Assessing the requirement for fishways on Gingin Brook

FISHCARE WA

Report to the

Gingin Land Conservation District Committee

Stephen Beatty & David Morgan

Centre for Fish & Fisheries Research

MURDOCH UNIVERSITY

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Summary *– The fish fauna upstream and downstream of four barriers (dams) on Gingin Brook were sampled during November 2003 in order to determine whether such barriers pose a significant obstruction to fish migration. A total of 773 fish from eight species were captured during the sampling period. Six of these species are endemic to the freshwaters of south-west of Western Australia including (in order of abundance): western pygmy perch, nightfish, western minnow, freshwater cobbler and mud minnow. Two further species are essentially estuarine and are also restricted to this region: Swan River goby and big headed goby. The feral mosquitofish, a native to eastern and south-eastern United States, was also relatively common throughout Gingin Brook. There were greater abundances and mean densities of all native fish species at sites immediately downstream of the major obstructions on Gingin Brook than upstream, with the exception of the big headed goby, which had similar densities. Overall, there were significant differences between the density of fish (all species combined) below the barriers than above (P = 0.001).*

Between sites upstream and downstream of obstructions, there were significantly more western pygmy perch ($P \leq 0.05$) and nightfish ($P \leq 0.1$) below structures with the mean density of these two species at sites immediately downstream of obstructions being 0.46 (±0.13) and 0.33/m^2 (±0.14), respectively, compared with densities of 0.08 (±0.05) and 0.05/m^2 (±0.05), respectively, immediately upstream of the obstructions. There was also a considerably greater mean density of western minnows below the obstructions compared with above, however, due to a high variation in number, this was not found to be significant.

It appeared that the major obstruction to fish movement on Gingin Brook, as reflected by the greatest difference in abundances in most native fishes downstream and upstream of the obstruction, was the town weir. The western pygmy perch, western minnow, nightfish and Swan River goby were all recorded in far greater density downstream of the weir when compared with upstream. The gauging station at Mortimer Rd and the weir at Cheriton Estate also pose significant barriers to fish migrations.

It is therefore recommended that initial consideration be given to the most cost-effective design for the greatest impediment on Gingin Brook, the town weir, and its effectiveness assessed by an ongoing monitoring program similar to that which has occurred on the recent fishway projects (see Morgan and Beatty, 2004 a, b, c). Once the effectiveness of this initial fishway has been assessed and confirmed, it is recommended that consideration then be given to fishway constructions on the Mortimer Rd gauging station and the Cheriton Estate weir.

Introduction

The regulation of rivers for water usage and hydrological data gathering has resulted in most of the rivers of south-western Western Australia being dammed to varying degrees. Historically, the dams that were constructed in this region neglected to take into account the prevailing aquatic fauna and what impact regulation may have on them. For example, many fish species undertake daily or seasonal movements, the latter often in response to spawning. Upstream migrations for spawning offset the downstream movement of eggs and larvae during periods of high flows. As a result of upstream migrations, fish often become accumulated below impassable barriers, such as dams, where they are exposed to increased teleost and avian predation. In south-western Australia the level of predation is often exacerbated by the presence of introduced fishes. It is only in the last two years that fishways have been constructed in Western Australia to allow free passage of fish around barriers such as dams.

The uniqueness of the freshwater fishes of south-western Australia has meant that fishways here are experimental, with the three that have been constructed in this State being purpose built to provide passage for specific species. For example, a vertical slot fishway was constructed at a gauging station on the Goodga River east of Albany to provide fish passage to the trout minnow (*Galaxias truttaceus*) and spotted minnow (*Galaxias maculatus*). A rock-ramp fishway was constructed on the Hotham River, near Boddington, to minimise the large numbers of western minnows (*Galaxias occidentalis*) that seasonally become congregated below the Lion's Weir, while a second rock-ramp fishway was built at Margaret River to benefit a range of species that occur in that river (Morgan and Beatty, 2004a, b, c).

Gingin Brook has been recognised as providing important habitat and refuge for both Moore River's and the south-west's fishes (Morgan *et al*. 2000). This is due to the fact that much of the main channel of the Moore River has become salinised through extensive land-clearing and that elevated salinities in much of the catchment have excluded those freshwater fish species that are unable to tolerant salinised waters. Thus, species such as the mud minnow (*Galaxiella munda*), western pygmy perch (*Edelia vittata*) and nightfish (*Bostockia porosa*) have been lost from the main channel and are now essentially restricted to the 'fresh' tributaries. Similar salinisation causing declines in the south-west's freshwater fishes has been reported for the Blackwood River (Morgan *et* al. 2003).

The aim of this study was to determine whether a number of structures on Gingin Brook, in the Moore River catchment, obstruct movement of fish throughout the brook and if so, provide recommendations on the need for fishways at specific sites.

Materials and methods

Environmental variables and sampling sites

The locations of the four major potential obstructions to fish migrations on Gingin Brook (Plate 1, Figure 1) were identified by the Water and Rivers Commission (Leanne Hartley, pers. comm.). These sites included the town weir, artificial waterfalls on Beattie Rd and at Cheriton Estate and a Water and Rivers Commission gauging station on Mortimer Rd. A hand-held GPS was used to record the coordinates of each site and a map constructed using the MapInfo™ program (Figure 1).

In order to assess whether these weirs posed an impediment to fish movement, sampling sites were selected immediately upstream and downstream of the four obstructions (a total of eight sites). The water temperature and conductivity was recorded at the bottom of the water column at three locations at each site during November, 2003.

Sampling of fish fauna

During November, 2003, a back-pack electrofisher (*Smith-Root model 12-A*) and scoop net were used to sample fishes (momentarily stunning the fish within an area with a radius of ~3m). In addition, a 10 m seine net was used to sample fishes from larger pools in which the electrofisher is less effective. Fishes were identified, abundances determined and area sampled recorded. The mean density of each species at each site was recorded using the formula:

$$D = N / A$$

Where D is the density of each fish species at each site, N is the number of fish captured at each site and A is the area sampled at each site.

A random sub-sample of each species captured at each site was taken and each individual was measured to the nearest 1 mm total length (TL). Length-frequency histograms of each species, split for sites upstream and downstream of obstructions, were plotted.

The mean density of each fish species (± 1 S.E.) at those sites upstream and downstream of the obstructions was determined, illustrated graphically and the significance of the differences in densities between upstream and downstream sites was determined using one-way ANOVA. A Levene's test was conducted to determine if variances were homogenous and, if they were found not to be, these data were log-transformed prior to conducting the ANOVAs.

The densities of each species upstream and downstream of the town weir, the Mortimer Rd gauging station and the Cheriton Estate weir were also plotted separately to

provide a comparison of the relative impact of each of these obstructions on fish movement (Plate 1).

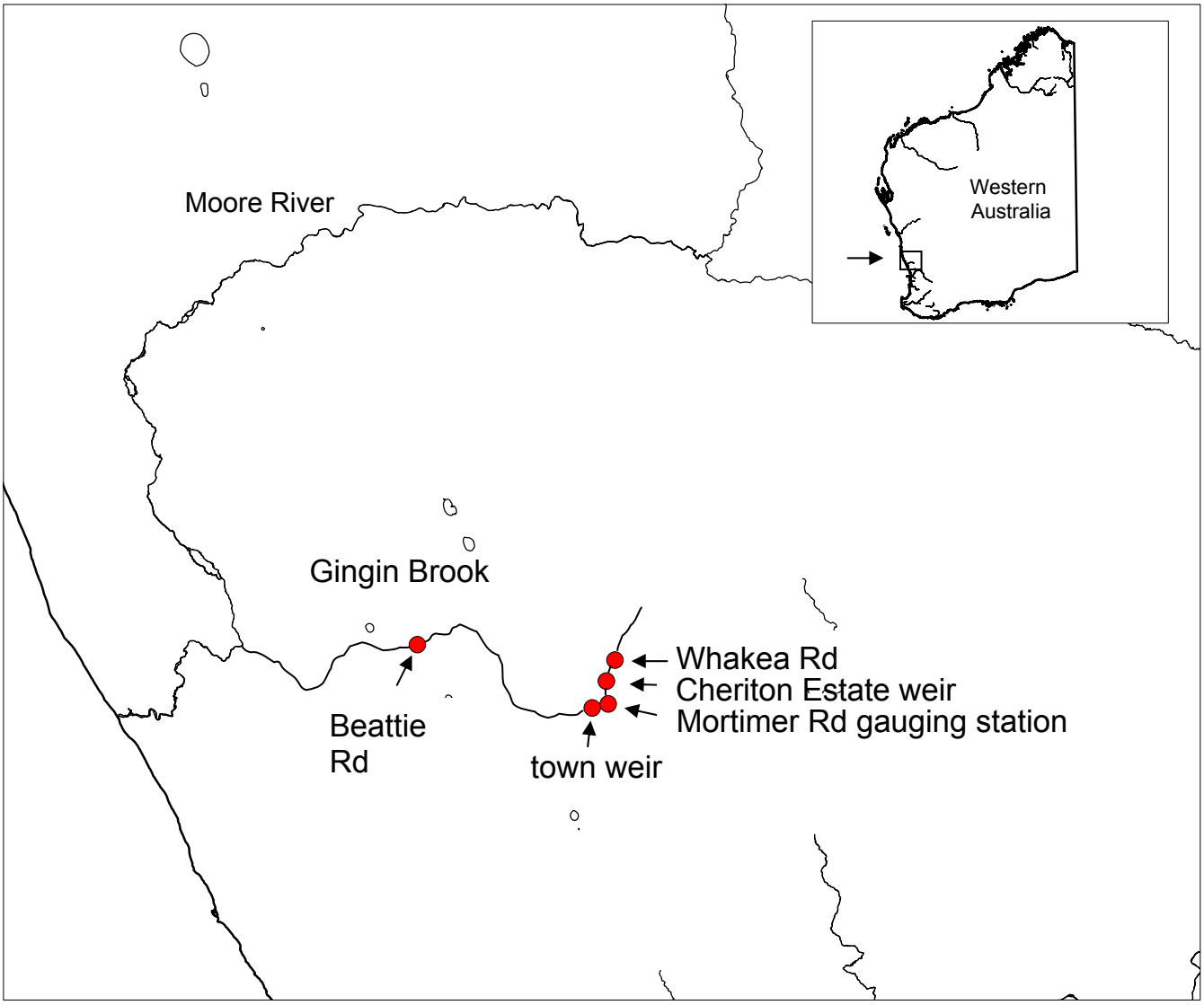

Figure 1 The barriers/weirs sampled on Gingin Brook to determine whether they presented barriers to fish migrations.

Plate 1 The sites sampled in Gingin Brook. A. Whakea Rd; B. Artificial waterfall at Cheriton Estate; C. Gauging Station on Mortimer Rd; D. Town Weir; E. Artificial waterfall on Beattie Rd.

Results and Discussion

Environmental variables and habitat modification

The mean water temperature above and below the four major obstructions on Gingin Brook was 20.2 °C (±0.87 S.E.) and 22.5 °C (±1.25 S.E.), respectively. Although not found to be significantly different probably due to small sample size (ANOVA, $P = 0.16$), the slightly warmer temperatures below the obstructions are due to the warming of the surface of the pool above the obstruction relative to the bottom water of the deeper pools above the obstructions. As only the warmer, upstream surface water flows over each obstruction the water below was slightly warmer than the bottom water in the pools above the structures.

A similar phenomenon was observed in conductivities with the mean recorded above obstructions (673.6 µS/cm ±67.6 S.E.) being slightly higher than that recorded below (618.3 µS/cm ±71.3), although this difference was not significantly different. Water with higher conductivity is denser relative to that with lower conductivity and therefore bottom water in deeper pools tends to be higher in conductivity and salinity than surface waters. Therefore, as the lower density surface water tends to flow over the obstructions and the conductivity was measured at the bottom of the water column, the relatively deep pools upstream of obstructions had slightly higher conductivities than the mixed water downstream.

The alteration of temperature and conductivity regimes upstream and downstream of the barriers was brought about by the obstructions effectively altering the morphology of the river whereby artificial pools form immediately upstream of the obstructions. The difference in water conditions would probably be more extreme during summer when flow rate is reduced or stops completely thereby further exacerbating the pooling effect above obstructions and increasing stratification of the upstream waterbodies. The pooling effect also creates habitat more favourable to the feral mosquitofish (*Gambusia holbrooki*) (see below).

Fish fauna of Gingin Brook

A total of 773 fish from eight species were captured during the sampling period (Table 1, Plate 2). Six of these species are endemic to the freshwaters of south-west of Western Australia including (in order of abundance): western pygmy perch (*Edelia vittata*), nightfish (*Bostockia porosa*), western minnow (*Galaxias occidentalis*), freshwater cobbler (*Tandanus bostocki*) and mud minnow (*Galaxiella munda*) (Plate 2). Two other species are essentially estuarine and are also restricted to this region: the Swan River goby (*Pseudogobius olorum*) and the big headed goby (*Afurcagobius suppositus*). The feral mosquitofish (*G. holbrooki*), a

Table 1 The location of sample sites (barrier/obstruction) on Gingin Brook and the density and total numbers of fish species captured above and below each obstruction.

Site description				**Species density per m^2 (total number in parenthesis)**								**Total**
Location of barrier	Latitude Longitude	Area sampled (m^2)	Upstream or Downstream of obstruction	Big headed goby	Swan River goby	Western pygmy perch	Western minnow	Nightfish	Freshwater cobbler	Mud minnow	Mosquitofish	
Whakea Rd	S31.31254º E115.9232º	90	NA			0.11 (10)		0.24 (22)		0.24 (22)		**0.59 (54)**
Cheriton Estate weir	S31.3279º E115.9159º	200	**Downstream**	0.03 (5)		0.73 (146)		0.32 (64)	0.13 (26)		0.02 (4)	**1.23 (245)**
Town Weir	S31.34762º E115.9037º	120	Upstream	0.02 (2)		0.13 (15)	0.01 (1)					**0.16 (18)**
Town Weir	S31.34854º E115.9045º	100	**Downstream**	0.02 (2)	0.31 (31)	0.53 (53)	0.76 (76)	0.68 (68)			0.02 (2)	**2.32 (232)**
Mortimer Rd	S31.3446º E115.9175º	100	Upstream	0.03 (3)		0.11 (11)	0.04 (4)	0.09 (9)			0.10 (10)	**0.37 (37)**
Mortimer Rd	S31.3446º E115.9175º	200	**Downstream**			0.245 (49)	0.065 (13)	0.15 (30)	0.02 (4)			**0.48 (96)**
Beattie Rd	S31.3013º E115.754º	100	Upstream		0.003 (1)	0.007 (2)		0.013 (4)			0.063 (19)	**0.086 (26)**
Beattie Rd	S31.3013º E115.754º	100	**Downstream**		0.06 (6)	0.33 (33)		0.16 (16)			0.10 (10)	**0.65 (65)**
Total (mean density)		**1210**		**0.01 (12)**	**0.03 (38)**	**0.26 (319)**	**0.08 (94)**	**0.18 (213)**	**0.025 (30)**	**0.018 (22)**	**0.037 (45)**	**0.64 (773)**

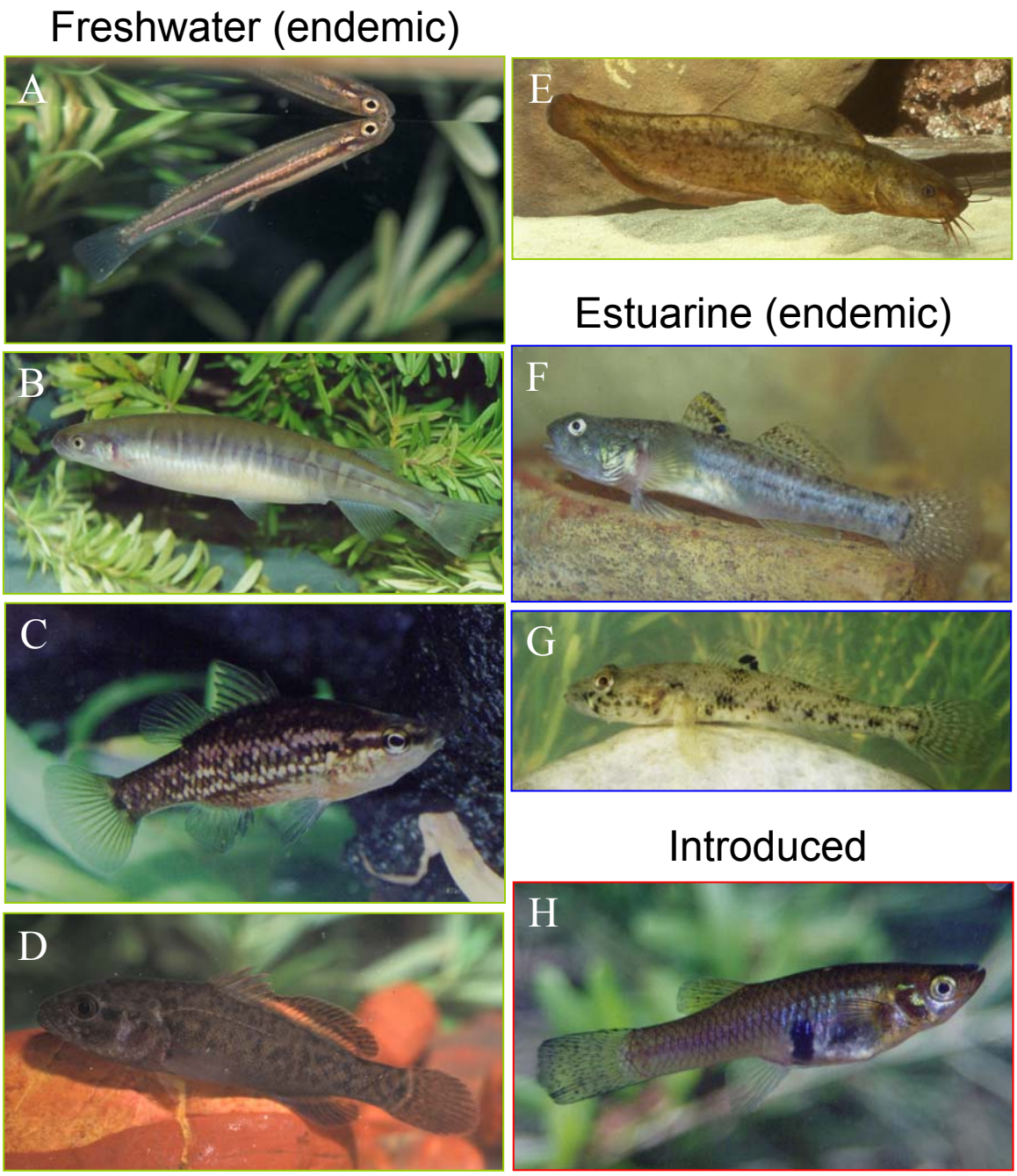

Plate 2 The fishes captured in Gingin Brook.
Freshwater endemic fishes: A. Mud minnow (*Galaxiella munda*); B. Western minnow (*Galaxias occidentalis*); C. Western pygmy perch (*Edelia vittata*), and; D. Nightfish (*Bostockia porosa*).
Estuarine fishes: E. Swan River goby (*Pseudogobius olorum*), and; F. Big headed or south-western goby (*Afurcagobius suppositus*).
Introduced fish: H. Mosquitofish (*Gambusia holbrooki*).

native to the eastern United States, was also relatively common throughout Gingin Brook (Table 1, Plate 2).

The western pygmy perch (Plate 2) was the most abundant species captured in Gingin Brook, representing ~41% of captures and was recorded at all sites and had a density that ranged from 0.007/m^2 upstream of the dam near Beattie Rd to 0.73/m^2 below the Cheriton Estate weir (overall mean of 0.26/m^2) (Table 1, Figure 1, Plate 1). The next most abundant species captured was the nightfish (Plate 2) (~28% of captures) which was captured at seven of the eight sites (aside from above the town weir) at a density that ranged from 0.013/m^2 above the Beattie Rd dam to 0.68/m^2 above the town weir with an overall mean density in the river of 0.18/m^2 (Table 1, Figure 1, Plate 1). The western minnow (Plate 2) was captured at four of the eight sites sampled at an overall mean density in the river of 0.025/m^2 (Table 1, Figure 1, Plate 1).

The western pygmy perch and western minnow are the most widely distributed and abundant endemic freshwater fishes in the south-west of W.A. The Arrowsmith River (just north of the Moore River) represents the northern most distributions of the western pygmy perch and western minnow (Morgan unpublished data) and they are found in all major river systems of the south-west to just east of Albany (Morgan *et al*. 1998). These species are known to breed in winter/spring and migrate upstream as part of the breeding cycle (Pen and Potter 1991a, b).

The Swan River goby (Plate 2) was only captured at the three sites downstream of the largest obstruction on Gingin Brook (the town weir) and had an overall mean density of 0.03/m^2 whereas the big-headed goby (Plate 2) was captured both below and above the weir at a relatively low overall mean density in the river of 0.01/m^2 (Table 1, Figure 1, Plate 1). The town weir is therefore obstructing the upstream migration of this species and effectively has blocked their movement past this point. The Swan River goby is widely distributed in south-western Australia and is found mainly in coastal waters from Kalbarri to Esperance. However, as found in the present study, this species is also found considerable distances inland and is tolerant of extreme temperatures and salinity and spawns in spring and autumn and also to some degree in summer (Morgan *et al.* 1998, Gill *et al*. 1996). The Moore River is the northern-most extent of the range of the big-headed goby and is found a wide range of coastal and inland aquatic systems throughout its range. This species is believed to spawn in late spring/early summer (Morgan *et al.* 1998).

Freshwater cobbler (Plate 2) was also captured in Gingin Brook downstream of the Cheriton Estate weir (0.13/m^2) and the Water and Rivers Commission gauging station at

Mortimer Rd (0.02/m^2) (Table 1, Figure 1, Plate 1). The freshwater cobbler is the largest native freshwater fish in this region (up to 600 mm TL) and is subject to recreational fishing. The Moore River represents the northern-most extent of its range and it is found in the more coastal reaches of river systems of south-western Australia and also in reservoirs as far south as the Frankland River (Morgan *et al.* 1998).

The mud minnow (Plate 2) was only captured at the most upstream site at Whakea Rd crossing at a density of 0.24/m^2 (Table 1, Figure 1, Plate 1). This species is listed as 'restricted' by the Australian Society of Fish Biology and it is found between the Margaret River and the Albany region, with the Moore River population representing a relict of a once much more widespread distribution (Morgan *et al*. 1998). The species spawns multiple times during winter and spring and is believed to have a one year life cycle, however, the presence of many large individuals in specific systems suggests that they may live longer. The Moore River population of mud minnow is therefore an isolated population and is of high conservation importance. Furthermore, the population is spatially restricted within the river and a one year life-cycle makes the population (species) extremely vulnerable to stochastic events, such as severe drought or pollution. The survey of the Moore River system by Morgan *et al*. (2000) did not record the mud minnow in Gingin Brook, but they did record them in the adjacent Lennard Brook, so this record is of considerable importance and extends their range within the Moore River catchment.

The feral mosquitofish (Plate 2) was captured at five sites situated both above and below the town weir with a density that ranged from 0.02/m^2 below the Cheriton Estate weir to 0.10/m^2 above the Mortimer Rd gauging station (Table 1, Figure 1, Plate 1). This species is one of the most widely distributed freshwater fishes in the world with a high tolerance of extreme environmental conditions such as salinity (it has been recorded in salinities nearly twice that of sea-water in the wheatbelt region) (Morgan and Beatty, 2004a). This relatively small species (<60 mm TL) poses a serious threat to endemic fishes of south-western Australia and can rapidly proliferate as they are a live-bearer, mature at a young age, and spawn over an extended period during warmer parts of the year. This species is very aggressive and fin-nips other fish, including western pygmy perch and young (<1 year old) nightfish (Gill *et al.* 1999). The loss of parts of the caudal fin results in a reduction in swimming ability (further increasing the chance of attack) and may subsequently lead to death of individuals (Gill *et al.* 1999). The impact of mosquitofish is reduced in more complex habitats that offer refuge to native species (Gill *et al.* 1999, Morgan unpublished data).

The impact of obstructions on the fish fauna of Gingin Brook

There were greater abundances and mean densities of all native fish species at sites immediately downstream of the major obstructions on Gingin Brook than upstream with the exception of the big headed goby, which had similar densities (Table 1, Figure 2). Overall, there were significant differences between the density of fish (all species combined) below the barriers when compared to above ($P = 0.001$).

Between sites upstream and downstream of obstructions, there were significantly more western pygmy perch ($P \leq 0.05$) and nightfish ($P \leq 0.1$) below structures, with the mean density of these two species at sites immediately downstream of obstructions being 0.46 (±0.13) and 0.33/m^2 (±0.14), respectively, compared with densities of 0.08 (±0.05) and 0.05/m^2 (±0.05), respectively, immediately upstream of the obstructions (Table 1, Figure 2). There was also a considerably greater mean density of western minnows below the obstructions compared with above, however, due to a high variation in number, this was not found to be significant (Table 1, Figures 2, 3 and 4).

It appeared that the major obstruction to fish movement on Gingin Brook, as reflected by the greatest difference in abundances in most native fishes downstream and upstream of the obstruction, was the town weir (Figure 3). The western pygmy perch, western minnow, nightfish and Swan River goby were all recorded in far greater density downstream of the weir when compared with upstream (Plate 1, Figure 3). The gauging station at Mortimer Rd (Plate 1) also appeared to also pose an impassable obstruction as the densities of the above species were also greater downstream when compared to upstream of the obstruction, however, these differences were not as great as those recorded at the town weir (Figures 3 and 4). Furthermore, there were relatively high densities of native fishes, particularly the western pygmy perch and freshwater cobbler, congregated below the weir at the Cheriton Estate site when compared with the Whakea Rd site (Plate 2). However, it must be noted that the latter upstream sampling site was some distance from the Cheriton Estate weir (Table 1, Figures 1 and 5). As only one sample was taken from each site, the significance of the differences in mean density of native fishes at individual obstruction was not tested.

In contrast to the higher densities of native fishes downstream relative to upstream of structures, the mean densities of the feral mosquitofish above obstructions was slightly greater than below (Table 1, Figure 2). As mentioned, this species is found in a wide variety of aquatic systems throughout the region, however, it tends to prefer slow moving waters such as lakes and reservoirs. Therefore, the pools created upstream of obstructions are more favourable to the mosquitofish than the sections of Gingin Brook that have a more natural,

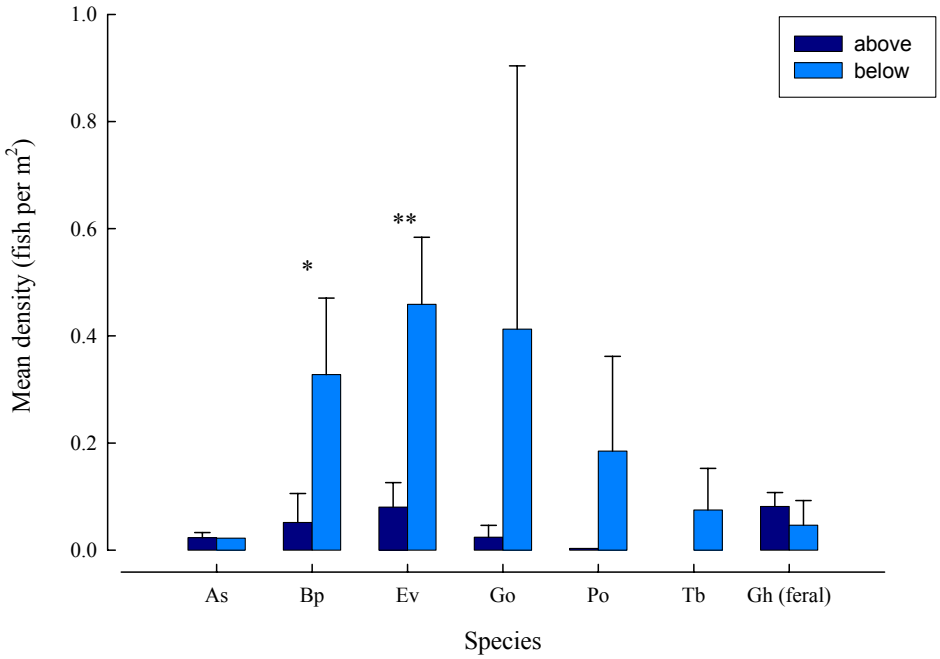

Figure 2. Shows the mean density (+ 1 S.E.) of each species above and below the main structures on Gingin Brook in November 2003. Species codes: As = Big headed goby, Bp = nightfish, Ev = western pygmy perch, Go = western minnow, Po = Swan River goby, Tb = freshwater cobbler, Gh = mosquitofish. N.B. * signficant difference in mean densities above and below structures at $P<0.1$ and ** significant difference at $P<0.05$.

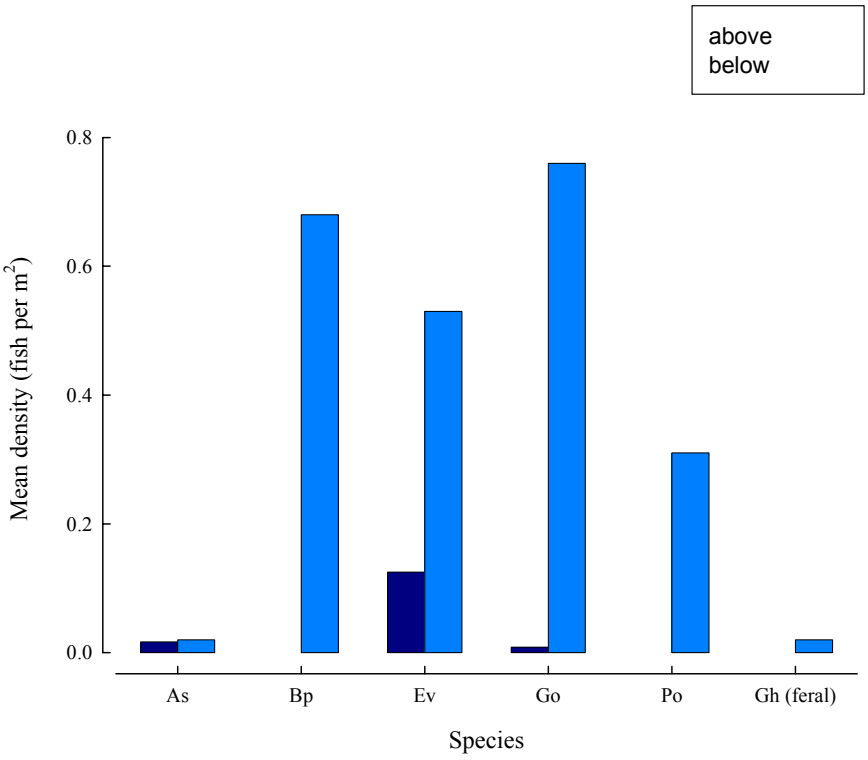

Figure 3 Shows the mean density (+ 1 S.E.) of each species above and below the town weir on Gingin Brook in November 2003. Species codes: As = Big headed goby, Bp = nightfish, Ev = western pygmy perch, Go = western minnow, Po = Swan River goby, Gh = mosquitofish.

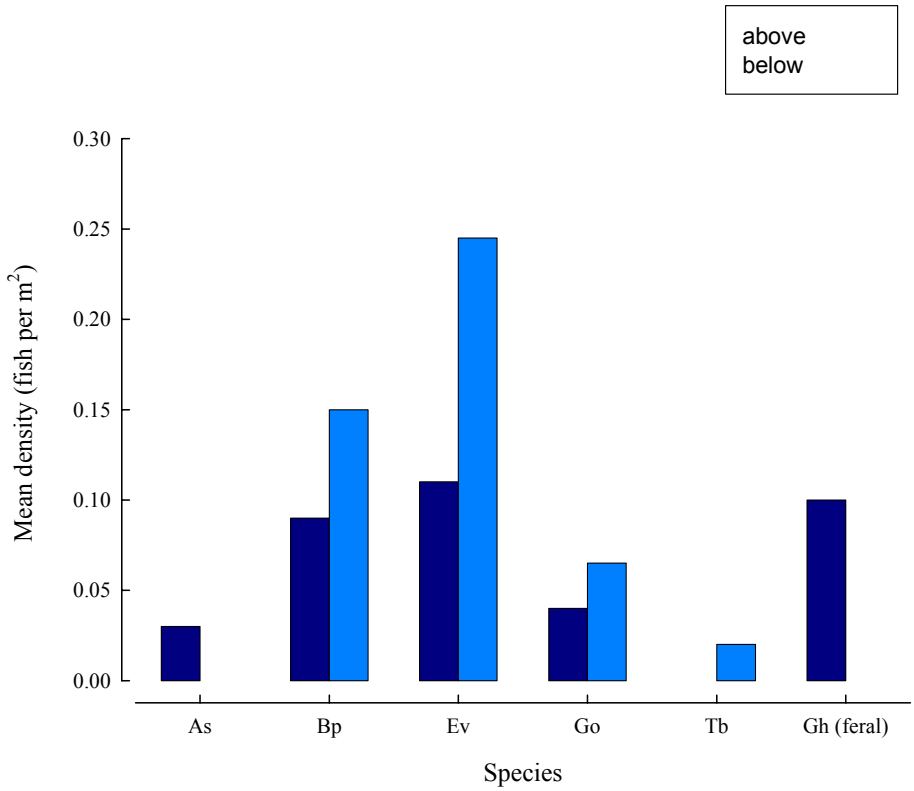

Figure 4 Mean density (+ 1 S.E.) of each species above and below the gauging station at Mortimer Rd on Gingin Brook in November 2003. Species codes: As = Big headed goby, Bp = nightfish, Ev = western pygmy perch, Go = western minnow, Tb = freshwater cobbler Gh = mosquitofish.

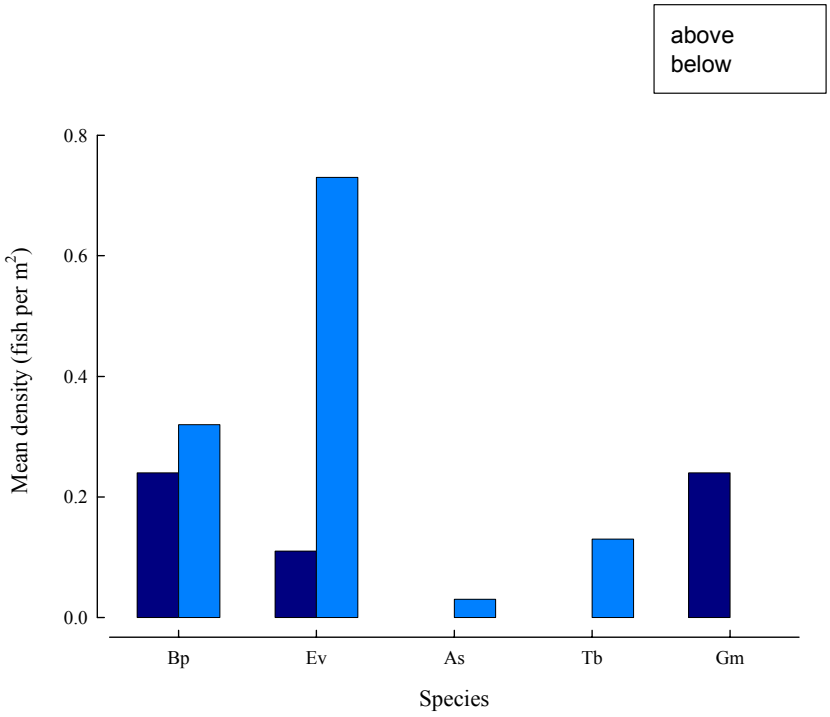

Figure 5 Mean density (+ 1 S.E.) of each species above (Whakea Rd) and below the weir at Cheriton Estate on Gingin Brook in November 2003. Species codes: As = Big headed goby, Bp = nightfish, Ev = western pygmy perch, Gm = mud minnow, Tb = freshwater cobbler, and Gh = mosquitofish.

faster flow regime. This was reflected in the increased densities of mosquitofish above the barriers as opposed to the native fish species that tend to undergo upstream spawning migrations that resulted in the increased densities below the barriers (Table 1, Figure 2).

The length-frequency distributions of native fishes upstream and downstream of obstructions also indicated that they were posing a barrier to fish movement. The length-frequency distribution of the western pygmy perch downstream of the obstructions showed a considerably greater proportion of larger fish (>45 mm TL) than upstream of the obstructions (Figure 6). This species attained sexual maturity at ~42 mm TL at the end of its first year of life in the Collie River (Pen and Potter, 1991) and therefore, it appeared that that the movement of mature fish, likely for the purpose of spawning, was impeded by the obstructions (Figure 6).

Similarly, there was no nightfish >45 mm captured at sites upstream of the obstructions whereas the majority of fish captured below the barriers were greater than this length (Figure 7). Female and male nightfish in the Collie River mature at 56 and 79 mm TL at the end of their second and first year of life for females and males, respectively (Pen and Potter, 1990). Therefore, the movement of mature nightfish also appeared to be impeded by the obstructions in Gingin Brook (Figure 7).

Although a few large (>80 mm TL) western minnows were captured at sites above the obstructions, large individuals were also captured below the barriers along with relatively large number of individuals with a size range of 50-75 mm TL, which were not captured upstream of the obstructions (Figure 8). This species matures at the end of its first year of life in the Collie River at sizes of 75 and 70 mm TL for females and males, respectively. Therefore, it was likely that the dominant size cohort recorded in Gingin Brook (Figure 8) were fish of approximately one year of age and their upstream migration for the purpose of first spawning was likely being impeded by the obstructions.

Freshwater cobbler was only captured at the sites immediately below obstructions and had a wide size range of 40-355 mm TL (Figure 9). In Wungong Dam, they spawn between November and January (Hewitt, 1992) and thus the high abundance immediately below the Cheriton Estate weir and absence upstream may indicate that it was being impeded by this obstruction (Table 1, Figure 9). As they are known to consume small freshwater fish (e.g. western pygmy perch) and crayfish (e.g. gilgies and marron), their presence below barriers may similarly compromise other species that become congregated below barriers.

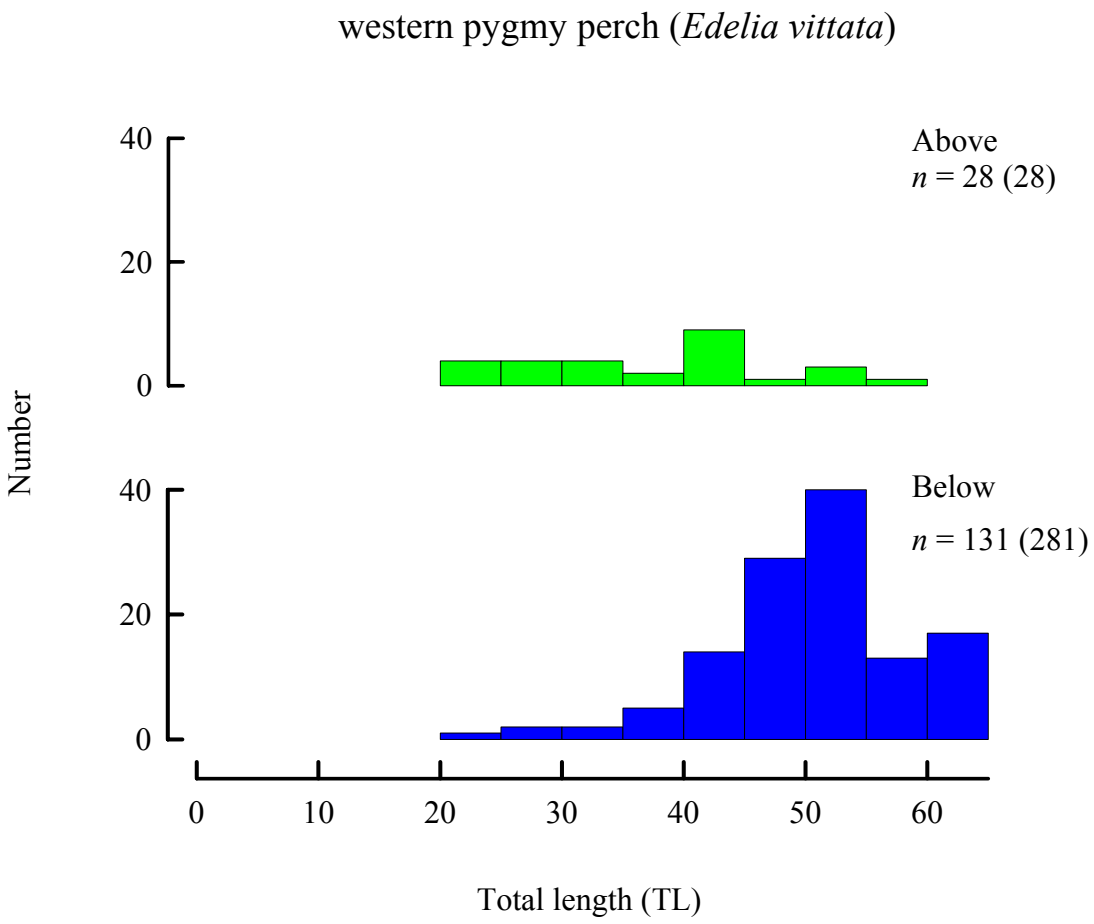

Figure 6 Length-frequency distributions of western pygmy perch (*Edelia vittata*) captured above and below obstructions in Gingin Brook during November 2003. N.B. *n* = number measured and total number captured is given in parenthesis.

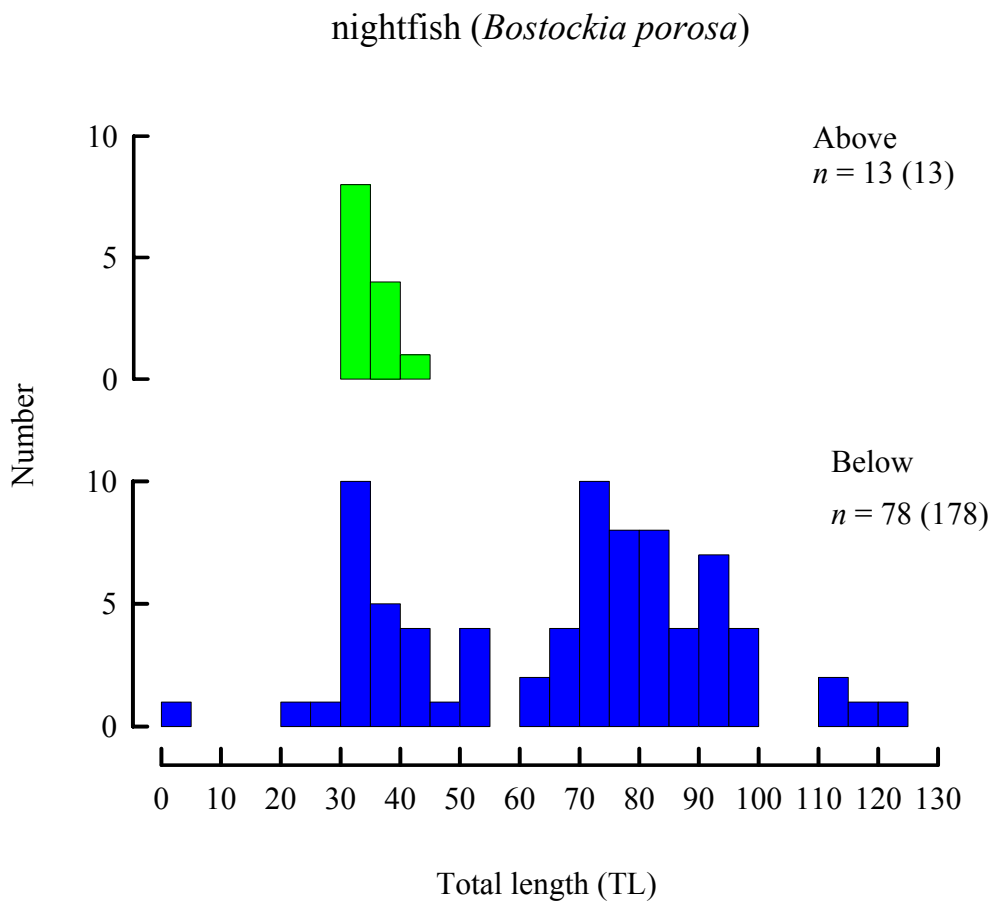

Figure 7 Length-frequency distributions of the nightfish (*Bostockia porosa*) captured above and below obstructions in Gingin Brook during November 2003. N.B. *n* = number measured and total number captured is given in parenthesis.

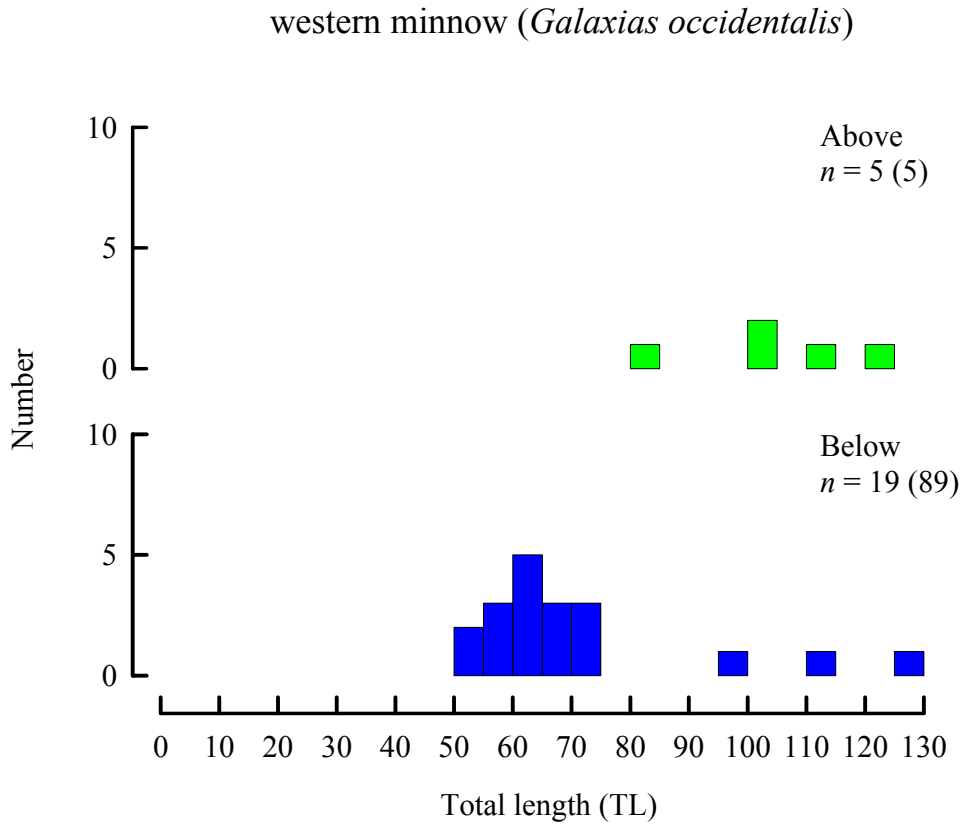

Figure 8 Length-frequency distributions of the western minnow (*Galaxias occidentalis*) captured above and below obstructions in Gingi Brook during November 2003. N.B. *n* = number measured and total number captured is given in parenthesis.

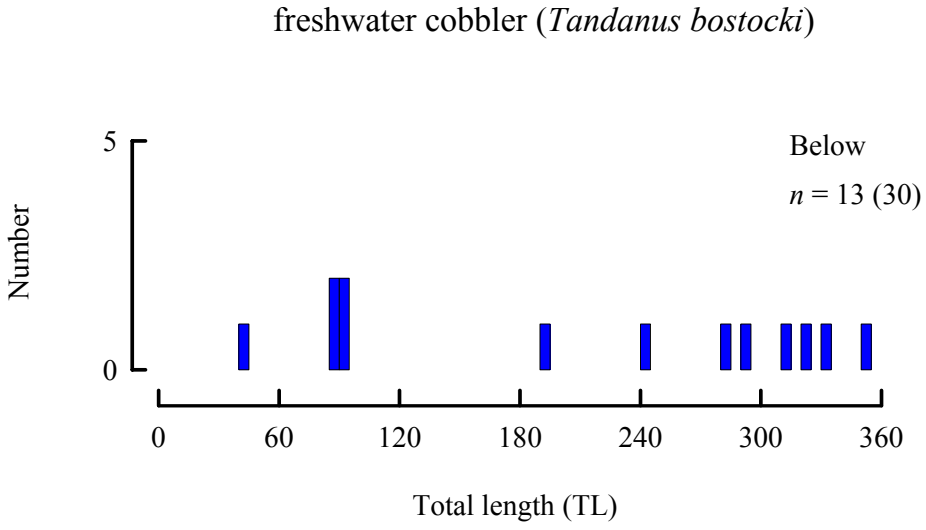

Figure 9 Length-frequency distributions of the freshwater cobbler (*Tandanus bostocki*) captured in Gingin Brook below obstructions during the sampling period. N.B. *n* = number measured and total number captured is given in parenthesis.

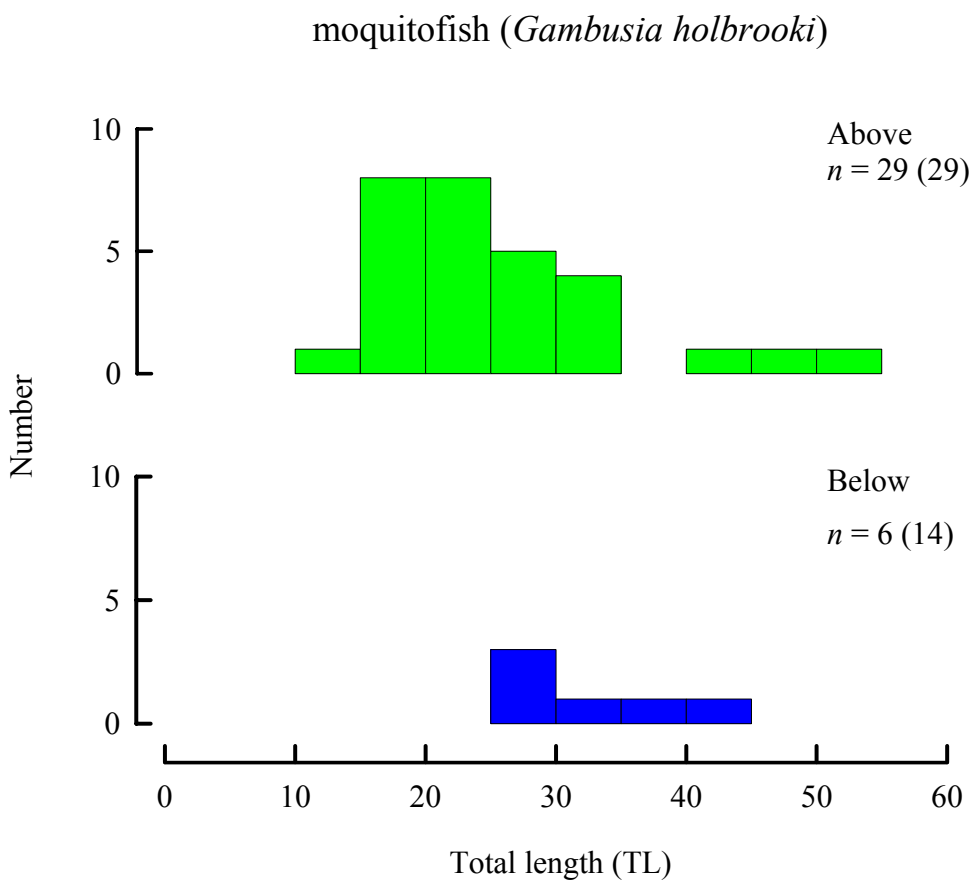

Figure 10 Length-frequency distributions of the mosquitofish (*Gambusia holbrooki*) captured in Gingin Brook during the sampling period. N.B. *n* = number measured and total number captured is given in parenthesis.

Feral mosquitofish above the obstructions had a much wider size range (10-55 mm TL) compared with immediately below the obstructions (25-45 mm TL), which suggested that greater recruitment occurred in the pools upstream of the obstructions compared with the faster moving water downstream of the weirs (with juveniles only captured above the barriers) (Figure 10).

Fishway construction on Gingin Brook

The length-frequency and density data suggested that the movement of larger, sexually mature native fish was being impeded by the obstructions in Gingin Brook, particularly the town weir, the Water and Rivers Commission gauging station at Mortimer Rd and the weir at Cheriton Estate (Plate 1). The construction of suitable fishways at these obstructions will mitigate this impact on the fish fauna by allowing passage over these obstructions, likely increasing spawning success of the populations and reduce avian and teleost predation of the fishes that were found in high densities immediately downstream of the obstructions. These fishways will also effectively result in the mixing of the currently fragmented native fish populations in Gingin Brook and increase the area of habitat available to these populations and allow Swan River gobies to populate parts of Gingin Brook upstream of the town weir.

There are a number of simple designs that could be constructed effectively on these obstructions and the most cost-effective design for each of the three barriers needs to be assessed. Recently constructed fishways in this region have been built on the Goodga, Margaret and Hotham Rivers and have been shown to be effective in allowing the passage of fish over obstructions that are similar to those present on Gingin Brook (Plate 3). The fishways on Margaret and Hotham Rivers are rock-ramps constructed using locally available granite by the Water and Rivers Commission (Morgan and Beatty 2004a, b). The Goodga River fishway (Plate 3) is of a vertical slot design and was constructed by the Department of Fisheries and Water and Rivers Commission with the aid of local volunteers and has also shown to be highly effective in allowing the passage of the endangered trout minnow (*Galaxias truttaceus*), effectively tripling its habitat area (Morgan and Beatty 2004c) (Plate 3).

It is therefore recommended that initial consideration be given to the most cost-effective design for the greatest impediment on Gingin Brook, the town weir, and its effectiveness assessed by an ongoing monitoring program similar to that which has occurred on the above mentioned fishway projects (see Morgan and Beatty 2004a, b, c). Once the effectiveness of this initial fishway has been assessed and confirmed, it is recommended that consideration then be given to fishway constructions on the Mortimer Rd gauging station and the Cheriton Estate weir.

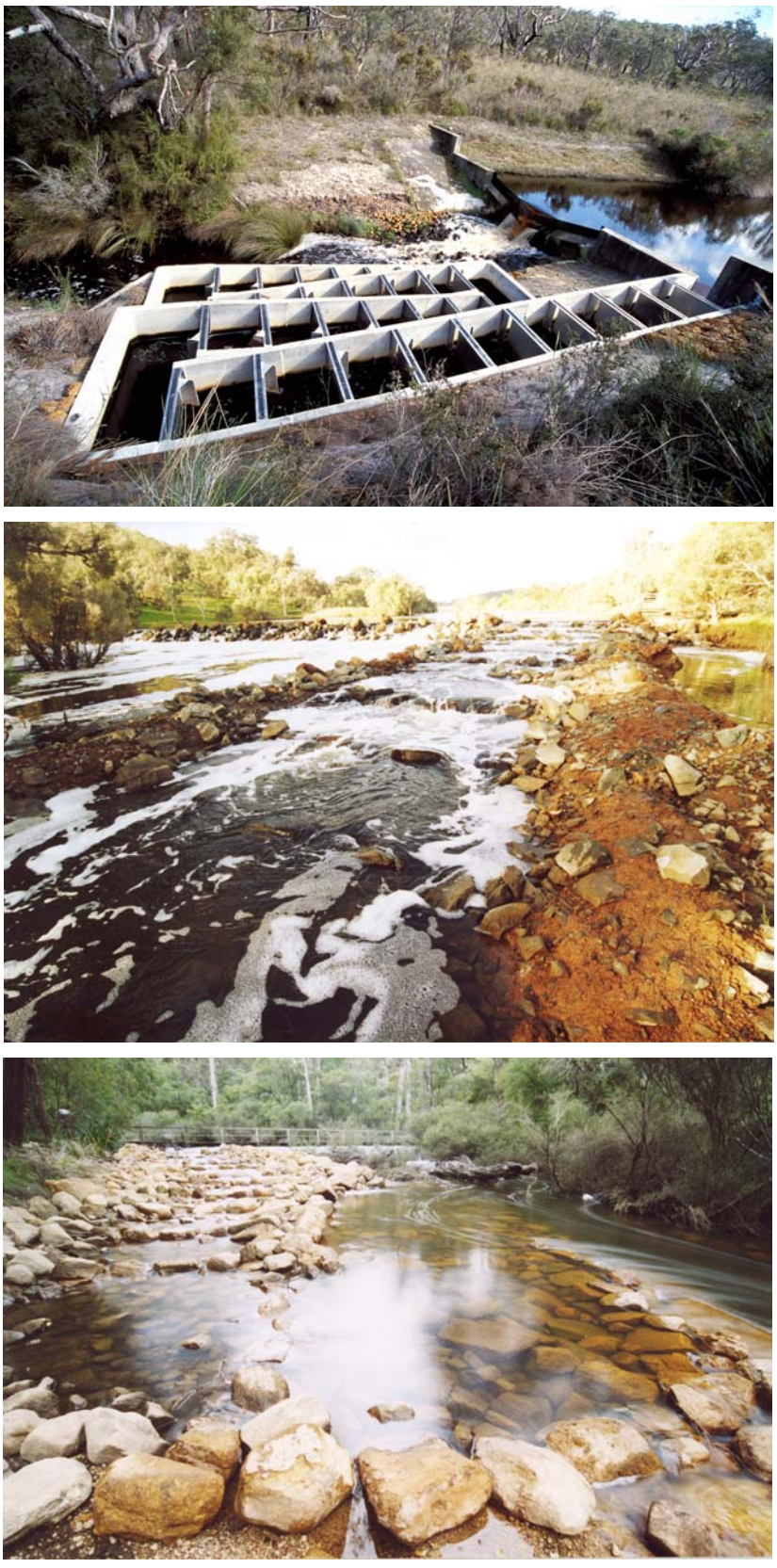

Plate 3 (Top) Goodga River vertical slot fishway, (middle) Hotham River rock-ramp fishway, and (bottom) Margaret River rock-ramp fishway (from Morgan and Beatty 2004a, b, c).

Recommendations

- Liaison should occur with the Water and Rivers Commission in order to design a fishway for the town weir on Gingin Brook. Included in the design phase should be an estimate of costing.
- In-kind support from local government, business and community groups should be sought e.g. provision and cartage of materials and labour.
- Funding be sought for the construction and monitoring of the fishway at the town weir on Gingin Brook.
- Fishway construction and design should take into account spawning and migration times of the fishes inhabiting Gingin Brook and should be designed to function not only during winter and early spring but also during periods of lower flows.
- A monitoring program should be an integral part of the project to assess the effectiveness of the fishway. This should involve a number sampling events in spring (peak time of spawning migration for many of the native species in Gingin Brook) prior to and following the fishway construction.
- Upon confirming the effectiveness of the fishway at the town weir, consideration should then be given to construction of fishways at the Water and Rivers Commission gauging station at Mortimer Rd and the Cheriton Estate weir.

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