

## Biological Assessment of Aquatic Habitat Rehabilitation in the Broken River and Ryans Creek, North East Victoria

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**SUMMARY:** The aim of this study was to evaluate the impact of stream rehabilitation work on the fish and macroinvertebrate communities of Ryans Creek and the Broken River in North-East Victoria. The rehabilitation of the streams involved the addition of logs and boulders in the stream channel, the replacement of willows with native riparian vegetation, control of bank erosion using rock beaching and riparian fencing to exclude stock. The criteria used to measure the success of rehabilitated reaches included comparison of trends in biotic community attributes, such as fish and macroinvertebrate diversity, with those in untreated reaches. Fish species diversity significantly increased in one stream but not in the other. No consistent trend for increasing macroinvertebrate diversity was observed in either stream. The implications of these results for the design of evaluation strategies for stream rehabilitation projects are discussed.

### MAIN POINTS

- The rehabilitation of streams via aquatic habitat enhancement can benefit the biotic community of the stream, especially the fish fauna
- Fish are suitable indicators for assessing stream rehabilitation treatments in medium sized streams
- Adequate evaluation of the effects of stream habitat rehabilitation may require several years and planning well in advance of commencement of rehabilitation work.

### 1. INTRODUCTION

This project investigated the response of fish and macroinvertebrate communities to the impact of operational river management works designed to rehabilitate aquatic habitat.

River management activities have been undertaken in Victoria since the 1950's however recent fundamental changes have taken place in the aim of such works. The emphasis has now shifted from solely protecting private and public assets, to include improving the overall stream environment (Gooley *et al* 1997). Although numerous stream activities have been executed with this new emphasis, the effect of these works remains largely unknown. Their success, or otherwise, has rarely been adequately evaluated, especially from the biotic perspective.

#### 1.1 Study sites and background information

Between 1960 and 1975, river works in the Broken River catchment focused on de-snagging, with the principal aim of decreasing the frequency of over-bank flooding. Such works are purported to have led to stream instability and reduced aquatic habitat values (Gooley *et al* 1997).

A major flood event in 1993 caused significant stream related damage in the Broken prompting broad-scale

river management works. At the same time attempts were underway to re-establish threatened native fish (trout cod, *Maccullochella macquariensis* and Macquarie perch, *Macquaria australasica*) for conservation reasons; and brown trout (*Salmo trutta*) populations for recreational fishing in streams within the area. Therefore there was an opportunity to assess the effects of river management works on the rehabilitation of the physical and biological components of the ecosystem. Two sites in the Broken River and Ryans Creek in the mid-Broken River in Victoria's North-East were subjected to habitat rehabilitation in the winter of 1996, and the effects on the stream and biota were subsequently assessed. This paper reports the biological assessment of the two habitat enhancement projects. Physical and hydraulic characteristics of the stream were also evaluated over the same spatial and temporal scale using standard engineering procedures. This component was undertaken by Mr. Michael Stewardson, CRC Catchment Hydrology, University of Melbourne (see Stewardson *et al* this proceedings).

The study sites were located in the Broken River, downstream of Swanpool, and in Ryans Creek at Mollyulah. Both sites had degraded habitat conditions and for the purposes of the study extra habitat, such as logs and boulders, was introduced to the streams with

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concurrent riparian management including stock-management measures and tree planting. At the Ryans Creek site, the experimental site was divided into two treatments, a rock treatment where extra boulders were added to the stream, and a wood treatment where logs were used. Both treatments were designed to create flow diversity and provide additional cover for fish and macroinvertebrates.

## 2. METHODOLOGY

### 2.1 Survey overview

The investigation compared the biotic community of the enhanced sites to the ambient state of the rest of the stream over time. Standardised indices of biodiversity were used to detect any changes in the aquatic fauna at each site. Data was collected before and after the treatments were completed. Hydraulic surveys were undertaken to monitor changes in the physical aspects of the stream before and after the rehabilitation treatments. For further details on this aspect of the project the reader is directed to Stewardson *et al* (this volume).

### 2.2 Survey methodology

The survey monitored the sites bi-monthly (six trips per year) from October 1995 until April 1998.

At the Broken River, the 500 m treatment site was divided into 5x100 m sections. Prior to each trip a single 100 m section of stream was randomly selected from these to survey. To compare the treatment sites to the rest of the stream, two control sites were randomly chosen from a suite of seven pre-selected sites spread along the river, above and below the treatment sites.

Fish were sampled at each site using a standard level of effort with double-pass, back-pack electrofishing gear and a set of ten fyke nets set over night.

Macroinvertebrates were obtained at each site using sweep and kick samples. The samples were picked over in the field for a standard time and live specimens preserved. Preserved samples were later identified and counted as whole specimens on the stage of a dissecting microscope. Most individuals could be identified to the taxonomic Family level, while some could be identified to Species level.

The results were used to derive indices of community diversity, and the indices from the two control sites were averaged to produce a mean. The mean diversity index was considered as representative of the ambient stream conditions and thus was used as a benchmark to compare the progress of the rehabilitated sites, and to measure any change in fish and macroinvertebrate communities.

At the Ryans Creek site, both 100 m treatment areas, were sampled and compared to control sites randomly chosen from a suite of six pre-selected control sites upstream. Electrofishing was the only fish assessment method used in Ryans Creek.

Macroinvertebrates were sampled at each of these sites as for the Broken River.

Diversity indices were calculated from the results for comparison and analysis, as for the Broken River.

Diversity is the relationship between the number of species and the number of individuals and is often used to describe the health of biotic communities. The more species present and the more individuals per species, the higher the diversity. The Shannon Wiener index of abundance and the number of species are commonly used indices to describe the status of biotic communities (Clarke and Warwick, 1994).

Trends over time for each treatment were compared to investigate any statistical differences using linear regression analysis. Statistical significance is defined as  $p \leq 0.05$  throughout.

## 3. RESULTS

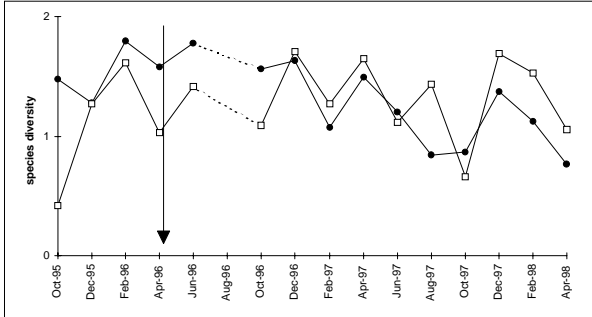
### 3.1 Broken River

The species richness, in terms of absolute numbers of fish species or invertebrate taxa, varied among sites and times sampled. However, the numbers of fish species encountered in a single sample averaged 3 and ranged from 1 to 6. The number of macroinvertebrate taxa averaged 19 and ranged from 9 to 30. For the whole study a total of 15 fish species and 71 macroinvertebrate taxa were collected from the Broken River.

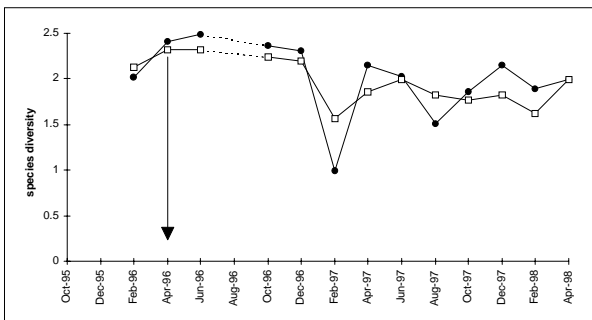
The average diversity of the fish community showed different changes over time, between control and treatment sites (Figure 1). Initially the treatment sites had a generally lower diversity compared to the rest of the stream however as the project went on the mean diversity of the treatment sites became higher than mean diversity in the rest of the stream. The difference in this trend was statistically significant ( $p=0.03$ ). Generally the fish diversity in the river has declined over the course of the project while the diversity at the treatment site has been maintained.

In terms of aquatic macroinvertebrates the effect of the treatments is less dramatic. There was no significant difference in the effect of treatment on macroinvertebrate diversity ( $p=0.7$ ) (Figure 2).

**Figure 1 Fish diversity.** Mean Shannon Wiener scores for control (●) and treatment (□) sites in the Broken River. Arrow represents when treatments were undertaken, error bars have been omitted for clarity



**Figure 2 Macroinvertebrate diversity.** Mean Shannon Wiener scores for control (●) and treatment sites (□) in the Broken River. Black vertical line represents when treatments were undertaken, error bars have been omitted for clarity.



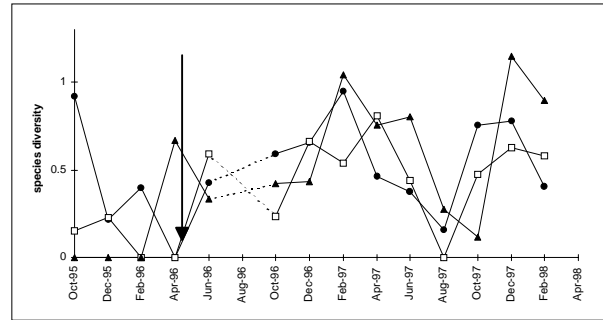
### 3.2 Ryans Creek

The species richness in Ryans Creek for fish species and invertebrate taxa also varied among sites and times sampled. The average number of fish species encountered in a single sample was 3, as in the Broken River, and ranged from 0 to 9. For macroinvertebrate taxonomic groups the average was 22 with a range of 12 to 33. For the whole study a total of only 8 fish species and 80 macroinvertebrate taxa were collected from Ryans Creek. Of these 8 fish species, the stream was dominated by blackfish (*Gadopsis marmoratus*) which made up to 56% of the total biomass sampled.

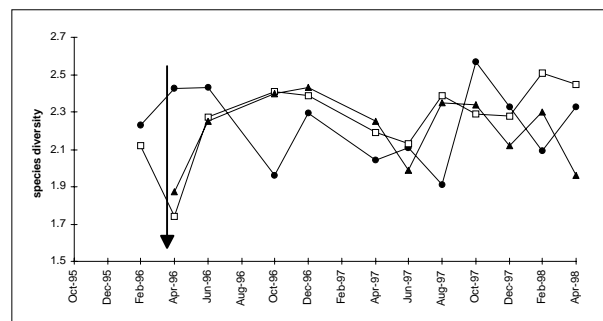
Diversity was also calculated for both fish and macroinvertebrates at Ryans Creek sites. The results indicated a slight tendency for higher fish diversity in both the rock and wood treatment sites over time compared with control sites. However monthly fluctuations at each site meant that this was not statistically significant ( $p=0.4$ ) (Figure 3). Macroinvertebrate communities at control and treatment sites were also similar ( $p=0.4$ ) (Figure 4). However, towards the end of the trial, mean diversity, particularly

at the rock treatment site, was often higher than at control sites.

**Figure 3 Fish diversity.** Mean Shannon Wiener scores for control (●), wood treatment (□) and rock treatment (▲) sites for all trips in Ryans Creek. Black vertical line represents when treatments were undertaken.

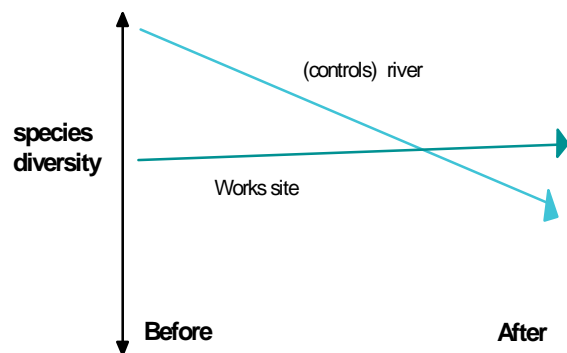


**Figure 4 Macroinvertebrate diversity.** Mean Shannon Wiener scores for control (●), wood treatment (□) and rock treatment (▲) sites in Ryans Creek.

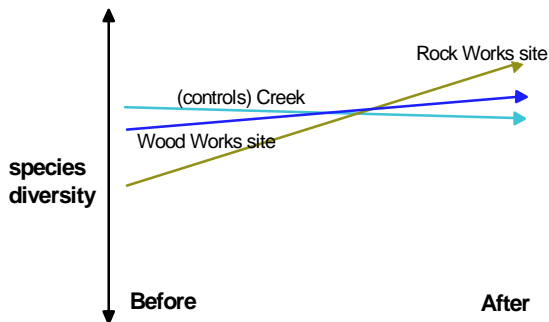


To highlight these complex patterns in diversity the following diagrams indicate trends in fish and invertebrate communities in the streams at the restoration sites and in the control sites (Figure 5 and Figure 6)

**Figure 5 Schematic of fish community response to restoration in the Broken River**



**Figure 6 Schematic of fish and invertebrate species response to restoration in Ryans Creek**



#### 4. DISCUSSION

In ecological studies, a diversity index is often used to measure how the total number of individuals is divided up amongst the different species. An index of diversity, such as the Shannon-Wiener, is often more informative than simple counts of individuals or total biomass, and is amenable to simple statistical analysis (Clarke and Warwick, 1994).

Addition of extra log and rock habitat to Ryans creek is likely to benefit species already present rather than allow the colonisation of additional species, therefore it may not be reasonable to expect large-scale changes in fish species diversity. Since rock and log cover is the preferred habitat of blackfish (Jackson *et al.*, 1996) it may be reasonable to expect an increase in the dominance of this species. Further analysis of this data set will proceed using life-history attributes of individual species (indicator species) such as river blackfish. Criteria such as reproductive success and growth or mortality rates may provide better indicators of “improvement” in the fish community over time.

Unfortunately, evaluation strategies (if present at all) for most river rehabilitation projects are conceived at the point when the rehabilitation is about to begin. This project suffered a similar shortfall, which meant that there was little time (6 months) to “bench-mark” the pre-rehabilitation state of the rivers before the engineering work began. Unfortunately this means that the classical method of analysing such a problem, the BACI design<sup>3</sup>, was impractical.

The simple comparison of linear trends used here lacks the statistical power of a properly constructed trial which ideally would have at least one full annual series of samples before any works, and more replicates for both treatments and controls. This is a common problem with river restoration evaluation and other workers are examining more complex and perhaps more appropriate methods such as intervention analysis.

<sup>3</sup> a statistical comparison of the “before” with the “after” condition that also contrasts a “control”, or no-treatment condition, with an “impact”, or treatment condition.

In a comprehensive parallel survey of the physical and hydraulic habitat (Stewardson *et al.*, this volume) significant increases were observed, in the hydraulic diversity of transects through the Broken River sites after treatment. However, there were also indications that hydraulic diversity declined at the Ryans Creek treatment sites over time. These observations are entirely consistent with the patterns observed in the diversity of the fish communities during our study.

The authors are not aware of any published Australian examples, and only a few international examples, of evaluation of similar habitat enhancement for rehabilitating stream fish stocks (Sheilds *et al.*, 1995; House, 1996) or invertebrate (Fuchs and Statzner, 1990) communities. Therefore the lag-time for a suitable response is largely unknown (Bryant, 1995). Many of the fish species encountered are relatively long-lived organisms (Cadwallader, 1984; Anderson, 1992; Graynoth, 1996), with life-spans in the order of years. Yet, the Broken River fish community at rehabilitated sites exhibited a higher diversity than the control sites just eight months after completion of the treatments and (apart from two minor dips) was consistently above controls for the remainder of the study (20 months). However, fish are relatively fecund organisms and populations may be controlled by annual fluctuations in survival of juveniles (Cushing, 1977). One explanation for the rapid response may be that the creation of habitat in the treatment sites has reduced the mortality or to put it another way, enhanced the survival of individuals, and therefore increased the population growth rate. Alternatively immigration to newly created habitats from outside the study sites, or indeed from controls to treatment sites may also explain the relatively quick response.

The increased diversity at the Broken River treatment site may therefore be due to an increased production of fish (i.e. more individuals shared among more species). Alternatively the creation of habitat at these sites may have simply attracted more individuals from other areas with poorer habitat. In other words we may have enhanced production, or merely redistributed the same production from the control to the treatment site. This is analogous to the “attraction versus production” debate in marine fisheries literature concerning artificial reefs (for reviews see Pickering and Whitmarsh, 1997; Grossman *et al.*, 1997). However, either way, this study shows that small scale habitat enhancements can show benefits to the local fish community.

The aquatic invertebrate taxa that we sampled largely have much shorter life-spans (e.g. weeks-months) than fish (Marchant *et al.*, 1984; Campbell, 1986; Hawking and New, 1996), and one might expect a relatively rapid response to habitat enhancement. Unfortunately the sampling frequency (bi-monthly) was more suited to examining longer-term patterns, and so may have missed any immediate response.

In a recent address at the Murray Darling Freshwater Research Centre (May, 1998), noted U.S. stream rehabilitation-ecologist James Gore, cited recovery periods for macroinvertebrates, of from 14 to 300 days for streams subject to disturbances such as construction etc., and up to twice that for recovery from major flooding etc. This is a similar time-scale to that followed by our study, of the rehabilitation of the Broken River and Ryans Creek, and yet no significant trend of improvement at treatment sites was observed. This would also indicate that by the start of this trial (in October 1995) the fauna of Ryans Creek should have had a reasonable opportunity to recover from the major flood in 1993 that caused major changes in channel morphology in Ryans Creek.

Stream macroinvertebrates collected during this study were only identified to a level possible without dissection under a binocular microscope (i.e. mainly to family level). Despite the changes in physical and hydraulic habitat that were detected by Stewardson *et al* (this volume), macroinvertebrate data showed no strong indications of enhanced diversity. It is possible that a more detailed (species level) and frequent (daily-weekly) survey of stream macroinvertebrates may have proven useful for evaluation of the rehabilitation. However, such a study was beyond the scope and resources of this study.

## 5. CONCLUSIONS

In general stream enhancement treatment in the Broken River and Ryans Creek may have had a positive effect on the biotic community, and certainly did so for fish in the Broken River. The South-East of Australia was experiencing drought at the time of the study. While in control sites fish diversity declined over the course of the study, the treatment sites managed to maintain a more diverse fish community. Low flow conditions and hot summers limit the amount of available fish habitat in a stream both by reducing the physical wetted area and dissolved oxygen levels. The increase in depth and hydraulic variability in the Broken River created by habitat enhancements may have created more refuge habitats that could be utilized by fish. Deeper water and shade from rock and boulder cover are likely to have provided thermal refugia for fish under the drought conditions of hot weather and low flows.

In the wood treatment site for Ryans Creek the low water levels experienced in the drought meant that much of the additional "habitat" was left high-and-dry, along the margins of the stream. This habitat could obviously not create the refuge areas mentioned above. This may have contributed to the poorer performance of the fish community in these treatment sites compared to those on the Broken River.

## 6. LESSONS TO BE LEARNED

- IF your stream supports a fish community and rehabilitating it is one of your goals, AND you don't have access to the necessary technical skills,

equipment and resources for frequent sampling and species-level invertebrate analysis, THEN USE FISH TO EVALUATE THE SUCCESS OF YOUR HABITAT RESTORATION

- DO design your evaluation strategy well in advance of rehabilitation work commencing to allow plenty of time to benchmark the pre-existing conditions
- DO evaluate the physical and hydraulic changes to your stream that result from the rehabilitation, alongside measurements of the fish fauna, as this may provide an explanation as to why your fish fauna does or doesn't respond, and provide clues as to how to improve your rehabilitation efforts.

## 7. ACKNOWLEDGMENTS

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