Department of Sustainability and Environment

# Monitoring of Native Fish Communities in the Broken Creek and Broken River

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# Monitoring of Native Fish Communities in the Broken Creek and Broken River

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**Front cover photo:** (clockwise from top left), Numurkah Weirpool, Broken River upstream of Gowangardie Weir, Broken River Murray cod sampled from upstream of Caseys Weir, Broken Creek upstream of Nathalia Town Weir. Photos: Justin O'Connor.

**Authorised by:** Victorian Government, Melbourne

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## Acknowledgements

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- DSE Animal Care and Ethics approval permit No. AEC 07/09
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## Summary

Connectivity of river habitats, which is recognised as important for maintaining and restoring native fish populations, is compromised by river regulation. The Murray Darling Basin is the most regulated river system in Australia and the Broken River system, in north eastern Victoria, is among the most regulated systems within the Murray Darling Basin. Some of the greatest threats to native fish populations in the Broken River system result from the presence of weirs which act as barriers to fish movement.

Knowledge of the status of native and introduced fish communities is important in managing natural resources. Our understanding of the fish community in the Broken Creek below the township of Nathalia is continuing to improve, however, a recent study indicated that native fish diversity and abundance upstream of the township of Nathalia is depressed relative to areas downstream. The reasons for these differences are not clear, particularly given that both areas have had fish passage improvement works since 2002. Similar to the Broken Creek, fish passage on the Broken River has also recently been improved with a vertical slot fishway commissioned at Casey Weir in November 2005. A study undertaken prior to the opening of this structure indicated that the weir inhibited fish movement with large congregations of fish accumulating below the weir at times.

In the Broken Creek a study was undertaken between Nathalia and Numurkah to:

- collect baseline fish data;
- assess upstream fish movement as a continuation of the lower Broken Creek fishway program; and
- identify areas with the potential for habitat rehabilitation.

While, in the Broken River a study was undertaken upstream of Shepparton to:

- provide information on the distribution, diversity and abundance of fish and;
- establish whether instream barriers continue to restrict fish movement.

In the Broken Creek a total of 342 individual fish representing three native and five introduced species were collected. Native fish species comprised only 20% of the total catch. There was a significant difference between the percent of native fish at these sites compared to sites previously sampled downstream of Nathalia. The condition of habitat varied through the study area. Generally, depth and width variation, and the amount of in-stream cover decreased from downstream to upstream sites. Catch per unit effort (CPUE) of large native fish was higher in the most downstream sites, which had better habitat than upstream sites.

The status of the fish community in the Broken Creek between Nathalia and Numurkah is poor compared to areas downstream of Nathalia. Given the presence of good habitat in lower sections of this reach and the low numbers of native fish, it appears that there may be little movement of fish into the area, possibly due to restricted fish movement below the Nathalia Weir as a result of low flows (drought); fishways not operating properly (e.g., closed); or fish still colonising

downstream of this area and as a result, there has been little population pressure (e.g., high density) to move upstream.

It would appear from the results of this study that some areas of the Broken Creek between Nathalia and Numurkah do not contain sufficient habitat to support fish populations. In these areas habitat rehabilitation may help improve the fish community in the immediate vicinity and also upstream populations.

In the Broken River a total of 945 fish representing six native and four exotic species were collected. CPUE was higher at sites immediately downstream of instream barriers than in mid-reach sections. A comparison of CPUE between 2005 and 2008 indicated that CPUE was higher at sites sampled in 2008 than those sampled in 2005.

CPUE was greater at sites located immediately below barriers when compared with mid-reach sites on each river system. CPUE data indicated that the weirs on the Broken River are acting as partial barriers to fish movement even though fish ladders have been installed. Fish ladders are not always completely efficient in the transport of fish upstream over a barrier and congregations of fish can sometimes still be found below these structures.

A comparison of CPUE data from the current study with a study from 2005 indicates that more fish were sampled in 2008 than in 2005. This includes a greater number of fish captured below Caseys Weir in 2008 when fish abundance would have been expected to decrease as a result of the installation of the fish ladder. Reasons for these differences in fish abundance are not clear, however, seasonal differences in fish distribution may account for these discrepancies.

This survey was the first to monitor sites upstream of Benalla Weir and indicates that the fish community upstream of this structure appears to be very different to that below it. In order to gain a better understanding of the status of the fish community in this section of the system future studies on the Broken River need to include a more comprehensive survey of Benalla Weir and areas immediately upstream of it.

Recommendations:

Broken Creek

1. Investigate habitat rehabilitation works in the mid reaches of the creek between Nathalia and Numurkah that have been channelised.
2. Continue monitoring sites for improved fish community particularly in response to any sustained increased flow events or habitat rehabilitation.
3. Review operation regimes of all fishways to optimise migration during key migration periods.
4. Review operation of Numurkah and Nathalia fishways.
5. Installation of PIT tag readers at the Numurkah and Nathalia Fishways.

Broken River

1. Continued monitoring of Broken River with future monitoring to include a seasonal component.
2. Comprehensive fish assessment of Benalla Weir using a wide range of sampling types.
3. Installation of PIT tag readers on the Benalla and Caseys weir fishways.
4. Production of an operation and maintenance schedule for the Benalla and Caseys weirs fishways.

# 1 Introduction

Knowledge of the status of native and introduced fish communities is important in managing natural resources. This knowledge is required to make decisions about whether management actions (e.g., habitat rehabilitation or increased fish passage) are required and what needs to be implemented to provide desired outcomes. The existence of baseline and continued monitoring is also vital to investigate the effects of management actions.

The fragmentation of rivers by dams and weirs is a global problem (Jungwirth 1998; Lucas and Baras 2001). Unimpeded passage for fish throughout streams is crucial for spawning migrations, recolonisation, general movement and habitat selection (Koehn and O'Connor 1990) and as such, connectivity of river habitats is recognised as important for maintaining and restoring native fish populations. In Victoria fish movement is protected by legislation through a number of Acts (Water Act 1999, Fisheries Act 1995, Flora and Fauna Guarantee Act 1988, Conservation, Forests and Lands 1987) and "…the prevention of passage of aquatic biota as a result of instream structures…" is identified as a potentially threatening process (Flora and Fauna Guarantee Act 1988).

The Murray Darling Basin is the most regulated river system in Australia. The Broken River system, in north eastern Victoria, is among the most regulated systems within the Murray Darling Basin. Although the Broken River system, which includes both the Broken Creek and Broken River, is a highly modified system, it supports a diverse native fish community. Some of the native fish species present in this system include the nationally threatened Murray cod (*Maccullochella peelii peelii*) and Macquarie perch (*Macquaria australasica*) while golden perch (*Macquaria ambigua*), silver perch (*Bidyanus bidyanus*) and Murray Darling rainbowfish (*Melanotaenia fluviatilis*) are listed as threatened in Victoria.

Some of the greatest threats to native fish populations in the Broken River system include the presence of barriers to fish movement. In the lower Broken Creek there are seven barriers to fish movement over a distance of about 60 km between Nathalia and the Murray River. Likewise, in the Broken River there are a number of barriers to fish movement between Shepparton and Benalla including Gowangardie, Caseys and Benalla weirs. Given that unimpeded fish passage is essential for the maintenance of healthy native fish populations, a number of fish passage facilities have been constructed on the weirs of the Broken River system. These include the construction of vertical slot fishways on the seven weirs in the lower Broken Creek, while Casey's and Benalla weirs have also had fish ladders installed.

Recent studies investigating the success of the lower Broken Creek fishways have indicated that these fish passage facilities are allowing fish to move upstream. Assessment of fish populations in reaches of the creek around Nathalia indicates that there have been significant increases in the diversity and abundance of native fish species. Furthermore, PIT tag readers have recently been installed on some of the fishways in the lower Broken Creek. These installations are expected to track the movements of both native and introduced fish within the lower Broken Creek and provide a greater understanding of the dynamics of fish movements both within the creek and between the lower Broken Creek and the Murray River. However, while our understanding of the fish community in the Broken Creek below the township of Nathalia is continuing to improve, a

recent study (O'Connor 2006) indicated that native fish diversity and abundance upstream of the township of Nathalia is depressed relative to areas lower downstream. The reasons for these differences are not clear, particularly given that this area has also been opened up to unimpeded fish passage since 2002.

Similarly to the Broken Creek, fish passage on the Broken River has also recently been restored at Caseys Weir where a vertical slot fishway was opened in November 2005. A study undertaken prior to the opening of this structure indicated that the weir was acting as a barrier to fish movement with large congregations of fish accumulating below the weir at certain times (O'Connor 2006). However, following its opening fish were collected moving upstream through the fishway indicating that it was successfully moving fish upstream.

In the Broken Creek a study was undertaken between Nathalia and Numurkah to:

- collect baseline fish data;
- assess upstream fish movement as a continuation of the lower Broken Creek fishway program; and
- identify areas with the potential for habitat rehabilitation.

In the Broken River a study was undertaken upstream of Shepparton to:

- provide information on the distribution, diversity and abundance of fish and;
- establish whether instream barriers continue to restrict fish movement.

# 2 Methods

## 2.1 Study site

The Broken River system is located in north-eastern Victoria and includes both the Broken Creek and Broken River (Figure 1). The Broken Creek diverges from the Broken River west of Lake Mokoan and flows approximately 200 km in a north-westerly direction to its junction with the Murray River near Barmah, while the Broken River flows in a westerly direction until it converges with the Goulburn River near Shepparton.

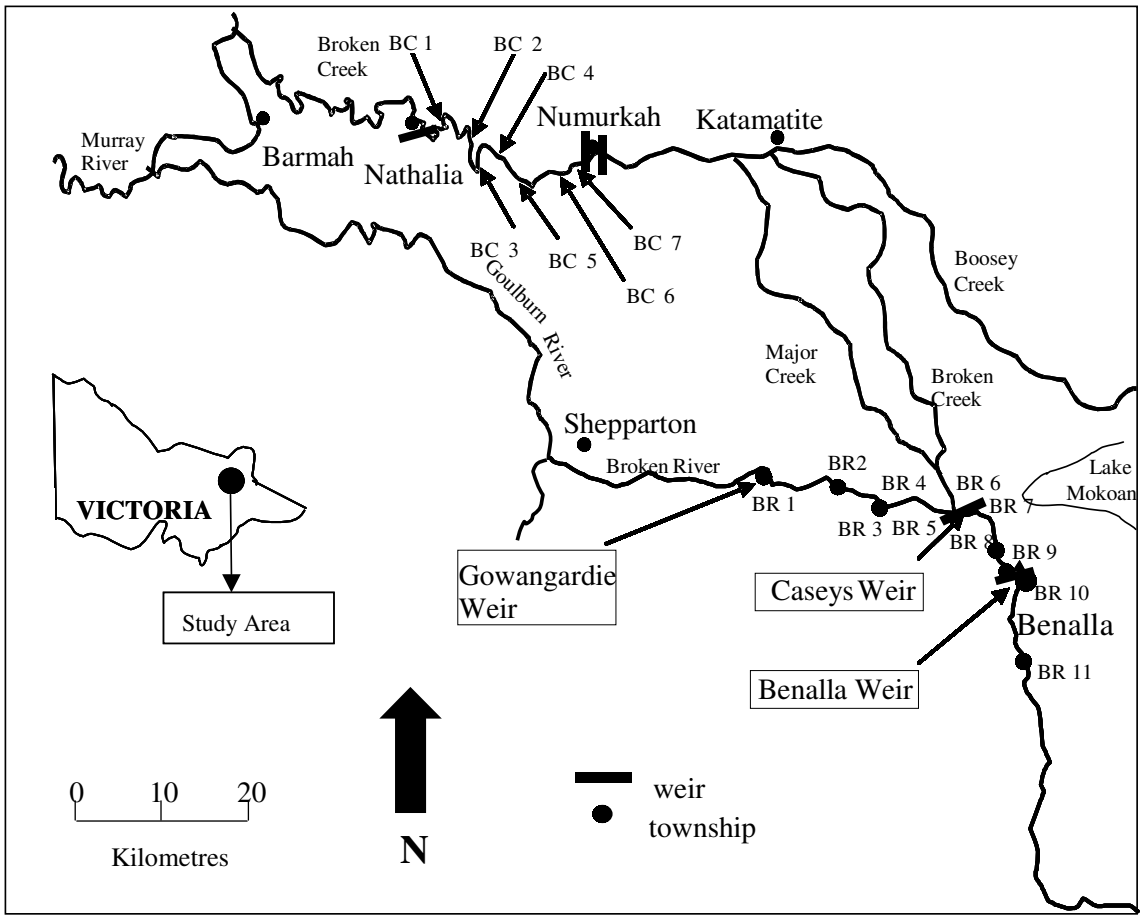


**Figure 1. Map of the Broken River system in north-eastern Victoria indicating study sites on the Broken Creek (BC) and Broken River (BR).**

### 2.1.1 Broken Creek

On the Broken Creek seven study sites were selected throughout the reach (approximately 50 km) between Nathalia and Numurkah (Figure 1, Table 1). Within this section of stream there were no weirs, however, weirs were present immediately upstream and downstream of this section of stream at the Numurkah and Nathalia town weirs. All habitat types present within this reach were targeted.

**Table 1: Site locations on the Broken Creek**

| Site No. | Locality | Grid Ref. |
|---|---|---|
| BC 1 | Nathalia Waaia Road | 7925-3410-60085 |
| BC 2 | Baxters Drive | 7925-3439-60070 |
| BC 3 | Walshes Bridge Road | 7925-3455-60035 |
| BC 4 | Walshes Bridge | 7925-3498-60038 |
| BC 5 | d/s junction Nine Mile Creek | 7925-3515-60015 |
| BC 6 | Unnamed track off Central Mundoona Road | 7925-3554-60022 |
| BC 7 | Sloleys Bridge | 7925-3573-60037 |

### 2.1.2 Broken River

Study sites on the Broken River were identified based on location of instream barriers. Sites were usually located directly downstream of an instream barrier or in the middle reaches between two barriers. At least three major instream barriers to fish movement are located on the Broken River, namely, Benalla Weir, Casey's Weir (Figure 2) and Gowangardie Weir (McGuckin and Bennett 1999). An addition smaller barrier is located on private property at Rupertsdale. Six survey sites were located on the Broken River downstream of the Benalla Weir while a further two sites were located upstream (Table 2). One site was located in Lake Benalla while the other was at Karn Road approximately 12 km upstream of Benalla Weir.

**Figure 2. Caseys Weir**

**Table 2: Site locations on the Broken River**

| Site No. | Locality | Grid Ref. |
|---|---|---|
| BR 1 | Karn Road | 8024-4088-59447 |
| BR 2 | Lake Benalla | 8024-4083-59546 |
| BR 3 | Downstream Benalla Weir | 8024-4083-59546 |
| BR 4 | Glencara property | 8024-4057-59595 |
| BR 5 | Upstream Caseys Weir | 8025-4050-59628 |
| BR 6 | Downstream Caseys Weir | 8025-4050-59628 |
| BR 7 | Upstream weir on Rupertdale property | 8025-4003-59640 |
| BR 8 | Downstream weir on Rupersdale property | 8025-4003-59640 |
| BR 9 | Ballantine Lane | 8025-3932-59646 |
| BR 10 | Gownangardie Weirpool | 8025-4030-59637 |

## 2.2 Water Quality

Water temperature (ºC), electrical conductivity (µS/cm), dissolved oxygen (mg/L), turbidity (NTU) and pH were measured in situ using a TPS FL90 water quality meter at most sites during each sampling event. These parameters were measured to ensure that water quality fell into tolerable ranges for fish.

## 2.3 Electrofishing

All sites were sampled by electrofishing, where fish were stunned by a controlled electric current using a boat mounted (Smith-Root® model 5.0 GPP) (Figure 3), bank mounted (Smith-Root® model 7.5 GPP) or back pack (Smith-Root® model 12B) electrofishing unit. Operating settings were generally 1000 Volts, 120 pulses per second and 50% duty cycle.

Boat mounted electrofishing within a site consisted of 12 90-second (actual electrofishing time) replicates. Bank mounted and back pack electrofishing within a site included eight 150-second (actual electrofishing time) replicates. In both cases, electrofishing was conducted in an upstream direction and was discontinuous with actual fishing taking place in all habitat types. Various site characteristics for each replicate were recorded including: mean depth, stream width, and length. The maximum depth of each site was also recorded.

All fish captured and observed (if positively identified) were recorded by species. Captured fish were measured for length (mm) (caudal fork or total length) and weight (g). Weight was measured on either of two electronic field balances (depending of fish size) accurate to 1 or 0.1 g. All fish captured greater than 200 mm in fork length were externally tagged with a dart tag and implanted with a PIT (passive integrated transponder) tag.


**Figure 3. Boat electrofishing**

### 2.3.1 Broken Creek

Boat mounted electrofishing was used to sample the five most downstream sites while the backpack unit was used at the two sites further upstream (sites 6 and 7) where water depth was too shallow for the boat to navigate.

The relative state of fish habitat at each site was also determined based on stream morphology (depth, depth variation, and width variation) and the amount of in-stream cover. Each of these categories was assigned a relative rating of high, medium or poor. Based on habitat observations sites were assigned to one of three classifications which were:

Habitat Class 1. High variation in stream depth and width with a high amount of instream structure (mainly in the form of large woody debris) (sites 1 – 3);

Habitat Class 2. Medium amount of variation in stream depth, low variation in stream width, and poor instream structure (sites 4 and 5); and

Habitat Class 3. Low variation in stream depth, medium variation in stream width and poor instream structure (sites 6 and 7).

### 2.3.2 Broken River

Most sites were sampled using either bank mounted and boat electrofishing units, but, two sites, located immediately downstream of Benalla and Caseys weirs were sampled using both bank mounted and/or boat electrofishing. This was to allow a comparison to bank mounted electrofishing surveys that were undertaken at these sites in 2005.

## 2.4 Data analysis

### 2.4.1 Broken Creek

The biomass of each species per site in this study was estimated by multiplying the mean weight (from fish of the species that were measured) by the number of fish of the species that were observed. The mean values of the percent of native individuals and percent of native biomass from this study were compared to results from farther downstream using a t-test. The number of large natives (i.e., Murray cod and golden perch > 200 mm) captured per metre of stream sampled was compared between habitat classifications using the Kruskal-Wallis test because the data did not meet the assumption of normality required for ANOVA.

### 2.4.2 Broken River

Sampling effort was standardised to Catch Per Unit Effort (CPUE) and was calculated as fish collected per 1000 seconds of electrofishing time. Fish abundance data collected using boat-mounted electrofishing was separated from data collected using bank-mounted electrofishing, as it was not possible to standardise the data collected using these two quite different sampling methods.

For both the boat and bank mounted electrofishing data sets, comparisons of CPUE were made for all fish, native fish, and exotic fish between sites directly below weirs with fishways and sites in mid-reach areas using the Mann-Whitney U test. Data from the Rupertsdale property site were not included in these analyses because no fishway had been installed on this structure. The Lake Benalla site was also omitted from these analyses because its habitat is unique to the study area (i.e. lake, not river).

A comparison was made of pooled CPUE for the boat electrofishing sites for all fish, native fish, and exotic fish between sites sampled in 2005 and 2008 using the Mann-Whitney U test. A further comparison using only Caseys Weir was done separately because of the expected effect of the installation of a fishway in the weir after the 2005 sampling event. Sites that were not sampled in both years using the same gear type were omitted from these analyses. Comparisons for the site immediately below the Benalla Weir could not be completed because it only included one replicate in each year.

# 3 Results

## 3.1 Broken Creek

### 3.1.1 Water Quality

All water quality measurements fell within expected ranges for this system compared to previous studies (O'Connor, unpublished data). The following ranges were observed: 13.4 – 17.4 °C temperature, 97 – 110% dissolved oxygen, 6.45 – 7.03 pH, 59 – 81 NTU turbidity, and 46.7 – 52.0 µS/cm electrical conductivity. For all water quality data see Appendix 1.

### 3.1.2 Habitat

The condition of habitat varied through the study area. Generally, depth, depth variation, and the amount of in-stream cover (in the form of large woody debris) decreased from downstream to upstream sites. Width variation was high at the downstream sites, low at the mid-reach sites, and very high at the upstream sites being strongly affected by whether or not the area had been

channelised. Sites were assigned to a habitat class based upon these observations with Sites 1-3 assigned to Habitat Class 1, Sites 4-5 assigned to Habitat Class 2 and Sites 6-7 assigned to Habitat Class 3. Sites 4 and 5 (Habitat Class 2) differed in depth variation with Site 4 having a high amount and Site 5 having a low amount of variation in stream depth.

### 3.1.3 Electrofishing surveys

A total of 342 fish representing three native and five introduced species were collected (Table 3). Native fish species comprised 20% of the total catch. Two threatened species, Murray cod and golden perch (EPBC 1999; Department of Sustainability and Environment 2005) were captured. The most abundant native fish species sampled was the Australian smelt (*Retropinna semoni*) which comprised 74% of the total catch of native fish. Goldfish (*Carrasius auratus*) (55%) and common carp (*Cyprinus carpio*) (34%) made up most of the catch of introduced species. Only two oriental weatherloach (*Misgurnus anguillicaudatus*) were captured. Forty eight fish were implanted with PIT tags (26 common carp, 14 golden perch, 7 redfin perch, and 1 Murray cod).

**Table 3: Number of native and introduced fish sampled, by species and site, from the Broken Creek in May 2008 using boat mounted and backpack electrofishing units.**

| | Native species | | | | Introduced species | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site No. | Murray cod | golden perch | Australian smelt | Total | common carp | goldfish | gambusia | redfin perch | oriental weatherloach | Total |
| BC 1 | 0 | 4 | 6 | 10 | 22 | 6 | 0 | 0 | 0 | 28 |
| BC 2 | 1 | 5 | 11 | 17 | 18 | 23 | 0 | 0 | 0 | 41 |
| BC 3 | 0 | 0 | 3 | 3 | 20 | 20 | 0 | 5 | 0 | 45 |
| BC 4 | 0 | 6 | 10 | 16 | 18 | 21 | 0 | 8 | 0 | 47 |
| BC 5 | 0 | 1 | 11 | 12 | 5 | 62 | 0 | 10 | 0 | 77 |
| BC 6* | 0 | 0 | 8 | 8 | 3 | 11 | 0 | 0 | 1 | 15 |
| BC 7* | 0 | 1 | 2 | 3 | 8 | 7 | 3 | 1 | 1 | 20 |
| Total | 1 | 17 | 51 | 69 | 94 | 150 | 3 | 24 | 2 | 273 |

* backpack electrofishing unit used

The proportion of native fish and biomass of native fish appears lower in the section of creek between Nathalia and Numurkah than farther downstream below Nathalia (Figure 4). There was a significant difference between the percent of native fish for these sites than sites previously sampled downstream of Nathalia (O'Connor 2006) ($t = 3.966$; $df = 11$; $p = 0.002$).

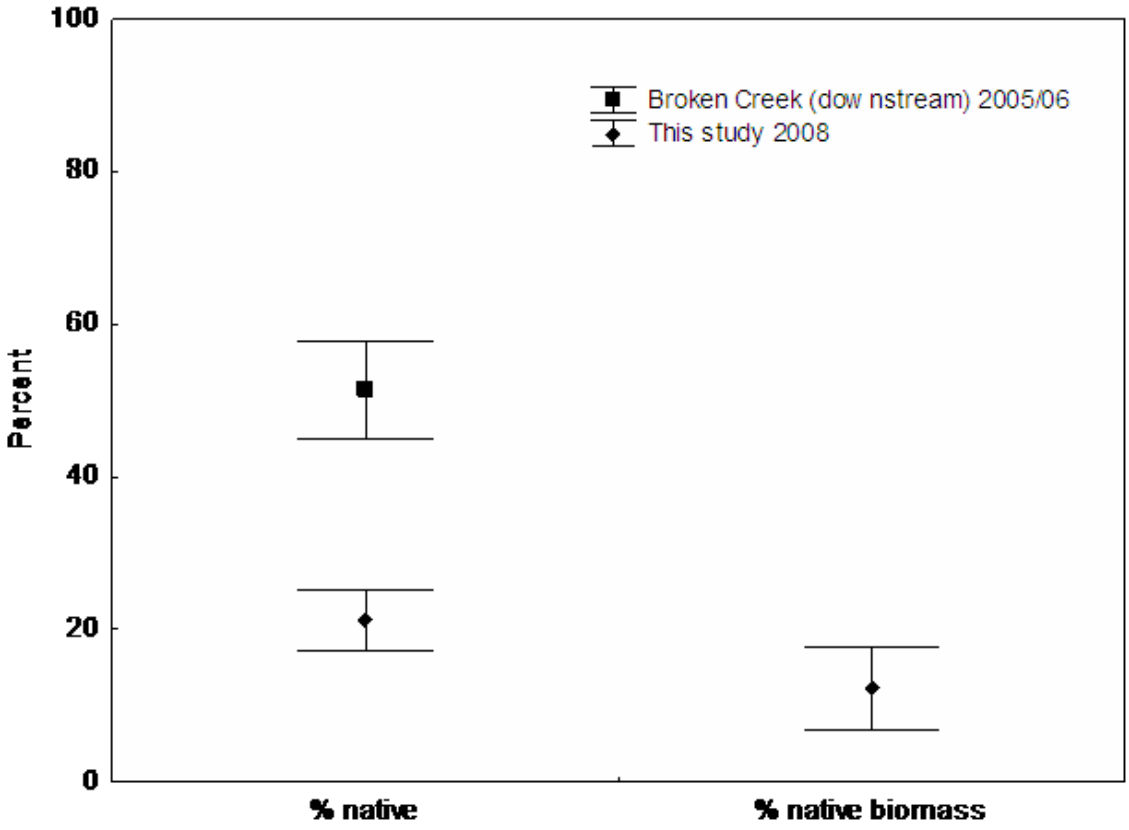


**Figure 4: Comparison of percent native and percent native biomass in the Broken Creek between Nathalia and Numurkah in 2008 and a previous study conducted in the Broken Creek (O'Connor 2006). Error bars indicate ±1 SE.**

The number of large native fish observed per metre of stream sampled appeared to be higher in Habitat Classes 1 and 2 compared to 3 (Figure 5). However, a significant difference could not be detected ($H(2, N = 76) = 4.169$; $p = 0.1245$). The relatively high value for habitat class two was the result of golden perch captured at site 4 (one of two sites in this class) with most of them being captured in replicates with the highest mean depth. The mean number of Murray cod and golden perch captured at sites using the boat mounted electrofishing unit in this study was 3.4 fish per 90-second replicate.

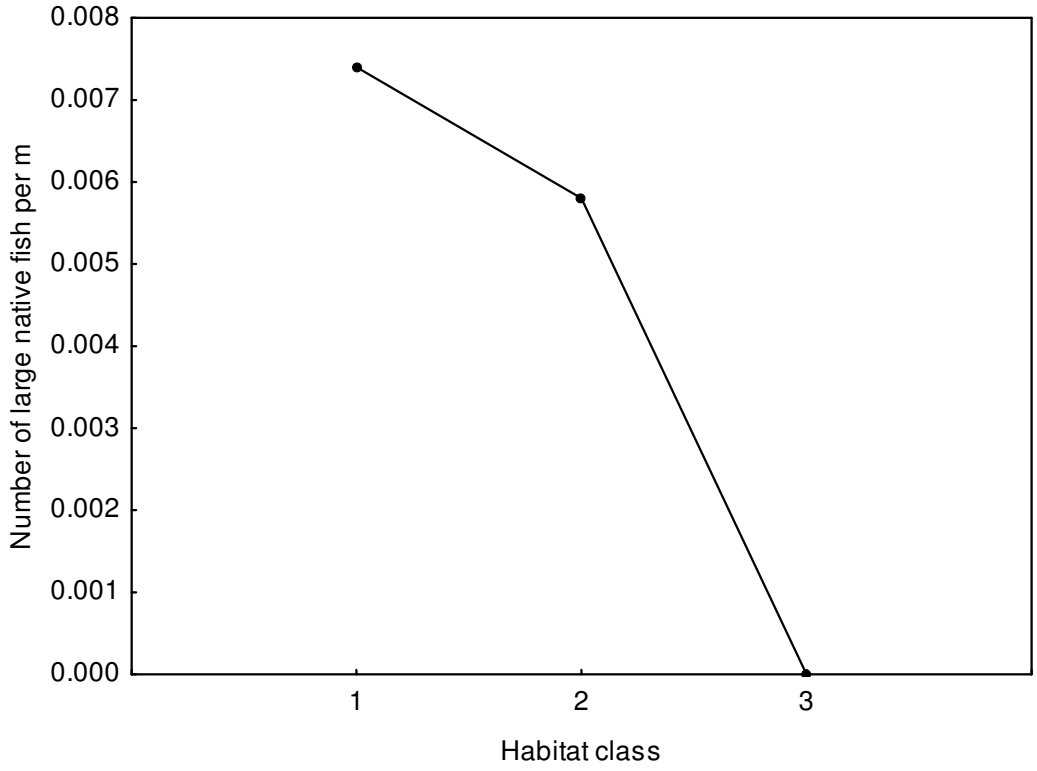


**Figure 5: Number of large native fish (Murray cod and golden perch > 200 mm) observed in the Broken Creek between Nathalia and Numurkah in 2008 for three habitat classifications.**

## 3.2 Broken River

### 3.2.1 Water Quality

Physio-chemical water quality parameters were similar at all sites and fell within the parameters considered normal for north eastern Victoria. Water temperature ranged from 11.6–13.6°C. Electrical conductivity varied only slightly between sites and ranged from 123–180 $\mu S.cm^{-1}$. Dissolved oxygen concentrations ranged from 94–112 $mg.l^{-1}$. Turbidity was generally low and ranged from 15–54 NTU while pH ranged from 7.2–8.0. For all water quality data see Appendix 1.

### 3.2.2 Electrofishing surveys

A total of 945 fish representing six native and four exotic species were collected. The number of fish species collected at each site ranged from three species (one native and two exotic) at the uppermost site at Karn Road while at the site immediately downstream of Caseys Weir seven fish species were collected (five native and two exotic) (Table 4).

Murray Darling rainbowfish and golden perch were the most widespread native species while river blackfish was the least widespread native species being captured at only a single site. Australian smelt and Murray Darling rainbowfish were the most abundant native fish species collected in the survey. Carp was the most abundant introduced fish species and it was also the most widespread having been collected at all sites.

**Table 4: Total abundance of species collected by bank mounted (BM EF) and boat mounted electrofishing (Boat EF) at survey sites on the Broken River. Abundances include counts of species observed but not collected.**

| Site | method | Murray cod | Golden perch | Murray Darling rainbowfish | Australian smelt | Carp gudgeon | River blackfish | Common carp | Goldfish | Gambusia | Redfin perch |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BR 1 | BM EF | | | | | | 8 | 13 | | | 6 |
| BR 2 | Boat EF | | 1 | 11 | 87 | | | 10 | | | 2 |
| BR 3 | Boat EF | | 6 | 27 | 83 | | | 20 | 2 | | 6 |
| BR 3 | BMEF | | 1 | 24 | 58 | 16 | | 1 | | | 12 |
| BR 4 | BMEF | | 2 | 129 | | 3 | | 4 | | | |
| BR 5 | Boat EF | 1 | 9 | 16 | | | | 5 | 1 | 3 | |
| BR 6 | BMEF | 17 | 4 | 3 | 24 | 3 | | 4 | 5 | | |
| BR 6 | Boat EF | 7 | 3 | 12 | 15 | | | 15 | 3 | | |
| BR 7 | Boat EF | 9 | 13 | 41 | 4 | | | 16 | | | |
| BR 8 | Boat EF | 3 | 11 | 3 | 2 | | | 10 | 1 | | |
| BR 9 | Boat EF | 13 | 16 | 91 | | | | 9 | | | |
| BR 10 | Boat EF | 5 | 3 | 8 | | | | 5 | | | |
| Total | | 55 | 69 | 365 | 273 | 22 | 8 | 112 | 12 | 3 | 26 |

### 3.2.3 Catch Per Unit Effort

#### 3.2.3.1 Boat mounted electrofishing sites

In general sites fished with the boat mounted electrofisher were dominated by small bodied native fish species including Australian smelt and Murray Darling rainbowfish (Figure 6).

Catch per unit effort (CPUE) was higher at sites located immediately downstream of instream barriers with fishways than in mid-reach sections. CPUE for mid-reach sites was lower for all fish ($Z = -3.32$; $N = 46$; $p = 0.0008$), native fish ($Z = -2.30$; $N = 46$; $p = 0.02$), and exotic fish ($Z = -2.99$; $N = 46$; $p = 0.003$). Overall, CPUE was four times higher below these barriers than in mid-reach sections.

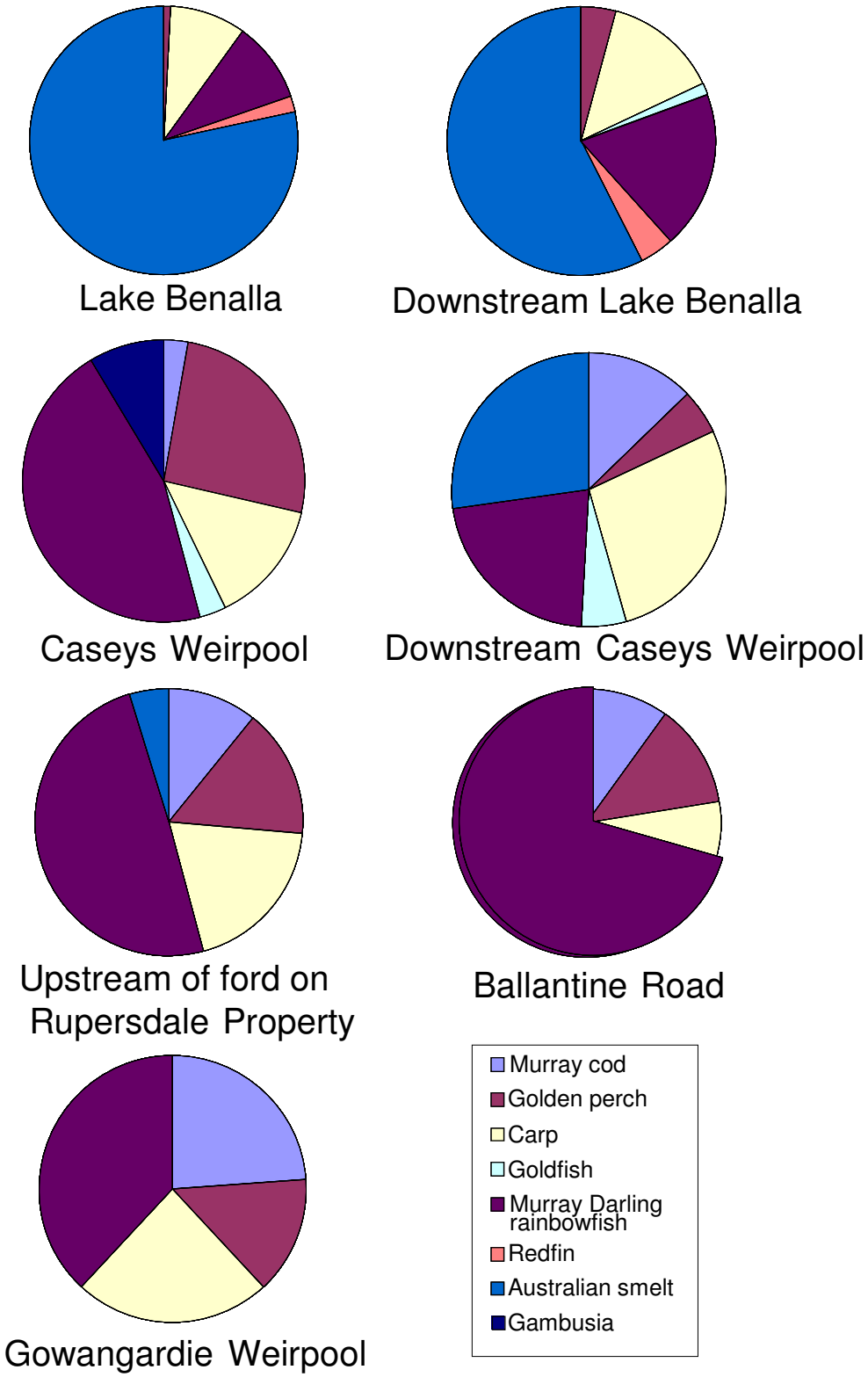


**Figure 6: Percentage species composition of CPUE of fish sampled using boat electrofishing in the Broken River fish survey**

A comparison of pooled CPUE for the boat electrofishing sites between 2005 and 2008 indicated that CPUE was higher in 2008 than in 2005. CPUE was 215 fish 1000 $sec.^{-1}$ below Caseys Weir and 78 fish 1000 $sec.^{-1}$ at other sites in 2008. CPUE was lower in 2005 for all fish ($Z = 4.81$; $N = 69$; $p < 0.001$), native fish ($Z = 4.31$; $N = 69$; $p < 0.001$), and exotic fish ($Z = 2.93$; $N = 69$; $p = 0.003$).

#### 3.2.3.2 Bank mounted electrofishing sites

Bank mounted electrofishing sites were also dominated by small bodied native species (Figure 7). Catch per unit effort (CPUE) was higher at sites located immediately downstream of instream barriers with fishways than in mid-reach sections. CPUE for mid-reach sites was lower for all fish ($Z = 2.28$; $N = 25$; $p = 0.02$) and native fish ($Z = 2.37$; $N = 25$; $p = 0.02$), but no difference was detected for exotic fish ($Z = 1.08$; $N = 25$; $p = 0.28$).

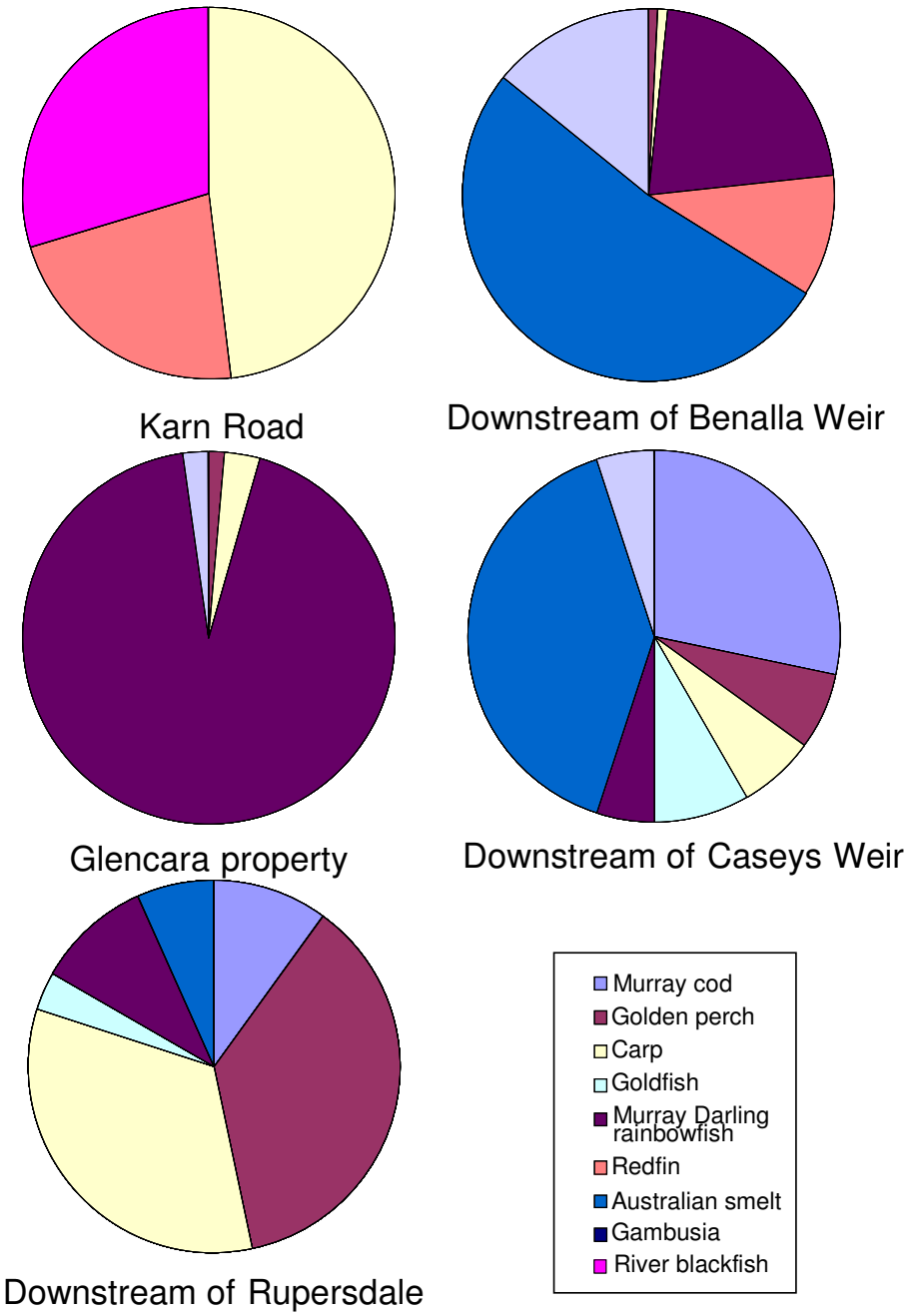


**Figure 7: Percentage species composition of CPUE of fish sampled using bank mounted electrofishing in the Broken River fish survey.**

# 4 Discussion

## 4.1 Broken Creek

The status of the fish community in the Broken Creek between Nathalia and Numurkah is relatively poor compared to areas downstream of Nathalia. Species composition is dominated by introduced species with the proportion of native fish lower than in the reach below Nathalia. The relative abundance of large native species is also low. O'Connor (2006) reported a mean of 20.7 Murray cod and golden perch captured per 90-second replicate downstream of Nathalia, six times higher than that observed between Nathalia and Numurkah at sites where the boat mounted electrofishing unit was used. O'Connor (2006) also reported that the abundance of native fish species had increased in the lower Broken Creek by 2005/06 following the installation of fishways. Most of this reach was opened to unimpeded fish passage by 2002. Similarly, the Broken Creek between Nathalia and Numurkah was also opened up to unimpeded fish passage with the completion of the Magnusson's/Ball's Weir in June of 2002. Furthermore, comparisons with previous studies indicate that the status of the fish community in this reach of creek has not improved since 2005. A comparison of the Walshes Bridge site in this study with the results of the 2005 study indicate that fish diversity has changed slightly with the presence of gambusia in 2005 but not in 2008. However, a comparison of abundance indicates that the fish population has remained similiar between these two periods and remains poor. Given that parts of the creek downstream of this area have been colonised during this same period it appears that there are other factors limiting the colonisation of this part of the creek.

A number of factors could be influencing the colonisation of the Broken Creek between Nathalia and Numurkah by native fish species from downstream. Habitat does not appear to be a limiting factor for large native fish in some areas of this reach of creek. Habitat at Sites 1 to 3 in this study, rated as Habitat Class 1, appeared similar to the habitat available in the Broken Creek below Nathalia where the abundance and diversity of the native fish community is better. However, while no statistical difference in the number of large native fish could be detected between the three habitat classifications in the study reach, the quality of habitat does appear to decline further upstream. Decreases in depth, depth variation and stream width variation further upstream appear to limit the presence of large native fish species. For example, most of the large native fish captured in Habitat Class 2 were captured in the deepest areas of Site 4, indicating that depth is probably an important variable with respect to the presence of large native fish species. Following from this, no large native fish were captured in Habitat Class 3 (sites 6 and 7), and given that stream depth at these sites was very shallow this is not unexpected.

The reasons for differences in the status of the fish community between the area below Nathalia and Sites 1 to 3 in this study are unknown. However, given the presence of good native fish habitat in Sites 1 to 3, low native fish abundance appears to be as a result of limited movement of fish into the area. Possible explanations for this limited movement may include: restricted fish movement from below the Nathalia into these areas as a result of low flows (drought) over the last few years; fish are still colonising downstream of this area and as a result, there has been little population pressure (e.g., high density) to move upstream; or inefficient fishway operation. While low flow and low population density factors will hopefully be overcome with time and increased rainfall, inefficient fishway operation can be improved immediately by undertaking a number of actions including:

- Efficient gate operation so that fishway gates should be fully open.

- Regular fishway maintenance. Woody debris lodged in the fishway (entrances, slots and pools) can result in increased water velocity preventing smaller fish from passing, as well as creating smaller widths in slots, preventing larger fish from physically being able to pass.
- Installation of trash booms is useful in reducing maintenance by keeping floating debris from clogging the trash rack.
- Fishway attracting flows should be favourable for fish entering the fishway. During low flows all water should be passed down the fishway.
- Flow variation enhances fish migration so flow should be manipulated to improve fish migration and to create a more natural healthy stream. For example, the pre-set amount of water could be released down the creek over a set period of time (one or two weeks), but the daily volume of water can be varied to create an artificial rise and fall for that period (Mallen-Cooper et al. 1995). Flow variation of as little as 0.15 m can be a strong stimulus for fish migration.

It would appear from the results of this study that some areas of the Broken Creek between Nathalia and Numurkah do not contain sufficient habitat to support permanent or temporary (migrating) fish populations. In these areas improvements to the habitat may help improve both the fish community in the immediate vicinity and also upstream populations as currently even upstream migrating fish may be reluctant to travel through these poor habitat areas. Habitat in some areas of this study site can be improved in an attempt to improve the status of the fish community. The addition of large woody debris in the middle reaches of the study site would improve habitat for large native species particularly given that all Murray cod and golden perch captured during this study were captured around woody debris. Through stream rehabilitation works variability in stream depth and maximum depth could be increased in areas like Site 5, which appear to have been channelised, would also be expected to improve habitat for large native fish species.

## 4.2 Broken River

All native fish species previously recorded by ARI (2005) were collected in the current survey. However, unlike the 2006 surveys the introduced gambusia was also captured in the current surveys. Overall species composition of assemblages within broad river reaches was similar, however, catch per unit effort was greater at sites located immediately below barriers when compared with mid-reach sites.

CPUE data indicated that the weirs on the Broken River are still acting as partial barriers to fish movement even though fish ladders have been installed. Fish ladders are not always completely efficient in moving fish upstream over a barrier and congregations of fish can still be expected below these structures. However, while there are still congregations of fish below these weirs, previous work undertaken on Caseys Weir indicates that this fish ladder is passing fish upstream and while the current study indicates that it is still acting as a partial barrier to fish movement Caseys Weir is no longer a complete barrier to fish movement as it was previously.

A comparison of CPUE data from the current study with a study from 2005 (ARI 2005) indicates that more fish were sampled in 2008 than in 2005. Reasons for these differences are not clear, however, seasonal factors in fish distribution may account for these discrepancies. Future sampling

of the Broken River should include a seasonal sampling component to possibly account for the current discrepancy between this study and the one conducted in 2005.

This survey was the first to monitor sites upstream of Benalla Weir and indicates that the fish community upstream of this structure appears to be very different to that below it. Only a single large native fish (golden perch) was sampled from within Lake Benalla. However, angler reports indicate that Murray cod are also captured in Lake Benalla, suggesting that the fishway may be moving fish upstream. No large native fish were sampled at the Karn Road site but given the lack of deep habitat in this area this is not surprising. Future studies on the Broken River need to include a comprehensive survey of Lake Benalla and areas immediately upstream of it. These surveys should include the use of multiple sampling techniques including electrofishing, mesh netting, drum netting, fyke netting and bait traps. The use of this wide range of sampling techniques would enable a comprehensive assessment of this complex habitat type which includes deep, slow flowing, dirty water which is difficult to assess for fish populations using electrofishing alone.

# 5 Recommendations

Broken Creek

1. Investigate habitat rehabilitation works in the mid reaches of the section of creek between Nathalia and Numurkah that have been channelised. Possible restoration works could include riparian restoration, instream habitat improvement including resnagging and creating channel variability in depth and width.
2. Continue monitoring sites for improvements in the fish community, particularly in response to any sustained increased flow events or habitat rehabilitation.
3. Review operation regimes of all fishways to optimise migration during migrational periods.
4. Review operation of Numurkah and Nathalia fishways.
5. Installation of PIT tag readers on Numurkah Town Weir fishway.

Broken River

1. Continued monitoring of Broken River with future monitoring to include a seasonal sampling component.
2. Comprehensive fish assessment of Benalla Weir and areas immediately upstream of it using a wide range of gear types.
3. Installation of PIT tag readers on Benalla and Caseys weir fishways.
4. Production of an operation and maintenance schedule for Benalla and Caseys weirs fishway.

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# Appendix 1

### Water quality from Broken Creek and Broken River

| Site No. | pH | Electrical cond. (µS/cm) | Turbidity (NTU) | Dissolved oxygen (%) | Temp. (°C) |
|---|---|---|---|---|---|
| BC 1 | 6.9 | 50.1 | 74 | 99 | 15.5 |
| BC 2 | 7.0 | 52.0 | 64 | 99 | 13.4 |
| BC 3 | 6.5 | 51.6 | 66 | 101 | 15.1 |
| BC 4 | 6.6 | 48.4 | 66 | 108 | 14.6 |
| BC 5 | 6.8 | 49.5 | 81 | 97 | 15.0 |
| BC 6 | 7.0 | 46.6 | 59 | 110 | 17.4 |
| BC 7 | 6.5 | 51.1 | 44 | 106 | 14.0 |
| | | | | | |
| BR 1 | 8.0 | 146 | 36 | 100 | 12.2 |
| BR 3 | 7.8 | 124 | 15 | 101 | 13.6 |
| BR 4 | 7.8 | 148 | 22 | 94 | 12.7 |
| BR 5 | 7.2 | 207 | 37 | 112 | 13.5 |
| BR 6 | 7.7 | 162 | 54 | 98 | 12.4 |
| BR 7 | 8.0 | 181 | 41 | 101 | 13.6 |
| BR 8 | 8.0 | 181 | 41 | 101 | 13.6 |
| BR 9 | 8.0 | 177 | 45 | 105 | 11.6 |

Note that water quality is not available for some sites

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