The distribution, biology and ecological impacts of three introduced freshwater teleosts in Western Australia*. Honours Thesis, Murdoch University, Perth, Western Australia.

Morgan, D. & Beatty, S. (2006a). *Re-establishment of native freshwater fishes in Bull Creek*. Report to Melville City Council.

Morgan, D.L. & Beatty, S.J. (2006b). *Overview of the Goldfish Control Programme in the Vasse River, Western Australia: 2004-2006*. Centre for Fish & Fisheries Research (Murdoch University) report to Geocatch.

Morgan, D.L., Chapman, A., Beatty, S.J. & Gill, H.S. (2006). Distribution of the spotted minnow (*Galaxias maculatus* (Jenyns, 1842)) (Teleostei: Galaxiidae) in Western Australia including range extensions and sympatric species. *Records of the Western Australian Museum* 23: 7-11.

Morgan, D.L., Gill, H.S., Maddern, M.G. & Beatty, S.J. (2004). Distribution and impacts of introduced freshwater fishes in Western Australia. *New Zealand Journal of Marine and Freshwater Research* 38: 511-523.

Morgan, D. L. & Sarre, G. A. (1995). *The freshwater fish fauna of the Bickley Brook Reservoir*. Report to the Water Authority of Western Australia.

Morrison, P.F. (1988). *Reproductive biology of two species of plotosid catfish, Tandanus bostocki and Cnidoglanis macrocephalus, from south-western Australia*. PhD Thesis, University of Western Australia.

Potter, I.C., Neira, F.J., Wise, B.S. & Wallace, J.H. (1994). Reproductive biology and larval development of the terapontid *Amniataba caudavittata*, including comparisons with the reproductive strategies of other estuarine teleosts in temperate Western Australia. *Journal of Fish Biology* 45: 57-74.

Prince. J.D., Potter, I.C., Lenanton, R.C.J. & Loneragan, N.R. (1982). Segregation and feeding of atherinid species (Teleostei) in South-western Australian estuaries. *Australian Journal of Marine and Freshwater Research* 33: 865-880.

Prince, J.D. & Potter, I.C. (1983). Life-cycle duration, growth and spawning times of five species of Atherinidae (Teleostei) found in a Western Australian estuary. *Australian Journal of Marine and Freshwater Research* 34: 287-301.

Sarre, G.A. & Potter, I.C. (1999). Comparisons between the reproductive biology of black bream *Acanthopagrus butcheri* (Teleostei: Sparidae) in four estuaries with widely differing characteristics. *International Journal of Salt Lake Research* 8: 179-210.

Sarre, G.A. & Potter, I.C. (2000). Variation in age compositions and growth rates of *Acanthopagrus butcheri* (Sparidae) among estuaries: some possible contributing factors. *Fishery Bulletin* 98: 785-799.

Smith, K.A. (2006). *Review of fishery resources and status of key fishery stocks in the Swan-Canning Estuary*. Fisheries Research Report (Western Australia) 156.

Tay, Y.M. (2005). *The diet of wild and cultured rainbow trout, Oncorhynchus mykiss in Western Australia*. Honours Thesis, Murdoch University, Perth, Western Australia.

Wise, B.S., Potter, I.C. & Wallace, J.H. (1994). Growth, movements and diet of the terapontid *Amniataba caudavittata* in an Australian estuary. *Journal of Fish Biology* 45: 917-931.

APPENDIX 1: Mean (±1 S.E.) density of fish and crayfish at various sites in the Canning River during the study period.

	Date	Total Area (m^2)	Native fishes			Estuarine fishes				Feral fishes			Native crayfishes	
			Western Minnow	Western Pygmy Perch	Nightfish	Swan River Goby	South-west Goby	Western Hardyhead	Sea Mullet	One-Spot Livebearer	Eastern Mosquitofish	Goldfish	Smooth Marron	Gilgie
Seaforth weir (below)	30/6/06	170	**0.10** (0.05)			**0.01** (0.01)	**0.01** (0.01)	**0.04** (0.04)			**0.01** (0.01)			
	1/8/06	140	**0.06** (0.06)	**0.02 (0.03)**		**0.04** (0.02)	**0.01** (0.01)					**0.01** (0.01)	**0.10** (0.07)	
	1/12/06	100	**0.77** (0.66)	**0.02**		**0.03** (0.02)	**0.21** (0.12)			**0.02**	**0.05** (0.02)		**0.08** (0.05)	**0.12** (0.09)
Seaforth weir (above)	1/12/06	200	**0.05**			**0.00**	**0.05**						**0.05**	**0.10**
Weir 500m upstream (below)	1/12/06	150	**0.40**	**0.01**		**0.07**							**0.07**	**0.27**
Weir 500m upstream (above)		120											**0.02**	**0.04**
Station St crossing	1/12/06	130	**0.30** (0.28)	**0.41** (0.29)	**0.01** (0.01)				**0.01**	**0.06** (0.05)	**0.02** (0.02**)**			**0.37** (0.29)
Orlando Rd crossing	1/12/06	130	**0.14** (0.11)		**0.01** (0.01)					**0.33** (0.20)	**0.03** (0.01)		**0.04** (0.04)	**0.28** (0.20)