Keynote presentations

Rehabilitation of fish habitats in the Murray-Darling Basin — where have we been and where are we going?

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Abstract

There has been a change in attitudes toward aquatic habitats over past decades, from the old days of 'river improvement' to recent 'river rehabilitation' initiatives. River rehabilitation and attention to the importance of aquatic habitats are currently on many agendas, but are we making progress and what have we achieved? This paper reviews past and present attitudes, management, community support, and trends in the underlying science and rehabilitation activities. Recommendations are provided to indicate where we should head from here and approaches we can take to achieve the most beneficial outcomes.

Introduction

Habitat can be defined as the natural home of the animal; rehabilitation can be defined as restoration to a proper condition, ideally involving the management agency, community, science, technology and techniques. This workshop paper is limited to considering structural habitats, but we must remember the importance of all other habitat attributes and the linkages and interactions between them. If other crucial habitat elements are not suitable then good rehabilitation outcomes cannot be expected. The most pertinent example of this is water quality, where fish kills can negate any population gains made by habitat rehabilitation. Put into the wider context, we need to take an holistic approach to rehabilitation and gain understanding of the interdependence between ecosystem components.

Consideration of aquatic environments has progressed considerably over past decades, from protecting public and private assets, to considering environmental assets, protecting those assets and now repairing environmental assets. This is highlighted by the progression in the publication titles *River Control in Australia and New Zealand* (Strom 1941), *River Improvement and Drainage in Australia and New Zealand* (Strom 1962), *Environmental Guidelines for River Management Works* (Department of Conservation and Environment 1990) and *A Rehabilitation Manual for Australian Streams. Volume 1.* (Rutherfurd *et al.* 1999a). Current philosophy is more clearly illustrated by the conducting of this workshop and the content of papers included in these proceedings.

It is somewhat ironic that this rehabilitation workshop is held in Albury, on the River Murray, close to sites where 24,500 snags were removed from the River Murray (between Albury and Howlong) from 1976 to 1987 (Murray-Darling Basin Commission unpublished report, cited in Gippel *et al.* 1992). In 2001, the first snags were reintroduced into the River Murray downstream of Lake Mulwala (Nicol *et al*. 2002), and in 2004 planning is underway for extensive resnagging of the River Murray between Albury and Lake Mulwala. The cost of this resnagging is likely to be approximately $600 per snag (Nicol *et al*. 2002). Thirty years since the snag removal, however, there have been substantial changes in the onus for undertaking such works. Whilst the snags were removed with minimal environmental consideration and consultation, planning requirements now make their reintroduction a more complicated affair.

Rehabilitation

The current importance of river rehabilitation in river management can be gauged by the fact that 20 per cent of papers at the 2nd and 3rd Stream Management Conferences (Rutherfurd & Bartley 1999a, 1999b; Rutherfurd *et al.* 2001a, 2001b) referred to rehabilitation in their title, while many other papers clearly involved components of rehabilitation. Papers presented at these conferences, and testing of the National Framework for River Restoration (Cant & Koehn 2000), show that agencies and catchment groups usually have good intentions and abundant goodwill, though can often lack clear direction, expertise and coordination in their rehabilitation efforts. Fish, and even more so fish habitats, still generally have a low regional profile, and there is often a lack of regional aquatic expertise. There is a need to incorporate fish habitat restoration into catchment management planning and to transfer knowledge to regional practitioners. Whilst there remains a need to improve regional expertise, general priorities for action are now established in the Native Fish Strategy (Murray-Darling Basin Commission 2004) and the processes for implementation provided by frameworks and technique manuals (e.g. Koehn *et al*. 2001; Rutherfurd *et al.* 1999a, 1999b).

An important component of habitat rehabilitation is the engagement of members of the local community to provide support, participate in activities including goal setting and monitoring, and increase their knowledge so they become stakeholders, advocates and drivers of the project. Local knowledge is vital to such projects and consideration must be given to local values and cultural aspects. The 'community' is a major stakeholder in fish habitat rehabilitation.

Integration of management with science is imperative for improved rehabilitation of fish. Management and science have different paradigms, however, (**Table 1**) and these need to be understood and drawn together for greater cooperation in projects.

Recent trends in science can influence the way it is used by management. There has been a change from natural-history-based observations to studies of fish ecology with increased scientific rigour. Field-based research has replaced the previous hatchery-based research on major angling species. Understanding of habitat requirements has increased and attention has moved to threat amelioration, with increasing emphasis on communities and ecosystems rather than single species. There is considerable new biological information for some species (e.g. Murray cod *Maccullochella peelii peelii*) and some life stages (e.g. larvae). Experimental design has improved and led to more comprehensive monitoring. There has been greater collaboration between scientists and managers and between disciplines (e.g. ecologists and engineers, hydrologists and geomorphologists). Examination of habitat patterns (e.g. Nicol *et al.* 2001; Koehn *et al*. 2004) and hypothesis testing of habitat use are now being undertaken (e.g. Bond & Lake 2005; Nicol *et al.* 2002).

The nature of science funding has also changed. Numbers of permanent staff in government agencies have been reduced, with increased numbers of contract staff with greater accountability to short-term, externally funded projects. Non-student research at universities has also been reduced. Consequently, there is no large group of scientists within any single institution dedicated to working to provide knowledge or solutions to management problems. Similarly, there is an increasing inability for scientists to provide advice, offer opinions or comment on management plans unless these are incorporated into their work plans and funded. This often poses a problem for management agencies seeking *ad hoc* advice.

Table 1. Differing aspects of science and management

Management	**Science**
• Applies planned actions to obtain outcomes	• Is a formal process of developing knowledge
• Provides intervention for change	• Investigates cause and effect
• Operates on the larger scale	• Experiments on the smaller scale
• Uses knowledge	• Provides reliable knowledge
• Manages entire systems	• Investigates system components

In lieu of scientific data, there has been an increasing reliance on the use of expert panels and expert opinion to support management decisions. While expert-opinion-based decisions are important for management, they do effectively 'mine' the intellectual capital of scientists, and this knowledge needs to be replenished through new research. Our knowledge of fish ecology, and fish habitats in particular, is limited in Australia, and so limits the lifespan of such 'mining' operations. New knowledge needs to be forthcoming, through 'growing' and 'harvesting' rather than 'mining'. A lack of testing of existing beliefs can result in the perpetuation of opinions until they become 'facts'. Opinions still need to be tested and knowledge gained in a scientific manner. New knowledge has recently challenged some entrenched beliefs of how Australian riverine ecosystems function (e.g. the Flood Pulse Concept; Humphries *et al*. 1999). Reliable management solutions will only be forthcoming with appropriate levels of endeavour and resources directed towards providing particular components of knowledge.

Science and management decisions are coming under increasing scrutiny and challenge by other scientists, stakeholders, lobby groups, hired consultants and the public. It is likely that such decisions will increasingly be subjected to legal challenge, especially if re-allocation of resources is required. There is therefore an increasing need to underpin management with quantitative scientific knowledge that can provide legally defensible evidence-based decisions. Adaptive management (AM) (**Figure 1**) links management and science explicitly, and offers the opportunity to test different management options in a scientific manner.

AM allows the integration of the underpinning science (such as biological information, habitat pattern, prediction and hypothesis testing, spatial scale, landscape ecology, ecological community interactions and ecosystem processes) with management. Theories can be tested through management using the AM process.

To facilitate rapid learning, Adaptive Experimental Management (AEM) (**Figure 2**) can be used, where multiple management strategies can be implemented simultaneously within an experimental framework, rather than sequentially which is more typical of trial-and-error approaches.

Adaptive experimental management can be used to maximise learning but requires:

1. Coordination amongst managers to realise collective benefits (for all, not just their own organisation);
2. Supportive centralised administration to provide discipline and continuity (e.g. Murray-Darling Basin Commission);
3. Effective ongoing monitoring to become a part of management rather than a reporting requirement or a research outcome;
4. Testing of different (potentially less than optimal) management scenarios.

Modelling is a powerful tool that can be used in AM. Used appropriately, modelling processes (rather than the modelling outcome), can be used to collate knowledge and information, engage stakeholders, simulate data requirements and monitoring regimes, and determine experimental design and decision points.

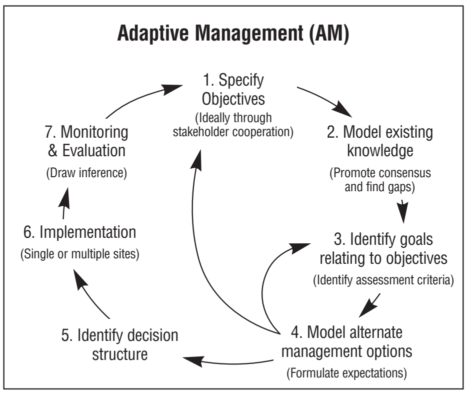

Figure 1. The Adaptive Management cycle (from Bearlin et al. 2002)

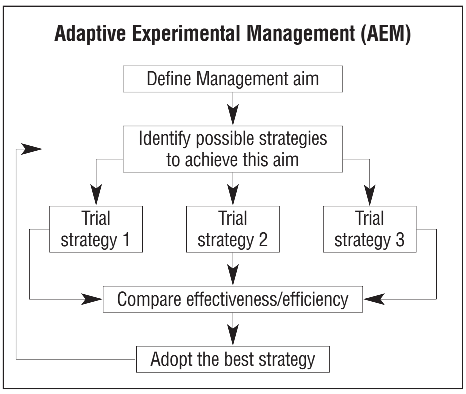

Figure 2. The Adaptive Experimental Management cycle (modified from Choquenot and Parkes 2000)

Importantly, AM allows management actions to add to the scientific knowledge base, and scientific knowledge to be added to the management process.

Habitat rehabilitation is often undertaken for a variety of reasons. The following case studies highlight some different reasons for, and outcomes from, fish habitat rehabilitation projects.

The Ovens River rehabilitation (Koehn 1987)

This small project was undertaken in 1986, with pre-work fish surveys conducted in 1984 and post-work monitoring in 1987 and 1997.

Aim: To test if increasing habitat would increase two-spined blackfish *Gadopsis bispinosus* numbers in a discrete area.

Methods: Conducted at only one site on the Ovens River at Porepunkah, it involved the addition of 20 m^3 of rock, one small log weir and (unintentionally) an amount of woody habitat (willow debris) (**Figure 3**). The rock consisted of about 360 granite boulders, about half of which became buried prior to monitoring in 1987.

Results: Substantial increases in the numbers of two-spined blackfish in the sections where both rock and wood habitat were added (**Figure 4**). The persistence of this result more than 10 years after the introduction of the habitat is encouraging. The effect of the increase in fish numbers in these sections on adjoining sections of the river, or on the overall fish population, is not known.

This highlights the need to understand the contribution that improved habitat makes to the overall fish populations. Is this more than an 'aggregation' response from adjoining areas? This project was not designed as a management experiment and consequently our ability to interpret results is limited. The results, however, indicate that the response of two-spined blackfish is likely to be easily detectable from a more comprehensive study. Consequently, management actions such as those undertaken in this study could easily be used in an AM framework to facilitate rapid learning about the response of fish population to such rehabilitation measures.

Seven Creeks rehabilitation (Saddlier *et al.* 2002)

Seven Creeks hosts Victoria's only self-sustaining population of the critically endangered species trout cod *Maccullochella macquariensis*. This project was overseen by the national recovery team and undertaken with the Goulburn-Broken Catchment Management Authority.

Aims: To improve the quality of in-stream and riparian habitat for trout cod and increase the downstream range of trout cod population.

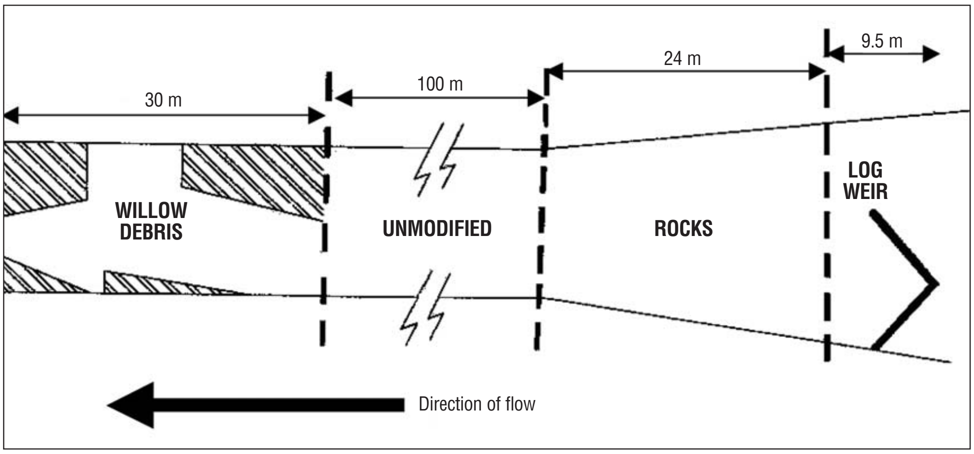

Figure 3. Diagram of the habitat rehabilitation site on the Ovens River

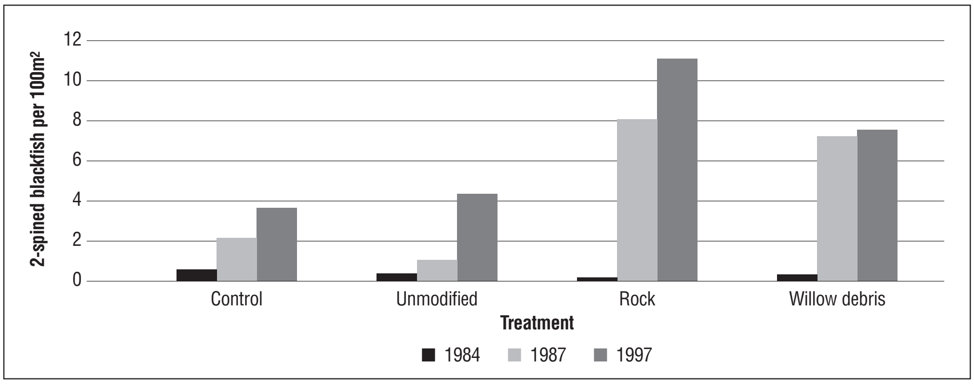

Figure 4. Numbers of two-spined blackfish collected from the control, unmodified, rock and willow sites in the Ovens River as monitored in 1984, 1987 and 1997

Fish, riverbed and bank morphology and macroinvertebrate monitoring were undertaken prior to in-stream works and will be repeated in subsequent years. Works included the reconstruction of pools and riffles, groynes to narrow the stream channel and the inclusion of in-stream wood (**Figure 5**). The cooperation of landholders has been integral to the rehabilitation of habitats for this icon species. Without this cooperation, the project would not have been possible, and the project has provided an opportunity to develop greater liaison between the management authority and landholders, stimulating a sense of community responsibility for the management of Seven Creeks.

Many land-managers within this study area (comprising 2.8 km) fenced off riparian zones, removing cattle access while the Goulburn-Broken Catchment Management Authority replanted the native vegetation.

Figure 5. Use of rocks and pile groynes to reduce stream width in Seven Creeks

Birch's Creek (Saddlier 2001)

This project was undertaken with the North-Central Catchment Management Authority, with a variety of aims.

Aims:

- Determine the status of the blackfish population; provide baseline data
- Increase in-stream woody habitat
- Revegetate riparian zones
- Determine the status of the roach population
- Assess the likely impact of roach on blackfish
- Provide community education for local school students
- Determine blackfish spawning success.

Whilst the aims of this project appear many and varied, they do reflect the components identified by the management authority and the community. As the project evolved, however, the education component expanded to include the community, and tertiary students became a larger and more integral component of the project. Educational demonstrations such as electrofishing (**Figure 6**), or explanation of the use of PVC 'spawning tubes' to monitor blackfish spawning (**Figure 7**), resulted in greater community involvement for other activities such as tree planting (**Figures 8 and 9**).

The educational component of this project was successful not only for the local landholders and community but also for school and tertiary institutions outside the immediate area. Additional knowledge was gained from the involvement of a PhD student from a regional university (M. Khan unpubl.data).

These case studies are typical of many smaller rehabilitation projects that have been undertaken, with most rehabilitation being based on particular problems or particular species. Demonstration reaches, such as are outlined in the Native Fish Strategy (Murray-Darling Basin Commission 2004) offer the opportunity to undertake rehabilitation on a larger scale aimed at a range of ecosystem components.

Figure 6. Demonstration of electrofishing as a fish sampling tool in Birch's Creek

Figure 7. Education demonstration of the ecology of river blackfish (in tank) and the use of 'spawning tubes' to monitor spawning

Figure 8. Community involvement in the replanting of riparian vegetation on Birch's Creek

Figure 9. Replanting of riparian zone trees on Birch's Creek

Concluding remarks and recommendations

Philosophically, river management has progressed from protecting public and private assets, to repairing ecosystems, including fish habitats. Most of the management processes and projects being undertaken are focused in the right direction, and progress is being made, although it can always occur more quickly and be refined further.

The following recommendations are made, loosely grouped under three (non-exclusive) headings, to improve fish habitat rehabilitation.

1. Management

- Increase interaction between managers and researchers.
- Incorporate fish habitat rehabilitation into regional plans.
- Incorporate science and experimental design into management actions.
- Use AEM as a powerful tool for a science-based approach to management change.
- Do benefit:cost analysis — to maximise benefits.
- Increase focus on ecosystem outcomes.
- Set realistic goals within the 'altered state'.
- Use multi-disciplinary and cross-jurisdictional approaches.

2. Science

- Increase reliable knowledge.
- Ensure knowledge transfer to regional practitioners.
- Undertake hypotheses testing and testing of techniques.
- Use appropriate monitoring to be able to answer the question asked.
- Use modelling to force explicit statements of expectation.
- Scale up — landscape ecology — undertake experiments at management spatial scales.
- Understand the longevity of benefits of rehabilitated habitats.
- Understand the interaction and integration of ecosystem components.
- Understand ecosystem resilience (the capacity for the ecosystem to repair itself) and likely recovery paths.

3. Community

- Engage community as stakeholders in the whole process from the beginning.
- Provide them with knowledge and ownership.

We must be aware that fish habitat rehabilitation is a new science, where the outcomes may be uncertain and recovery may not follow our expected or predetermined paths. Our goals and expectation of outcomes should be realistic as we are operating within constraints of past management and system commitments. Repair may require multiple interventions and we should not expect to get exactly what we had before. Reliable knowledge of biological responses to management applied at large scales will assist environmental outcomes, but the best outcomes will be achieved through a mix of good management, science and community support and ownership.

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