Migration patterns of fishes on the Margaret River fishways: 2006

Prepared for

Department of Water
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Cape to Cape Catchments Group

Prepared by

Centre for Fish and Fisheries Research

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

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By

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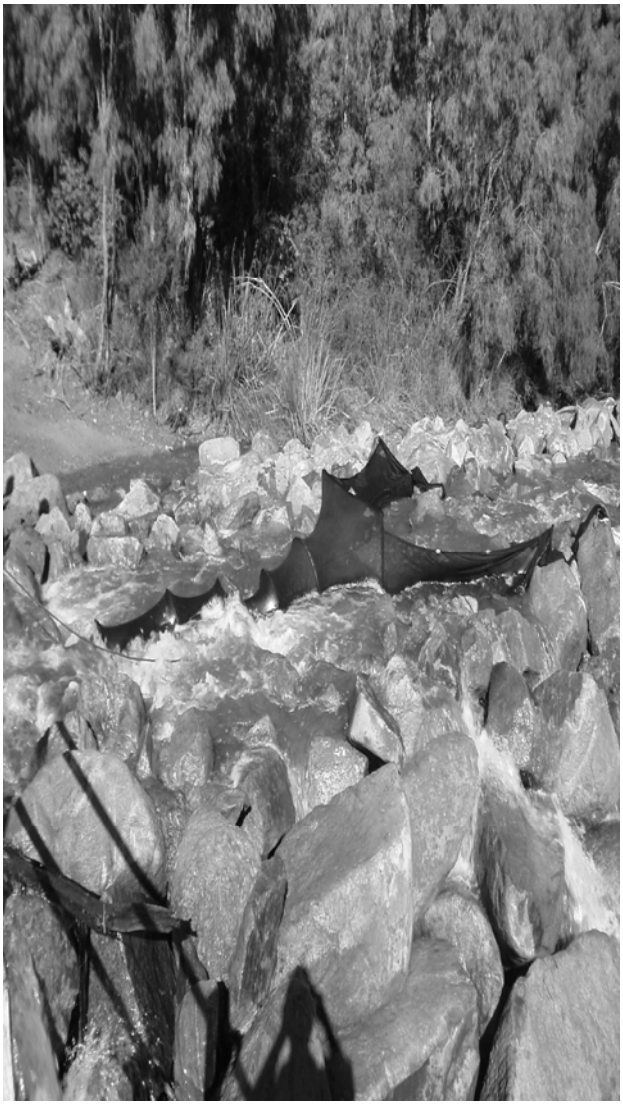
Front cover: Pouched Lampreys migrating upstream over the Margaret River waterfall

Summary

The Margaret River is the only river in Western Australia to boast two fishways. The first was constructed in 2003 at the Apex Weir and the second was built at the Barrett St Weir during summer 2005 and first operated in 2006. These fishways now provide fish passage in a system that was highly regulated and one in which fish migrations were previously impeded by the weirs. The Apex Weir Fishway was previously found to be operating effectively and this study presents the first monitoring of the Barrett St Fishway and compares the relative effectiveness of each fishway. Monitoring of these fishways occurred during July, August, September and November 2006. Monitoring in July commenced when the river first flowed and August sampling coincided with a peak in river discharge for the year. The Barrett St Fishway secures a greater proportion of the downstream flows when compared to the Apex Weir Fishway; however, there was no significant difference between the levels of utilisation of these structures by the fish. Both structures facilitate similar levels of upstream movement of Western Minnows, the most common migratory species in the system.



These fishways also allow the upstream and downstream movements of various life-history stages of this species. Downstream movements of other species were recorded, both on the fishway and over the weir walls, the latter of which may result in the death of larval lampreys and Western Minnows and these structures should be retrofitted to mitigate this potential impact on these species. The construction of the fishways however partially mitigates this impact. Both fishways on Margaret River continue to operate effectively and provide population connectivity of the river's fishes.

Contents

Introduction

Margaret River is one of the few river systems in south-western Australia that has not become salinised as a result of large scale land clearing; having much of its natural riparian and fringing vegetation still intact. However, it is one of the few rivers in the region that has seen the main channel regulated with the construction of two weirs. As a consequence, the Department of Environment (now Department of Water), in conjunction with the Margaret River Regional Environment Centre, Cape to Cape Catchments Group, Shire of Augusta-Margaret River and Centre for Fish & Fisheries Research (Murdoch University) have constructed two fishways on the river. Details of the construction and utilisation of the first fishway built, at the Apex Weir, are presented in Morgan & Beatty (2004). The fish fauna of Margaret River is documented in Morgan *et al*. (1998) and Morgan and Beatty (2003). The latter study presents findings of a survey of the fish during March 2003, and reports on the capture of five native species, one feral species and the Pouched Lamprey (*Geotria australis*).

Fish utilisation of the first fishway built on Margaret River was high (Morgan & Beatty 2004), but as a further impediment to migrations existed upstream, i.e. the Barrett St Weir, the second fishway was constructed by the Department of Environment. The second fishway became operational during 2006 and thus the aims of this study were to determine the effectiveness of this structure in providing fish passage. A secondary aim was to compare the migration patterns of fish at both fishways.

Methodology

Fishway monitoring period and discharge

The two fishways on the Margaret River were sampled on four occasions over three 24h periods during 2006. These sampling events were conducted in July (24^{th}-27^{th}), when the river began flowing (see Figure 1); in August (22^{nd}-25^{th}), coinciding with peak discharge for the year; September (27^{th}-30^{th}), when discharge was declining, and; during November (8^{th}-11^{th}), when discharge was reaching a minima. Daily discharge for Margaret River, 1970 to 1^{st} November 2006, was obtained from the Department of Water and was illustrated using SigmaPlot (see Figures 1 and 3). Note, that at the time of producing this report discharge data was only available until November 1^{st} and the data for the following 10 days were extrapolated.

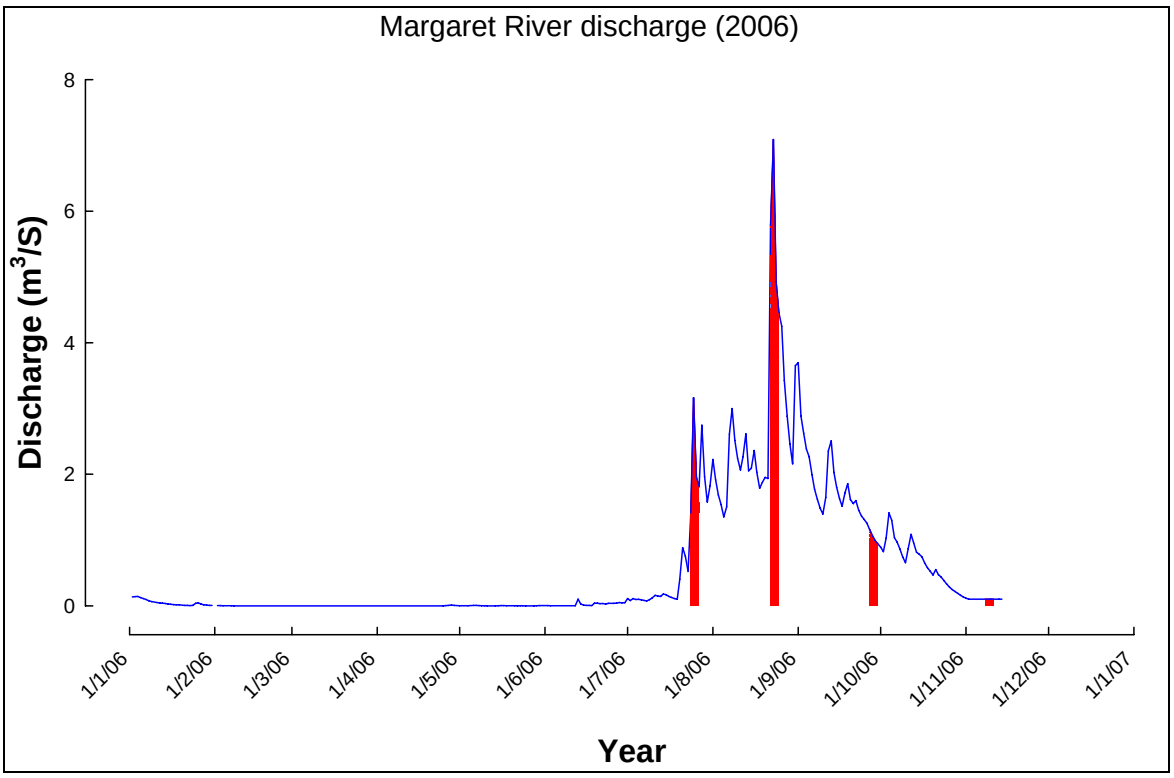


Figure 1 Daily discharge (m^3/S) for Margaret River during 2006 and the four fishway monitoring periods in July, August, September and November (shaded).

Environmental Variables

A discharge profile of the uppermost section of each fishway was taken and mean discharge rate determined on each fishway in each sampling period. Furthermore, in order to determine and compare the flow profiles of the two fishways, cross-sections were examined in more detail in September and November. In these months, depths were measured at ~40cm intervals along each cross section and the mean flow rate recorded by a hand held electronic flow meter at each point. The mean flow-depth profile of each cross-sectional profile was then plotted for each fishway.

During each sampling period, the water temperature, conductivity, and pH was recorded at three locations on the Apex Weir fishway and a mean determined.

Fishway monitoring

On each monitoring occasion fyke nets, consisting of 2 mm woven mesh, were set on both fishways (Figure 2). On each fishway one fyke net was set facing downstream, to capture fish moving up the fishway, and another was set facing upstream, to capture fish moving down the fishway (Figure 3). Each net was set for a period of 72 h and checked every 24 h, i.e. replicate sampling for determination of mean species movement. All fish captured were identified, measured for total length (TL, mm) and released immediately. Similarly, all freshwater crayfish captured in the nets were identified, sexed, orbital carapace length measured (OCL, mm) and released. Length-frequency analysis of fish and freshwater crayfish was undertaken and histograms plotted for each species in each sampling event. The relative percentage of the fishway that was blocked by the fyke net was determined and the actual catches of fish on each sampling occasion were adjusted to account for total number of fish that used the fishway.

During August and September fyke nets were also set under the wall of each weir in order to determine whether fish moving downstream were falling over the dam wall rather than using the fishway.

Analysis of variance (ANOVA) was used to determine whether there was any significant difference in the mean number of Western Minnows moving upstream (number per fyke net, adjusted for width of fishway covered) over the two fishways during the study period (pooled for the four months). The adjusted number of minnows captured per fyke net was log10 transformed prior to analysis.

In order to further characterise the fish usage of the two fishways, the total number of fishes on each fishway was determined in August and November, after the fyke nets had been removed. To achieve this, each structure was sampled using a back pack electrofisher with mild shocking of the water occurring in a downstream direction towards a 5 m seine net at the base of each structure to prevent fish escape. All fish were identified and promptly released above each weir in order to allow continuation of their migration.

Figure 2 Fyke nets set on the Margaret River fishways. Left – monitoring upstream and downstream migrations on the Barrett St Fishway; Right – the Apex Weir Fishway.

Species utilisation of the Margaret River fishways

Discharge

Historical discharge data for Margaret River indicates that since 2000 only modest flows occurred and that discharge during 2001 and 2006 were the lowest on record (Figures 1 and 3). Despite the considerably low discharge during 2006, the fishway was utilised by fish. Even when discharge approached its minima in November 2006, both the fishways were still allowing fish to migrate past these obstructions.

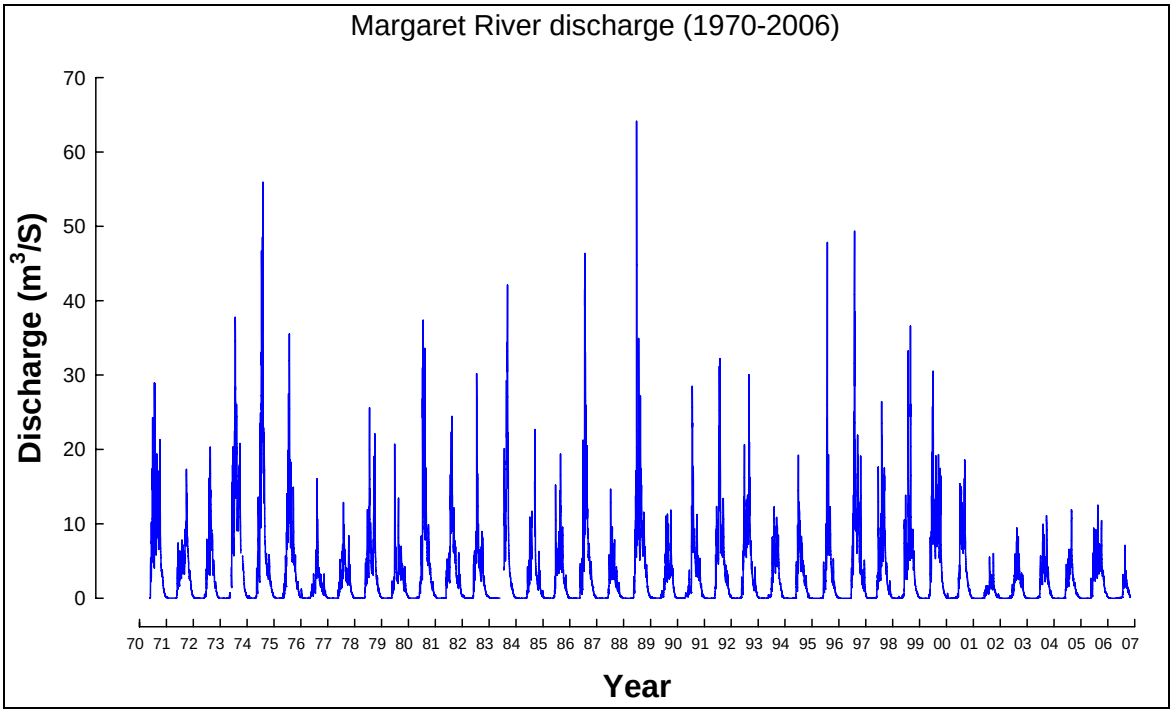


Figure 3 Daily discharge (m^3/S) for Margaret River between 1970 and 2006. Note the comparatively low discharge from 2001 to present.

The Barrett St Fishway had a greater mean discharge compared to the Apex Weir Fishway in all months, but was more than double during July and August (Figure 4). The cross-sectional profiles of the Barrett St Fishway revealed that this structure had a much greater mean water depth than the Apex Weir Fishway in September and November (Figure 5). This, and the higher mean velocities and slightly wider cross-sectional width of flow, resulted in the higher discharge rates down this fishway compared with the Apex Weir Fishway. The volume of discharge down the Apex Weir fishway and its time of operation during the period of reduced river discharge could be increased by increasing the depth of the exit notch on the weir wall.

A general trend of increasing temperature was observed during the study period (Figure 4). A sharp drop in conductivity occurred in August due to the input of fresh surface flows coinciding with the initial flood event of 2006 (Figures 1 and 4).

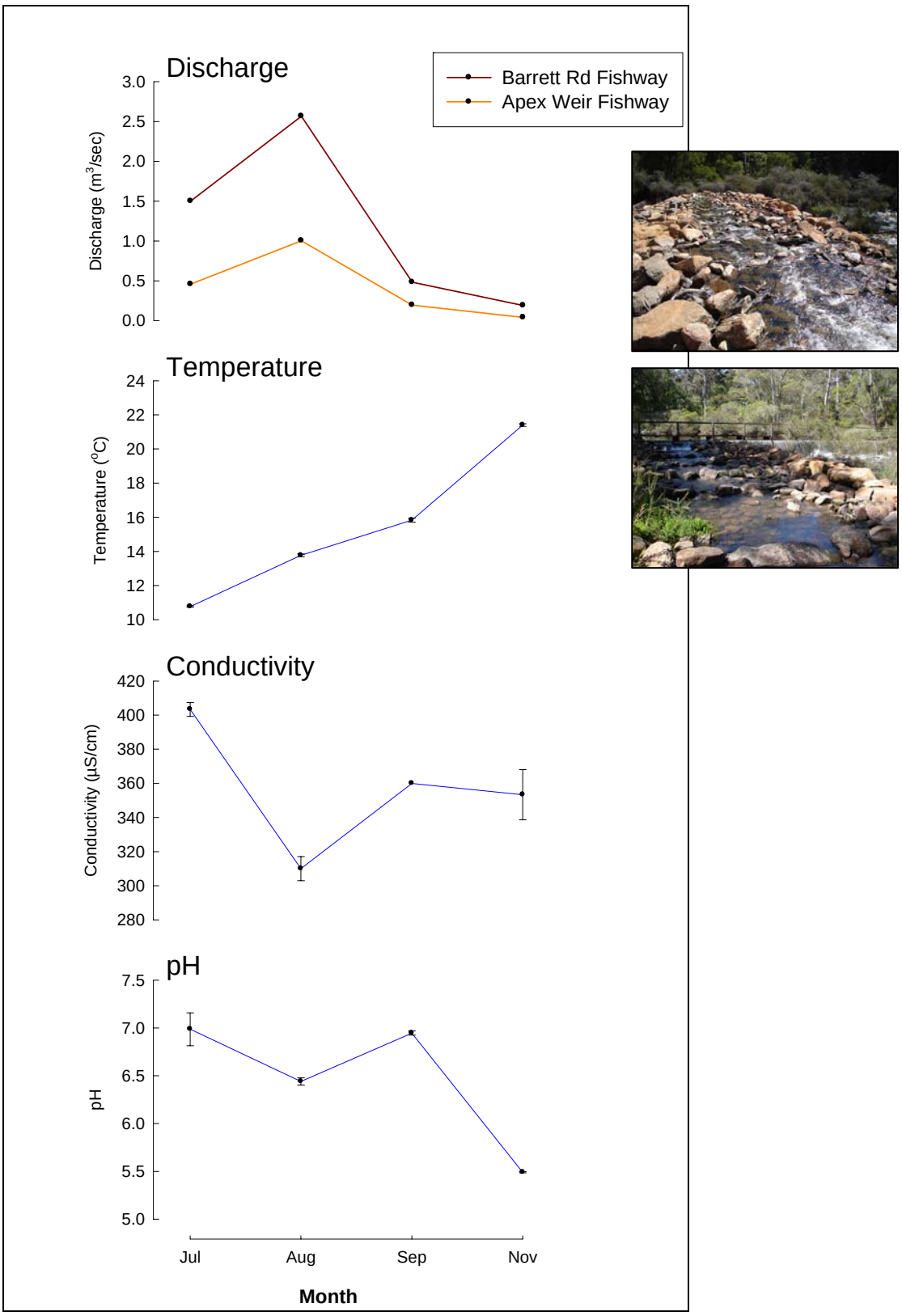


Figure 4 Discharge (m^3/S) for the two Margaret River fishways and water temperature, conductivity and pH during the sampling events.

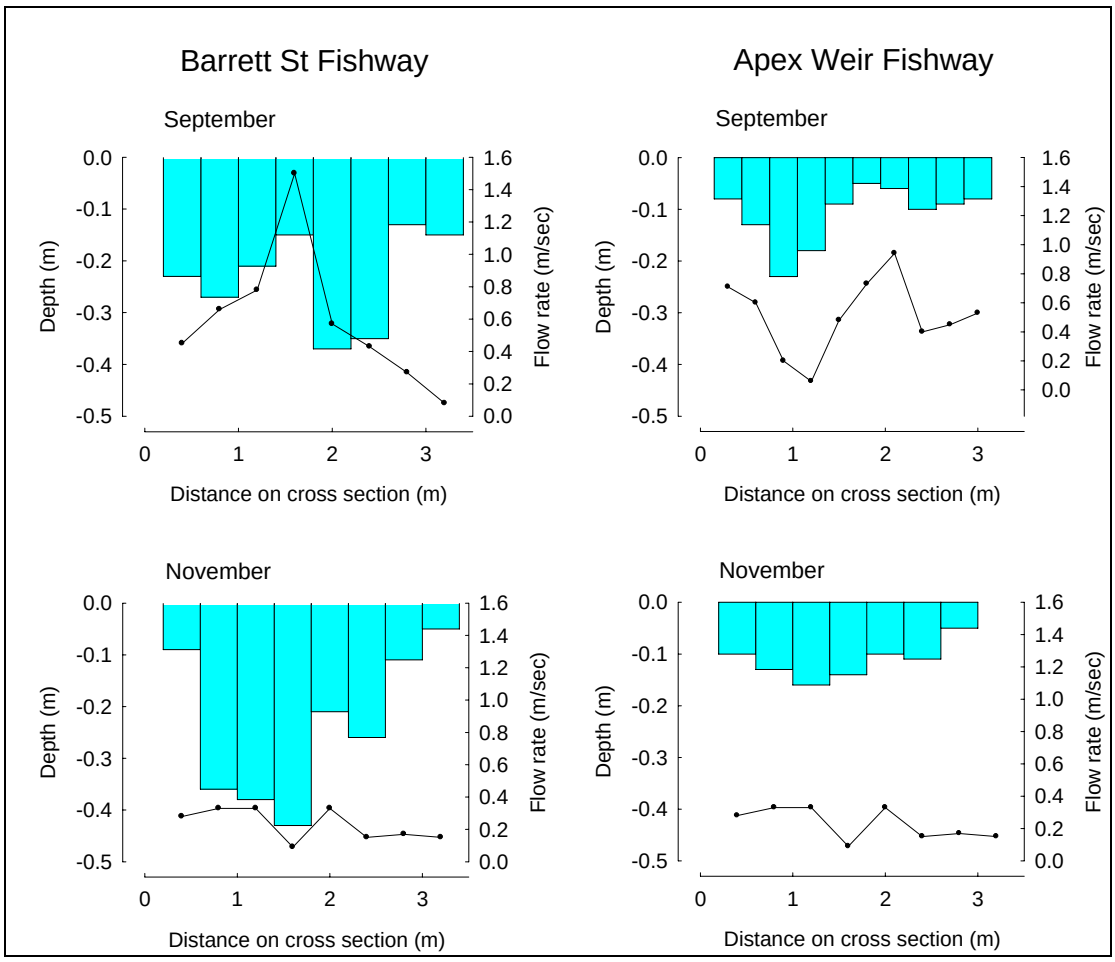


Figure 5 Cross-sectional depth flow profiles of the upper section of the Margaret River fishways in September and November.

Western Minnow (*Galaxias occidentalis*)

Western Minnows were recorded migrating upstream on both fishways during each sampling occasion (i.e. July to November) (Figure 6). The highest mean upstream migration at the Apex Weir Fishway occurred during August, which coincided with the peak discharge for the year (Figures 1 and 6). In contrast, upstream migration was lowest at the Barrett St Fishway during this period. It is apparent that a greater proportion of flows at the latter weir are directed down this fishway when compared to the Apex Weir Fishway, with discharge over these fishways being considerably higher at the Barrett St Fishway during this month (i.e. 2.5 m^3/S cf. 1 m^3/S). Thus, this higher discharge at the Barrett St Fishway resulted in flow rates approximately double the Apex Weir Fishway during August (i.e. ~1.6 m/S cf. 1 m/S). From this it can probably be assumed that flow rates greater than 1.5 m/S limit sustained (i.e. the length of a fishway) upstream movements of this species.

In other months sampled, the number (mean) of Western Minnows moving upstream was considerably greater at the Barrett St Fishway than those at the Apex Weir Fishway.

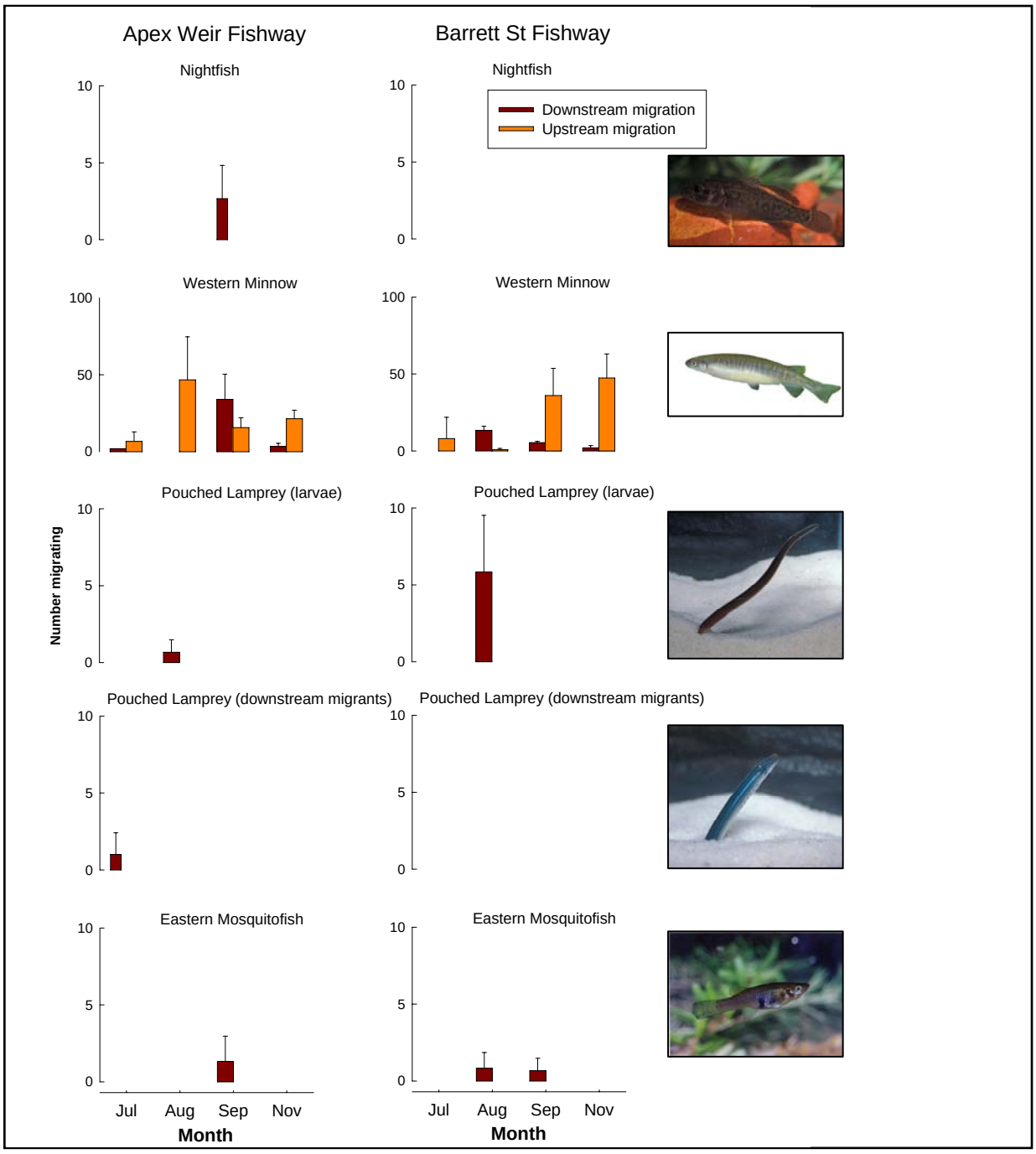


Figure 6 Mean upstream and downstream migrations of Nightfish, Western Minnows, larval (ammocoete) and metamorphosed (downstream migrant) Pouched Lampreys and Eastern Mosquitofish on the Apex Weir Fishway and the Barrett St Fishway in July, August, September and November 2006.

During July, all but one of the Western Minnows using the fishway were moving upstream (Figures 6 and 7). These fish were migrating upstream as a precursor to spawning. The species is known to breed in its first year of life (Pen & Potter 1991, Morgan *et al*. 2005), and during this study, all those captured in July and August that were moving upstream were yet to spawn, i.e. they had clearly discernable ovaries or testis (Figure 8). The only

fish moving downstream in August were juveniles (0+ or new recruits) that had hatched during winter 2006 (Figure 7). Large numbers of adults were recorded moving downstream during September, and these fish had clearly recently spawned. There were still considerable numbers of fish moving upstream at this time, some of which were mature adults that were yet to spawn, while others were 0+ fish. Similar migration patterns occurred during November.

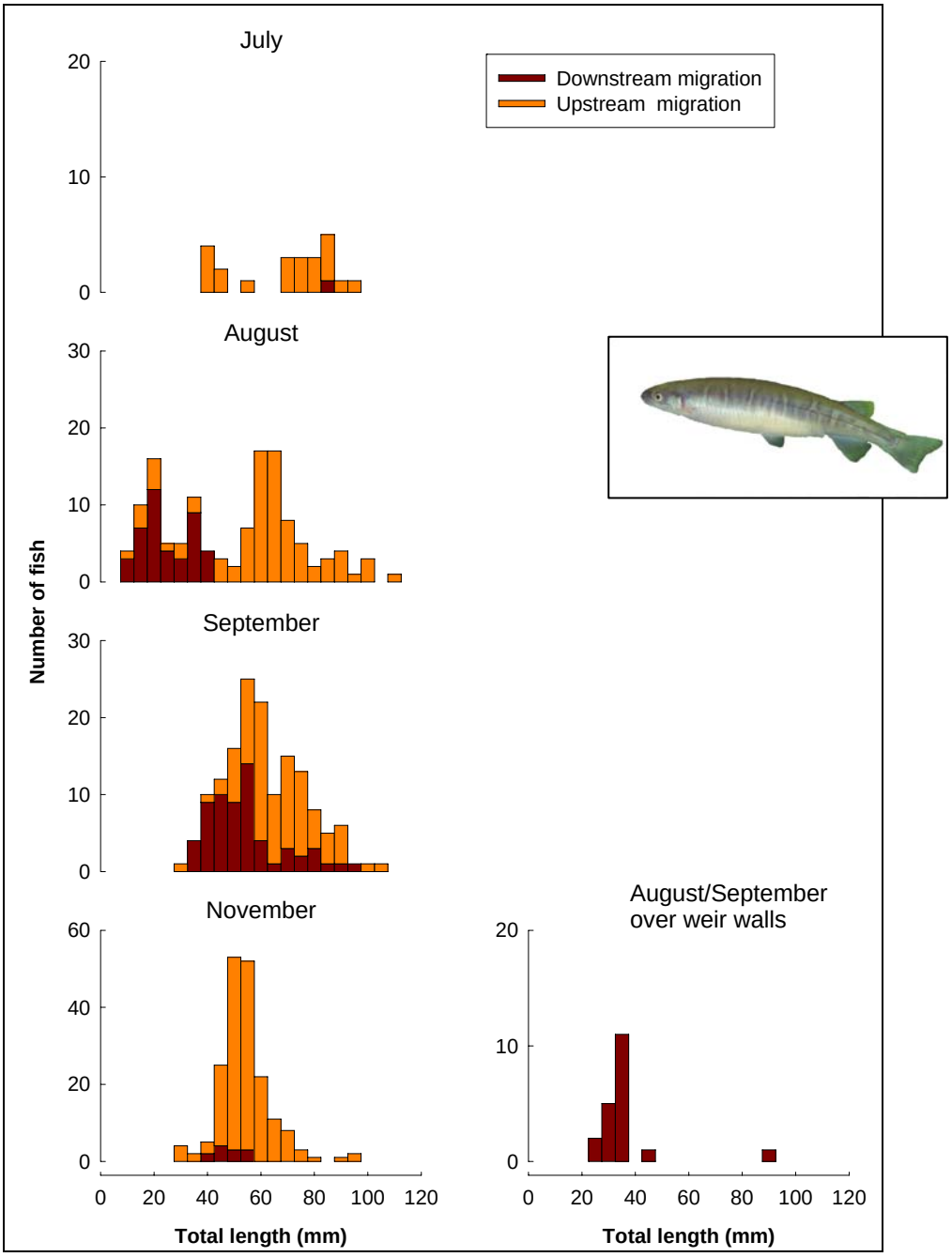


Figure 7 Combined length-frequency histograms of Western Minnows migrating upstream and downstream over the fishways on Margaret River in July, August, September and November 2006. Also included are the lengths of those fish that 'swam' over the weir rather than using the fishways.

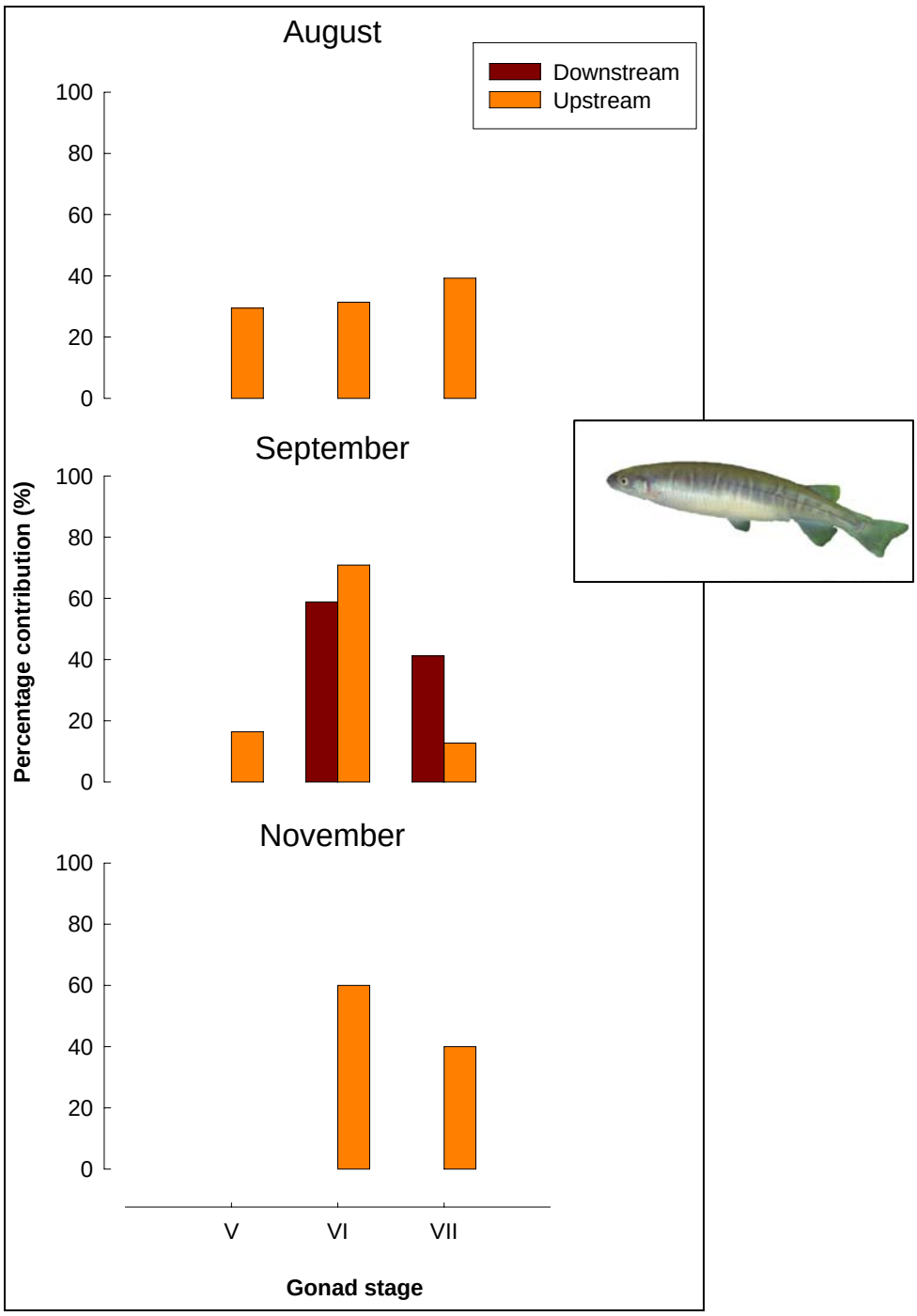


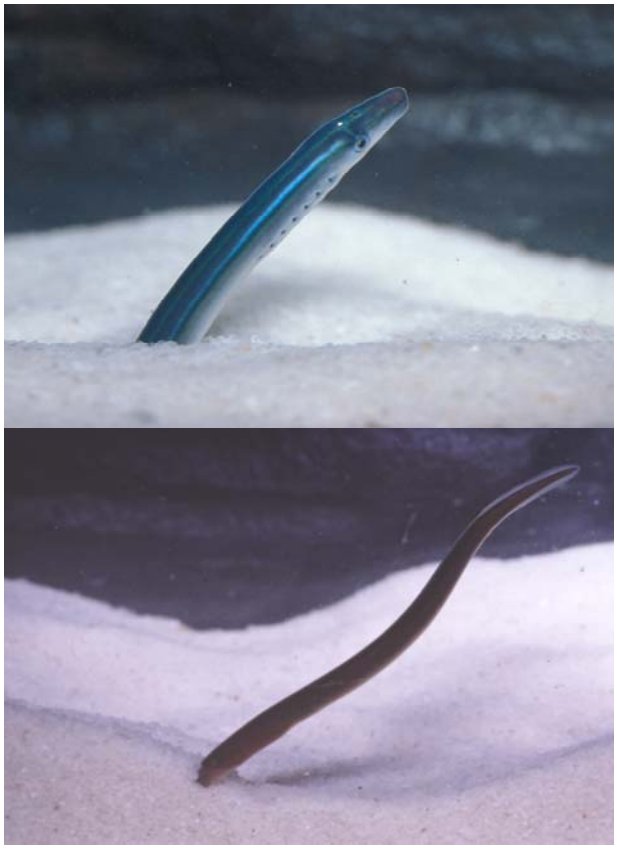
Figure 8 Gonad stages of Western Minnows (both sexes) between August and November. Stage V is mature, stage VI is spawning, and stage VII is spent (i.e. recently spawned).

There was no significant difference ($p = 0.568$) in the mean number (adjusted for fishway coverage) of Western Minnows found to move upstream over the two fishways during the sampling period. In fact, the usage of the two fishways by this species was very similar with an average of 22.6 ±6.8 SE fish.night^{-1} captured moving over the Apex Weir Fishway compared to 23.4 ±7.3 SE fish.night^{-1} over the Barrett St Fishway. This highlights that the two structures are both very effective in facilitating the upstream movement of this species in the Margaret River.

Using electrofishing techniques, after the completion of fyke netting, a remarkably similar total number of Western Minnows was recorded on the two fishways with 89 (nine and 80

in August and November, respectively) and 86 (26 in August and 60 in November, respectively) fish recorded from the Barrett St and Apex Weir fishways, respectively. This similarity supports the migration data for this species which suggests that the two fishways are both allowing similar upstream movements of this species to occur. Also of note was the capture of 12 Smooth Marron and a single Western Pygmy Perch in November on the Apex Weir Fishway.

Pouched Lamprey (*Geotria australis*)



The upstream migration of adult Pouched Lampreys is highly variable, and from anecdotal reports from community members it was limited in 2006. Two adult lampreys moving upstream were captured at the base of the Apex Weir in November during this study; and a dead adult was found at the weir. During September 2003 three adults were captured on Apex Weir Fishway and up to 100 adults were observed at the Barrett St Weir (Morgan & Beatty 2004). During the 1990s large numbers of adult lampreys were observed at these weirs and the waterfall, and it is possible that the stronger migrations of lampreys in the 1990s were influenced by the higher discharges in the river at this time. Thus, greater discharges increase the connectivity to the ocean across the sand bar at the mouth of the river, thereby providing greater access to the river.

The larval stage of the species spends much of its time (~4.5 years) buried under substrates, and within Margaret River the highest densities of larval beds occur in sites characterised by a high degree of shade and a high abundance of organic material (Morgan & Beatty 2004), factors that are known to influence larval densities (Potter *et al*. 1986). The highest densities of larval beds are known to exist above the Barrett St Weir, where they were found at densities of over 1 lamprey/m^2 (Morgan & Beatty 2004). Ammocoete movement in a downstream direction was recorded on the fishways in August only, with higher numbers recorded moving down the Barrett St Fishway. We hypothesize that the scouring of habitats, caused by high discharge during this period, and thereby exposing buried ammocoetes may have led to this month being the only month that we recorded ammocoete movements (see also *Fish 'swimming' over the weir walls, rather than using the fishway*). After four or so years in the river and at > 80 mm TL (Figure 9), the ammocoetes metamorphose. These metamorphosed larvae, or downstream migrants, migrate to the sea during winter where the greatly increase in size. The juveniles were only captured on the fishways during July, but were recorded in considerable numbers 'falling' over the weir walls in August (see *Fish 'swimming' over the weir walls, rather than using the fishway*).

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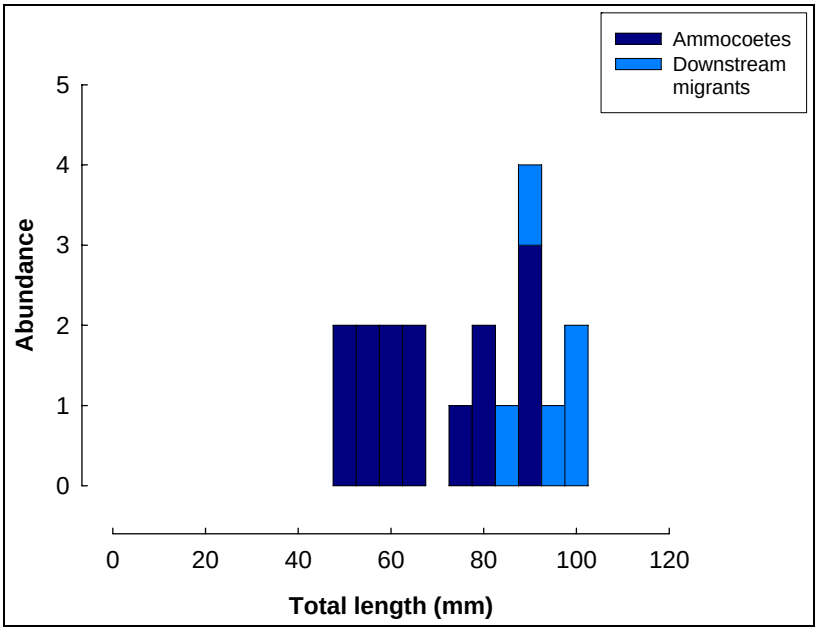

Figure 9 Combined length-frequency histograms of larval (ammocoetes) and downstream migrants (juveniles) of the Pouched Lamprey captured moving downstream.

Decapod crustaceans (Smooth Marron, Gilgies & Freshwater Shrimp)

Figure 10 illustrates the usage of the fishways by the freshwater crayfishes (Smooth Marron and Gilgie) and the South-west or Freshwater Shrimp during the study period. Only limited upstream movement of the freshwater crayfishes occurred on these structures, probably due to the considerable flow rates and lack of strong upstream swimming ability of these species (i.e. generally move by crawling). However, there was a degree of upstream and downstream movement of marron on the Apex Weir Fishway in November, which may have been related to feeding activity as the discharge rates slowed (Figure 10). There was no clear difference in the sizes of Smooth Marron captured moving either upstream or downstream over the fishways (Figure 11).

Considerable numbers of South-west Shrimp were recorded moving downstream over the Barrett St Fishway in August, September and November, with peak movement coinciding with the major discharge in August (Figure 10). Considerable upstream movement of this species also occurred in November over the Apex Weir Fishway (Figure 10). These movements may have been related to breeding.

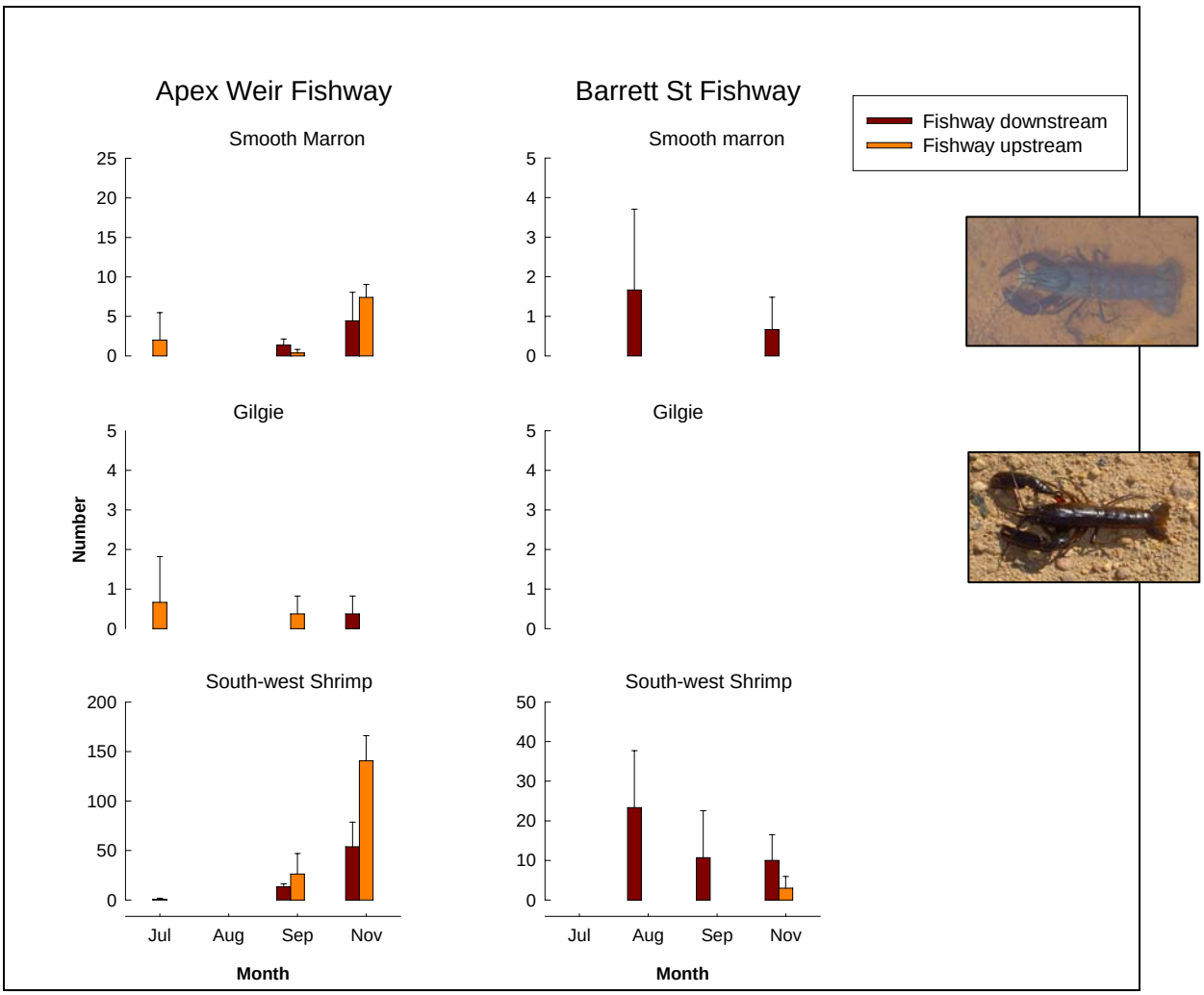

Figure 10 Mean upstream and downstream migrations of Smooth Marron, Gilgies and Freshwater Shrimp on the Apex Weir Fishway and the Barrett St Fishway in July, August, September and November 2006.

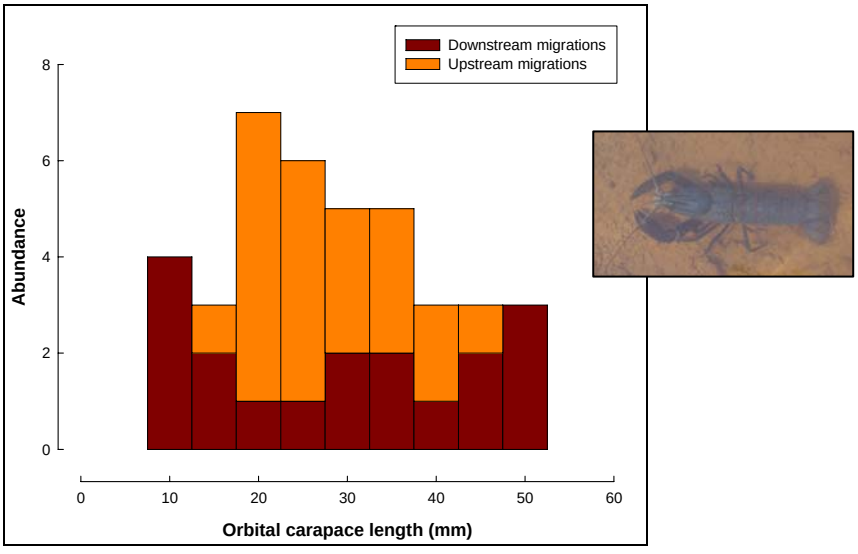

Figure 11 Combined length-frequency histograms of Smooth Marron moving upstream and downstream over the Margaret River fishways.

Fish 'swimming' over the weir walls, rather than using the fishway

During August sampling, large numbers of Western Minnows, Pouched Lampreys and Eastern Mosquitofish were captured falling over the weir wall (Figure 12). These Western Minnows consisted almost entirely of small juveniles born during winter 2006 (Figure 7), while the lampreys consisted of both ammocoetes and downstream migrants. Of note is that downstream migrants were only captured falling over the Barrett St Weir, this downstream migratory phase of the species comprises recently metamorphosed individuals that are migrating to the sea. It is possible that the reason they were not found moving of the Apex Weir is the fall from the Barrett St Weir results in their death. The large number of ammocoetes captured falling over the weir wall is also of concern, and migrations of this life-stage has not previously been noted, at least in south-western Australia. It is possible that the peak discharge that was recorded during this time led to their beds (they burrow into substrate) being eroded and resulting in them moving to find new habitats. The higher numbers of this species and the Western Minnows falling over the Apex Weir compared to the Barrett St Weir may be indicative of the greater diversion of water down the Barrett St Fishway, compared to the Apex Weir Fishway.

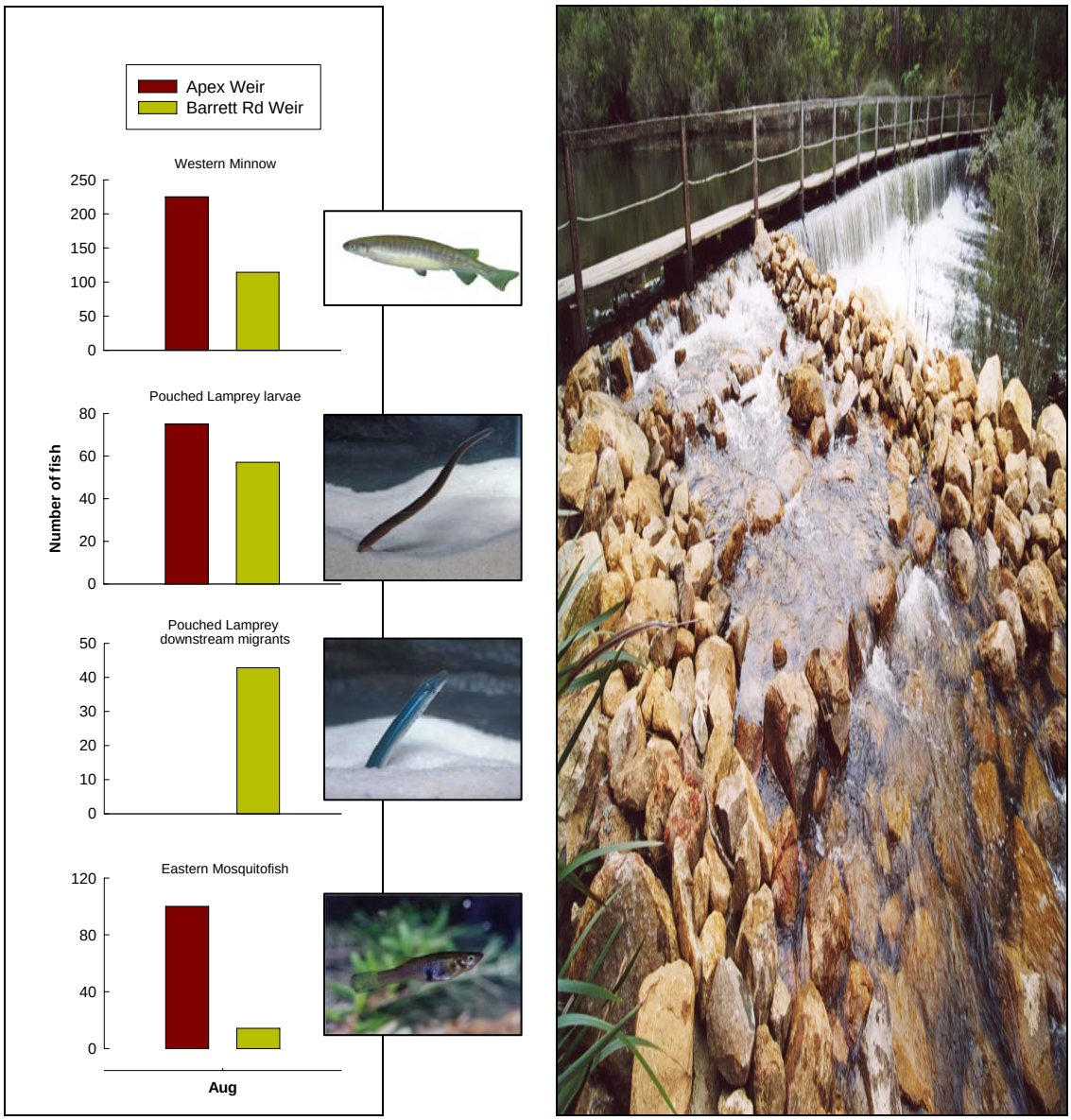

Figure 12 Downstream movement of fish over the weir walls, i.e. fish 'swam' over the weirs rather than using the fishways.

Conclusions

This study has demonstrated that both the Barrett St and Apex Weir Fishways on Margaret River are effective in facilitating the upstream migration of the Western Minnow over two considerable artificial barriers on the river. The fishways were shown to have comparable operational success with very similar mean numbers of Western Minnows recorded moving upstream over the two structures.

The Barrett St Fishway had a greater discharge than that of the Apex Weir Fishway due to a deeper cross-sectional profile. This increased the flow velocity on the Barrett St Fishway, and it appeared that the Western Minnow's flow limit for sustained (fishway length) upstream movement may be ~1.5m/sec. It was found that juvenile Western Minnows and Pouched Lampreys were falling over the weir walls during the peak discharge period in August which may result in their death or injury. The fishways would partially mitigate this by allowing lower gradient downstream movements; however consideration should be given to retrofitting these weirs to reduce this impact. It is also recommended that the notch on the Apex Weir Fishway exit be increased in size to allow greater discharge and length of operational time.

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