Use of rehabilitated freshwater and estuarine habitat by recreational fish species

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Paul Brown

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Executive Summary

Aquatic habitat rehabilitation projects are often completed with no formal evaluation of their effectiveness. In Victoria, the Delatite, Goulburn, Acheron, Mitchell, Tambo and Snowy rivers, have recently had investment in rehabilitation of reaches. Methods and materials used included large woody debris (LWD) in various configurations including half-logs and artificial bank-cover structures (LUNKERs); and rock as boulder fields, bank reinforcing and current-deflecting groynes. Many projects were funded by revenues derived from recreational angling licences, yet there was no formal evaluation of the effectiveness of these methods in providing habitat for fish.

This study is a preliminary assessment to determine if the rehabilitated habitats in six distinct areas are inhabited by fish species of interest to the recreational fisher. Where possible, we will also compared the relative-abundance, and species-composition of the fish community at these rehabilitated sites with comparable reference sites, or ‘before’ surveys at these locations.

To determine what fish species are present at rehabilitated habitat sites a range of qualitative and quantitative fish sampling methods were used. These included electrofishing, remote-camera observation and snorkel-diver observation. Methods were often innovative and selected as the most appropriate for each particular site.

In the Delatite River at ‘Gundamain’, there is evidence that the abundance of sportfish and species diversity has increased after rehabilitation. The habitat was designed for adult brown trout; and abundance of adult brown trout has significantly improved at this site (+225%) since the work was done. The increase in habitat complexity and diversity may also have improved the habitat for a range of other fish and crustacean species, as overall fish-diversity increased and the abundance of blackfish and crayfish also rose after habitat rehabilitation.

In the Acheron River, no trout were sampled from Australia’s first LUNKER-based rehabilitation project. However, the capture of blackfish and Murray crayfish from the LUNKER structure is an encouraging sign of the ability of this design to provide useful habitat for a range of Australian native species of fish and crustaceans. As a structural aid to rehabilitating habitat in Australian trout streams, the LUNKER is yet to prove effective. Installation of these devices into shallower, ‘wade-able’ sites within streams will assist future evaluation.
Drift diving adequately confirmed brown and rainbow trout inhabiting the rehabilitated reaches in the Goulburn River. Relative densities observed were comparable to those recorded by drift diving in a New Zealand trout stream by Young and Hayes (2001).

Popular angling species bream and luderick were observed in association with rehabilitated habitat (FADs) in the estuarine zone of the Mitchell and Tambo rivers, and to a lesser extent in the Snowy River estuary. The mean abundance of these species on FADs in the Tambo and Mitchell was similar to that observed on nearby natural LWD. Other angling species were also observed including flathead, estuary perch, longfinned eels and mullet.

This rudimentary evaluation of several sites rehabilitated with artificial structural habitat and riparian vegetation management shows that habitat rehabilitation has provided 'homes' for brown and rainbow trout, blackfish, Murray crayfish, black bream and luderick. These species are all of interest to the recreational angler. The question of 'how well the rehabilitated sites perform' has only been partially answered and as expected, the answer is site-dependant, but also complicated by the non-standard methods that had to be employed. Recreational fishers can be assured that projects such as the Delatite River restoration; the Goulburn River angler access and riparian vegetation management program; and the Gippsland rivers FAD program are working to sustain or improve habitat for sportfish species. Recreational fishers should also be aware that these rehabilitated areas are 'worth fishing'.

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Introduction

Several habitat rehabilitation projects have recently been completed in the north-east and Gippsland regions of Victoria. In the Delatite, Goulburn, Acheron, Mitchell, Tambo and Snowy rivers, sites have been rehabilitated using large woody debris (LWD) in various configurations including half-logs and artificial bank-cover structures (LUNKERs), and rock as boulder fields, bank reinforcing and current-deflecting groynes. In most cases there was no formal evaluation of the effectiveness of these methods in providing habitat for fish. A formal and scientific evaluation of these projects is difficult as in most cases there is little, or no, comparable data on the fish inhabiting the site before restoration. However, there is a need to know (at the very least) if fish of recreational value inhabit these artificial habitat structures. Without this knowledge, future investment in the rehabilitation of more sites, using similar methods would seem speculative.

We propose a preliminary assessment to determine if these rehabilitated habitats are inhabited by fish species of interest to the recreational fisher. Where possible, we also propose to compare the relative abundance, and species-composition of the fish community at these rehabilitated sites with comparable reference sites at each location.

Objectives

1. Determine whether habitat rehabilitation provides ‘homes’ for fish species of interest to the recreational angler.
2. Compare rehabilitated sites with equivalent and adjacent reference sites to determine ‘how well the rehabilitated sites perform’ as homes for recreationally valuable fish species.

Hopefully, Victoria’s recreational fishers will benefit because project outcomes will include better guidance and advice to catchment and fisheries managers on which methods are working and which aren’t. Recreational fishers will also learn if species-of-interest inhabit these habitat rehabilitation structures, and therefore if they are ‘worth fishing’.

Background to study sites

The Delatite, Acheron and Goulburn rivers are popular and valuable recreational fisheries for both brown (Salmo trutta) and rainbow trout (Oncorhynchus mykiss). These rivers also have a significant biodiversity value for native fish and invertebrates. Habitat rehabilitation in these streams has focused on improving the habitat value for trout and enhancing current access for recreational anglers. Gravel mining historically degraded a 400-m reach of the Delatite River at ‘Gundamain’ near Mansfield. Habitat improvement work was completed in 2003 by the Goulburn Broken Catchment Management Authority in partnership with the new owners of the surrounding land - River Rock Quarries, and the adjacent property ‘Gundamain’, the Rex Hunt Futurefish Foundation’s Healthy Waterways Program, Goulburn-Broken Catchment Management Authority, and PIRVic (Figure 1).

Degradation of the riparian zone led to erosion and bank slumping on a 100-m reach of the Acheron River at Acheron. The Goulburn Broken Catchment Management Authority completed habitat improvement work in 2002, as a demonstration-site for LUNKERs (Large Underwater Neighbourhood Keepers for Rheotactic salmonids), a design...
using timber and rock to provide complex overhead cover for trout. The design enables high quality fish habitat to be added to sites where bank reinforcing for erosion control is required (Figure 2).

The riparian zone of several sites on the Goulburn River near Gilmore’s Bridge and Thornton, had become overgrown with willow (Salix fragilis). Since 2001, recreational fishing licence revenues were used to fund angler-access projects, clearing willow thickets and remediation of habitat with instream coverstructures (eg. half-logs, LWD, and boulders) for trout. Downstream of Gilmore’s Bridge in 1999/2000 an anabranch channel, totally obstructed with willows, was cleared (Figure 3). Instream habitat was reinstated in the anabranch (LWD, boulders and half-logs). Upstream of Gilmore’s Bridge the right-bank was cleared of a dense growth of willows in the previous winter (2004) and some re-planting of native vegetation as well as installation of riparian fencing has ensued. The bank is well grassed although the site was still largely clear of overhanging woody vegetation. Upstream of Thornton Bridge, the rightbank was also cleared of willows in winter 2004. Instream habitat was enhanced with two small rockgroynes, boulders and LWD.

Figure 1.Gundamain site on the Delatite River immediately after rehabilitation work (left), and two years later (right) looking upstream

Figure 2. Acheron River LUNKER demonstration site (looking downstream) immediately after rehabilitation work (left), and being fished by an angler two-years later (right, looking upstream)
Figure 3. Goulburn River anabranch downstream of Gilmores' Bridge, choked with willows before rehabilitation (left) at low flows, and ~12 months after rehabilitation demonstration (right) at moderate flows.

The Mitchell, Tambo and Snowy river estuarine reaches are popular and valuable recreational and commercial fisheries for a number of estuarine fish species, including black bream (Acanthopagrus butcheri), luderick (Girella tricuspidata), and estuary perch (Macquaria colonorum).

To stabilise bank-slumping, large reaches of the Mitchell and Tambo estuaries have had the stream banks reinforced with quarried rock During 2002–2003 several ‘engineered logjams’ were constructed to improve environmental values. These structures are made of multiple large hardwood logs. The logs lead in from the bank. They are cabled together as well as to anchor-logs driven into the streambed. Evaluation of benefits from these sites using controlled angling, and invertebrate surveys has, so far, proved inconclusive (Haupt and Candy 2003). Earlier and smaller-scale work in the Snowy River in 2000, was also designed to re-introduce large woody debris adjacent to a reach of remnant rain forest at Lochend (Figure 5). This was again in recognition of the role of LWD in stream and estuarine ecology, and specifically as preferred habitat for many fish species.

Figure 4. (left) Tambo River at Rough Rd prior to installation of artificial multi-log structures (photo: EGCMA). (Right) Mitchell River February 2005, after installation of similar multi-log structures.
Figure 5. Snowy River at Lochend showing some of the series of LWD (single and double logs) installed for habitat rehabilitation in 2000 (photo: EGCMA).

Methods

To determine what fish species were present at rehabilitated habitat sites a range of qualitative and quantitative fish sampling methods were used. These included electrofishing, remote-camera observation and snorkel-diver observation. Methods were selected as the most appropriate for each particular site and details are given below for each location. Each location was surveyed once during December 2004–January 2005. Only one, the Delatite River, had any comparative ‘before’ data useful to the assessment. For the Delatite River and the Acheron River sites, fish were captured using backpack electrofishing. At other sites methods were observational using snorkelling observers, or underwater video, and no fish were captured.

Delatite River at ‘Gundamain’

Prior to any habitat rehabilitation at this site, in November 2002 a fish population assessment (removal method) was carried out in anticipation of future rehabilitation activities. Block-nets were positioned at the upstream and downstream end, closing a 400-m reach to fish movement. Within the nets, four slow and careful passes, were made with two backpack electrofishers and a net operator. All fish captured at each pass were anaesthetised, identified, counted, measured and weighed. Numbers of fish captured during each subsequent pass were recorded. Each pass took approximately 1 hour, therefore there was >1-hour delay between fishing any point within the site. Population sizes, were estimated using MICROFISH 3.0 (Van deventer and Platts 1989). In December 2004, one year after rehabilitation, the same survey method was repeated to re-estimate the populations of large brown trout, two-spined blackfish, and Murray crayfish at the same site. Seasonal timing and flows were assessed as similar and thus comparable between surveys.

Acheron River LUNKER's

For the Acheron River site, a preliminary relative abundance estimate of fish was made using 2-backpack electrofishers at a single 100-m site two years after rehabilitation. No prior data was available for this site. All fish caught were anaesthetised, identified, counted, measured and weighed, before release. Due to depth being greater than wading-depth along much of the LUNKER, the electrofishers were only able to sample with low efficiency. However, this method represented the best available alternative, as the site was not suitable for access by boat-electrofisher. Underwater video was also assessed as impractical due to high turbidity, and low visibility (<0.5m).
Goulburn River, at Gilmore’s Bridge and Thornton

Presence of sportfish and suitable habitat was assessed using a team of 3 drift-divers using snorkel swimming gear on 18 January 2005. River flow was 5000 ML/day at Eldon. Horizontal underwater visibility was estimated at 2m. Three sites were assessed; the entire 100-m anabranch downstream of Gilmore’s Bridge, 150-m reach upstream of Gilmore’s Bridge, and a 200-m reach upstream of Thornton Bridge. At the end of each drift, counts of trout observed, along with their size estimate (small, medium or large), were collated from divers. Notes were made about habitat features observed underwater.

Mitchell River Fish Attracting Structures

Artificial habitat, in the form of multi-log fish attracting device (FAD), was observed with an underwater video camera (Aqua-vu, DT) mounted on a 4-m, extendable guide-pole. The equipment was deployed from a small punt moored to the FAD. Extensive observations of fish within their habitat were made, with little apparent disturbance to their behaviour. Replicate two-minute “samples” of the fish community were filmed at randomly chosen positions within the FADs (n=9). Comparative samples were filmed at nearby natural LWD-snags (n=5), and at reference sites in between the FADs, where no obvious LWD was present (n=8). Observations were made in situ using the viewing screen of the Aqua-vu unit, while simultaneously recording to mini-DV. Digital videotapes were later displayed in the lab and each sample was reviewed. Fish were identified where possible and counted. Fish that could not be identified were classified as ‘unidentified’.

Tambo River Fish Attracting Structures

Artificial habitat, in the form of half the multi-log fish attracting devices (FAD) were again sampled with similar techniques to those developed on the Mitchell River (details given above). Replicate, two-minute samples of fish communities were made on the FADs (n=10), and at similar reference sites (n=10) on the opposite riverbank. Insufficient natural LWD was present to enable useful comparisons (n=2). Following this, snorkel divers made a careful search of the remaining FADs and recorded any additional fish species observed.

Snowy River Fish Attracting Structures

Artificial habitats, in the form of several single and double-log structures were sampled using the remote video methods detailed above. Replicate two-minute samples of the fish community were made on the artificial habitat, at adjacent reference sites (with no LWD) and at nearby natural LWD. Following this, snorkel divers made a careful search of the remaining FADs and recorded any additional fish species observed.

Mitchell, Tambo and Snowy River data were analysed and for the most abundant species, mean abundance at FAD, and natural LWD sites was statistically compared with a general linear model ANOVA using p=0.05 as the critical value to indicate statistical significance. Behaviour of fish at reference sites was different to that observed at FADs and natural LWD, therefore they were excluded from statistical analysis (see Discussion section for details).

Results

Delatite River at ‘Gundamain’

‘Before Rehabilitation’

In November 2002, prior to the habitat rehabilitation, 134 fish and 71 crustaceans from 6 species were actually sampled for a total biomass of 5.262 kg. However, the sample contained only 4 adult brown trout (>250 mm fork length) with a combined biomass of 2.7kg.
Table 1. Abundance estimates of fish and crustaceans sampled at Delatite River site, 'Gundamain', before (2002) and after (2004), habitat rehabilitation. Figures with (± standard error) are estimates of the population derived from depletion sampling. Population estimates were obtained from the depletion-rate of individuals over three electrofishing passes, for brown trout adults and fry (<80 mm total length), two-spined blackfish (Gadopsis bispinosis) and Murray crayfish (Euastacus armoratus)(Table 1 and Figure 6).

<table>
<thead>
<tr>
<th>Species</th>
<th>2002</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown trout (adults)</td>
<td>4 (± 0.2)</td>
<td>13 (± 0.9)</td>
</tr>
<tr>
<td>Brown trout (fry)</td>
<td>77 (± 4.5)</td>
<td>7 (± 0.3)</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Two spined blackfish</td>
<td>74 (± 12.7)</td>
<td>184 (± 209.4)</td>
</tr>
<tr>
<td>Mountain galaxias</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Pygmy perch</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Murray crayfish</td>
<td>48 (± 11.5)</td>
<td>86 (± 10.6)</td>
</tr>
<tr>
<td>Yabby</td>
<td>35</td>
<td>17</td>
</tr>
</tbody>
</table>

Acheron River LUNKER’s

Anglers adjacent to the LUNKER structure captured trout in the previous summer of 2004 (P. Brown personal observation). In January 2005, three years after installation of LUNKER’s, we only sampled two-spined blackfish (n=15) and Murray crayfish (n=2) from the 100-m reach. No trout were sampled. The majority of fish, (~90%) were sampled from the shallower downstream end of the LUNKER. The upstream end was too deep to effectively wade and electrofish. Few fish were sampled from natural LWD present on the opposite bank to the LUNKER.
Goulburn River at Gilmore’s Bridge and Thornton

Anabranch downstream of Gilmore’s Bridge, right bank:

Habitat quality was good. The riverbed had ample cover provided by luxuriant growth of macrophytes. The presence of large boulders, sunken logs and half-log structures provided good structural overhead cover and velocity shelter. Depth varied up to >2m.

Two small (~200mm) rainbow trout were observed at the upstream end of the anabranch and one large rainbow trout (~300mm) was observed on the edge of the backwater at the downstream end. A school of Australian smelt was also observed in the backwater at the downstream end.

Upstream of Gilmore’s Bridge:

Habitat, for adult trout, was also of good quality with an undulating riverbed to approximately 3-m deep. Although there was markedly less weed growth, plentiful cover was provided by submerged LWD. Much of this appears to be remnants of original hardwood riparian vegetation, rather than the debris from recent willow clearing.

Two large brown trout (>400 mm), one medium brown trout (~300mm) and two small rainbow trout (~150 mm) were observed along with two Murray crayfish.

Upstream of Thornton Bridge (right bank):

Habitat for adult trout was excellent though this reach. Although aquatic macrophytes were sparse there was good depth variability and velocity refuge provided by large amounts of LWD and boulders. Two medium sized brown trout (~300mm) and one Murray crayfish were observed.

Gippsland Fish Attracting Structures (FADs)

Abundance indices, i.e. the mean numbers of black bream, luderick and unidentified fish per 2-minute sample, varied significantly between rivers (p<0.05). The Mitchell and Tambo had similar abundance of bream that was higher than the Snowy. For luderick, the Tambo River had significantly higher abundance than both the Snowy and Mitchell rivers. An analysis of differences in abundance indices amongst treatments depends upon which river the FADs were in.

Mitchell River

Black bream, luderick, carp (Cyprinus carpio), longfinned eel (Anguilla reinhardtii) and numerous small unidentified gobid fishes, were seen during video observations (see video appendix, DVD). Black bream (n=256) and luderick
(n=6) were the most numerous, during twenty-one, 2-minute counts. The average numbers of black bream, luderick and unclassified individuals, that were counted per 2-minutes on the FAD, LWD and reference sites are shown in Figure 7.

There was no statistical difference (p>0.05) among the numbers of black bream, luderick, unidentified fish and total number of fish observed on FADs, and at natural LWD sites in the Mitchell River. However we observed high numbers of bream moving rapidly through the view during video samples of reference area's with no LWD. The inverse was true of luderick, with high numbers observed using the FADs, and fewer elsewhere.

**Tambo River**

Black bream, luderick, carp, and numerous small-unidentified gobid fishes, were also seen during video observations on the Tambo River (see video appendix, DVD). Again, luderick and black bream were the most numerous, with 115 and 223 counted, respectively, during twenty-one, 2-minute counts. The average numbers of luderick, black bream, and unclassified large fishes that were counted per 2-minute sample on the FAD, LWD and reference sites are shown in

![Graphs showing fish counts](image)

**Figure 7.** Mean number of black bream, luderick, and unidentified fish observed during replicate 2-minute video observations of FAD (n=9), reference (n=8) and natural LWD (n=5) sites in the Mitchell River. Error bars show standard deviation of the mean.
**Figure 8.** Mean number of black bream, luderick, and unidentified fish observed during replicate 2-minute video observations of FAD (n=10), reference (n=10) and natural LWD (n=2) sites in the Tambo River. Error bars show standard deviation of the mean.

There was no statistical difference (p>0.05) between the numbers of black bream, luderick, unidentified fish and total number of fish observed on FADs, and at natural LWD sites in the Tambo River. There was a non-significant trend for high bream and luderick abundance on the FADs. Again, fish in association with the FADs were less active and sedentary in behaviour than those observed at reference sites (without LWD).

Four FADs and intervening littoral (ie. nearshore area) were searched by two snorkel-divers. A total of seven fish species were observed on the FADs. Additional species not seen by video camera included, common galaxias (Galaxias maculatus), two unidentified gobiid species, carp, unidentified sprat species (Hyperlophus sp.), and toadfish (Tetractenos sp). Luderick were noted as very numerous (eg. 100's) on each FAD with several specimens around 30 cm +. Approximately seven large bream (≥1 kg) were also seen associated with the deeper water at the end of the FAD. In between the FADs, among the artificial rockwork protecting the banks, were black bream, luderick, common galaxias, flathead (Platycephalus sp.), longfinned eel and carp. However, all co-occurring species were less numerous than on the FAD’s and fewer large individuals were seen (eg. single 1 kg bream).

**Snowy River**

Luderick, black bream, longfinned eels, estuary perch and sea mullet (Mugil cephalus) were observed during video observations on the Snowy River at Lochend (see video appendix, DVD). Luderick and mullet were the most abundant (27 and 61 seen respectively) during twenty-one 2-minute video samples (FAD n=14, reference n=8, natural LWD n=3). Overall, fewer fish were seen than at either the Mitchell or Tambo sites and counts were extremely variable between samples. Bream were notably rare in comparison to the other Gippsland sites. The mullet and estuary perch were all noted on two natural LWD snags. Black bream (n=3) were only noted on a single FAD and luderick were only noted on three FADs.

Ten LWD structures and the intervening littoral areas were searched by 2 snorkel-divers. The camera system was better at visual discrimination underwater than the divers. Underwater visibility was measured at 1.5-2.0 metres using the camera and video whereas snorkelers observed loss of visible discrimination at 1.3 metres (horizontal distances). The Snowy River had similar underwater visibility to the Mitchell River and slightly poorer than the Tambo River.

Diver observations were in general agreement with video samples. Relatively few fish were seen (cf. Mitchell, and Tambo) on either FADs, natural LWD or at reference sites. Many LWD items had only a few luderick (eg. <5). Large longfinned eels were seen on approximately half the structures. An occasional small bream was also seen. FAD structures were not holding substantial numbers of fish in the Snowy River.

**Discussion**

In many cases we have shown that fish of value to the recreational angler (ie. sportfish) are found in association with artificial habitat, or within rehabilitated river reaches. The scope of this assessment was limited to that simple objective. However, it is also apparent that in many cases, the effectiveness of habitat rehabilitation compared to areas without-, or periods before-, this treatment, is difficult to gauge with this type of simple assessment.

In the Delatite River there is evidence that the abundance of sportfish, and species diversity has increased after rehabilitation. The project to rehabilitate the Gundamain-reach after damage by gravel mining, was useful in that it allowed a comparison in time. Despite the short-length of the reach and the limited time after rehabilitation, the positive change in large trout abundance approached the magnitude of that reported in longer-term studies in the USA (see review in Brown 2003). This suggests that further restoration of the remaining reach degraded by gravel mining at Gundamain, using similar methods, would have similar positive results. This project can clearly be...
classified as a habitat restoration where the degraded condition of the stream was restored to match the characteristics of healthier parts of the same stream (e.g. narrower, deeper, rocky-cover, more riparian vegetation). The habitat was designed for adult brown trout; and abundance of adult brown trout has significantly improved at this site (+225%) since the work was done. The increase in habitat complexity, and diversity may also have improved the habitat for a range of other fish and crustacean species, because fish-diversity increased and the abundance of blackfish and crayfish also rose after habitat rehabilitation. However, our certainty about the cause of this improvement is perhaps compromised by the uncontrolled design of the study. We cannot be certain that elsewhere on the Delatite River without the assistance of our habitat rehabilitation, these increases in abundance and diversity were not also happening. This type of uncontrolled experimental evaluation is termed 'level 3' in Rutherford et al's (2000) rehabilitation manual, where the authors suggest that while it should be adequate to "convince sceptical senior managers", it would "generate debate (but not necessarily complete rejection) amongst scientists...". While acknowledging that there is still some doubt surrounding the cause of the increase abundance and diversity at Gundamain it is a promising pilot study that supports the case for trout fishery management and increased river-health, by using habitat rehabilitation.

The Acheron River site was designed as a demonstration of the LUNKERs method of adding quality fish habitat, as overhead cover, to sites requiring bank stabilisation or erosion-control (Vetrano 1988). This is the first LUNKER built in Australia. Again, the target fish species were trout, as the Acheron is a popular local trout stream. Unfortunately the site presented severe limitations to effectively sampling its fish. Even after prolonged low flows the low water clarity limited the effectiveness of underwater observation. Much of it was too deep to wade, and yet too small for boat access—preventing effective electrofishing. Whilst an electrofishing survey was attempted, the disappointing nature of the results is symptomatic of the limited sampling efficiency that was possible. No trout were sampled from the LUNKER. However, the capture of blackfish and Murray crayfish from the LUNKER structure is an encouraging sign of the ability of this design to provide useful habitat for a range of Australian native species of fish and crustaceans. As a structural aid to rehabilitating habitat in Australian trout streams, the LUNKER is yet to prove effective. Installation of these devices into shallower, wade-able sites within streams will assist future evaluation.

Drift diving adequately confirmed brown and rainbow trout inhabiting the rehabilitated reaches in the Goulburn River. These habitat rehabilitation sites mainly concern riparian vegetation management, although some artificial instream habitat was also added with LWD, half-logs or boulders. The driftdiving method has proved reliable overseas (Schill and Griffith 1984; Teirney and Jowett 1990) as a method of estimating relative abundance of trout populations, or of estimating population size in combination with fish-marking (Young and Hayes 2001). A total of 8 brown and rainbow trout were observed in and around 450 m of habitat rehabilitation in the Goulburn River. As the first drift dive survey of the Goulburn, we have little local data to compare this observation with. However, this count is comparable to those recorded in New Zealand’s Ugly River, by Young and Hayes (2001) who observed 15 and 22 trout per km in two drift dives over a 5.5-km reach. During periods of exceptional underwater visibility (>2 m for the Goulburn), such as this, the method may have potential for developing a relative index-of abundance. The ease with which observations were made of otherwise invisible, underwater habitat, highlights the potential of the method for qualitative instream-habitat surveys. Popular angling species bream and luderick were seen associated with rehabilitated habitat (FADs) in the estuarine zone of the Mitchell and Tambo rivers, and to a lesser extent in the Snowy River estuary. The mean abundance of these species on FADs in the Tambo and Mitchell was similar to that observed on nearby natural LWD although the sampling variability was high and the power of the statistical test low. Difficulties in sampling this complex habitat in brackish water meant that traditional netting, and electrofishing methods were impracticable. Underwater camera surveys are being increasingly used as alternatives to standard methods for fish and habitat surveys (Frezza et al. 2003). Therefore, innovative underwater observational methods, using both video and snorkel-divers, were trialed. Together they provided a robust insight into fish behaviour and distribution around the FADs.

Discrete video 'samples' potentially allowed a statistical comparison between three treatments (FAD, LWD and reference). However, behavioural differences in the way fish used the various habitats, represented by the
'treatments', may bias abundance estimates obtained from video samples. The field crew noted that individual fish videoed in the reference samples were generally moving fast (travellers); whereas fish around FAD's or associated with natural LWD were moving slower (lurkers). Given the discrete time period of the 'samples', those at FAD or natural LWD sites were not equivalent to samples at reference sites. Abundance estimates over a discrete time period at reference sites may therefore not be validly compared to those at FADs or natural LWD. However, this behaviour is consistent with the way we believe fish use LWD; as habitat to feed in (luderick were observed grazing on algae on the FADs); as velocity shelters in tidal currents; and as hiding and ambushing locations. Unfortunately, the original intention was to compare abundance at FADs with that of reference sites. The addition of a few natural LWD was an opportunistic afterthought and sample size was low for the natural LWD. However, since fish behaviour on FAD and LWD was similar we can make valid comparisons and it is reassuring that there were no significant differences between FADs and natural LWD. Luderick seemed to have particularly 'preference' for FADs, with few observed on natural LWD in locations with high numbers on FADs. The more complex FADs, may offer an extensive surface area for grazing on algal film for this largely herbivorous species. While black bream abundance was generally high in the Mitchell and Tambo rivers, it was mainly small individuals that were seen with the camera. Large bream (~1 kg) were more often observed by snorkel divers while inspecting the deeper water at the end of the FADs. Each observational technique offers advantages and disadvantages. The visual acuity of the camera underwater in low-light conditions was better than that of the swimmers; therefore camera surveys would be advantageous given marginal visibility. The ability of the camera to be positioned near the riverbed, and pointing-up at an angle toward the surface, was useful to maximise the available light reflecting off mid-water targets (ie. fish). For timid species, like bream, the camera was also less obtrusive than the swimmers. Luderick were bolder, and didn't change their behaviour whether observed by swimmers or camera. Camera surveys, recorded on digital video, are advantageous when fish counts are high, or identification is problematic. The recording can be revisited, enlarged, played-back, freeze-framed etc, for recounting or confirmation. Snorkel-diver surveys identified the greater range of species, probably due to the relatively wide-area of coverage and hence, better probability of observing rare (sparse) species.

The video-sampling method shows potential for semi-quantitative relative abundance estimates for comparisons among freshwater or estuarine sites with equivalent habitat, or stratified by habitat types. It is applicable wherever underwater visibility approaches 1.5 m or more; and is quick, cheap and simple. The high between-sample variance in the present study reflects spatial and temporal patchiness of fish abundance. Longer sample periods are one way to potentially reduce this patchiness over time. Greater numbers of samples, applied in a random way within habitat strata, would possibly even out spatial patchiness and improve ability to conduct quantitative comparisons.

Conclusions

In Victoria, and probably the rest of Australia, there is clearly a systemic problem in the inability, or unwillingness, of rehabilitating agencies to adequately plan for the evaluation of habitat rehabilitation projects. The basic standard of before-and-after testing at both rehabilitated sites and control sites, was not met in any of the projects studied here. It is vital that habitat management agencies and funding bodies realise that, while many of our results are encouraging, under-funding of evaluation may result in rehabilitation-dollars being wasted.

This rudimentary evaluation of several sites rehabilitated with artificial structural habitat and riparian vegetation management shows that habitat rehabilitation has provided 'homes' for brown and rainbow trout, blackfish, Murray crayfish, black bream and luderick which are all of interest to the recreational angler.

The question of 'how well the rehabilitated sites perform' has only been partially answered and as expected, the answer is site-dependant, but also complicated by the non-standard methods that had to be employed. However:

- There were 250% more catchable sized trout, and perhaps more blackfish and Murray crayfish in a reach of the Delatite River after rehabilitation – Rehabilitated reaches of the Goulburn River contained 'reasonable' numbers of trout, comparable to those observed with the same drift-diving methods in another (NZ) river. –
Complex LWD structures (FADs) in the Mitchell and Tambo rivers held similar numbers of black bream and luderick to natural LWD (snags), suggesting that such structures are a useful substitute for natural snags, until riparian vegetation management can provide natural snag-recruitment to the stream.

- Further evaluation of trout fishery rehabilitation using LUNKERs is required, in areas more suitable for survey using electrofishing.

Recreational fishers can be optimistic that projects such as the Delatite River restoration; the Goulburn River angler access and riparian vegetation management program; and the Gippsland rivers FAD program are working to sustain or improve habitat for sportfish species. Recreational fishers should also be aware that these rehabilitated areas are 'worth fishing'.

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**References**


**Video Appendix 1**

See attached DVD "RFL Habitat Evaluation: Mitchell, Tambo, and Snowy rivers"