Australian Government

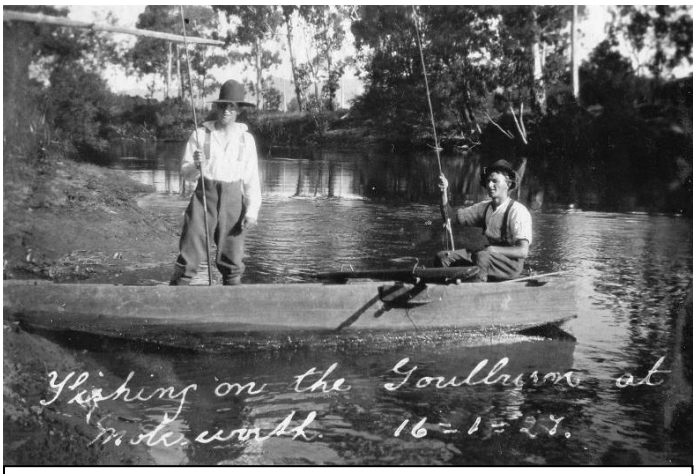
MURRAY–DARLING BASIN AUTHORITY

Proceedings of the Murray-Darling Basin Authority Native Fish Forum 2009

1st - 2nd September, Albury Entertainment Centre

Photo of Thomas Bryan, original settler of 'Prospect Hill', with three cod caught from the Goulburn River c1927. The right fish is a trout cod while the middle fish could be a Murray cod or a Trout cod.

Photographer: Sadie-Thomas Bryan



Fishing the Goulburn River at Molesworth, 16/1/1927.

Photographer: Sadie-Thomas Bryan

Water flowing over the Sugarloaf Weir, early 1930's. Note anglers on left fishing the famous 'Dome Hole'

Source: R. Stillman

Part of a catch of 117 Macquarie perch from Italian Gully, Sugarloaf Weir, from 4 anglers circa 1929. In the photo are 61 Macquarie perch, two trout of about 8 pound and a cod of 12 pound.

Source: R. Stillman

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Foreword

Over 170 delegates from around the Murray-Darling Basin were welcomed to the Murray-Darling Basin Authority (MDBA) Native Fish Forum in September 2009.

The Native Fish Strategy (NFS) for the Murray-Darling Basin was approved by the Murray-Darling Basin Ministerial Council in May 2003 and released in May 2004. The NFS provides a response to the key threats to native fish populations in the Murray-Darling Basin (MDB) and is designed to bring communities and governments together to enhance native fish populations throughout the Basin over the next 50 years.

Key threats to native fish range from flow regulation, habitat degradation, lowered water quality and man-made barriers to fish movement, to the introduction of alien fish species, fisheries exploitation, the spread of diseases, and inappropriate translocation and stocking of fish. Under these threats native fish populations in the Basin's rivers have declined to an estimated 10 per cent pre-European levels. The NFS is built around 13 objectives, outlined below. These objectives have been condensed into six driving actions, which are designed to catalyse investment and support for the Strategy.

The Native Fish Strategy has 13 objectives:

1. Repair and protect key components of aquatic and riparian habitats;
2. Rehabilitate and protect the natural functioning of wetlands and floodplain habitats;
3. Improve key aspects of water quality that affect native fish;
4. Modify flow regulation practices;
5. Provide adequate passage for native fish;
6. Devise and implement recovery plans for threatened native fish species;
7. Create and implement management plans for other native fish species and communities;
8. Control and manage alien fish species;
9. Protect native fish from threats of disease and parasites;
10. Manage fisheries in a sustainable manner;
11. Protect native fish from the adverse effects of translocation and stocking;
12. Ensure native fish populations are not threatened from aquaculture; and
13. Ensure community and partner ownership and support for native fish management.

and six driving actions:

1. Rehabilitating fish habitat;
2. Protecting fish habitat;
3. Managing riverine structures;
4. Controlling alien fish species;
5. Protecting threatened fish species; and
6. Managing fish translocation and stocking.

Given the considerable progress made in the implementation of the Strategy in the first five of its fifty year lifespan, it was timely to again assemble all of the key players involved in the implementation of the NFS, in order to critically analyse progress and promote cooperation and knowledge transfer in a facilitated environment.

The objectives of the Forum, then, were to:

- achieve a broad understanding of the outcomes/progress of research and adoption projects and demonstration reach programs supported by the MDBA;
- provide an opportunity for active engagement between members of the various taskforces and stakeholder groups set up to implement the NFS; and
- provide a vehicle for cross-fertilisation of ideas regarding native fish management, including future priorities for research and on-ground management in light of what has been achieved so far.

The 2009 Forum proved to be a great opportunity to present a report card on progress, celebrate key successes in the early years of this fifty year strategy and identify a clear direction for the next five years of native fish management.

We hope you enjoy reading the proceedings papers arising from talks presented at the forum and gain new inspiration and enthusiasm for native fish management.

Jim Barrett

Director, Native Fish Strategy

DISCLAIMER:

Please note that the contents of this document represent the 'unfiltered' view of individuals present at the forum, not necessarily a consensus view, or the views of the Murray-Darling Basin Authority.

The feedback and suggestions collated from the forum discussion session (Appendix 2) will be submitted for the consideration of the MDBA Native Fish Advisory Panel, and beyond them to jurisdictional partners. Supported recommendations will be incorporated into future Native Fish Strategy planning and work programs where feasible.

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A Lost World of Native Fish: What Are We Trying To Restore?

Will Trueman

Native Fish Australia

Background

Five years ago the Murray-Darling Basin Commission launched the Native Fish Strategy with the specific goal of restoring native fish populations within fifty years to at least 60% of what they were at the time of European settlement. Meeting this goal is complicated by the fact that there have been limited records available to assess the original distribution and abundance of native fish.

A project commenced by the author in 2006 to validate angler reports of the past occurrence of the endangered Trout cod in the Goulburn River in Victoria was expanded to collect information on all of the larger native fish species across the whole of the southern half of the Murray-Darling Basin. Preliminary findings were reported in the 2008 Native Fish Forum. The final report, in the form of a book, is in the process of being published by the Murray-Darling Basin Authority.

Summary of Findings

A solid body of evidence indicates that the Trout cod had been originally abundant in slopes and upland habitats and in some cases penetrated well into the montane zone in all catchments from the Macquarie River south. The species centre of distribution, rather than being the central Murray and Murrumbidgee Rivers as previously believed, was the foothills of the Great Dividing Range. Large populations existed downstream into the eastern lowlands and upstream to an altitude of 1,100m ASL. Many accounts describe Trout cod generally being more abundant than Murray cod in higher altitude habitats.

Unexpectedly a number of species were recorded as having been abundant upstream of the lowlands. Silver perch were common in some NSW upland rivers and those in the slopes zone in Victoria. Catfish too were common in some NSW upland rivers and were very common in lagoons and some creeks in the slopes zone in Victoria. Examples have been identified where Murray cod, Trout cod, Macquarie perch, Silver perch and Catfish maintained strong populations after being isolated from the lowlands by dams or weirs demonstrating that these species are not dependent on lowland conditions for good recruitment. Some of the smaller species such as Pygmy perch, Flatheaded galaxias, Purple spotted gudgeon and Hardyheads appear to have also been common in some non-lowland habitats. Conversely Macquarie perch were very common in some lowland areas and blackfish once had been common throughout the lowlands, particularly in lagoons.

Key Messages

Non-lowland habitats were once areas containing a high diversity of native fish including the larger species. There is no prospect of the Native Fish Strategy achieving its goal unless broadscale restoration of native fish populations in slopes, upland and even some montane habitats takes place. This may be a more difficult

undertaking than doing so in the lowlands as much of the uplands have been isolated by dams and both upland and slopes habitats have often been highly modified or degraded. While there is some knowledge of the requirements for recruitment of the larger native fish in the lowlands, far less is known of the conditions favouring recruitment upstream. The best remaining slopes habitat is in the Ovens River catchment and is the subject of a major effort to restore native fish populations. The best remaining upland habitat, the Murray River between Towong Upper and Murray Gates, has been overlooked to date.

There is evidence that in the past some of the larger native fish species spawned and recruited very well in isolated lakes and impoundments. Examples include Lakes George, Burrumbeet and Sambell. Large impoundments containing inflowing rivers also once supported flourishing populations of native fish. Today, for the most part, native fish do not appear to recruit in these environments and impoundment populations are largely maintained through stocking.

Management/Research Recommendations

The reference conditions for native fish utilized in the Sustainable Rivers Audit will need revision in light of the evidence of the former diversity and abundance of native fish species in non-lowland habitats. Restoring native fish populations upstream of the lowlands requires an identification of the conditions favouring native fish recruitment in these habitats. The Seven Creeks is the only remaining example where both Trout cod and Macquarie perch continue to thrive in a modest sized upland waterway and understanding why may hold the key to restoring upland populations elsewhere. Similarly Cataract Dam contains self supporting populations of Murray cod, Trout cod, Macquarie perch and Silver perch. Detailed study of these populations and their environment may provide an insight into native fish recruitment in upland impoundments and their feeder streams.

There needs to be a reconsideration of fish stocking programs for recreational angling as they may be distorting the original species assemblages and relative abundance. Key species in many instances are not being stocked as they are currently protected from angling, such as Trout cod, or are less popular with anglers, such as Silver perch and Catfish. Finally, there is a need for more historical research on native fish and the original environment in general, but particularly in the Murrumbidgee catchment and the northern half of the basin.

Acknowledgements

The author wishes to thank the Murray-Darling Basin Authority and Native Fish Australia for their support of the project, and the many anglers, libraries and historical societies that supplied a wealth of history.

Habitat Associations of Native Fish for Rivers in Each Catchment and Altitude Zone based on Historical Sources

	Macquarie				Lachlan				Murrumbidgee					Upper Murray			Central Murray		Lower Murray
	M	U	S	L	M	U	S	L	M	U	S	EL	WL	M	U	S	EL	WL	WL
MC	++?	**++**	**+++**	**+++**	+?	**++**	**+++**	**+++**	+?	**+++**	**+++**	**+++**	**+++**	?	++	**+++**	**+++**	**+++**	**+++**
TC	+++?	**+++**	**++**	+?	++?	**+++**	**++**	?	**+++**	+++?	**+++**	**+++**	+?	?	+++	**+++**	**+++**	++?	+
GP	**+**	**+**	**++**	**+++**	-	**+**	**+++**	**+++**	**-**	**+**	**+++**	**+++**	**+++**	-	**-**	**++**	**+++**	**+++**	**+++**
SP	?	**++**	**+++**	**+++**	-	**++**	**+++**	**+++**	**+**	**+++**	**+++**	**+++**	**+++**	-	**-**	++?	**+++**	**+++**	**+++**
MP	**+++**	**+++**	**++**	?	**++**	**+++**	**++**	+	**+++**	**+++**	**+++**	**++**	++	?	**+++**	**+++**	**+++**	++?	+
CF	+	**++**	**+++**	**+++**	-	**++**	**+++**	**+++**	-	?	**+++**	**+++**	**+++**	**-**	**-**	**+++**	**+++**	**+++**	**++**
BF	**+++**	**+++**	**+++**	+?	**+++**	**+++**	**+++**	++?	**+++**	**+++**	**+++**	**++**	**++**	**++**	**+++**	**+++**	**+++**	**+++**	**++**

	Mitta Mitta			Ovens			Broken			Goulburn				Campaspe			Loddon		
	M	U	S	U	S	EL	U	S	EL	M	U	S	EL	U	S	EL	U	S	WL
MC	+?	**++**	**+++**	+?	**++**	**+++**	++?	++?	**+++**	?	**++**	**++**	**+++**	**-**	+++?	**+++**	+++?	**+++**	**+++**
TC	+++	**+++**	**+++**	++?	**+++**	**+++**	++?	++?	+?	+?	**+++**	**+++**	++?	**-**	+++?	+?	+++?	?	?
GP	**-**	**-**	**+**	**-**	?	+	**-**	?	**++**	-	**-**	+?	**+++**	**-**	**+**	**++**	-	-?	**+++**
SP	**-**	**+**	**++**	**-**	**++**	**++**	**-**	+?	**+++**	-	**-**	++?	**+++**	**-**	++?	**++**	?	+?	**+++**
MP	**+++**	**+++**	**+++**	**++**	**+++**	**+++**	+++	**+++**	**+++**	++	**+++**	**+++**	**+++**	**-**	**+++**	++?	+++	++?	?
CF	**-**	**-**	**++**	**-**	**++**	**+++**	**-**	++	**+++**	**-**	**-**	**++**	**+++**	**-**	**++**	+++?	++	++?	**+++**
BF	**+++**	**+++**	**+++**	**++**	**+++**	**++**	+++	**+++**	**+++**	**+++**	**+++**	**+++**	**+++**	++?	**+++**	++?	**+++**	**+++**	**+++**

Key

MC = Murray cod TC = Trout cod GP = Golden perch SP = Silver perch MP = Macquarie perch
CF = Catfish BF = 'Blackfish' (either or both River blackfish or Two spined blackfish which are not distinguished)

M = Montane U = Upland S = Slopes EL = Eastern Lowlands WL = Western Lowlands

+++ = common ++ = reasonably common/patchy distribution + = small presence - = rare or absent
? = inferred presence, identity of species in doubt or records limited
Associations depicted in bold supported by multiple records or lines of evidence and are considered reliable.

Native Fish Strategy Highlights – The First Five Years

Jim Barrett

Director Native Fish Strategy, MDBA

Objectives / Background

The Native Fish Strategy was approved by the Murray-Darling Basin Ministerial Council as a 50 year initiative and was launched in May 2003. The purpose of this presentation is to record some of the key highlights in the first five years, and to explore future challenges and opportunities.

Summary of findings

As enunciated in a recent independent review into the performance of the Strategy in its first five years, the NFS has, overall, been very successful in progressing on-ground action, science and community understanding of its overarching objectives and driving actions. This has largely been due to:

- Effective governance arrangements;
- A range of forums that enable continuing community participation;
- Coordination at both the “grass roots” and State government levels, achieved through the employment of five NFS Coordinators;
- Financial and staffing resources provided under the previous MDBC arrangement.

Key messages

The NFS has made a number of significant achievements, both under its own steam and in conjunction with the cooperation or funding from other programs, such as The Living Murray. Some of the more profile achievements include:

- The establishment of 9 Demonstration reaches;
- The Sea to Hume fishway program;
- The ability to respond to crises, including drought and bushfires;
- A range of activities that have improved the potential for effective Carp control.

As well, projects funded through the NFS have led to a number of significant scientific discoveries and technologies, such as:

- The requirement for small-bodied native species to migrate;
- The subsequent design of “dual” fishways;
- The design of the Carp separation cage for large scale Carp removal;
- The finding that undershot gated weirs contribute to increased mortality and injuries of native fish;
- The discovery that irrigation can injure native fish during extraction from main river channels, and irrigation channels also cause thousands of fish to die due to low DO, predation, or being physically pumped on to crops;
- The identification of a relatively small number of Carp “hot spots”;
- The ability to tell the difference between stocked and wild fish.

Management / Research Recommendations

Future challenges include:

- Ensuring the relevance of the NFS to the Commonwealth *Water Act 2007*, and Basin Plan;

- Continuing jurisdictional support, both in terms of governance, and staffing and financial support;
- Implementation of the existing Demonstration reaches;
- Continued funding.

There are, however, a number of real opportunities that could eventuate over the next few years:

- Use the low water levels due to the drought to address the thermal pollution problem in key structures;
- Build fishways in the northern Basin;
- Install fish friendly pumps on priority irrigation offtakes;
- Opportunistically replace undershot weirs.

Acknowledgments

Past and present members of the NFS team, the NFS IWG/Advisory Panel, and members of the CST and NFS Task Forces.

An Engaging Time

Adrian Wells

Murray-Darling Association and Chair, NFS Community Stakeholder Taskforce

Abstract

Community engagement by the Community Stakeholder Taskforce of the Native Fish Strategy.

The Community Stakeholder Taskforce was established well before the Native Fish Strategy was launched to initially engage the Murray-Darling Basin community about the draft Strategy.

Once the Strategy was officially launched in 2003, the Taskforce adopted a very proactive approach to actively advocate for, and engage the community about, the Native Fish Strategy across the Basin. This has been done through presentations, tours, public events, and fostering partnerships. The Taskforce has also conducted a series of Native Fish Awareness Weeks; managed and updated a Communications Plan; identified education and awareness materials; and has been involved in annual Native Fish Forums and workshops. Engagement about native fish has also been an effective way to 'hook' communities, schools and individuals into other natural resource management issues.

The Taskforce provides a broad perspective of community stakeholders with an interest in rehabilitation of native fish populations and habitats. Since 2001, the Taskforce has adapted to change and responded to community feedback.

The Five Year Review of the Native Fish Strategy has noted that significant progress has been made with raising awareness of the Strategy and that the various community engagement activities have all been highly regarded by stakeholders. The presentation reflected on nine years of community engagement, the likely impact of the Review, and identified what new challenges lie ahead for community engagement.

The MDB Native Fish Strategy 5th Year Review

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Objectives / Background

The Native Fish Strategy (NFS) was developed and launched in 2003 to address key threats to native fish populations of the Murray-Darling Basin (MDBC 2003a,b). In order to achieve the vision of ensuring that viable native fish populations and communities are sustained throughout the rivers of the Basin, the NFS includes the goal of rehabilitating native fish communities in the Basin back to 60% of their estimated pre-European settlement levels after 50 years of implementation.
The NFS includes actions designed to achieve 13 objectives related to improving the status of native fish populations in rivers across the Basin. The 13 objectives are to be achieved by implementing six driving actions that include management, research and investigation, and community engagement activities.

This project reviewed progress of the NFS against its objectives over the first 5 years of implementation and includes the following main elements:

- A summary of the initiatives and outcomes that have been progressed under the NFS over the past five years;
- An analysis of the extent to which the Strategy has achieved its stated objectives, in terms of the increasing health of fish populations across the Basin; and
- Recommendations on future directions.

The review has been based primarily on the reports, materials and discussions provided by the NFS program, the NFS management team, and the project Steering Committee. This has been supplemented by:

- A search of the scientific literature based on citation of the NFS program as a funding source;
- Direct discussions with key staff from relevant agencies in each jurisdiction, including Native Fish Advisory Panel (NFAP) members and NFS Coordinators, as well as with members of the Community Stakeholder Taskforce.
- Email correspondence and telephone discussions with representatives from numerous government agencies, catchment management organisations, research institutions and community stakeholder groups.

In undertaking this review, the Review Team considered the following:

- A recent report by the Sustainable Rivers Audit that included information on the condition of native fish. This report suggested that native fish populations in most of the valleys across the Basin were in poor condition.
- The governance arrangements for management of the NFS.
- Progress against the resource condition targets assigned to the driving actions in the NFS Implementation Plan.
- The quality of research and development (R&D) projects funded by the NFS.
- Potential barriers to the implementation of the NFS.
- The appropriateness of current monitoring and evaluation arrangements.
- Future directions for the NFS.

Summary of findings

In summary, the Review Team made the following conclusions:

- The existence of the NFS, and its continued implementation, has been successful in raising awareness and garnering support for the management of native fish across the Murray-Darling Basin. The NFS is well regarded by stakeholders and its community engagement and communication activities are highly valued. It is recommended that the Murray-Darling Basin Authority (MDBA) and other stakeholders maintain their commitment to achieving the objectives of the NFS over its 50-year life. While there has been considerable activity associated with implementing various components of the NFS, a long-term commitment will be required if the goal of rehabilitating native fish communities in the Basin back to 60% of their estimated pre-European settlement levels is to be achieved.
- The NFS is one of a number of NRM programs being conducted in the Murray-Darling Basin. The recently formed MDBA has an opportunity to improve on the coordinated management of natural resources across the Basin and the Review Team recommends that the objectives and targets of the MDBA Basin Plan and the NFS be aligned as part of this process, and that opportunities for the NFS and the Plan to be mutually supportive and linked be actively explored. The Review Team strongly recommends that the integrity of the NFS be retained in this process. Failure to do so risks losing the good will, cooperation and momentum the NFS has built since it commenced, and could make community acceptance of the Basin Plan more difficult.
- Overall, the NFS has been well managed by the NFS management team and well served by the task forces dedicated to specific actions and management responses. There remain, however, opportunities to bolster links with stakeholders such as the recreational and commercial fishing industries, traditional owners and catchment management organisations across the Basin. Recent initiatives by the NFS management team and Community Stakeholder Taskforce to promote and establish partnerships with these organisations are to be encouraged, especially in exploring different avenues to secure funding for on-ground habitat rehabilitation works.
- The objectives and driving actions of the NFS remain relevant. The R&D projects funded have been relevant to the objectives and driving actions of the NFS, and of a good scientific standard. The scope of such projects could, however, be broadened to include a wider ecological perspective so that biota other than native fish and the ecosystem processes that affect the condition of native fish populations are also considered. The NFS management team and the NFAP should also require that, whenever possible, current and future projects publish their results in the scientific literature. This is particularly important for areas that represent a relatively large investment, such as the Invasive Animals CRC and its work on daughterless Carp.
- Initiatives such as the Sea to Hume program and monitoring the response of fish to watering of Barmah Forest serve as good examples of adaptive management, where by insights gained through the implementation and monitoring of interventions are used to refine native fish management and habitat management approaches, and transfer learning for the benefit of native fish management elsewhere.
- Despite the good work and achievements of the NFS to date, the recent SRA assessment has highlighted the generally poor condition of native fish populations in river valleys across the Basin. This is at least in part due to antecedent conditions across the Basin (e.g. drought, low inflows), but it also suggests that many of the drivers that have had a detrimental affect on native fish condition still persist. This highlights the necessity for taking an ecosystem view when rehabilitating rivers and floodplains and managing native fish.

- Assessment of progress against driving actions was based on whether resource condition targets and actions described in the NFS Companion Document had been met. In many instances it was not clear what progress had been made, as in many circumstances there are no formal arrangements for assessing outcomes. This situation needs urgent attention so that future reviews have the information required to assess progress against resource condition and other targets.
- Review of the numerous actions identified in the NFS Companion Document has been mixed. In a number of instances, resource condition targets had clearly not been met. There are no doubt many reasons for this (e.g. mismatch between the scale of the ecosystem drivers or disturbances affecting fish compared with the scale of the management response, effect of drought, low water availability, poor water quality). However, it also highlights the ambitious nature of many of the resource condition targets, especially those affected by water resource management and the flow regime of river and floodplain areas.
- A strategic review of the NFS priorities is recommended, supported by a synthesis and review of the information and knowledge generated by the NFS R&D projects. This will serve to prioritise the actions necessary to address current and emerging threats to the condition of native fish populations across the Basin. This work will also be important for considering the interactions necessary with other MDBA NRM programs as they are incorporated into the Basin Plan. The Review Team recommends that the strategic review be used to identify a smaller number of high-priority targets and actions than was the case for the original NFS. Initiatives to address the high priority actions can then be built around an adaptive management cycle that includes conceptual models to identify key processes and knowledge gaps, targeted interventions, dedicated monitoring and evaluation and further review.
- There are numerous barriers to progress that exist and those involved with the NFS are to be commended for addressing perennial problems related to sometimes differing priorities of government departments. While conservation and fisheries management legislation was considered to be sufficient, progress on actions (particularly on-ground works) can get caught up in a myriad of State and local government laws and regulations (e.g. OH&S, public liability). A review of such laws is recommended so that they can be addressed quickly and efficiently as projects are proposed. Capturing the knowledge base generated by the NFS and those associated with it is an important long-term priority for the NFS. Establishment of the proposed fish information system or database should be given a very high priority, especially as the knowledge generated by R&D projects (and projects elsewhere) continues to expand.
- The SRA will provide valuable information from which to assess the condition of native fish populations in river valleys across the Murray-Darling Basin. However, additional investment is required to collect or collate information required to assess the specific resource condition targets, as well as the activities and interventions included in the NFS and its Companion Document.
- The NFS is encouraged to include some long-term projects in its R&D portfolio (e.g. understand the role of climatically driven flow variability (including floods and droughts) on ecosystem and population processes such as energy dynamics, trophic interactions and recruitment patterns). This will provide valuable new insights on to the wider environmental drivers that affect native fish populations to complement the body of work already delivered by the R&D program.

Key messages

- The objectives and driving actions of the NFS are still relevant to the goal of rehabilitating native fish communities across the Murray-Darling Basin.
- The NFS has generally been well-served by the management team and various task-groups.
- The level of cooperation, collaboration and good-will between various stakeholders and across jurisdictions has generally been good. The effort required to achieve this should not be underestimated, and will be an important contributor to the future success of the NFS.
- The R&D projects are relevant to the NFS objectives and generally of a good standard.
- Despite the above, recent SRA results indicate that the condition of native fish populations across most river valleys is poor. This reinforces then need to continue with the initiatives identified in the NFS.
- The goals and resource condition targets originally outlined in the NFS are ambitious, and a high proportion of the activities listed were considered to be of a high priority for action. So many potentially competing (high priority) actions and finite resources mean that progress towards desired outcomes has been mixed. At 5 years into a 50-year program, now is a good time to reflect on what has been achieved to date and build on this to refine and prioritise the key medium to long-term outcomes and activities to be pursued by the NFS over the next 5-10 years.

Management / Research Recommendations

In reviewing the progress of the NFS, there were many instances where too little information was available from which to assess whether goals and resource condition targets had been met, or were on a trajectory toward being met. These issues could be addressed through several measures:

- Improvements to the data and project management systems and reporting systems would assist future reviews, both in easing access to information and in ensuring that short-term goals can be ticked off and action taken to address lags in achieving those goals.
- Attention to the design of statistically rigorous monitoring initiatives.
- For longer-term goals, especially those associated with on-ground actions, monitoring and evaluation efforts should be increased.

A strategic review of the NFS priorities is recommended, supported by a synthesis and review of the information and knowledge generated by the NFS R&D projects together with information generated outside the NFS R&D projects. This will serve to prioritise the actions necessary to address current and emerging threats to the condition of native fish populations across the Basin. This work will also be important for considering the interactions necessary with other MDBA NRM programs as they are aligned with the Basin Plan. The strategic review can be used to identify a smaller number of high-priority targets and actions than was the case for the original NFS. Initiatives to address the high priority actions can then be built around an adaptive management cycle that includes conceptual models to identify key processes and knowledge gaps, targeted interventions, dedicated monitoring and evaluation and further review. Consideration should also be given to how best to link MDBA NRM initiatives with those undertaken by CMAs and other state bodies. This should consider both funding priorities and on ground works.

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Acknowledgments

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Environmental Works and Measures Program – An Overview of TLM Icon Site Works

Ben Dyer
Director Construction, The Living Murray Environmental Works and Measures Program, MDBA

Objectives / Background

The Living Murray (TLM) Environmental Works and Measures Program (EWMP) aims to improve the health of the River Murray system by making the best use of water for the environment. The program funds infrastructure to deliver and manage water at the icon sites to achieve The Living Murray First Step environmental objectives. This infrastructure includes regulating structures, water delivery channels and fishways. The program will cost approximately $275 million and focuses on achieving environmental outcomes at the six TLM icon sites.

What has been achieved?

The most significant achievement of the EWMP has been the development of major works proposals to enable large-scale environmental watering at three of the icon sites. Development of these works proposals has involved detailed investigations, feasibility studies, hydraulic modelling and engineering design. They will be the largest on-ground wetland and floodplain restoration projects in Australia. These projects are discussed in more detail under ‘What is being planned?’

As part of the Sea to Hume Fishway program, fishways have been completed at 8 of the 14 weirs along the River Murray, and at the Tauwitchere and Goolwa barrages. More than 3,500 snags have been reinstated for fish habitat.

At the Chowilla Lindsay-Wallpolla icon site, regulators to manage environmental water have been constructed at Lake Wallawalla, Horseshoe Lagoon, Websters Lagoon and at Bank E. mobile pumps have been purchased to enable wetland watering.

At the Gunbower–Koondrook–Perricoota icon site a regulator has been built on Little Gunbower Creek, and the Barmah Cut and Shillinglaws regulators have been upgraded to manage environmental flows.

What is being planned?

The main focus of the EWMP is the construction of major infrastructure that will enable the large-scale watering of over 37,000 ha of forests and wetlands across three icon sites.

These works include:

Gunbower–Koondrook–Perricoota

- Gunbower Forest
  - The upgrade of Hipwells Road channel and the construction of associated regulators to supply environmental water to the forest.
- Koondrook–Perricoota Forest
  - A channel from Torrumbarry weir into the forest to deliver environmental flows.
  - Regulators and levees to restrict flows out of the downstream end of the forest.

Hattah Lakes

- Hattah Lakes
  - Three regulators and three levees to allow water to be retained within the lakes to allow increased durations of watering.
  - A pumping station to supplement natural flows from the River Murray into the lakes and thus allow the frequency and magnitude of watering events to more closely resemble the natural regime.
  - Excavation of small sections of the natural creek beds to increase the frequency of natural inflows.

Chowilla Lindsay–Wallpolla

- Chowilla Floodplain
  - A large regulator on Chowilla Creek to raise the water level within the anabranch system to allow gravity watering of wetlands and the floodplains across the Chowilla anabranch system.
  - Smaller secondary regulators to control flows into and out of the anabranch system.
  - Fishways on two existing weirs to provide fish passage between the anabranch system and lock 6 weir pool.
- Lindsay–Wallpolla Floodplain and Islands
  - A regulator on Potterwalkagee Creek to raise the water level along the creek and thus allow gravity watering of wetlands and the floodplain.
  - Smaller secondary regulators to control flows into and out of the anabranch system, in particular to allow a longer section of creek to receive regular flows.

Sea to Hume Fishways

The Sea to Hume Fishway program is funded by EWMP and will result in all of the weirs along the River Murray downstream of Hume dam having a world class fishway. In addition to this, the EWMP is funding the construction of two fishways on the Edward River in NSW (an anabranch of the River Murray) which will allow fish in the Edward River to migrate upstream to the Barmah Millewa forest and into the main River Murray channel and thus on to the largely unregulated streams of the Ovens and Kiewa rivers.

The above proposed works enable watering of the wetland and floodplain ecosystems using regulated supplies of environmental water and without reliance on flood flows in the River Murray. The operation of the proposed works can be adapted to a wide range of conditions and water availability, and they will enable very efficient use of the available environmental water. This will be particularly important in the future under potential climate change conditions.

In the most part, these projects are in the advanced stages of development. Construction of some of the fishways is underway, whilst the first of the other projects is likely to commence in late 2009. All of the proposed works are expected to be completed by the end of 2012.

MDBA Basin Plan

David Winfield
Director Monitoring Evaluation and Compliance, Basin Plan Division, MDBA

Objectives / Background

The Basin Plan will be the first integrated statutory water plan across the Murray-Darling Basin. It will set a sustainable diversion limit to water that can be taken from the Basin water resources. The Act requires that this limit is set at a level that will not compromise key environmental assets, key ecosystem functions, the productive base of the water resource and key environmental outcomes. The Basin Plan will also include an Environmental Watering Plan, a Water Quality and Salinity Plan, as well as trading rules. State Water Resource Plans will need to be accredited against requirements set out in the Basin Plan. For most Basin State water resources this process will begin in 2014/15, with Victorian water resources coming under the Basin Plan in 2019. It is not yet clear how the proposed Basin Plan will incorporate consideration of native fish, but they may be considered as environmental assets or ecosystem functions, as environmental objectives or targets and in monitoring and evaluation. The content of the proposed Basin Plan will be decided by the 6-member Murray-Darling Basin Authority and it is expected to be proposed for consultation from June 2010.

How Successful are Environmental Flows for Enhancing Fish Populations?

Alison King
Arthur Rylah Institute for Environmental Research, DSE

Objectives / Background

Environmental flows, or environmental watering, broadly aim to restore ecologically important components of the natural flow regime within flow degraded rivers and their floodplains. The Native Fish Strategy identified environmental flows as one of the key rehabilitation interventions required to restore native fish communities in the MDB. Importantly, there are increasingly larger volumes of water becoming available for environmental use, through private and other non-government groups, State Government, The Living Murray Initiative, and the Commonwealth Governments. But how successful have we been at utilising environmental water to achieve native fish outcomes? And what are the lessons we need to learn to improve management of future watering opportunities? This presentation reviews some examples of recent applications of environmental water in the Southern MDB and their benefits for native fish. Importantly, it also explores future management challenges for the delivery of environmental flows and optimising benefits for native fish.

Summary of findings

- Environmental flow management to achieve outcomes for native fish has rapidly developed in recent years, with the majority of environmental flow studies in rivers and creeks now specifically considering native fish objectives in environmental flow recommendations.
- In 2005, the largest environmental water allocation in Australia to date was delivered to the Barmah-Millewa Forest. 513 GL of the Barmah-Millewa Environmental Water Allocation was managed by a group of managers, technical experts, scientists and hydrologists, to achieve multiple ecological objectives, including for native fish. Research demonstrated substantial benefits for a range of native fish at Barmah-Millewa, but also at Chowilla, Lindsay Island and the Lower Murray Channel in South Australia as the flow pulse progressed downstream.
- However, since then the region has been in severe drought, and the delivery of environmental water has been allocated largely at the scale of individual wetlands or creeks only, with some allocations specifically targeting native fish. For example, environmental water has been allocated to maintain wetland habitats at a number of sites for the critically endangered Murray hardyhead and the threatened Southern pygmy perch. Although not originally targeted for achieving native fish objectives, environmental water allocated to the Gunbower wetlands and the Hattah Lakes has also resulted in some surprising responses from native fish. Environmental water has also been allocated to some rivers and creeks principally to maintain water quality during drought conditions, eg. Broken Creek.
- However, floodplain inundation (including from the use of environmental water) can also present significant risks to the native fish community. These risks include enhancing the spawning and recruitment success of some exotic species (eg. Carp and Oriental weatherloach), increasing the risk of fish kills as a result of blackwater, and the stranding of native fish on the floodplain.

These issues are discussed in terms of recent research examples and management recommendations. The challenge of reducing such risks for native fish with the

proposed installation of large environmental regulators at a number of 'The Living Murray' icon sites on the Murray River floodplain will also be discussed.

Key messages

- Environmental flows can provide a range of benefits for native fish, particularly by enhancing spawning and recruitment, improving dispersal, increasing habitat diversity and maintaining wetland habitats.
- The recent drought conditions have substantially reduced our ability to achieve large-scale environmental watering events that connect the river to its floodplain, however, this is where we are likely to see the biggest 'bang-for-the-buck' for native fish.
- Recent environmental watering events during drought conditions have largely focussed on maintaining critical habitat for threatened fish and maintaining water quality during low flow conditions in some rivers.
- The delivery of environmental water can also result in some negative environmental outcomes, including increased risk of blackwater, increased recruitment of some exotic species (eg. Carp), isolation and stranding of fish on the floodplain, and the non-return of nutrient rich water to the River channel to support ecosystem productivity. However, some of these outcomes can be managed by careful consideration of risks and other management options such as active removal of Carp.
- Although recent proposals for large environmental regulators on the Murray River floodplain will have substantial ecological benefits for other ecosystem attributes, they do pose significant risks for native fish. The scale of these risks to native fish and potential ameliorations are currently being assessed.

Management / Research Recommendations

- Need to more widely consider how environmental flows/watering can be optimised to achieve benefits for native fish. These need to be considered as 'large-scale experiments' with the aim of learning from each intervention.
- Need to develop whole-of-river system watering strategies and objectives, ie. use environmental water not only to individual wetlands but also 'in-channel flows' and true floodplain connection. This is the only way to truly maintain ecological function of floodplain rivers.
- Careful consideration needs to be given to the delivery of environmental water to dry / drying wetlands and creeks to reduce the risk of detrimental blackwater events.
- Knowledge on how to allocate water to achieve native fish outcomes is limited, but improving. To improve the management of environmental flows for native fish, targeted, long-term monitoring should be conducted over a range of flow conditions within an adaptive management framework. Monitoring and research therefore needs to target the causal mechanisms of how fish respond to flows – this generally cannot be achieved by standard surveillance monitoring.
- Water managers, scientists and relevant stakeholders should work collaboratively in multi-disciplinary teams to ensure that the ecological outcomes of environmental watering events are maximised.
- Given the paucity of information on how fish respond to flood events, and the highly infrequent nature of major floods, scientists and managers need to take advantage of any suitable conditions that may arise.

Acknowledgments

I'd like to acknowledge the numerous researchers and managers that have contributed their reports, scientific opinion and knowledge to this overview. I'd also like to acknowledge the considerable input of Zeb Tonkin, John Mahoney and Leah Beesley into the research we have conducted on the response of fish communities to environmental watering events at Barmah-Millewa Forest and other wetlands in the Murray River Valley.

Overview of Progress with Demonstration Reaches

Peter Jackson,
Chair, Demonstration Reach Steering Committee

Objectives/Background

The Native Fish Strategy for the Murray-Darling Basin 2003-2013 has identified habitat degradation as a major contributor to the decline of native fish populations. A key management action to address this threat is the establishment of Demonstration reaches.

A demonstration reach is large scale, usually 20 to 100km of river or a substantial area of floodplain, close to a significant human population where a number of management interventions can be applied. The objective is to "demonstrate" to the broad community, the cumulative benefits of river rehabilitation to fish populations and to river health. Interventions may include riparian rehabilitation, re-establishment of fish passage, rehabilitation of instream habitat, improvement of water quality and control of alien species.

The demonstration reach concept recognizes the benefits of treating multiple threats to fish populations, the importance of engaging the community and the value of increased stewardship/ownership through developing multiple partnerships. The outcomes of demonstration reach projects will also be a valuable guide to ongoing rehabilitation works in the particular catchment or in other catchments throughout the Basin.

This paper will give a broad overview of progress to date with Demonstration reaches. More detailed information will be provided in the papers that follow.

Summary of Findings

Progress to date with Demonstration reaches is summarized below in chronological order:

- Planning for Demonstration reaches in each state apart from the ACT commenced in 2005 and the (then) Murray-Darling Basin Commission commenced allocating funds to jurisdictions specifically for Demonstration reaches in the 2006/07 financial year. A maximum of $100,000 each was allocated to South Australia, Victoria, New South Wales and Queensland for planning, communications, on- ground works and monitoring.

- In April 2006 key participants from each jurisdiction were invited to a workshop in Canberra to reinforce the concept of Demonstration reaches, discuss experiences with establishing Demonstration reaches and the progress to date. The workshop also sought to ascertain the best way forward. Some key recommendations of the workshop were:
  - To encourage indigenous engagement and participation.
  - "Badge" Demonstration reaches as compatible with "River Health" initiatives with fish being used to engage communities in river rehabilitation issues.
  - Demonstration reaches should be of a scale to enable meaningful monitoring of the target species.

- In 2007 there were eight Demonstration reaches in various stages of development. Two were in NSW, three in Victoria, one in South Australia and two in Queensland.

- In November 2007, the (then) Murray-Darling Basin Commission compiled a summary of progress on Demonstration reaches. Whilst acknowledging that significant "lead in" time is required for these large scale projects the report concluded that there was significant community support for the concept and opportunities for partnership. In some cases, on-ground works had commenced.
  The following recommendations were made:
  - The need for robust monitoring programs.
  - The application of testable hypotheses.
  - The development of "whole of life" plans
  - A basis for costing interventions.

- In 2008 the (then) Implementation Working Group of the Native Fish Strategy agreed to the following:
  - Commissioning of a consultant to develop a monitoring framework for Demonstration reaches. This resulted in the development of the Boys et al. (In Press) Monitoring and Evaluation (M&E) framework.
  - The provision of an additional $100,000 for the four jurisdictions specifically for monitoring and evaluation. This was in recognition of the need for a rigorous monitoring framework and the difficulty experienced by jurisdictions in obtaining funds for monitoring.
  - Clarification that "Demonstration reaches" by definition had to include a rigorous monitoring program. However it was recognized that river rehabilitation projects that did not include monitoring were important community engagement tools and should be supported by the Native Fish Strategy. These were given the name "River Rehabilitation Reaches".
  - The establishment of a Demonstration Reach Steering Committee to oversee the development of Demonstration reaches across the Basin including the funding application process.

- In the 2008/09 financial year the additional funding for monitoring commenced with all projects requested to develop M&E Plans consisted with the Boys et al (In Press) guidelines. These plans have been submitted to a review panel for endorsement and will be considered as part of the application process for the 2009/10 funding round.

- At a further meeting in 2008, the (then) IWG agreed to some funds to be used to hold a series of workshops throughout the Basin to examine ways to increase indigenous involvement in Demonstration reaches. The meeting also approved the allocation of funds in 2009/10 for a demonstration reach in the ACT and for a contingency fund for projects that assist the progress with Demonstration reaches.

- In 2008/09 funds were allocated to seven Demonstration reaches. These were:
  - South Australia — Katarapko Creek (Katfish Reach)
  - NSW — Namoi Reach and Brewarrina to Bourke Reach
  - VIC — Hollands Creek and Ovens River
  - QLD — Dalby Reach (Dewfish Reach) and Border Rivers.

Apart from the Border Rivers Reach, all these Demonstration reaches are well advanced and have "whole of life" plans and monitoring and evaluation plans and have commenced on-ground works. It is expected that a "whole of Life" plan and a preliminary M&E plan will be submitted for the Border Rivers Reach in the 2009/10 funding round.

Key Messages

- Each state has at least one established demonstration reach apart from the ACT. This should be addressed in 2009/10.
- The recommendations of the MDBC 2007 report are being addressed, specifically the need for robust monitoring and the development of “whole of life” plans. The issue of indigenous engagement is starting to be addressed.
- A Steering Committee has been formed to oversee the development of Demonstration reaches. To date it has had to deal largely with “process” issues related to funding applications, endorsement of M&E plans and the transition of the Commission to the Authority. It needs to start taking a strategic approach to the ongoing development of Demonstration reaches. This will be discussed further in the “Where to now” paper.
- The development of Demonstration reaches is being driven largely by NFS Co-ordinators and members of NRM and CMA groups. There are to be congratulated for the progress to date and the Steering Committee needs to be mindful of their needs in the future to ensure the progress continues.
- Community involvement and participation has been largely enthusiastic and good partnerships are being developed in a number of projects.

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Acknowledgements

Thanks to Melissa Morley, Craig Boys, Fern Hames, Phil Duncan.

Getting Organised – Katfish Reach Case Study

Mike Harper
Department for Environment and Heritage SA

Background

The Katfish Reach Project is located on the Katarapko/Eckert Creek anabranch system between Berri and Loxton along the River Murray in South Australia. The area hosts the River Murray National Park (Katarapko section), Gerard Aboriginal Reserve as well as crown and private land. The total area is nearly 9,000 hectares, and traverses over 38 kilometres of River Murray frontage. The site is a South Australian River Murray priority floodplain.

Summary of Findings

Between the light bulb going on and the Katfish Reach project getting legs it took over a year and half and involved the following decisions and actions:

- Is creating a Demonstration Reach the best marketing decision for the project or would the project be better placed to receive support/funding under a different natural resource program such as River Care;
- Both agency and community interest in establishing a Demonstration Reach was assessed;
- A Project Brief was developed which described the site, the Demonstration Reach program, site issues, project benefits, possible stakeholders, a 5 year program (now totally shot to pieces) and possible funding sources;
- To lock in support and identify roles and responsibilities for the project an MOU was established between the major players which involved agencies, a community group and a business sponsor. The Project Brief was essential in bringing the MOU parties together.

In partnership with the Katfish Reach Steering Group the following planning documents have been developed;

- Implementation Plan (identifies project vision, objectives and proposed actions)
- Investment Proposal (identifies preferred actions, concept designs and costs)
- Monitoring and Evaluation Framework (identify intervention, condition and compliance monitoring)
- Communications Strategy

To ensure the long term success to the Katfish Reach project the following additional documentation (planning) is required;

- Project Charter (asset construction phase)
- Site hydrological plans
- Major infrastructure operational and maintenance plans

Without a conscious decision the Katfish Reach Steering Group started on the road of “Whole of Life Planning”

“Whole of Life Planning” starts when you get the idea for a project and does not stop while the project is still active. It can be compared to the adaptive management concept (see figure 1)

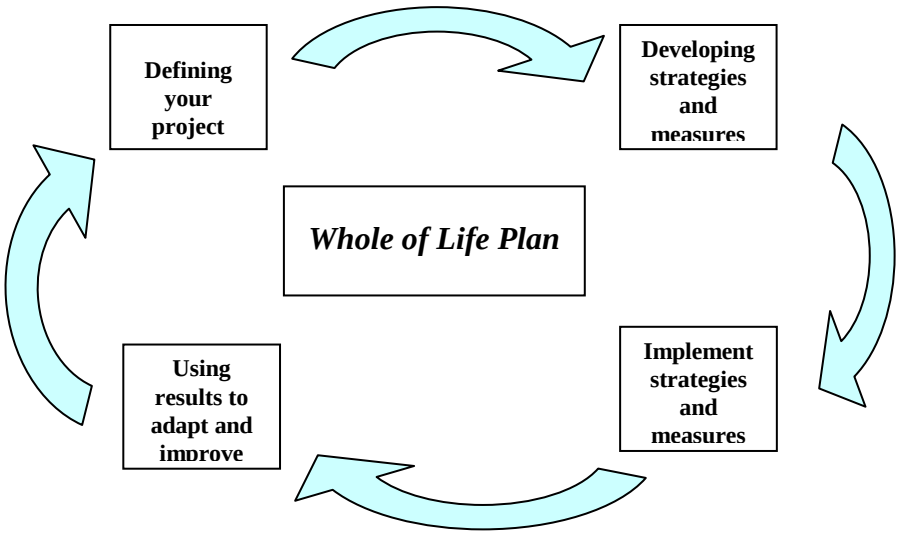

Figure 1 Whole of Life Plan Diagram

Key Messages

If you do your homework (planning) properly before project commencement the task of developing a successful project is greatly enhanced.

Having a project MOU involving the major players which sets out organisational relationship parameters may seem an over kill at the time but is invaluable once individuals move on and new players enter the arena.

Planning to engage all players ASAP in the project enables relations and partnerships to fulfil their full potential which will greatly enhance project outcomes. A Katfish Reach example is the partnership which has been developed with the Gerard Aboriginal Community in regards to their natural resource training program.

The Katfish Reach Investment Proposal has been an invaluable document during the process of soliciting financial support for the project.

“Whole of Life Planning” is a living process which maintains project focus and ensures project continuity when players (organisations and individuals) change over time.

Getting Organised

Jonathan McPhail
Department of Primary Industries and Resources of South Australia

Objectives / Background

A significant part of the Native Fish Strategy is the implementation of Demonstration reaches. Since the first proposed reach Hume – Yarrawonga, another nine Demonstration reaches have been implemented across the Murray-Darling Basin. The development of the reaches has been integral to the connections made with the local community, indigenous communities, industry groups, and all levels of government, but also the attempt to address the major environmental and fish problems of each reach. The success of the implementation of the demonstration reach is a result of having a good planning process and being organised.

Summary of findings

The planning process enables the user to manage the project from the planning phase through to the implementation and ongoing site management using an adaptive management framework. The key steps that define the planning process are:

- Defining the project:
  - Who will design and implement the project?
  - What is the overall vision and scale of the project?
  - What are our targets/what are we trying to restore?
- Developing strategies and measures:
  - Assess the level of biodiversity and estimate how it is coping?
  - What are the threats and the seriousness of the threats?
  - Who are the key stakeholders and what actions are needed?
  - What specific outcomes are we trying to achieve?
  - What actions are needed to achieve the outcomes?
  - Identify indicators and methods to determine if our actions are achieving the desired outcome?
- Implementing strategies and measures:
  - What do we specifically need to do and who will do it?
- Use results to adapt and improve:
  - How do we know if our actions are working?
  - Do we need to modify our objectives, strategic actions and work plans to achieve our vision?
  - Share the findings by identifying key audiences and appropriate communication products

Key messages / Lessons Learnt

Queensland

- Planning is a key link into other programs within the Demonstration reach.
- Planning without any action can cause a break-down in partnership; this may be caused by a lack of funding.
- Realistic goals and timeframes need to be set.

New South Wales

- The need for clear and realistic objectives and milestones that are based on relevant information established from the start; engaging stakeholders (or representatives) from the start; and the importance of adaptive management and reviewing progress to improve future implementation.
- Community engagement is an essential component of demonstration reach planning and implementation processes to inspire action, foster ownership, and ensure effectiveness and longevity of rehabilitative efforts.

Victoria

- Demonstration reaches involve complex projects as they involve multiple interventions, planning helps to bring these together to form a clear and understandable approach for managers and community groups.
- Planning is also helpful in understanding the risks of the project, which limits any blockages.
- Linkage of the elements of on-ground works, the community and research is significant to the future planning and adaptive management of Demonstration reaches

Management / Research Recommendations

- Reviewing the adaptive management practices across the basin.

Acknowledgments

Stephanie Challen, Fern Hames and Tony Townsend

Progressing Monitoring and Evaluations at Demonstration reaches

Craig Boys[1], Wayne Robinson[2] and Peter Jackson[3]

[1]Industry & Investment NSW – Fisheries
[2]University of Sunshine Coast
[3]Private Consultant

Objectives / Background

The implementation of Demonstration reaches is important to the success of the Murray-Darling Basin Authority's Native Fish Strategy, which aims to enhance native fish populations throughout the Basin over the next 50 years. Demonstration reaches are sections of river where multiple threats to river health are managed through adaptive rehabilitation. They promote the need for holistic river rehabilitation to restore fish assemblages (i.e. all native fish species rather than individual species). As well as enhancing public awareness, they are also seen as a crucial step to refining guidelines for the restoration of rivers elsewhere in the Basin.

The need to monitor and evaluate the effectiveness of these rehabilitation works is also well identified, although to date monitoring at Demonstration reaches has been inconsistently applied. To remedy this, the MDBA commissioned a cross-jurisdictional team of scientists to develop a scientifically-robust and cost-effective framework to guide the monitoring and evaluation of ecological response to river rehabilitation carried out within a demonstration reach (Boys et al. 2009). The manual explained the need for ecological monitoring of Demonstration reaches, described elements of a good monitoring program, and discusses different types of monitoring able to be undertaken, and how they should be applied. The main components of the M&E framework have been presented at the 2008 MDBA Fish Forum (Boys et al. 2008) and to Queensland NRM bodies involved with the establishment of Demonstration reaches.

Since then, a process has been undertaken with the aim of assisting the main proponents of Demonstration reaches in the MDB to develop or refine M&E plans in their particular State. This paper outlines this process along with what progress has been made to date and what is planned for the future.

Summary of findings

Figure 1 outlines the process that is underway. Those agencies undertaking monitoring in 6 Demonstration reaches submitted monitoring plans for review: Katfish Reach (SA), Dewfish Reach (Qld), Hollands Creek Demonstration Reach (Vic), Ovens River Demonstration Reach (Vic), Bourke to Brewarrina Demonstration Reach (NSW) and Namoi Demonstration Reach (NSW). Proponents M&E plans have been reviewed and a report of the findings has just been sent to the Demonstration Reach Steering Committee (DRSC). After discussion, the DRSC will contact proponents to advise them of any unresolved concerns. It will be the onus of the proponent to either respond by revising the M&E plan to mitigate these concerns or provide a sufficient alternative explanation.

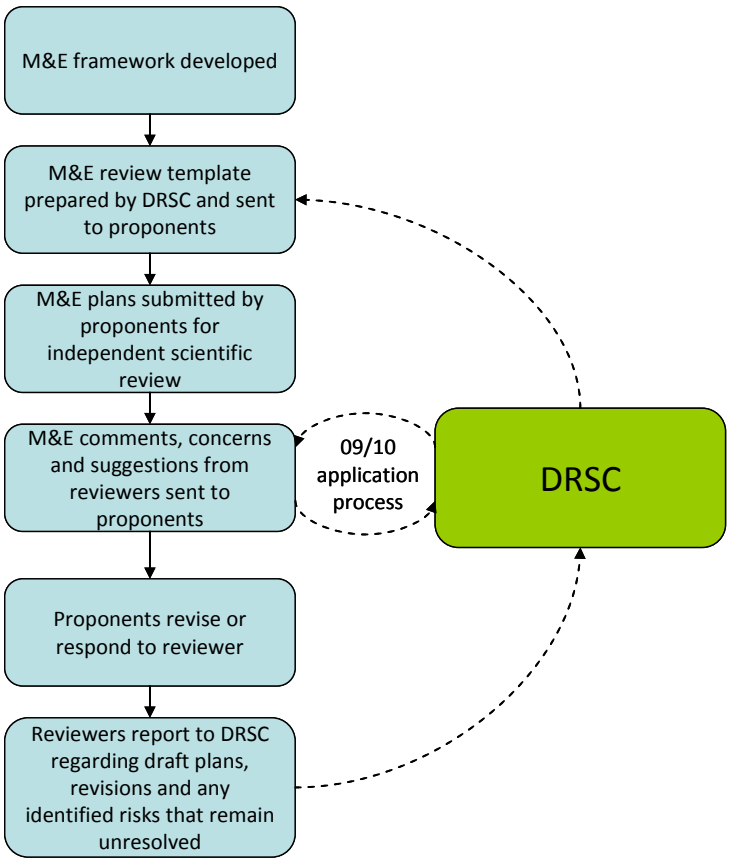

Figure 1. Process adopted to progress the adoption of M&E framework and how it feeds into the larger process of reviewing demonstration reach applications

Monitoring the condition of the demonstration reach as a whole will be important when reporting to stakeholders the ecological responses coming from the entire suite of interventions. Whilst such condition monitoring can be used to identify general trends, it will not allow the underlying mechanisms or causes of these trends to be determined. It is for this reason that a key recommendation of the Boys et al. (2009) M&E framework was (where possible) to combine reach scale condition monitoring with the monitoring of responses to specific interventions. This intervention based monitoring may occur at sub-reach scales and often will involve controlled experiments. The information from multiple lines of evidence should strengthen the interpretability of any reach scale trends and also enable lessons to be learnt that will progress rehabilitation practice. It should be noted that not all reaches will be of appropriate scale to undertake intervention based monitoring. Because the consultation process with the proponents is not yet complete, it would not be fair to divulge at this point in time exactly what each reach is planning on undertaking with respect to intervention based monitoring. However, Table 1 shows to total suite of interventions that are collectively been looked at across all Demonstration reaches. The next step will be to use this information to view demonstration reach M&E from a basin-wide perspective and open dialogue as to whether it is worth shifting efforts in some areas to better deliver a cohesive demonstration reach model for the basin.

Table 1. Intervention-based M&E being planned across all MDB Demonstration reaches in relation to NFS 13 driving actions

Intervention-based M&E being planned across all MDB Demonstration reaches in relation to NFS 13 driving actions												
Aquatic & riparian habitats	Wetland	Water quality	Flow regulation	Fish passage	Recovery plans threat fish	Mgt plans other natives	Carp	Disease	Sustain fisheries	Translocation & stocking	No impact aquaculture	Community support and ownership
General aquatic habitat; aquatic macrophyte re-veg in combination with Carp exclusion; willow removal; re-snagging; *bank stabilisation; riparian fencing and offstream watering*	**Regulate inundation with regulator**	*Storm water runoff*	**Regulate flows and drying with regulator; Irrigation offtake screening**	**Vertical slots (2),** *rock ramps,* **Deelder fishlock**	**-**	-	**Integrated Carp mgt (harvest, Judas, Carp cages); Carp sep cage on fishway;** *Bio-bin composting trial*	-	-	**Restocking**	-	-

* This table shows those interventions being monitored (**bold**) or in which monitoring is planned but still dependent on additional funding being sought (*italics*). It is not a complete list of those interventions being undertaken in reaches, only those being monitored. Dashes show where an intervention is not being monitored.

Key messages

- A process is underway (and nearing completion) that should see a more consistent approach to demonstration reach M&E which is more closely aligned with the Boys et al. (2009) framework.
- All reaches now have clearly defined conceptual models, hypotheses, and indicators with which to test them. Work is continuing to resolve experimental design concerns.
- A report outlining the draft M&E plans and any unresolved risks or concerns has been sent to the DRSC and these findings will be relayed to the proponents to assist them with the 09/10 application process.
- Like any ecological M&E program, its success is dependent on a long term commitment that corresponds to the time it is likely to take see responses in key ecological attribute.

Management / Research Recommendations

- Continue to work with proponents throughout the 09/10 application process to refine M&E plans if necessary.
- Increase efforts to promote a basin-wide cohesive approach to demonstration reach M&E.
- Schedule a workshop for main demonstration reach proponents for early next year to promote cross-fertilisation of ideas between jurisdictions regarding demonstration reach monitoring (and overall implementation), to improve practices, refine models and promote a basin-wide approach to Demonstration reaches.
- Consider how we monitor stakeholder satisfaction.
- Continue to do what needs to be done to ensure the longevity of the M&E programs so that they align with the likely temporal response of the ecological indicators being studied.

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Acknowledgments

Thanks to the Demonstration Reach Steering Committee, including Melissa Morley, Phil Duncan and Fern Hames. Thank you to all the proponents who have been willing and cooperative when working through a peer review process that will hopefully enable us to achieve the best outcomes with respect to demonstration reach M&E.

One Thousand and One Cups of Tea and the Native Fish Strategy: Engaging with the Community

Fern Hames[1] and Wayne Tennant[2]

[1]Arthur Rylah Institute, Department of Sustainability & Environment
[2]Goulburn Broken Catchment Management Authority

Background

This paper discusses the role of 'community engagement' as an intrinsic component of the implementation of Murray-Darling Basin (MDB) Native Fish Strategy Demonstration reaches. Demonstration reaches have now been in place for three years and thus it is timely to review the effectiveness of our efforts and share learnings from our experiences. Community engagement approaches are outlined, successes and challenges are identified, and recommendations for achieving more effective engagement in these projects are provided. The approach of implementing one particular Demonstration Reach in Victoria is discussed in detail.

Rivers and streams provide significant environmental, social and economic values and assets to local communities as well as the wider population. The environment is valued for ecosystem services and for contributing to the resilience and uniqueness of natural ecosystems, while social aspects are valued for the many life-fulfilling experiences they provide to communities (Tennant and Pettigrew 2006). Economic aspects are valued for the goods and services they provide that enable communities to prosper financially.

Successful approaches to improving river health must incorporate the recognition of values held by the community and include development of a shared vision. Such a vision needs to clearly identify those values and assets and the risks posed by threats (past, current and over time). Developing a shared vision requires effective engagement of our community. Traditionally, engagement has been at best patchy, and often confined to a one-way flow of information in natural resource management (NRM) projects. This approach does not readily allow for identification of the range of community values held for a site, nor effectively build community involvement in projects. However, communities need to be engaged and involved in decision-making, implementation and monitoring. This assists in developing a shared vision and ensuring ongoing advocacy for NRM projects.

Native fish are often a priority value for local communities and thus a potential catalyst in harnessing community participation in river rehabilitation programs which aim to support river health and the MDB Native Fish Strategy. Community engagement is an intrinsic element of MDBA Native Fish Strategy Demonstration reaches, which aim to showcase the cumulative benefits for native fish of combining multiple management actions on a particular river reach. Effective engagement should build support for and involvement in project activities, ensure long-term sustainability of integrity of works and site advocacy, provide pathways of sharing learnings and demonstrate the cumulative benefits of multiple management interventions.

Planning Engagement

What is engagement?

Engagement involves a range of processes, depending on issues, activities and communities. Early development of a Communications/ Engagement Strategy and Operational / Action Plan will enable identification of the range of appropriate processes and identify:

- the key messages for a project
- the relevant communities/ stakeholders
- levels / types of engagement for each
- applicable tools, methods and activities
- timelines and
- roles and responsibilities.

An example is provided in the Communications Plan for the Hollands Creek Demonstration Reach, which considers the above elements, and identifies the different levels of Engagement (see Table 1, ARI 2007):

- Inform: providing information (education)
- Consult: Obtain feedback
- Involve: Work with to ensure concerns and aspirations are understood and considered
- Collaborate: Partner in decision-making including the development of alternatives and identification of preferred solutions; and
- Empower: place final decision making and implementation into other hands.

A key aim of effective engagement is to shift communities / individuals, along the continuum from 'Inform' towards 'Empowerment'. Depending of the status of the project and the community involved, a project may be operating in one or a number of engagement spaces. Whatever the state, engagement is a continuum (see Fig. 1).

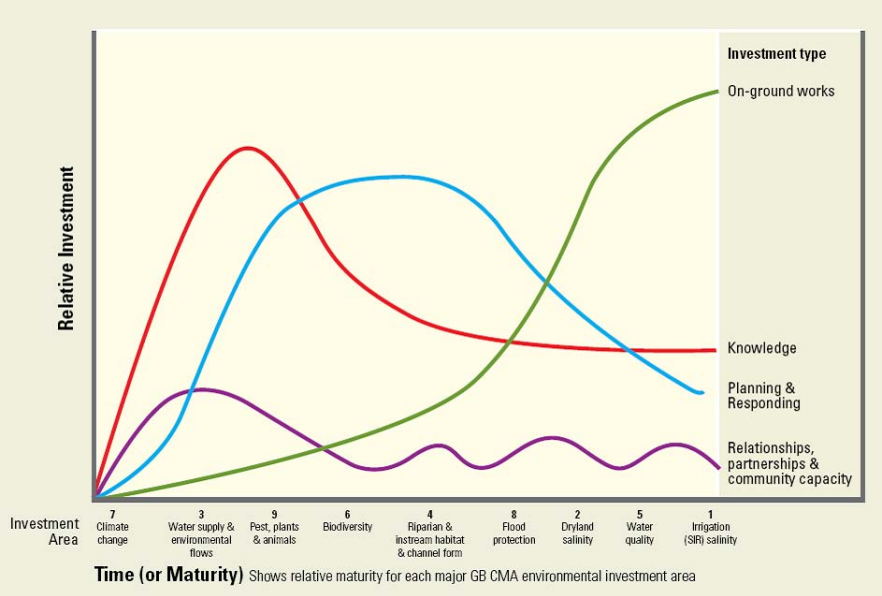

Figure 1 – The ongoing nature of community engagement

Table 1 - Hollands Creek Demonstration Reach Project Operational Engagement Plan (Section 1)

Hollands Creek Demonstration Reach Project Operational Engagement Plan – July 2007

Project Name:	Hollands Creek Demonstration Reach. Community Engagement	**Date:**	July 2007

What success looks like for:	**The project team:**	**The organisation/Minister:**	**The community/other stakeholders:**
	Productive relationships between partners ARI and GB CMA and Tatong Community Effective engagement with identified stakeholders An informed community on the progress & value of the Hollands Creek Demonstration Reach project	Recognition & support for the Project	Involvement in the development of the action plan for the Demo Reach. Co-ordinated involvement in the works. Continued involvement in the management of the site

STAKEHOLDER ANALYSIS AND TOOLS

INFORM	**CONSULT**	**INVOLVE**	**COLLABORATE**	**EMPOWER**
Stakeholders	**Stakeholders**	**Stakeholders**	**Stakeholders**	**Stakeholders**
Government Agencies – DSE, DPI, MDBC, DPI, G-MW Benalla City Council Residents (ratepayers & non-ratepayers) Local tourism operators Media Tourists	Indigenous Community	Molyullah Tatong Landcare Group Tatong Angling Club Hancock's Other landholders (not on HCCRG)	Hollands Creek Community Reference Group	Project Team Minister (s)

INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
Tools:	**Tools:**	**Tools:**	**Tools:**	**Tools:**
Media Releases Newsletter articles Info Sheets, Frequently Asked Questions? websites Project Displays Project Signage Letters (external stakeholders) Website Project Newsletter Briefing Notes/Reports Presentations Public meeting Open Day	Briefings Presentations Field Trips	Briefings Meetings Field Trips Works Program	Community Reference Group Meetings Workshops Field Trips	Project Team Meetings Briefing Notes/Reports Field Trips
Promise:	**Promise:**	**Promise:**	**Promise:**	**Promise:**
We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how your input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how your input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Who should we engage?

Demonstration reaches are, by definition, complex projects as they involve multiple on-ground management interventions, research, monitoring and evaluation, and a wide range of relevant agencies and communities. “The community” radiates out from those agencies with a direct role or interest in the project to relevant interest groups and individuals. A key to community engagement is to identify relevant stakeholders and develop relationships, and involve and partner with as many relevant stakeholders as possible.

Communication types and levels of engagement should be considered for all stakeholders. These stakeholders form ‘the community’ and may include project partners and their agencies, other relevant agencies (local, State and Federal), local government, indigenous communities, key landholders and other local residents, Landcare groups, recreational fishing groups, other relevant recreational groups/ clubs/ networks, schools and other educational institutions, local businesses, tourists, and the media (local, regional, metropolitan and national). The previous example Operational Engagement Plan for the Hollands Creek Demonstration Reach identifies a range of relevant stakeholders and appropriate levels of engagement for each (see Table 1, ARI 2007):

Summary of findings: Engagement in Demonstration reaches

In addition to showcasing the cumulative benefits for native fish of combining multiple management actions on a particular river reach, Demonstration reaches should model the outcomes of effective engagement for other reaches and other NRM projects. There are considerable learnings from existing Demonstration reaches, in terms of successful principles, techniques and tools as well as common pitfalls.

Demonstration reaches are a relatively new concept, and processes are still evolving; much so-called ‘engagement’ has been limited to information or education, but genuine two-way dialogue and engagement has also been successfully undertaken.

Basin-wide, community engagement in Demonstration reaches has included:

- Community and agency Steering groups/ Community Reference Groups, stakeholder meetings
- Websites/ pages
- Information signs: on participating landholders’ fences, project infrastructure or sites, and on larger shared information-shelter-signs
- Information afternoon BBQs
- Field Days, Workshops, Open Days
- Carp Musters
- Community Water Quality monitoring
- Promotion materials, e.g. Project posters, hats
- Fact sheets, brochures
- Revegetation days
- A Fishway opening
- Conference presentations
- Case studies
- Calendars
- School visits/ presentations
- An Education module
- Media articles, interviews (radio, TV, print)

A Victorian experience – the Hollands Creek Demonstration Reach

Our Victorian experience is derived from involvement in two Demonstration Reach projects (Ovens River and Hollands Creek; Raymond *et al.* 2009) and several other similar projects (e.g. Tahbilk lagoon; Clunie *et al.* 2008). Within this paper we focus on the Hollands Creek Demonstration Reach. The Hollands Creek Demonstration Reach project supports the Goulburn Broken Catchment Management Authority (GBCMA) Regional River Health Strategy and MDBA Native Fish Strategy and targets a range of primary assets within the Hollands Creek. The project focuses on protecting and expanding suitable habitat for Macquarie Perch populations. Stream improvement works in Hollands Creek target key threats to native fish including loss of suitable instream habitat, degraded stream frontages, water quality and connectivity. Monitoring the impact of the works, by the project Reference Group and the Arthur Rylah Institute (ARI) is a key element of the project.

Community engagement for the project began with agency discussions with Landcare officers and other individuals familiar with the community, to 'map' and gain a sense of the key people and elements of the relevant communities for this project, and to draft an Engagement Strategy and Operations Plan. Key people for the project included landholders, the relevant indigenous community, local angling club, local government, Landcare, other State government agencies (e.g. Department of Primary Industries) and people from the local township. An email invitation, newspaper advertisements and locally distributed flyers invited individuals to attend an initial meeting to learn about the proposed project, discuss values and issues for the site, decide whether to proceed with the project, and discuss ways in which the community wished to be involved. This was a formally facilitated session, which gave validity and respect to all comments. All values held for the reach, issues identified and perceived or real threats to the site were recorded, and a report produced and distributed. It was evident that landholders along the creek, many of whom are 4th or 5th generation creek-property-owners, hold a strong connection to the creek and are solidly committed to its health and future. Those present at the initial meeting agreed to support the project and establish a Community Reference Group.

Meetings have subsequently occurred monthly (bi-monthly in winter) and initially established membership and terms of reference for the group. The meetings provide a forum for discussion of a range of issues with respect to the creek, including fish habitat and fish population requirements, land management along the creek, weed control practices, fishing history, water extraction and proposed developments which may impact on native fish. The group's meetings have hosted guest speakers, discussed and adjusted Demonstration Reach works plans, clarified fish barrier issues with the local water authority and planned events such as Field Days. Landholders in the group actively support and implement works in their properties, supplement project works with individual revegetation programs, and undertake regular Waterwatch water quality monitoring. The Tatong Anglers Group is represented in the Community Reference Group and has also revegetated sections of the creek, provided catering and logistical support at Field Days and has made a

recent recommendation to the Reference Group that a section of the creek be permanently closed to all fishing, to better protect the resident Macquarie Perch population.

Highly successful annual Field Days have included a viewing of stream improvement works, electrofishing demonstrations, Waterwatch workshops, local indigenous Taungurung storytelling, historic photo displays, children's fishy activities and a stream-life-session from "the bug man".

The participating agencies have worked with the Community Reference Group to design and develop signs for landholders' fences, a double-sided information shelter with one side featuring the Demonstration Reach and Macquarie Perch and the other side featuring local (Ned Kelly) history. Robust signs for key public access points have also been developed, and have been physically installed by Community Reference Group members.

Meetings are routinely advertised in the local media, the GBCMA website has several pages dedicated to the project, Information Sheets have been developed and distributed, stickers produced, and project presentations delivered at a range of forums. The Community Reference Group is now planning to integrate the local school (recently reopened) with the project.
The project would not be a success without the ongoing and growing support of the communities and individuals of the Tatong Valley and through the strong partnership approach from the GBCMA and ARI, Department of Sustainability and Environment. Although the Hollands Creek Demonstration Reach was originally proposed by ARI, DSE and the GBCMA, the community is now a strong driver of this project, with exceptionally strong ownership of the project and ongoing advocacy for the Reach.
The major challenges are to ensure that a focus remains on the protection of native fish with the context of protecting river health and that we respond appropriately to new and emerging issues and continue to address issues in a coordinated and integrated manner.

Engagement challenges

Our experience in Victoria plus experience on Demonstration reaches around the Murray-Darling Basin has identified several challenges common to most projects. Engagement must be dynamic and flexible. It is important to recognise that different approaches are appropriate for different communities. Communities' needs and priorities change and an adaptive response should also reflect the adaptive management approach for other aspects of Demonstration reaches.
Vandalism, of signage in particular, and theft can be an ongoing issue for many sites. Responses to this have included more robust signs; or less robust, almost disposable, cheap, readily-replaceable signs. A more enduring result has been achieved by analysing the causes of the vandalism and actively engaging with that sector of the community to build advocacy and ownership for the site.
Some projects have experienced the perceived or real 'takeover' of events or entire projects by interest groups with a single agenda, potentially in conflict with the project's aims. This can range from simply dominating discussion at an information

session or meeting, to real conflict in a community reference group due to a perceived specific-interest group ‘takeover’. It is important to maintain focus, and regularly reflect on the agreed shared vision.

Overwhelmingly, the main challenge to effective engagement is that it is enormously time consuming, and often difficult to measure. Significant resources, effort, and time can be invested in many activities where it is difficult to identify or measure each or results.

Key messages

To genuinely and effectively engage, it is important to understand and define what we mean by 'community', particularly the relevant communities and stakeholders for this particular project; why engagement is relevant and important for this project and what forms it should take. It is important to identify our key values, issues and messages and maintain focus; and deliver on several key aspects of engagement, such as flexibility, availability and reliability. Development of an Engagement Strategy and Operations / Action Plan greatly assists in this process.
Projects need to establish a scientifically structured method / assessment process to monitor community understanding, involvement and confidence.
It is critically important to identify the correct people to contact with respect to indigenous communities.

Key lessons learned from participation within the Demonstration reaches, other river health projects and projects supporting the Native Fish Strategy include:

- Strong community ownership and participation (individuals, agencies and government) in the development of strategies and plans, implementation of works, and monitoring the outcomes is essential
- Early recognition of the range of values and issues for a site is essential
- Acknowledge differences, focus on commonalities
- Establish a clear shared vision and articulate it to the partners and the community so that we are working together and in the same direction
- Develop clear Communications and Engagement Strategies and Operations / Actions Plans for projects, and use and review them
- Manage expectations, especially with respect to time and funding
- Effective engagement takes a significant investment in time; be prepared for a long term commitment & persistent effort (NB: the NFS is also a long term Strategy)
- Community values change over time and require flexible and adaptable management agencies, programs and strategies
- Be flexible & responsive but maintain focus
- Be honest, genuine, available, inclusive, reliable
- Don’t “over promise and under deliver”
- Use plain English; avoid jargon
- Aim for two-way dialogue, not just one-way information
- Ancient conflicts over land persist: new conflicts over water have emerged and overlay the old
- Learn from the past - many of the practices employed in times gone by threaten the very condition and status of our waterways: acknowledge errors of past practices
- Learn from science, monitoring and adaptive management (prepare to adapt to new findings)
- Remember that there has been progress in the improvement to stream condition

- The community are becoming increasingly concerned and involved in programs and projects
- Share and celebrate the rewards of improved practice and asset condition
- Explore ways to better identify and measure the reach and results of engagement activities
- Effective engagement results in effective ownership, uptake and long term sustainability of projects.

Improvement and protection often takes time; be patient, remain passionate and work together for the protection of one our most valued assets – our Rivers, our Landscapes, our Communities.

How to measure success?

Success should be assessed by the willingness of agencies and communities to move from "Informing" to "Empowerment". The results from this include:

- Increased participation within projects
- Commitment to long term management of the investment
- Changes in community attitudes towards "native fish" and "rivers" (in general).

These measures can be assessed by applying a simple social assessment at the commencement of the project and undertaken regular assessments, at intervals determined and agreed on by project partners.

Management / Research Recommendations

- Development of simple but robust measurement and monitoring tools for effective engagement
- Recognition of the importance of effective engagement in such projects, reflected in adequate resourcing
- Organisation of a range of forums to enable sharing of learnings between Demonstration Reach practitioners.

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Indigenous Engagement in Demonstration Reaches

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[2]Conservation Manager & NFS Coordinator, Industry & Investment NSW.

Objectives / Background

The concept of a 'Demonstration Reach', as outlined in the MDBC Native Fish Strategy (2003-2013), involves the use of the reach as a promotional tool to show the community and other stakeholders the benefits of on-ground aquatic habitat rehabilitation for aquatic species and overall ecosystem health. Some of the main objectives of Demonstration reaches recognise the importance of community engagement and awareness raising, and the value of capacity building, consultation and increased ownership through developing partnerships.

Indigenous engagement can bring multiple benefits to Demonstration reaches and the local communities including knowledge and expertise, insights into the pre-European state of the riverine environment, unique understanding and appreciation of our natural resources and a means to achieve on-ground outcomes that provides local training and employment opportunities.

This paper looks at ways in which Indigenous engagement in Demonstration reaches has been successful to date and, drawing on observations and the lessons learned, considers how Indigenous engagement can be better incorporated in Demonstration reaches in the future.

Summary of findings

Through building on the success of current engagement activities and through value-adding to future endeavours via leveraging of funding and partnerships, broader and more effective Indigenous engagement can be achieved within and around Demonstration reaches.

Key messages

- Indigenous engagement can be very beneficial to Demonstration reaches and should be encouraged.
- There are good examples of successful Indigenous engagement in Demonstration reaches and similar projects.
- Communication and persistence is a key component to developing good relationships over time.
- There is a wealth of knowledge held by Indigenous people that can be elicited through oral histories and story telling.
- Mentoring as part of an engagement program can add to the knowledge and skills being exchanged by participants. Teaching young Aboriginal people about their history and connection to the land can give them a purpose and direction in life.
- Achieving on-ground outcomes, engagement, training and employment opportunities can not only empower and rebuild ownership in Aboriginal people for the health of the riverine environment, but often has a flow on effect into other areas of general community well-being.

Management / Research Recommendations

- Indigenous engagement should be an integral part of the planning and capacity building activities within Demonstration Reach Projects.
- The capture of oral histories within the river valleys where Demonstration reaches occur would add to Indigenous engagement, as would the addition of bilingual information into existing NFS publications where they are due for review and reprinting.
- The inclusion of mentoring opportunities within engagement and capacity building activities is a way to meet the need within the Indigenous community to capture and pass on traditional ecological, cultural and spiritual knowledge to younger generations.
- While the NFS does not have the funding to support training and employment of Indigenous communities long term there is an opportunity to value add to broader programs through partnerships, providing intermittent/seasonal work, providing work experience and on-ground training, and possibly using existing funding to leverage or support coordination of overall funding bids.
- There is a strong interest in undertaking cultural use mapping on a wider scale across the Basin, and while this is not a direct activity of the NFS, support to the responsible areas within the organisation could assist in it occurring on a wider basis.

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Acknowledgments

A special thanks to Melissa Morley for her support in the recent discussions with Indigenous stakeholders. Also thanks to all NFS Coordinators and Demonstration Reach managers for their assistance in organising and attending meetings.

From Small Things Big Things Grow: Building Partnerships in Demonstration reaches

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[1] Condamine Alliance Natural Resource Management Group
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Abstract

The Native Fish Strategy is a partnership. The development and maintenance of solid partnerships and collaborations with key stakeholders is fundamental in sustaining viable fish populations and communities throughout the Murray-Darling Basin (the Basin). Demonstration reaches are an important part of the Native fish Strategy. A demonstration reach is a section of river where a number of management actions are carried out to demonstrate to the community the benefits from rehabilitating native fish habitat and populations. Demonstration reaches are important in engaging stakeholders and building partnerships because they induce a strong sense of stewardship for native fish in the community and thus generate greater interest and involvement in the protection and rehabilitation of their habitat (Barrett and Ansell 2004).

Demonstration reaches have been in place throughout the Murray-Darling Basin for three years. This paper briefly describes how partnerships in Demonstration reaches have matured over time to include a wide range of partnerships as government funding becomes more elusive. This in turn, has reduced the demand on partners so they are not overburdened but motivated to be involved in catchment-wide projects. The ability to build on the partnerships formed in the Demonstration reach and transfer them to projects within the catchment is an example of efficient project management. The Dewfish Demonstration Reach in Queensland is used as a case study in how to successfully use partnerships from the demonstration reach to the whole of the catchment.

Objectives / Background

As Demonstration reaches aim to bring resources together at one place, to maximize the benefits of multiple interventions, they provide many opportunities to engage with a range of partners. Generally key partners, that is, the people who have an influence on the project are affected by the outcomes or can assist with a team's objectives, are identified at the planning stage of a demonstration reach. However, with the success of projects, no matter how minor, comes an opportunity to leverage support and generate a wider range of participants and partners. The ability to take advantage of unique collaborations requires a level of creative and strategic thinking. As government funding gets less and less, identifying and maintaining a wide range of partners to undertake or fund natural resource management has become very important.

The table below highlights examples from across the Basin where less obvious partnerships have been created to achieve project outcomes in the Demonstration reaches.

Demonstration Reach	State	Partnership/Opportunity	Outcome
Namoi Demonstration Reach	NSW	As part of the Namoi demonstration reach, resnagging activities were undertaken (milestone: 60 snags reintroduced into the system); Idemitsu Boggabri coal Pty Ltd operate within the boundaries of the demonstration reach; Boggabri Coal have previously been involved in habitat rehabilitation works, with riparian revegetation and woody weed management completed on their property; as part of a new development within the coal mine, an area of forest was cleared and a formal arrangement was made with NSW DPI for the mining company to acquire, stockpile and deliver suitable trees for instream habitat and bank erosion protection works along the demonstration reach.	Over 185 snags have been reintroduced along the reach as a result of the arrangement with Boggabri Coal; Costs associated with the acquisition, stockpiling and delivery of suitable snags has been an in-kind contribution from the coal mine; There has been increased involvement by Boggabri Coal in rehabilitation activities, with additional revegetation and weed management occurring, as well as fencing works; The arrangement between NSW DPI and Boggabri Coal has been extended beyond 2009, with suitable logs continuing to be stockpiled when appropriate.
Katfish Reach	SA	At the beginning of the Katfish Reach project we developed a MOU with the major player (State agencies, a community group and Banrock Station Wines).	Through the MOU Banrock Station Wines donated $50,000 to the project to assist in the development of the Katfish Reach Implementation Plan and to foster community involvement.
Hollands Creek	Vic	The Tatong Angler Group (TAG) is a long –established trout angling group centred around the Hollands Creek. The group has demonstrated a commitment to riparian rehabilitation via revegetation projects and has strong linkages with creek. Hancock Victorian Plantations (HVP) manages extensive pine plantations in the Hollands Creek catchment and there have been some local debates around forestry practices and water quality issues.	Several members of the TAG sit on the Hollands Creek Demonstration Reach Community Reference Group and provide valuable and active contributions and input. They also provide practical support (e.g. catering at Demo Reach Field Days) and have recently made a proposal to close a section of the creek to all fishing, to protect the Macquarie perch population. HVP representatives have attended Hollands Creek Demonstration Reach Community Reference Group meetings and discussed the Code of Forest Practice and their commitment to best practice. HVP have also provided co-funding to support an Information Shelter-sign. Experience in Demo Reaches has also guided partnership developments at other sites , e.g. Tahbilk Lagoon (with Tahbilk Winery).
Dewfish Demonstration Reach	Qld	Civil construction company Ostwald Bros were contracted to complete a vertical slot fishway on Loudoun Weir. After state and federal funding fell short before construction was completed, Ostwald Bros generously funded the project. Although their contribution is unknown, it has been estimated to exceed $90 000. Ostwald Bros supported the project because they felt a sense of ownership and could see the environmental and community benefits.	The first vertical slot fishway in the Queensland part of the Basin will soon be operating at Loudoun Weir on the Condamine River. The fishway will be the first in Australia to be completed with financial support from corporate investment.

Although Demonstration reaches play a valuable role in river rehabilitation, if we are to achieve the 'big picture' vision of the Native Fish Strategy, it is essential to work on a catchment scale.

Case study: A Queensland experience

Rehabilitating the Condamine River Catchment has proved to be a vast and complex project where partnership building has remained central to both the success of the Dewfish Demonstration Reach and the River Rescue Program. Kevin Graham and Francine Holt from the regional Natural Resource management body, Condamine Alliance (CA) provides the following insights into what is happening in their neck of the woods and how it is relevant to yours.

The Dewfish Demonstration Reach in the Condamine catchment has a much greater meaning than itself. It is intended to be the catalyst for reach rehabilitation works on a regional scale as opposed to being developed as a "stand alone" product. It is the flagship project of the Condamine River Rescue Program - a strategic development framework that is guiding catchment scale rehabilitation of six priority reaches across the Condamine catchment. The Dewfish Demonstration Reach will promote and demonstrate the principles of the Native Fish Strategy and act as a model for greater engagement and uptake of rehabilitation and protection measures across the catchment.

To date, CA has invested in the following planning and projects as part of the River Rescue Program and the Dewfish Demonstration Reach.

Program Outputs	Condamine River Rescue Program	Dewfish Demonstration Reach
The Condamine River Rescue Program (Strategic Plan)	✔	✔
The Dewfish Demonstration Reach Whole of Life Plan supported by a DDR Communication and Engagement Plan, DDR Carp Management Plan and most recently DDR M&E Plan.	✔	✔
Condamine River Rescue Management Plan for 6 reaches of the Condamine – SMEC June 2008	✔	✔
Condamine River Rescue Rehabilitation Designs (Edward Street Weir and Loudoun Weir) – SMEC November 2008	✔	✔
Baseline Data - Biodiversity Survey and Reports – Myall Creek, Canal Creek, Oakey Creek and the headwaters of the Condamine River up-stream of Killarney – Queensland Primary Industries & Fisheries 2008/09. The management plans and biodiversity survey highlighted the health of each reach and the actions step needed as well as the diversity of fish species	✔	✔
Loudoun Weir Fishway modification and repair.	✔	✔
Showcase site development at Archers Crossing (Chinchilla) and Passmore Reserve (Clifton).	✔	
Bowenville Reserve (between Toowoomba and Dalby); new showcase site is under development in the township of Dalby.		✔
Bowenville Pilot Reach Development – Dewfish Demonstration Reach		✔

Summary of findings

Each rehabilitation reach provides a unique set of circumstances and challenges (assets and threats) but the principles remain the same.

- Engagement – 3 different types of people: engagement with suspicion, engagement through hostility, engagement through trust.
- Need regular communication with stakeholders to understand and manage expectations
- Need to find “quick wins” to maintain interest of stakeholders and community
- Public site access is important to lift profile of work – however vandalism is an issue which must be addressed at such sites.
- Promote social and economic change through natural resource management.

Key messages

- A healthy catchment promotes healthy lifestyle for all of natures creatures… including humans!
- Healthy and vibrant native fish populations are an indication of healthy catchments and catchment communities.
- Good partnerships are strategic, always leveraging resources with an eye on the future.
- Develop an understanding of the community and their needs.
- Allow people to understand how various issues (i.e. employment, habitat, native fish) are related.
- Learn from mistakes together, and share the adaptive management approach.
- Develop a strong culture of friendliness.
- Ensuring broad stakeholder engagement in river system management requires innovation, time and resources as well as knowledge of stakeholder engagement and facilitation tools, methods and approaches (Thomson & Allison, 2006).

Management / Research Recommendations

- Ensure promotion of M&E results from the Demonstration Reach at a regional level to stakeholders and community – make sure we interpret what that means to each stakeholder….not just what it means to native fish! We don’t need to reinvent the wheel with research but we need to highlight “relevance” – this means relating outcomes to stakeholders values
- Identify and promote the “unique” attributes and assets associated with reach sites to assist engagement – stakeholders may not relate to fish but they may relate to other assets and/or issues.
- Continue to identify and implement “quick win” projects to maintain interest and momentum over time.
- Be flexible, pro-active, creative and open-minded in order to identify opportunities for leverage and secure resources for implementation – (funds, in-kind, equipment, materials, knowledge and advice)
- Invest in relationship development activities to attract and retain program partners.

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Demonstration reaches – Where to Now?

Peter Jackson
Chair, Demonstration Reach Steering Committee

Objectives/Background

Demonstration Reach projects have been underway in all Basin states (except the ACT) for over three years. Whilst an assessment of the impact of these reaches on native fish populations will have to await the outcome of monitoring programs and is a number of years away, it is appropriate to ask some questions about the direction that the projects are taking and to identify some of the problems/issues that have arisen. This paper provides a list of issues that should be considered by the Demonstration Reach Steering Committee and the proponents of Demonstration reaches in determining future directions. In doing so it recognizes that jurisdictions have embraced the concept of Demonstration reaches with very successful results and that any future directions should build on this success and the level of community support that has been generated.

Summary of Findings

The following issues should be considered when discussing the future directions of Demonstration reaches:

The Demonstration Reach Concept
The original demonstration reach concept remains valid with a strong emphasis on "demonstrating" the value of multiple interventions in rehabilitating native fish populations. However it is appropriate to also give emphasis to their value in demonstrating how community engagement and ownership of river rehabilitation can be achieved. A number of projects have demonstrated the value of giving Demonstration reaches a catchy name (e.g. Katfish Reach and Dewfish Reach).

It is important to recognize that Demonstration reaches are entirely compatible and complimentary to broader "River Health" initiatives. Healthy rivers means healthy fish populations. However Demonstration reaches ensure that specific interventions related to fish health are undertaken and that appropriate monitoring programs are set up. In this context the value of fish as broad indicators of river health should be emphasized.

How do Demonstration reaches relate to "whole of river" rehabilitation?
Some NRM/CMA groups are developing whole of river rehabilitation plans and are unsure how Demonstration reaches may fit into their broader rehabilitation processes. It would appear that Demonstration reaches are valuable in this context in engaging the community, establishing partnerships and demonstrating the values of river rehabilitation.

The work can then be extended into the broader catchment via "river rehabilitation reaches". Over time the outcome of demonstration reach projects will inform best practice for rehabilitation reaches.

How many Demonstration reaches?
Consideration needs to be given to how many Demonstration reaches should be underway at any one time. There are resource implications in having too many including the dilution of funds and demands on NFS coordinators. Is it better to have one well funded and managed demonstration reach in each state? What are the

basin-wide implications? Can we still cover the suite of interventions and habitat variability?

Size of Demonstration reaches
The length of Demonstration reaches has largely been determined by practicalities rather than biology. There is a need to consider the landscape dimensions of Demonstration reaches in relation to the life histories of the fish communities that are the target for rehabilitation, at least as a first step.

Monitoring and Evaluation
Most Demonstration reaches have robust Monitoring and Evaluation Plans to ensure that the appropriate level of monitoring is undertaken over the next five or so years. From a Basin-wide perspective are a wide range of interventions being monitored and is there enough replication to obtain valid results? If not, how can this issue be addressed?

The monitoring plans are focused on the impacts of interventions on native fish populations. There is a need to develop a simple but robust way of monitoring the effectiveness of community engagement.

Reporting Progress with Demonstration Reach Projects
Demonstration reaches are implemented over a long period of time and the results, in terms of impacts on fish populations will not be available for five years or more. There is a need to have an interim reporting process so that communities remain engaged. Reporting back on interim targets (e.g. opening of a fishway, completion of x km of riparian rehabilitation etc.) will be important.

Knowledge sharing
There needs to be a process set up to allow knowledge exchange between Demonstration reaches on all aspects of their application. In a more formal sense it is important that the outcomes of the projects are translated into practical management outcomes that inform the implementation of river rehabilitation throughout the Basin.

Indigenous Engagement
Opportunities to enhance indigenous engagement in demonstration reach projects need to be investigated and implemented. The recommendations of the indigenous engagement scoping study (in preparation) should be implemented.

Funding
Funding remains an issue for Demonstration reaches. Innovative approaches such as having them declared high value habitats needs to be looked at.

Key Messages

- Any future directions need to build on the success and goodwill already established.
- Demonstration reaches need to be seen as an integral part of river health initiatives and as an important tool towards whole of river rehabilitation.
- Consideration needs to be given to how many Demonstration reaches are established at any one time.
- Consideration should be given to how a whole of Basin approach can be achieved particularly in relation to the range of interventions covered.
- Monitoring should include the success of community engagement and interim results should be relayed to the community.
- There should be a process for knowledge sharing.

- Initiatives should be implemented to increase the level of indigenous engagement if Demonstration reaches.
- Innovative approaches to funding Demonstration reaches should be investigated.

Management /Research Recommendations

The Demonstration Reach Steering Committee should consider the key messages from this paper and other ideas raised at the Forum and progress them as appropriate in consultation with NFS coordinators and proponents of Demonstration reaches.

Acknowledgements

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Where to Next for Habitat Management Areas?

Dr Bill Phillips
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Objectives / Background

In 2005 the then Murray-Darling Basin Commission funded the first of four projects in a series that this paper will consider.

The first, commissioned in mid-2005, was a review to explore the concept of establishing a system of Habitat Management Areas (HMA) across the Basin, as advocated through the Native Fish Strategy 2003-2013.

"Habitat Management Areas aim to protect remnant areas of healthy fish habitat. A system of Habitat Management Areas that encompasses a 'multiple-use management' framework would be particularly relevant to the Basin. 'Multiple use management' in Habitat Management Areas would not normally exclude popular recreational pursuits such as fishing and camping, which are important to many local communities along the Basin's inland waterways. State fisheries and catchment management legislation already contain provisions for closed seasons, closed areas and protection of critical habitats. A system of Habitat Management Areas may simply formalise and coordinate the protective measures already in place, and identify areas where additional measures will enhance and secure the viability of native fish and freshwater ecosystems".

The first HMA project (Phillips and Butcher, 2005) examined international and national experiences in this field, the science needed to underpin the establishment of such a network, the management prescriptions and approaches needed, and the policy and administrative practicalities of doing this across the Murray-Darling Basin. Among the recommendations from this project were two that were taken forward in a subsequent project (Phillips, 2008) which attempted to document the full spectrum of 'potential HMAs' across the Basin, and develop a 'tool kit' to assist practitioners with moving forward to apply the concept, especially at the scale of Catchment Management Authorities.

During 2008, the MDBC also commissioned the preparation, under the Wetlands.edu training initiative, of three training modules relating to the following topics:

- Management models and approaches for riverine and floodplain wetland habitats (HMAs)
- Management of floodplain wetlands to improve native fish (and other) habitat values, and
- Managing Carp in floodplain wetlands.

Then, in June of 2009, further funding was forthcoming to 'piggy-back' on the newly established Macquarie RiverSmart initiative, and to work with the stakeholders along the Macquarie River in central NSW to:

(a) ground-truth the GIS layer for protected areas along the Macquarie river developed by the 2008 project, so as to ensure comprehensive information is held on where these are, their management situation, contribution to river health, fish and other biodiversity, and

(b) document the current range of incentives schemes being offered for the establishment of protected areas ranging through covenants, landholder assistance, and other more government based approaches.

Summary of findings

In short, the Phillips and Butcher 2005 report took a very broad definition of 'protected areas' and this resulted in them identifying 15 different mechanisms for establishing riverine protected areas; these ranging from international instruments (such as Ramsar site and Biosphere Reserve listings) through to the typically grass-roots based approaches such as 'Demonstration reaches'.

Phillips and Butcher (2005) proposed a vision for this initiative of, "A network of riverine and floodplain sites that work collectively to maintain biological, social and cultural values and improve river health across the Murray-Darling Basin."

Through the Phillips 2008 project, an audit was attempted for eleven 'potential HMA' categories across the Basin (Ramsar wetlands, Biosphere reserves, Living Murray Initiative sites, World heritage properties, Indigenous Protected Areas, heritage rivers, native fish-related management areas and Demonstration reaches, species and ecological communities listed under national or State/ACT biodiversity conservation legislation, sites formerly on the Register of the National Estate and State parks and reserves included in the so-called CAPAD dataset). This indicated there are close to 4,500 such areas, although if State Forests are not included this reduces by approximately 1,700 to around 2,800 sites. A sub-set of these represents the current 'riverine protected areas' network of the Murray-Darling Basin. Allowing for the omission of exclusively dryland, terrestrial parks and reserves, and taking into account some duplication across these protected area types (some areas have several 'tags') it seems likely that there are at least 1,000 sites that could form the foundation of a Basin-wide collaborative 'riverine protected areas' (HMA ?) initiative.

The 2008 audit project proved to be far more resource intense than expected due to the challenges associated with accessing, and then drawing together the many disparate data sets; each being maintained and housed within different government 'silos' (both national and State government-based). A one-stop-shop for this data should be a priority for the future, and the Authority is urged to invest further in seeing these beginnings of a fully comprehensive GIS-based data management system for protected areas of the Basin brought to fruition and then maintained.

The Phillips and Butcher (2005) report also dedicated considerable attention to the issues of communication and awareness raising about this proposed initiative; noting that if not handled with care there was the risk of it being misunderstood with respect to its intentions by some sectors.

The project underway at present is gathering more data on the distribution, extent and roles being played by existing parks and reserves along the Macquarie River. This level of information is necessary in order to being to understand where gaps lie. In parallel, the NSW Department of Primary Industries is about to commence detailed habitat mapping and assessments long the Macquarie river below Burrendong dam. This will also provide vital information to support prioritisation work for any future strategic approach to advancing the HMA concept. At the same time, the range of incentive mechanisms available to riparian landholders is being documented so as to gain an understanding of where opportunities may exist for encouraging community and landholder 'buy in' for taking this 'pilot study' forward.

Key messages

- HMAs can take many forms and a 'horses for courses' approach is probably wise.
- There is now a considerable 'toolkit' available to guide application of the concept, although the current 'pilot study' on the Macquarie river will add to that greatly.
- Systematic development of HMA networks is best advanced through processes that have the necessary data to hand for that particular river valley, and are driven by multi-stakeholder groups.
- Local level consultations are needed in order to understand local issues, and management roles, plus to document the more localised forms of existing or potential HMAs. Areas such as Crown lands managed by local government as urban parks and reserves for example may not be detected with higher level assessments.

Management / Research Recommendations

- Development of a one-stop-shop for riverine/riparian protected areas data across the Basin should be a priority, with a standardised data recording system developed.
- There is a need to pilot test a whole-of-river type approach to demonstrate that HMAs as a concept can be applied without fear of community back-lash.
- While good science is needed to know where key habitats are, there are inherent dangers with focussing only on these. Rivers have to be managed as whole entities, and traditional protected area approaches applied to terrestrial systems are inappropriate for riverine systems.
- There is a need to tailor and trial existing incentive systems for riparian landholders to offer support for HMA-related activities along rivers. Gaining strong engagement and support from these stakeholders is vital.

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Phillips, B. and Butcher, R., 2005. River Parks: Building a system of 'Habitat Management Areas' across the Murray-Darling. An international and national review of freshwater 'protected areas' for conserving aquatic biodiversity and river health. Client report to Murray-Darling Basin Commission.

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Acknowledgments

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Understanding Ecosystem Resilience to Drought Disturbance and Protecting and Managing Drought Refugia in the Murray-Darling Basin

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Background

The current 'millennium drought' has been the worst since European settlement, placing unprecedented pressure on the water resources of the Murray-Darling Basin (MDB). As a result, normally perennial aquatic habitats have become intermittent or dry, and water allocations to river reaches, wetlands and lakes across the MDB have been drastically reduced or stopped altogether. As a result, the aquatic habitat available to fish populations has attenuated within a range of systems across the basin. Any remaining aquatic habitats often contain native fishes of high conservation value such as threatened species and/or populations or are critical refuges for fish biodiversity in highly desiccated catchments.

In response to this situation, the MDBA initiated a drought expert panel under the Native Fish Strategy to consider the management of native fish during drought (Lintermans and Cottingham 2007). Key recommendations of the panel were to identify and catalogue drought refugia and to instigate management planning and develop a long-term vision to protect key refugia and vulnerable native fishes. Following this, the NFS tendered two separate projects to develop an understanding of the impact of drought on native fish populations and factors that contribute to their resilience and to investigate the characteristics and distribution of drought refugia across the basin, creating a refuge management template to facilitate long term strategies for protecting these habitats. These two projects: MD1086 (Ecosystem resilience and the importance of refugia for native fish communities/populations) and MD1087 (The protection of drought refugia for native fish in the Murray-Darling Basin) are being run in unison under a collaborative team from SARDI, Vic DSE (ARI), MDFRC, Monash and Griffith Universities and Riverness consulting. Whilst the two projects were tendered independently, the joint project integrates the understanding and management of native fish and refuge habitats under the impacts of drought disturbance.

Ecosystem resilience and the importance of refugia for native fish communities/populations (MD1086)

This project aims to identify the impact of drought disturbance on native fishes and to explore multiple mechanisms that enable native fishes to tolerate periods of drought and to maintain viable populations that can persist and recover following drought periods. This includes a review of current knowledge regarding the tolerances of native fishes to drought impacts and other biological traits that convey resistance and resilience to those impacts. This is completed in conjunction with the development of conceptual models that: 1) describe the response of native fish species to drought disturbance and 2) identify resistance and resilience traits that may determine species responses and identify thresholds for species persistence. These conceptual models will be further developed into detailed mathematical models that will predict the response of fish species under scenarios of recurrent

and increasing levels of drought disturbance. These models will be developed using long term data sets that have been collected during drought periods by project team members and will be ground-truthed in the field at two separate pilot valleys to be determined under the MD1086 management project. These models will indicate the likely loss of species from the fish assemblage under multiple drought scenarios, dependant on habitat or refuge characteristics modelled to change under drought disturbance. These models are intended to be applicable at a management scale and to be applied broadly to sets of refugia that may occur within individual catchments. In this way, the project outputs should enhance managers' capability to understand refugia characteristics and the likelihood that key species may be lost under multiple drought scenarios. Models may also be used to inform on various management interventions for protecting refuge habitats and resident fish populations.

Results and Progress

A draft review has been produced summarising the impacts of drought on freshwater ecosystems and the responses of native fish. This report also details the biological traits of MDB fishes that are likely to contribute to their resistance and resilience to drought disturbance. These traits have been used to develop metrics that can be used to calculate resistance and resilience factor scores. A preliminary analysis has found a strong linear gradient of high to low resistance and resilience; however, a small group of fishes do not fit the general pattern. Instead, they possess high resistance to drought but poor resilience. This group contains many of the species currently under significant threat from drought disturbance, including Blackfish, Pygmy perch, Murray hardyhead, Flatheaded galaxias. It also contains species suffering from both drought and historic human-related disturbances such as Olive perchlet and Purple spotted gudgeon. We conclude that key resilience factors may drive susceptibility to disturbance. Further analyses are underway to determine which of the resistance factors or species traits are most strongly implicated in these results.

The report also outlines conceptual models that describe the responses of fish to seasonal cycles of drought and cumulative disturbance under supra-seasonal drought. These models use a succession of seasonal models with increasingly harsh summer impacts and increasingly poor opportunities for resilience during 'wet' seasons. Presently, these conceptual models, along with species traits and resistance and resilience factor scores, are being used to develop mathematical models also informed using long term drought-related data sets made available by team members. Models will be developed over the coming year and ground-truthed this summer using field data.

The protection of drought refugia for native fish in the Murray-Darling Basin (MD1087)

The magnitude and area of aquatic habitat affected by the current drought and the significant threat that it poses to several vulnerable fish species and populations has raised concerns among environmental and natural resource managers and elicited management responses across multiple management jurisdictions. This project aims to assist the management of refuge habitats by developing criteria and definitions for various 'types' of refuge habitats and to produce a spatial refugia network showing the location of key refuge habitats while linking key information regarding the refuge characteristics, fish species and management actions relevant to each.

An important task is the development of a critical refugia list that will identify refuge habitats for key species or biodiversity protection during the summer of 2009/10. This list, as well as information regarding the types of refugia, key fish species for

protection and the various management options available for refuge protection were developed through a series of questionnaires and a workshop attended by various representative regional and state managers and ecological experts. The outcomes of this process will be complemented by regionally focussed sessions to be held in each catchment across the Basin during spring 2009. This information will be collated into a refuge status report that will be made available towards the end of the year.

An important aspect in enhancing the protection of drought refugia is understanding the legislative and policy framework under which managers work to implement environmental protection and natural resource management actions. In partnership with Riverness consulting, a draft report has been produced outlining the applicability of state legislation and policy documents and their potential to be used to drive the protection of drought refugia. This has been sent out to stakeholder agencies and policy managers for comment, and the final report will be available later in 2009.

Regional sessions are under development for September and October this year to focus regional and catchment experts and managers on identifying, characterising and prioritising local refuge habitats and identifying local fish conservation status and priorities. This process will greatly contribute to the production of a Basin wide refugia network, which will include a detailed GIS layer containing the location and key information regarding identified refuge habitats. This information will, in turn, be made available for the use of other NFS projects such as the fish hot-spots project which will further utilise this type of information for prioritising fish management in the Basin.

Over the next year, two pilot valleys will be selected for focussed attention. The project will undertake, in partnership with regional management bodies, a process of detailed identification and characterisation of local refugia including measurement of key habitat and water quality parameters as well as the assessment of fish assemblage and population structure. These data will be used to ground truth models under MD1086 as well as providing a framework for developing detailed refuge management plans for pilot valleys. This planning process will then be used to develop a generic framework for developing refuge management plans that can be adapted to and utilised by regional managers to enhance the long term protection and management of drought refugia across the MDB.

Reference

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Drought and Threatened Species

Janet Pritchard[1], Michael Hammer[2], Arkellah Hall[3], Alan Lugg[4], Luke Pearce[4], Jo Kearns[4], Fern Hames[5] and Jarod Lyon[5]

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[3] Department for Environment and Heritage SA
[4] Industry and Investment NSW
[5] Arthur Rylah Institute, Department of Sustainability and Environment

Objectives / Background

Drought is a recurrent, natural event in the Murray-Darling Basin, and native fish have evolved to meet the challenge. Under natural conditions, fish species would have found refuge in remnant pools and waterholes, ready to disperse and recruit into new habitats once the drought had broken. They were much more abundant prior to the arrival of Europeans than now, and populations were correspondingly more resilient to environmental changes (Lintermans and Cottingham 2007).

The extended drought that began in 1997 and peaked with record low inflows in 2006 has not yet broken. There has been some seasonal increase in rainfall, but inflows to the River Murray System and its tributaries remain very low. Many in-stream and off-channel habitats are in extremely poor condition, especially those which act as refuge habitats for threatened species with highly fragmented and localised distributions.

Extreme events such as drought and bushfire in the Basin can threaten the survival of key native fish populations. In 2008 the Native Fish Strategy established a small contingency fund to facilitate rescues/interventions of Basin fish populations under imminent and extreme threat (implementing one of the key recommendations of the Drought Expert Panel, Lintermans and Cottingham 2007). The initial response to a fish crisis may be delayed by jurisdictional financial or project approval processes, and the MDBA may be able to alleviate such delays through the provision of a small amount of funds for the initial crisis response. Jurisdictions then co-invest in the latter stages of emergency responses (for example, through funding ongoing husbandry or captive maintenance or reintroduction). It was anticipated that a contingency fund of $50,000 would facilitate 2-3 rescues/interventions per year.

Emergency interventions undertaken in late summer 2009

Extended drought across the southern Basin and extreme bushfires in Victoria saw an unprecedented demand on the emergency fund this year. Within one week in early March, the Native Fish Strategy received five applications for emergency funding from NSW, SA and Victoria. Due to exceptional circumstances all applications were supported within four days of being received, blowing out the contingency fund budget to almost $200,000, although noting that this was equally matched by jurisdictional contributions. The drought responses are detailed in this paper and the bushfire interventions in the following paper.

Murray cod in Merran Creek, Edwards-Wakool system, NSW

The Wakool/Niemur/Merran system had been deprived of water since spring 2008 and by early 2009 had dried to a series of disconnected pools. A small combined stock and domestic supply/environmental replenishment flow was released into the top end of the Colligen and Wakool Rivers and middle reach of the Merran Creek

(via Waddy Cutting) in January 2009. This resulted in a major blackwater/deoxygenation event that initiated a significant fish kill in the Colligen Creek and top end of the Niemur River and a smaller kill in the Merran. Several landholders in the upper reaches of Merran Creek made representations to Industry and Investment NSW that remnant pools were diminishing rapidly and the fish communities within them were at imminent risk, particularly the nationally threatened Murray cod (*Maccullochella peelii peelii*). Industry and Investment NSW staff and local landholders captured 105 Murray cod (25-120cm), 20 Golden perch (15-40cm) and 9 Silver perch (15-30cm) from the remnant pools in Merran Creek and transported them to larger refuge waterholes in the nearby Wakool River.

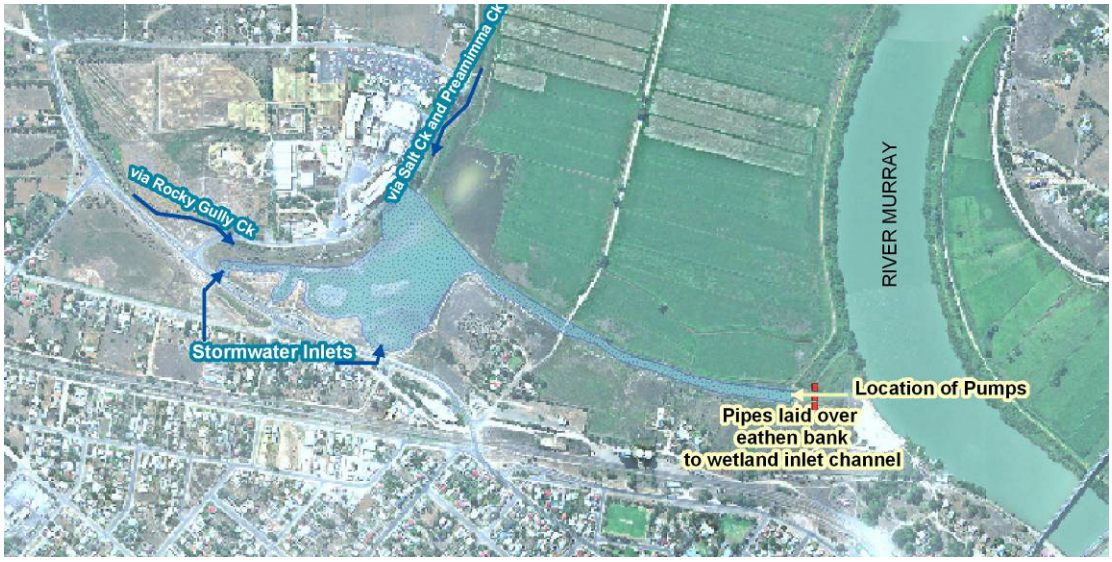
Clockwise from top left: Dead Murray cod from the top of the Niemur River as Colligen water flowed down. Note the blackwater. Photo: John Lolicato; Remnant pools in Merran Creek with high woody habitat loading, Murray cod in cradle, Golden perch being released from cradle (Photos: Michael Koukoukalis, Industry and Investment NSW)

Southern pygmy perch in the Upper Murray catchment, NSW
Extended drought conditions have significantly impacted one of the last remaining and most significant Southern pygmy perch populations in NSW (*Nannoperca australis*, listed as endangered under the NSW Fisheries Management Act). In March 2009, reduced streamflow in the Upper Murray catchment near Jingellic left the pools that support pygmy perch in imminent danger of drying up. MDBA funds supplemented a Industry and Investment NSW rescue of over 1,700 fish to captive maintenance facilities at Narrandera and Tumut. Moreover, mapping of the catchment was undertaken to identify all refuge pools, the extent of the distribution of Southern pygmy perch, and other fish species, as well as barriers to fish passage and other significant habitat features. This will aid NSW planning for reintroductions as well as supporting population recovery in situ over the next ten to fifteen years years.

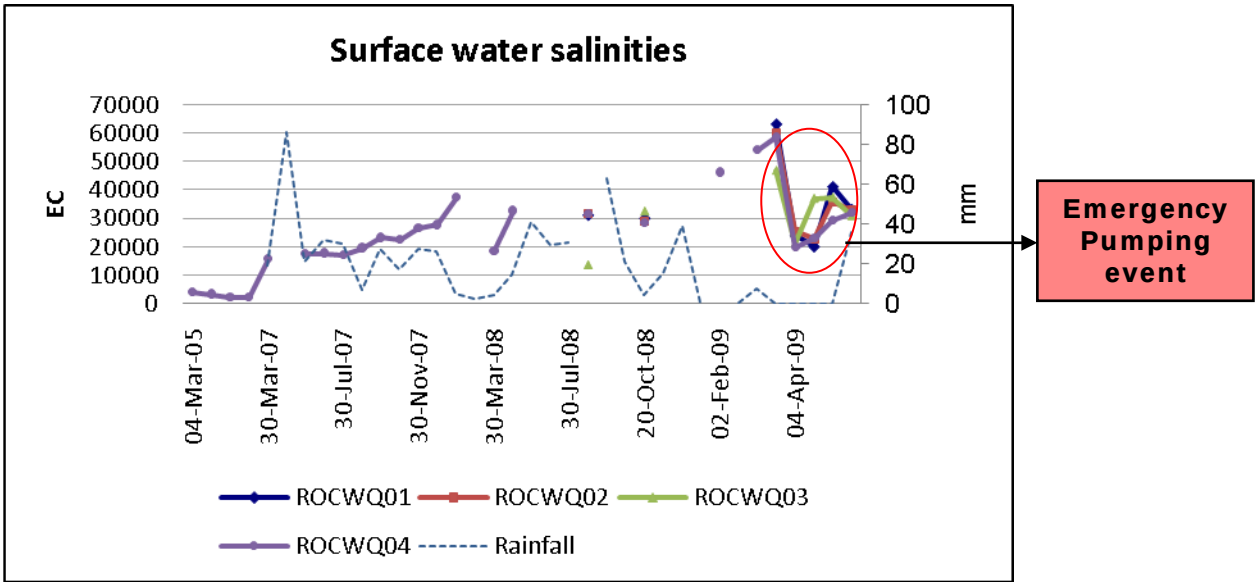
NSW DPI staff sampling refuge pool habitat in the Upper Murray catchment and one of the large adult Southern pygmy perch collected. Photo credits: Luke Pearce.

Murray hardyhead in Rocky Gully, South Australia
Rocky Gully Wetland is one of the last remaining offstream freshwater refuge sites below Lock 1. Results from quarterly DEH Drought Action Plan monitoring in early 2009 indicated Rocky Gully showed a breach in many critical environmental triggers. Results from water quality monitoring, in conjunction with fish monitoring, recorded salinity, pH and dissolved oxygen levels exceeding triggers for Murray hardyhead (*Craterocephalus fluviatilis*) at the site. The Murray hardyhead is currently listed as 'Vulnerable' under the Environment Protection and Biodiversity Conservation Act 1999, 'Endangered' *Provisional* under the National Parks and Wildlife Act 1972 and 'Protected' under the Fisheries Management Act 2007 (SA). The breaching of environmental triggers prompted an emergency response of a fish rescue attempt and watering of the site with MDBA funding the pumping infrastructure needed and the Commonwealth Environmental Water Holder providing the water in March 2009. This co-ordinated emergency response improved water quality dramatically and

recent rainfall has secured further flows into the wetland dropping salinity levels from as high as 60,000EC to ~20,000EC (see Graph 1). It is anticipated that the next round of DEH Drought Action Plan monitoring will indicate a recovery of water quality parameters and hopefully survival of the EPBC listed Murray hardyhead population.



Map of Rocky Gully Wetland and location of pumping and built earthen banks to retain the delivered water.



Graph 1: Surface water salinity changes prior and post emergency pumping in March 2009.

First day of emergency pumping at Rocky Gully Wetland, South Australia. March 31st 2009.

Macquarie perch in Hughes Creek, Goulburn-Broken catchment, Victoria

The Macquarie perch (*Macquaria australasica*) is a native Australian freshwater fish which was previously widespread throughout the south-eastern reaches of the Murray-Darling Basin, but has declined significantly in abundance and range over the past 50 years (Gray et al 2000). Macquarie perch is recognised as a threatened species under the Victorian Flora and Fauna Guarantee Act 1998 and also considered nationally endangered under the Environmental Protection and Biodiversity Conservation Act 1999.

There are several remnant Macquarie perch populations which have been identified as important, by the Draft Flora and Fauna Guarantee Action Statement for this species (DSE 2009). One such population exists within Hughes Creek, a small tributary of the Goulburn River.

Fish surveys of Hughes Creek were conducted during March 2009 between Avenel and Tarcombe, using a combination of backback electrofishing and fyke netting. A total of 53 Macquarie perch individuals were collected, whereby 36 were found to be in poor condition as a result of poor water quality in two sites. These two sites were isolated pools with dissolved oxygen concentrations of below 3 mg/L. Furthermore, no juvenile Macquarie perch were found during these surveys, indicating unsuccessful annual recruitment of this species. Following these findings, a translocation project was initiated, which temporarily transferred 32 Macquarie perch individuals to secure aquaculture facilities at Snobs Creek (DPI), where they will remain until conditions are once again suitable for Macquarie perch in Hughes Creek.

Clockwise from top left: Sampling at low water levels in Hughes Creek; Macquarie perch in poor condition, noting the presence of Lernea spp and pale body colour; Fish transporter used to relocate Macquarie perch from Hughes Creek to Snobs Creek Aquaculture facilities.

What happens after the emergency?

The following two examples of intervention work undertaken in 2008 describe what happens to the 'rescued' fish populations, and what on-going management is required after the initial emergency passes.

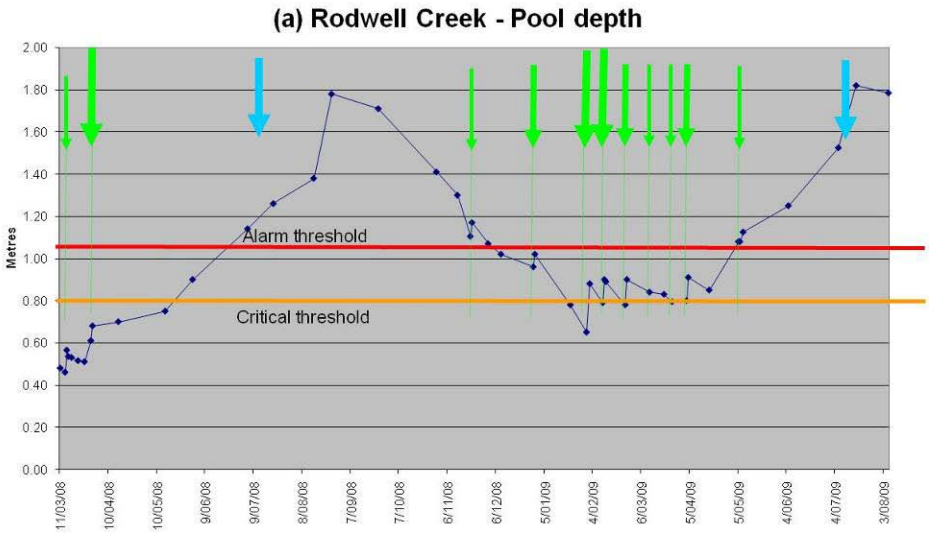
River Blackfish in Rodwell Creek, SA

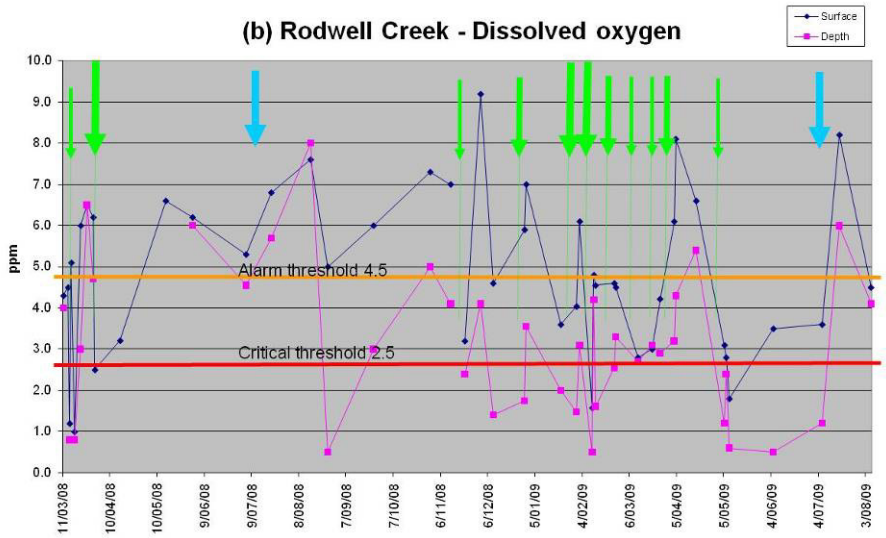
An emergency activity was funded in 2007/08 to conserve a River Blackfish (*Gadopsis marmoratus*) population at Rodwell Creek in South Australia (total cost to the then MDBC $8,352). Only four small populations of blackfish remain in the Lower Murray region, with Rodwell Creek the last in the Bremer Catchment (now known only from a single pool). Monitoring in March 2008 indicated critically low water levels in the remnant pool, and two emergency actions were initiated: (1) an on-site rainwater tank was installed to receive water tanked to the site and water was subsequently released to the stream pool to maintain water and oxygen levels; (2) a sub-set of fish remaining in the pool were transferred to temporary captive maintenance at SARDI Aquatic Sciences as a risk management (backup) measure.

From the initial investment, the Department for Environment and Heritage (SA) have continued the stewardship for this species, commissioning regular watering and fish and environmental monitoring as part of a Drought Action Plan (monitoring

undertaken by Aquasave and SARDI). Monitoring in autumn 2009 provided very encouraging results with a good number of healthy blackfish surviving, and matching good pool conditions.

Refuge pool on Rodwell Creek being watered in response to breach of environmental triggers for safeguard of river blackfish. Photo credit: Dylan Sortino.





Data from environmental monitoring in support of urgent drought related intervention at Rodwell Creek, South Australia for (a) pool depth) and (b) dissolved oxygen. Critical thresholds were used as tigers for watering, with watering events indicated with green arrows, periods of winter low stream flow in blue (DEH Drought Action Plan data).

Reintroduction plan for the Southern-purple spotted gudgeon, SA

The Southern purple-spotted gudgeon (*Mogurnda adspersa*) is a small colourful fish with a distinct conservation unit in the southern Murray-Darling Basin. The species underwent large declines in the region in the 1970s and was feared extinct until it was recently rediscovered at one site in the Lower Murray. This remnant site has since dried following extensive water level lowering below Lock 1 (~1.5m since January 2007). In 2008/09 the NFS supported the urgent establishment of a captive maintenance facility and breeding program for rescued wild fish, as well as development of a supporting reintroduction plan to help guide recovery of the species over the next ten to fifteen years. The draft reintroduction plan demonstrates that NFS and MDBA management support is not just reactionary, there is also commitment to encouraging more sustainable management of threatened species over the longer-term.

A draft of the plan is currently out for targeted stakeholder comment and it is anticipated that the reintroduction plan will strongly link to the South Australian Drought Action Plan being implemented by the Department for Environment and Heritage (SA). It should also provide the necessary information to support broader species recovery efforts by other organisations and groups outside of South Australia (i.e. reintroduction to former habitat across the southern Murray-Darling Basin).

Male Southern purple-spotted gudgeon rescued from drying habitat on the Lower Murray, and now a key part of a captive breeding program (he is guarding eggs). Photo credit: Michael Hammer.

Key messages

- The range of management options for threatened species suffering under extended drought conditions includes in-situ watering, habitat improvements, translocation of populations at risk, emergency rescues, establishment of captive breeding programs and long term recovery planning.
- Local observers are invaluable for monitoring deteriorating environmental conditions at key sites for at-risk populations. When accompanied by regular monitoring with clearly defined environmental thresholds, the opportunity to undertake more considered and successful management responses and the avoidance of last resort measures such as ex-situ captive maintenance is greatly increased.
- Survey data on fragmented and isolated threatened species has the potential to date very quickly (e.g. several size classes and a large recruitment event of juvenile Macquarie perch were recorded in the Broken River, Victoria, in early 2006, but not one Macquarie perch has been recaptured in the following three years despite intensive sampling (Jarod Lyon pers. comm.).
- Quarterly monitoring (collected by SARDI and Aquasave) through the SA DEH DAP feeds survey data into a 'prioritisation matrix' that then directs management options for species and populations throughout the year. The setting of critical triggers within the monitoring program also enables quick decisions to be made when a site has breeched the known tolerance for a given species.
- Emergency interventions are not short-term. It can take several years for conditions in natal streams and rivers to recover sufficiently to support populations once more (e.g. Barred Galaxias after the 2006-07 fires in Victoria. Raadik *et al* 2009).
- How successful have the 2009 emergency interventions been? After only a few months it is really too early to tell, especially regarding the longer-term viability of rescued populations back in the wild. Nevertheless swift action has likely prevented the local, if not regional, extinction of populations of five threatened species (Bremer catchment River Blackfish, Southern pygmy perch, Southern purple-spotted gudgeon, King Parrot Ck Macquarie perch and Barred Galaxias).

Management / Research Recommendations

- We need to retain but also look beyond immediate response measures to include medium-term policy responses and risk management strategies with particular regard to improving threatened species recovery planning. The South Australian draft Drought Action Plan which is already being implemented is a good example of this.
- Regular (annual) targeted monitoring and distribution surveys need to be built into threatened species recovery plans, and be adequately resourced, to ensure timely warnings are received if populations are under stress and at risk of collapse.
- Hard questions need to be answered for threatened species where it is deemed likely that the populations will need annual rescues if current drought conditions continue and climate change scenarios come to fruition. Being mindful that local extinctions are often irreversible: Do we maintain fish ex-situ every year (as has occurred with NSW pygmy perch in the Upper Murray over the last few years)? Do we try to modify in-stream and riparian characteristics with the aim of minimising the drought risk to the population? Do we seek appropriate new areas to translocate remnant populations into? Can we let some populations of a threatened species crash and suffer local extinction so that we can focus limited resources on recovering other more stable populations? How viable are the remnant populations in the face of climate change predictions? Do we need to commit environmental water allocations to identified high priority sites deemed critical for threatened native fish?
- The precautionary principle is even more important when considering fragmented and under stress threatened populations. To be effective, management intervention needs to be swift and comprehensive at the first signs of significant stress to prevent the risk of local or even total extinction. More reactive, late responses often incur greater expense and suffer lower success due to lowered numbers of poorly conditioned and stressed fish.
- There is a lack of knowledge on the spatial distribution of suitable habitat for many threatened fish species. Species habitat requirements and habitat mapping should be built into recovery plans.
- Many SA, VIC and NSW government- and agency-run aquarium facilities are nearing capacity, already housing threatened populations from previous rescues. It will become harder to find sufficient aquarium space to accommodate viable populations to maintain genetic integrity if drought severity continues and future rescues are required.
- The challenge for MDBA is how to prioritise amongst rescue actions with only very limited funds available. ‘First in best dressed’ may not be the best way to support emergency interventions, although it is recognised that there will always be an opportunistic element to the proposals received (who is looking and when). It is recommended that the jurisdictions should, through the NFS Native Fish Advisory Panel, nominate their top 2 to 3 populations at risk and keep MDBA briefed of their status, especially at early-mid summer.

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Acknowledgements

The 2008 emergency interventions were co-funded by jurisdictions and the Murray-Darling Basin Authority under the Native Fish Strategy's 'Emergency Response Contingency' fund. We acknowledge the many committed and motivated individuals and agencies across the jurisdictions that keep a watching brief over threatened fish populations. Without them we wouldn't know what was in trouble and what needs to be done. Thanks also to Heleena Bamford, Jason Alexandra and Jody Swirepik of MDBA who ensured a quick turn-around of paperwork to make sure that MDBA's response times really were rapid.

Bushfires and Threatened species

Jarod Lyon and Fern Hames

Arthur Rylah Institute, Department of Sustainability & Environment

Objectives / Background

The most commonly recognised effects of fire are the impacts on plants and terrestrial animals. Many plant species need fire to continue their lifecycle (i.e. wattles, banksias and eucalypts) while fire often opens up new habitats to terrestrial animals (e.g. kangaroos, wallabies and wombats). However, fire can also have major impacts on aquatic ecosystems. There are several ways in which aquatic organisms can be affected by fire. These include increased water temperatures (Hitt 2003; Minshall and Brock 1991), increases in stream pH (Cushing and Olsen 1963), and increases in nutrients (in particular nitrogen and phosphorus) (Bayley et al. 1992; Beschta 1990). However, probably the greatest threat to aquatic fauna as a result of fire comes from increased sediment loads due to increased run-off potential of recently burnt ground (Benda et al. 2003; Meyer and Pierce 2003; Beschta 1990). Suspended sediment loads are often at their highest following flash flooding events which occur directly after an area has been burnt by wildfire. Such events cause debris flows (or "mass wasting") that contain tremendous amounts of sediment, and it is these flows which are generally attributed with decimation of fish populations.

In February 2009 a series of major wildfires burnt through the Central Highlands of Victoria. The fires had massive impacts on rural communities and involved an enormous emergency response. Human losses were of an unprecedented scale, and losses of numerous buildings, stock and other infrastructure were also recorded. The Kilmore East-Murrindindi North Complex Fire was first reported on Saturday 7 February, when it started in two locations and then merged near Glenburn. A total area of 164,120 hectares was burnt by this one fire (including 122,931 hectares of public land in 35 sites) (DSE 2009a).

A range of key natural values were impacted by the fire. Mountain Ash (*Eucalyptus regnans*) and Alpine Ash (*Eucalyptus delegatensis*) forests were burnt before seeds had matured. Leadbeater's Possum (*Gymnobelideus leadbeateri,* listed as threatened under the *Flora and Fauna Guarantee Act 1988* and the *Environmental Protection and Biodiversity Conservation Act 1999*) were directly killed by fire and many habitat trees and food sources were burnt. Buxton Gum (*Eucalyptus crenulata,* also listed under both Acts) occurs in just two populations; one of these suffered high burn severity. Fire sensitive Cool Temperate Rainforest sites were also burnt. Three Spotted Tree Frog (*Litoria spenceri;* listed under both Acts) sites occur within the fire area. Other impacts included damage to scar trees, and over 800km of roads required closure or rehabilitation (DSE 2009b). Over 49% of the fire area was affected by moderate to high soil burn severity. As 52% of the area has steep slopes, this puts many areas both within and downstream of the fire area at increased risk of erosion and runoff. The potential exists for large increases in sediment loading and flooding, placing water sources, homes, roads and native fish at risk. This risk will remain elevated for 2-3 years until hydrologic function and vegetation recovers. Prolonged drought conditions may delay recovery further (DSE 2009a).

Two nationally threatened fish species occur within the fire area. The Macquarie Perch (*Macquaria australasica*) is an Australian native freshwater fish endemic to the south-eastern reaches of the Murray-Darling Basin. Over the past 50 years, a decline in this species range and abundance has been documented (Gray *et al* 2000). Macquarie Perch is currently listed as a threatened species under the

Victorian Flora and Fauna Guarantee Act 1998 and also listed nationally as endangered under the *Environmental Protection and Biodiversity Conservation Act 1999*.

The Goulburn Broken catchment in north central Victoria contains five of seven important Macquarie Perch populations, as highlighted in the draft Action Statement for the species (DSE 2009c). One such remnant population exists within King Parrot Creek. In February 2009, wildfires burnt over half of the King Parrot Creek catchment (DSE 2009d). Several sections of King Parrot Creek around Flowerdale were burnt to the water's edge, resulting in significant riparian vegetation loss (Plate 1).

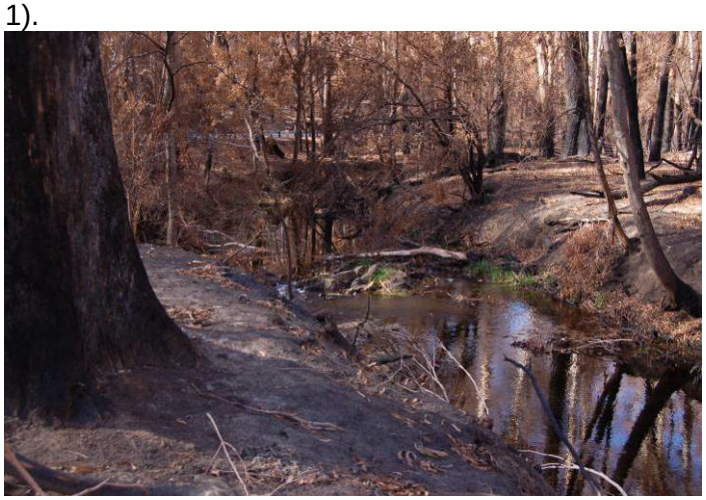

Plate 1. Burnt riparian vegetation, King Parrot Creek, March 2009

Barred Galaxias (*Galaxias fuscus*) is found only in the headwaters (above 400m altitude) of the Goulburn River catchment in the Central Highlands of Victoria. Barred Galaxias are currently listed as Endangered under the *Environmental Protection and Biodiversity Conservation Act 1999* and Critically Endangered under the *Victorian Flora and Fauna Guarantee Act 1998*. The species is thought to be non-migratory and relatively sedentary, therefore local impacts can be catastrophic (DSE 2003, Raadik *et al* 1996). It appears that the current distribution represents the fragmentation of a previously much wider range; at least five previously known populations are now extinct. Twelve of the 21 known Barred Galaxias populations occur in the area impacted by the February 2009 fire. Eight of these populations constitute 80% of the ten major known populations for the species. Seven of the remaining unburnt populations were impacted by fires in 2006/07, leaving only two sites unburnt. Populations in sites burnt this year had already been impacted by several years of low flows from successive years of drought. Waters within the fire area still known to contain Barred Galaxias include the upper Taggerty River, Keppel Hut Creek, the Rubicon River, Little Rubicon River, Robertson's Gully/ Leary's Creek, Luke Creek and S Creek (DSE 2009e). Riparian vegetation along these waterways was also burnt to the water's edge (Plates 2 and 3). Fire may also have resulted in burn or collapse of existing barriers protecting Barred Galaxias from trout predation. New barriers may also have formed in these small streams, potentially resulting in increased fragmentation of fish populations. Extensive salvage logging is also underway and planned for Mountain Ash forests within the fire ground.

Left: Plate 2. Burnt riparian fern gully, Robertson's Gully, March 2009

Below: Plate 3. Burnt riparian vegetation, Taggerty River, March 2009.

Summary of findings

In February 2009, a joint recovery project between Department of Sustainability and Environment (DSE), Department of Primary Industries (DPI) Snobs Creek Centre, Murray-Darling Basin Authority (MDBA) and the Goulburn Broken Catchment Management Authority (GBCMA) was initiated to rescue Macquarie Perch from King Parrot Creek and Barred Galaxias from twelve identified streams in the upper Goulburn catchment before post fire rainfall caused sediment slugs, potentially resulting in fish kills. This translocation project was highlighted as a key objective in the Emergency Stabilization and Rehabilitation Plan (DSE 2009a).

Macquarie Perch

Monitoring of Macquarie Perch populations within King Parrot Creek over the past few years (Kearns 2008, MacDonald 2008) was essential in identifying locations where Macquarie Perch were most abundant and could thus be sourced for translocation. Community members with a history of Macquarie Perch advocacy and the Strath Creek Landcare group also provided valuable information and strong support for the translocations.

A total of 35 individuals were collected from King Parrot Creek. While the majority of individuals were in relatively good condition, signs of physical stress were evident with one fish found deceased, most likely as a result of reduced water quality (DO ~ 3.5mg/L) following recent wildfires. There were an additional three individuals with cloudy eyes and pale skin, which are symptoms of physical stress.
The size range of Macquarie Perch captured was between 110 mm and 390 mm, (Figure 1), with 66% within 130 – 170mm in length.

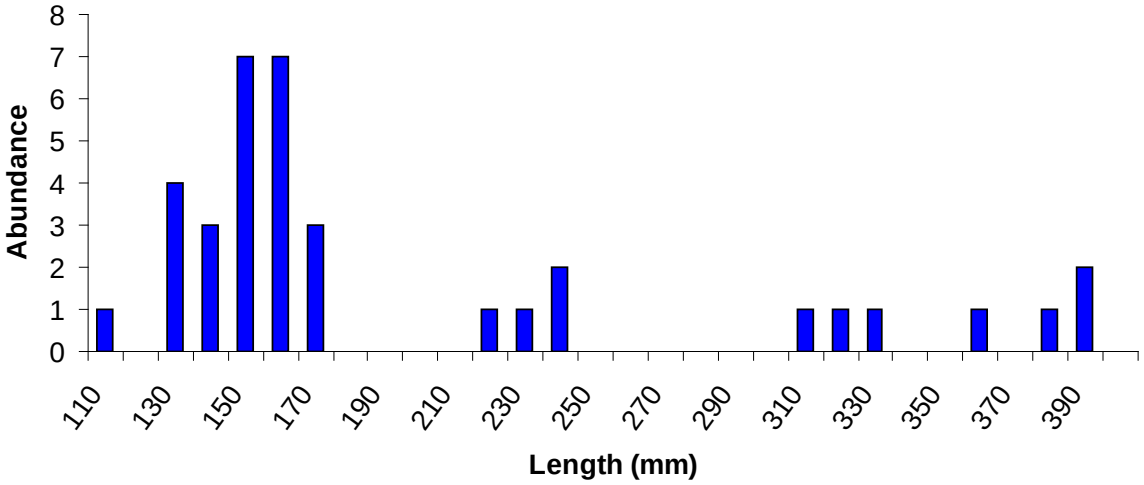

Figure 1. Length distribution of Macquarie Perch captured in King Parrot Creek at Burslem's Bridge, during February 2009.

Tree clearing was observed along King Parrot Creek (Plate 4) and many other waterways in the fire ground. Large mulch piles were also established beside King Parrot Creek (Plate 5).

Plate 4. Tree removal, King Parrot Creek, March 2009 *Plate 5. Mulch pile, King Parrot Ck, March 2009*

Barred Galaxias

Barred Galaxias have been collected from drought and fire-affected sites in the past, successfully maintained in aquaria at ARI and subsequently returned to natal streams once habitat had improved (Raadik *et al* 2009). This previous experience supported similar action in this case, with fish collected for temporary captive maintenance (TCM) from eight of the 12 impacted populations. Fish could not be located from one population (with the creek dry), another was still in TCM from the 2006-7 fires, and two populations were considered safe in the wild as the catchments had only been lightly burnt (DSE 2009e).

Fish were collected as follows:

Site	Number of fish collected
Robertson's Gully	6
S Creek	56
Upper Taggerty River	80
Little Rubicon River	46
Keppel Hut Creek	56
Luke Creek	76
Criss Cross Creek	0 (dry)
Kalatha Creek	0 (mostly not fire affected)
Stony Creek	0 (mostly not fire affected)
Torbreck Creek	4
Rubicon River	70
Total:	394

All fish were transported to the Arthur Rylah Institute (ARI, DSE) Heidelberg, where each population is housed in a separate aquarium with separate chilled, recirculating water systems.

A Trout barrier installed in Leary's creek was also damaged by the fire and has been repaired (Plate 6). Other known barriers are being assessed.
Subsequent rain events have resulted in significant sediment mobilisation in some of the fire-affected Barred Galaxias sites (Plate 6).

Plate 6. Sediment mobilisation in Leary's Creek (downstream of Robertson's Gully), and damaged Trout barrier, Marysville township, April 2009

Key messages

1. Thirty five Macquarie Perch were collected from fire affected King Parrot Creek at Burslem's Bridge and successfully translocated to aquaculture facilities at Snobs Creek Centre (DPI) in February 2009.
2. Twelve fire-affected Barred Galaxias sites were assessed and a total of 394 fish were collected from eight of those sites. "Rescued" fish were transferred to recirculating aquaria facilities at ARI, DSE in February - March 2009.

3. Signs of fish stress were evident most probably as a result of recent bushfires and low flow conditions.
4. The success of this translocation project was aided by ongoing monitoring which identified locations where Macquarie Perch were most abundant within King Parrot Creek, and where Barred Galaxias occurred in streams within the fire ground.
5. Tree clearing along waterways may further delay riparian vegetation rehabilitation.
6. Staff with specialist knowledge of natural asset values can provide valuable information to support decision making during fire suppression, rehabilitation and recovery phases. Close involvement in fire campaigns and planning can also support informed decisions on emergency recovery actions such as translocations.

Management / Research Recommendations

- Plan for this year – another extreme fire season is predicted, as a consequence of ongoing dry conditions
- Gain approval for fish translocations in severe circumstances. Establish translocation approvals in advance for likely scenarios, which can be immediately effected at agreed triggers.
- Involve staff with natural values knowledge in all fire phases and establish asset registers to enable efficient identification of key values, threats and actions.
- Staff with relevant knowledge must actively engage with the responsible agencies to attempt to mitigate the potential impacts of salvage logging to Barred Galaxias catchments and populations.
- Are the populations of threatened species sustainable (both in the face of fire and drought)?
- What are the downstream impacts of fire-related sediment in streams?
- What is the current status of existing barriers and have new barriers formed?
- How can isolated populations recover after such devastating events? Are there processes by which this can be aided?
- Investigate species resilience in a changing climate.
- Support community advocacy for threatened species and continue to build understanding of the importance of riparian vegetation.

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Macquarie Perch in the King Parrot Creek and advice on additional potential sites. We also thank Victoria Police for approving access to Barred Galaxias sites in the Marysville district whilst the area remained closed as a crime scene.

Assessing Inland Acid Sulfate Soils

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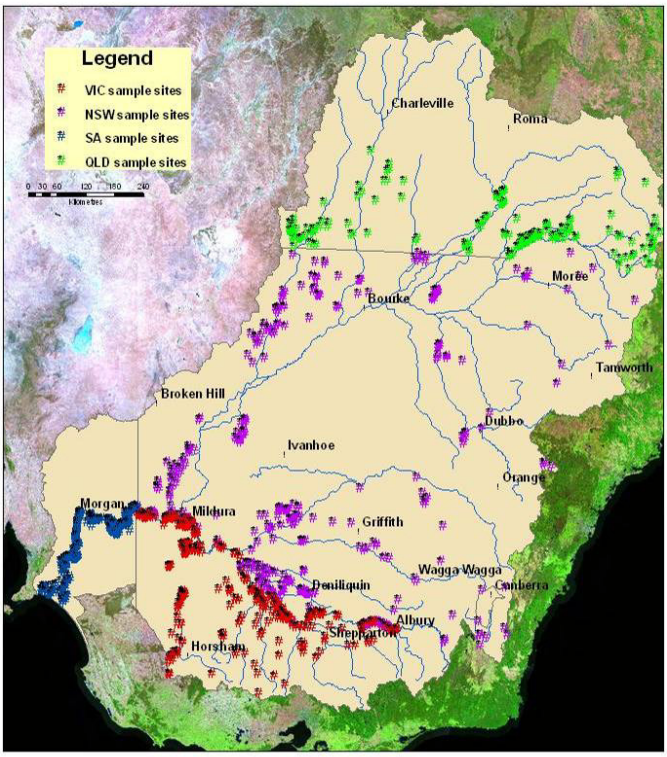
Objectives / Background

Acid sulfate soils (ASS) form naturally when sulfate-rich water (e.g. saline groundwater, sea water) mixes with sediments containing iron oxides and organic matter. Under waterlogged, anaerobic (oxygen-free) conditions, bacteria convert sulfates to sulfides. These sulfides react with metals to form sulfidic sediments. If left undisturbed and covered with water, sulfidic sediments pose little threat. When exposed to oxygen, such as under drought conditions, chemical reactions may lead to the generation of sulfuric acid. When these sulfuric sediments are re-wetted and the amount of sulfuric acid produced exceeds the buffering capacity of the system, there is a risk that significant amounts of sulfuric acid may be released into the water, impacting on the health of the wetland. Other risks associated with acid sulfate soils include mobilisation of heavy metals and rapid deoxygenation of the water column.

Whilst ASS has been the subject of research, management and policy development in Australia's coastal environments for a number of decades, it is only in the recent years that the potential threat to inland aquatic environments has been recognised. Record low inflows and river levels in the Murray-Darling Basin in recent years have led to the drying of many permanent wetlands resulting in the exposure of acid sulfate soils and the risk of acidification in some wetlands. The potential extent and threat posed by inland acid sulfate soils requires urgent assessment.

In 2008, the Murray-Darling Basin Ministerial Council requested an urgent Basin-wide assessment of the threat posed by acid sulfate soils to key wetland environments. This assessment, the Acid Sulfate Soils Risk Assessment Project ('the Project'), aims to assess the spatial extent of, and risk posed by, acid sulfate soils at priority wetlands in the Murray River system, Ramsar wetlands and other key environmental sites in the Murray-Darling Basin, and to identify and assess management and mitigation options.

A panel of experts and wetland managers identified which wetlands should be included in the Project from the tens of thousands in the Murray-Darling Basin. Selected wetlands include those of ecological significance as well as those that may pose a threat to the surrounding environment if they are affected by ASS.
The Project involves a three-tiered assessment approach aimed at identifying sites with an increased likelihood of ASS. A desktop assessment, the first of these assessment levels, was carried out on 19,000 wetlands, which identified approximately 1,500 wetlands requiring further investigation. Using a method developed for the Project, these wetlands have now been assessed using a rapid on-ground sampling approach, the second tier of assessment. This rapid on-ground assessment involves field and laboratory measurements of water quality and wetland sediments. The data from these rapid assessments will determine whether the third and final level of assessment will be required at a wetland to conclusively determine the presence and risk of ASS. This detailed assessment will be carried out by ASS scientists in consultation with wetland managers, and will allow conclusions to be drawn as the extent of risk posed by ASS to key wetlands of the Murray-Darling Basin.


Legend
VIC sample sites
NSW sample sites
SA sample sites
QLD sample sites
Charleville
Roma
Moree
Bourke
Tamworth
Broken Hill
Dubbo
Ivanhoe
Orange
Morgan
Mildura
Griffith
Wagga Wagga
Deniliquin
Canberra
Albury
Shepparton
Horsham
MDBA Wetlands Unit

Methods for Discriminating Hatchery Fish and Outcomes of Stocking in the Murray-Darling Basin

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[2] Industry and Investment NSW.

Objectives / Background

Over the past 30 years, it is estimated that more than 60 million native fish have been stocked into the Murray-Darling Basin to enhance fish populations. Although stocking of hatchery-reared fish continues to be used as a major management tool for inland fisheries, very little is known of the fate of stocked fish or their impacts on resident fauna. The outcomes of stocking and methods for discriminating hatchery fish have been identified as key research needs in the Murray-Darling Basin Authority's Native Fish Strategy. This project forms part of the implementation of the Native Fish Strategy by addressing research needs related to the outcomes of native fish stocking.

Project outcomes

- Identified and documented legislative requirements for registering the use of calcein, alizarin red S and other chemical agents for marking hatchery fish in Australia (e.g. Food Standards Australia and New Zealand, and the Australian Pesticides and Veterinary Medicines Authority).
- Tested and refined new methods (including brood stock injection, osmotic induction marking and isotope immersion) at relevant scales for routine use in government and privately operated hatcheries.
- Developed a portable detection unit to allow for routine, non-lethal detection of marked fish in the field.
- Conducted experimental stocking of chemically marked fish and undertaken field sampling to determine the contribution of stocked fish to populations.
- Documented the findings of the research, and implications thereof for fish stocking and conservation and recreational fisheries within the Murray-Darling Basin.
- Initiated co-ordinated basin-wide implementation of chemical marking protocols via “Chemical Marking of Hatchery Fish: Techniques and Applications” workshop for key stakeholders and practitioners.

The 'Sea to Hume' Program – Monitoring to Inform Natural Resource Management

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[2]NSW Department of Primary Industries,
[3]SARDI Aquatic Sciences

Objectives / Background

The construction of dams, weirs, locks, and hydroelectric power stations interrupts important ecological processes essential for maintaining healthy environments. In Australia, such construction has reduced aquatic biodiversity including native fish populations by reducing opportunities for migration and dispersal. In light of this, the Murray-Darling Basin Commission (now Authority) initiated a program to improve fish passage to over 2000 km of the Murray River, from the 'Sea to Hume Dam' by installing 14 new fishways (Figure 1). The program was established with a concurrent monitoring program which had five main objectives:

- To determine if the fishways are reducing fish accumulations downstream of weirs
- To assess if fishways are appropriately designed and located
- To assess the ecological performance of each fishway
- To assess improvements to the Murray River fish community post fishways
- To improve the functionality of existing fishways

A team of freshwater fish scientists from three states within the Murray-Darling Basin (NSW, Victoria, South Australia – tri-state collaboration) were assembled to quantitatively assess fishway performance and any associated longer term benefits from improved fish passage. The tri-state research team were to test four major questions:

(1) are the fishways optimally designed, located and operated;
(2) are accumulations of fish downstream of barriers being reduced;
(3) are the fishways enabling passage of a wide size range (40 to 1000 mm long) and the whole fish community; and
(4) are there positive changes in abundance and diversity of native fish in the Murray River post fishway construction.

Summary of findings

Summary of fishway assessments

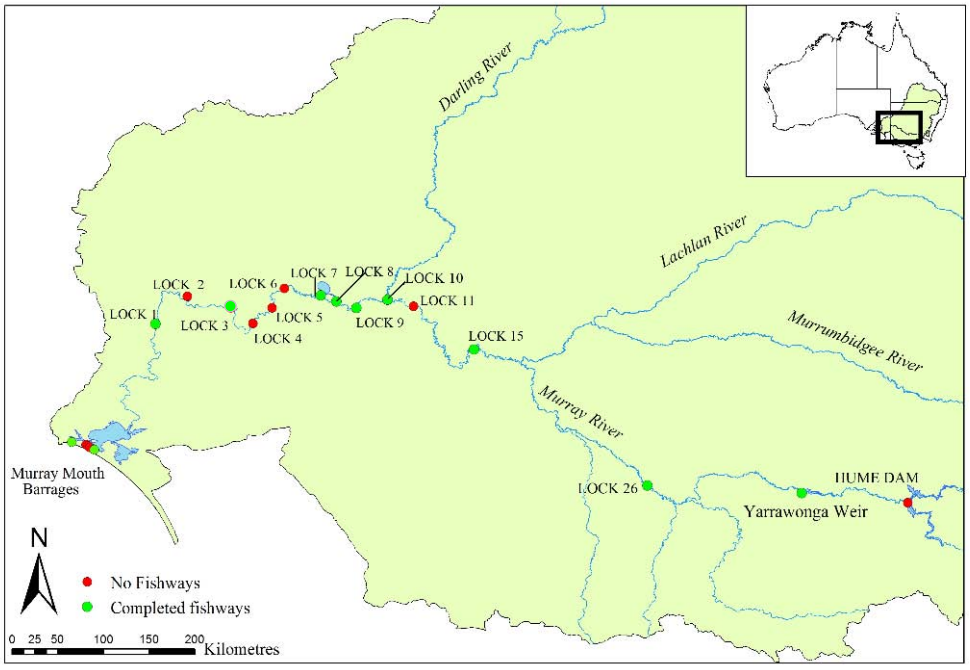
Since 2001, the tri-state team has conducted compliance monitoring at all completed fishway sites (Lock 7, 8, 9, 10, Goolwa and Tauwitchere) with the exception of Lock 3, which has only recently been completed, and Lock 1, which has not been fully operational since it was opened due to extremely low tailwater levels. Fishway assessments have revealed the following: Since 2001, the tri-state team has conducted monitoring at all completed fishway sites (Goolwa, Tauwitchere, Lock 7, 8, 9, 10) with the exception of Lock 3, which has only recently been completed, and Lock 1, which has not been fully operational since it was opened due to extremely low tailwater levels. Fishway assessments have revealed the following:

- A large number of fish, species and size-classes utilise the fishways.
- A large biomass of fish seasonally ascend the fishways, with flow and temperature being critical factors for species such as golden perch, silver perch, bony herring, Murray cod and carp.

- The fishways are out-performing design specifications with fish <40 mm and >1000 mm in length using the fishways. Unlike many fishways elsewhere in the world, the fishways constructed on the Murray River (1:32 slope) are helping to restore fish passage for smaller sized fish.
- Large numbers of small-bodied fish attempt to ascend fishways, but knowledge of the migratory ecology of small-bodied fish species remains limited.
- Baffles (mid-water) inserted into a vertical-slot fishway can help to reduce water turbulence and so may increase the passage of small-sized fish.
- Large vertical-slot fishways at Goolwa and Tauwitchere are effective in passing large-bodied freshwater fish, but high velocity/turbulence appears to be preventing the ascent of small-bodied fish.
- Non-native carp can be readily trapped in fishways and high biomasses can be removed.

The findings combined with monitoring (electrofishing) of fish populations downstream of Locks 1, 2 and 3 (data not shown here), indicate that the activities carried out under the 'Sea to Hume' program are facilitating the decrease of native fish accumulations downstream of weirs after fishway construction. This trend is expected to improve spawning migrations and dispersal opportunities for fish populations in the Murray River.

Figure 1. Map of the Murray River highlighting the location of existing and future fishways.



Evolution of Sea to Hume fishways

The 'Sea to Hume' program has promoted the installation of fishways (1:32 slope) with lower water velocities and turbulence than the traditional 1:18 vertical-slot fishway such as that constructed at the Torrumbarry weir in the 1980s. The Torrumbarry weir fishway is known to pass fish > 90 mm, however fishways constructed as part of the 'Sea to Hume' program pass fish as small as 40 mm and in excess of 1 m. The success of the 1:32 slope design, with increased floor roughness to assist the passage of small-bodied fish and crustaceans, has resulted in it being used at Locks 1, 7, 8, 9 and 10.

One of the major ecological findings of the current program, the extent and biomass of small-bodied fish attempting to migrate, presents a particular challenge for fishway design. To pass small fish the slope or gradient of the fishway can be reduced, which reduces water velocity and turbulence, but this adds to fishway length and capital cost, and may decrease attraction for large-bodied fish. A series of vertical-slot fishway turbulence/lock experiments was undertaken with the objective of achieving greater functionality in passing small-bodied fish while keeping the length of the fishway the same. As a result of this research the 'dual fishway' (a 1:18 vertical-slot and small fish lock) was developed. As such, a dual fishway has recently been completed at Lock 3 and will be incorporated into future fishways (at Locks 2, 4, 5, 6). The exception to this is Lock 11, where a denil fishway and a fishlock will be installed due to the physical nature and limited lifespan of the current weir.

The adaptive management approach to fishway design adopted by the Murray-Darling Basin Authority and the Fish Passage Task Force has resulted in constant improvements to fishway design as the construction program has progressed. Two examples of how research and adaptive management have resulted in the evolution of fishway design are detailed below. The first details how research was used to develop an operating protocol for the Lock 3 fishlock, while the second investigates the effects of light intensity on fish movement through a fishway.

Diel movement patterns of small-bodied fish and the development of an operating protocol for the Lock 3 fishlock

The Lock 3 fishway design represents a major departure from the 1:32 vertical slot fishways constructed during the initial stages of the 'Sea to Hume' program. Lock 3 incorporates a high gradient fishway (1:18) for large fish (>100 mm length) and an automated fishlock for small-bodied fish (<100 mm). To ensure the new fishlock is operated efficiently the tri-state team investigated the diel movement patterns of small-bodied fish at Lock 8 between February and March 2009. The aim of the study was to develop an operating protocol for the new fishlock at Lock 3. Six treatments were tested to document diel movement patterns: dusk (16:00-20:00), twilight (20:00-24:00), night (00:00-04:00), dawn (04:00-08:00), morning (08:00-12:00) and afternoon (12:00-16:00). The fishway was trapped for 1 hour each during each treatment. All fish captured were identified and a sub-set weighed and measured.

Key messages and Management / Research Recommendations

- A total of 407,775 fish were captured representing 7 native and 1 non-native species (Table 1). A total of 236,784 freshwater shrimp and prawns were also captured.
- Length frequency analysis revealed the presence of a wide range of size-classes and cohorts of small-bodied fish species.
- The experiments at Lock 8 revealed the presence of a diel movement pattern in small-bodied fish, as well as in small individuals of larger bodied fish species (Figure 2). Most fish were captured (in order of increasing abundance) during morning, afternoon and dusk treatments. In contrast, most freshwater shrimp were captured during twilight and night treatments.
- A large number of small-bodied fishes (>400,000) and shrimp attempted to move upstream during the experiment. Therefore, the provision of upstream passage for small sized fishes and macroinvertebrates is important for the health of the overall fish community.
- The diel movement pattern observed forms an important base for the development of the operating protocol for the new fishlock at Lock 3, and is reflected in the recommended cycling for the new fishlock.
- Based on the results, 16 x 90 min fishlock cycles are proposed for each 24 hour interval. The fishlock operation for each single cycle consists of a four-phase process. The proposed 90 min cycle currently assumes a default phase-timing as follows:
    1. Attraction phase: 30 min,
    2. Filling phase: 20 min,
    3. Exit phase: 30 min, and
    4. Transition phase: 10 min.
- This protocol has been provided to SA Water for programming the Lock 3 fishlock. The tri-state team plan to optimise efficiency and functioning of the fishlock at Lock 3 in 2009/10 through a series of experiments.

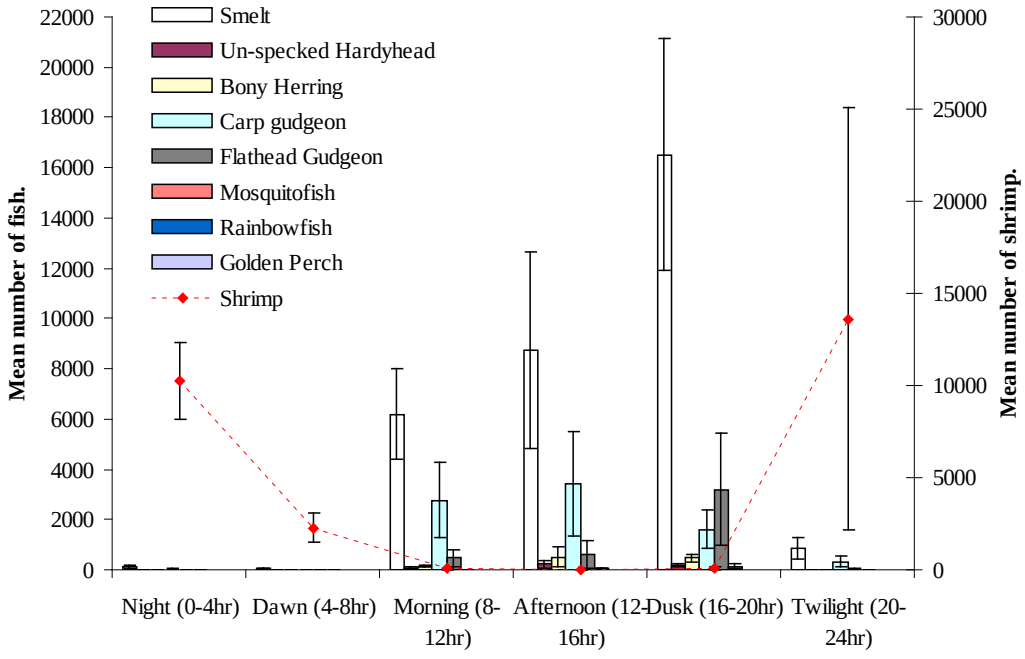


Figure 2. Mean number and standard error bars of fish species (primary y-axis) and freshwater shrimp (secondary y-axis) trapped at Lock 8 during February and March 2009 presented for each diel treatment.

Table 1. Total numbers of fish and freshwater shrimp, mean, standard error (S.E.), minimum and maximum lengths for fish species captured at Lock 8 fishway during February and March 2009.

	Species	Number of fish	Mean Length	S.E.	Min Length	Max Length
Small bodied species	Australian smelt	283,243	35.2	0.1	24	71
	Un-specked hardyhead	4,616	27.0	0.3	17	56
	Murray-Darling carp gudgeon	70,076	31.5	0.1	10	62
	Flat-headed gudgeon	38,221	40.3	0.7	18	87
	Murray-Darling rainbowfish	36	59.8	4.3	42	77
	Eastern gambusia (Non-native)	2,060	28.7	0.2	19	46
Large bodied species	Bony herring	9,509	53.4	1.9	21	356
	Golden perch	16	315.5	11.4	195	352
Total catch during the experiment		407,775				
Freshwater shrimp (*Paratya australiensis*, *Macrobrachium* spp.)		236,784				

Light Experiment

The strong link between fish movement through a fishway and diel time period suggests that light intensity may be influencing the movements of small-bodied fish through fishways. To quantify this, a short-term study was conducted at lock 8 in March and April 2009. Four different light treatments were tested: daylight (control), dark, low light intensity, and artificial light. The daylight treatment varied with ambient conditions, while the dark treatment was established by placing polyethelyne tarp over the fishway. Low light intensity was achieved with weed matting, and artificial lighting (Figure 3) was provided by placing between 2-5 florescent lights (daylight tubes) within each cell. Trapping ran for 1hr, with all fish being counted and identified.

Key messages and Management / Research Recommendations

- Over 64,300 small fish from six species were collected throughout the two week experiment (Table 2).
- Species included un-specked hardyhead, Gambusia, carp gudgeon, bony herring, flat-headed gudgeon and Australian smelt.
- Length-frequency analysis revealed the presence of a large range of size-classes.
- Light conditions varied significantly between treatments, however artificial light was not different from daylight, and the dark treatment was not different from the low light treatment.
- The results revealed that the number of small-bodied fish successfully ascending the fishway is impacted by light conditions. Fewer fish move through the fishway during dark and low light treatments compared with daylight and artificial light treatments (Figure 4).
- Importantly, the number of fish moving during the artificial light treatment was similar to the daylight treatment suggesting that artificial lighting may potentially be used as surrogate for daylight in fishways with low light intensities.
- In contrast to fish, the abundance of freshwater shrimp increased as light intensity decreased (i.e. dark, low light treatments).
- Similarly, it is also possible that artificial lighting may be advantageous in various culverts (i.e. low light levels) or fishways, however this requires further testing and refinement before being implemented.

- Future light experiment studies should include a range of fish species and size-classes, and if possible, the full range of aquatic fauna.

Figure 3: Artificial lighting suspended from the fishway grid mesh at Lock 8

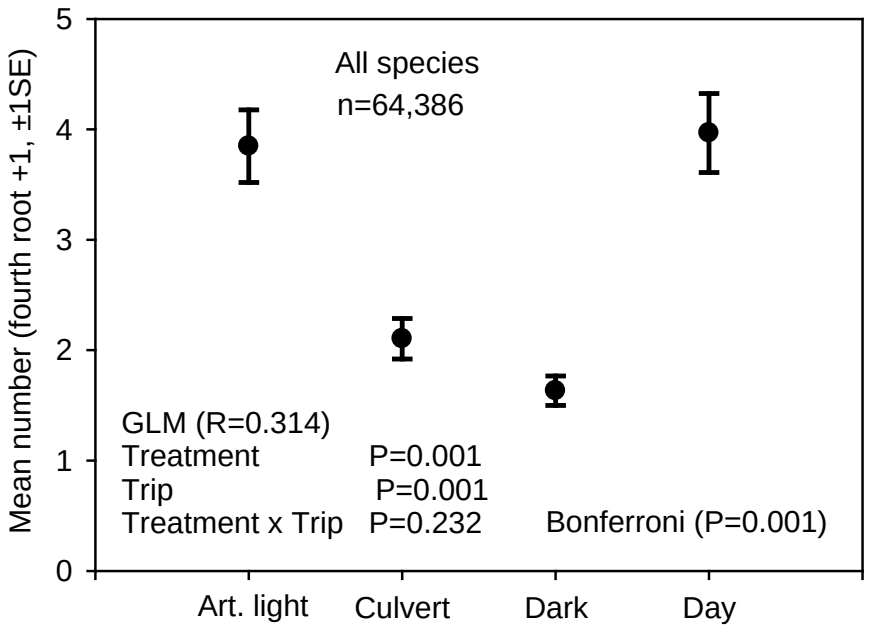


Figure 4: Mean number of fish (all species) captured during each treatment - fourth-root standardised per two hour sampling period.

Table 2: Total number of fish, mean, standard deviation (S.D.), minimum and maximum lengths, and mean weight (g) for fish species captured at Lock 8 fishway during March/April 2009.

Species	Number captured	Mean length (mm)	Minimum length (mm)	Maximum length (mm)	SD (±1)	Mean weight (g)
Un-specked hardyhead	479	35.7	19	58	8.2	0.4
Eastern gambusia	206	30.2	23	40	3.8	0.2
Carp gudgeon	3867	34.6	25	47	3.0	0.3
Bony herring	4421	57.2	25	328	44.6	1.8
Flat-head gudgeon	58	59.5	36	96	19.4	2.1
Australian smelt	55356	36.7	21	56	5.2	0.3
Total	**64,387**					

Acknowledgments

This study was funded by the Murray-Darling Basin Authority (NFS, TLM). The authors gratefully acknowledge guidance received from Martin Mallen-Cooper, Ivor Stuart, Jim Barrett, Ben Dyer, Lex Cogle, David Hohnberg, Stuart Little and the members of the Fish Passage Task Force. We would like to thank staff from all the locks for their assistance with field trials. Technical support was provided by Andrew Pickworth, Graham Hackett, Ian Magraith, John McKenzie and Jarrod McPherson.

Assessment of the Vaki Riverwatcher Infrared Fish Counter for Monitoring Performance of the Murray River Fishways

Lee Baumgartner[1], Mick Bettanin[1], Jarrod McPherson[1], Matthew Jones[2], Brenton Zampatti[3], Kathleen Beyer[3]

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[2]Arthur Rylah Institute, Department of Sustainability and Environment
[3]SARDI Aquatic Sciences

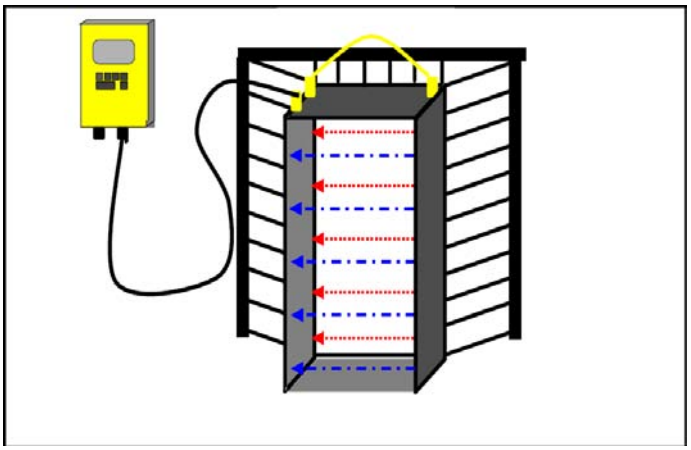
Objectives / Background

The Murray-Darling Basin Authority has made a major investment in Murray River fishways to restore fish passage between the Sea and Lake Hume. Evaluating the success of this program currently relies on capture-dependent techniques for collecting fish (e.g. electrofishing, netting, trapping and tagging). Trapping fish within fishways has disadvantages in that it is labour-intensive, fish are physically handled (potentially affecting behaviour) and some fish exhibit trap shyness. Fixed PIT tag reader systems have now been installed at Locks 7, 8, 9, 10, 15, 26 and at Yarrawonga Weir, providing automated data collection, however, a population of tagged fish must be maintained for this system to work over a long time frame, requiring additional costs for capture and implanting of tags. The development of reliable electronic systems that do not rely on fish capture may overcome these problems and make the monitoring of fishways a feasible and cost effective proposition in the long-term.

The latest assessment of innovative counting technology involved procurement of a new technology developed in Iceland; the Vaki Riverwatcher. This technology is basically an electronic fish counter which measures the size, date and shapes of fish which pass through an infrared scanner. The system comprises a scanner unit, display unit, storage cabinet and photo tunnel. The scanner unit generates the infrared grid and can be used in isolation or in conjunction with a photo tunnel. It consists of two scanner plates (200 x 600 mm) inside a frame, ranging from 100 – 450 mm apart. Inside the scanner, light diodes send infra-red light beams to receivers on the other side. Fish need to be directed through the scanner unit (540mm X 215mm X 35mm) to break the infrared beams. The unit can detect migrations in either an upstream or downstream direction by the way a fish interacts with the infrared beams. A phototunnel can be attached to the scanner unit and contains a video camera and lighting system. When fish are detected on the scanner unit, the phototunnel automatically activates and a five second video is recorded. An automated lighting system is integrated within the phototunnel which can allow video footage to be recorded at night, or in low light conditions.

The control unit receives and stores the information from the scanner and phototunnel via connection to a windows-based personal computer (Figure 1). Water temperature is measured at programmable intervals and the date and time of day that each fish passes the counter is also recorded. This allows fish movements to be correlated with environmental factors. Information generated by the scanner unit and phototunnel are then processed by control software which is a specialised database designed to interpret data generated by the scanner unit and phototunnel. The software collects information on fish size, time, date, swimming speed, water temperature and generates a silhouette outline of the migrating fish (Figure 2). This information is then processed and presented as a text and image summary of fish migrations whilst the unit is in activation.

The system can be installed in fish ladders, pools, traps or similar places where migratory fish may pass. Riverwatcher watcher systems are relatively energy efficient (power consumption; 210mA @ 12 volts) and can be can used with mains power or solar panels with a deep cycle battery. The system can also be connected via a modem if automated remote operation is desired and is designed to detect migrations of fish greater than a minimum body depth of 40mm. An assessment of an infrared fish was undertaken at Lock 10 (Wentworth, Murray River; below the confluence of the Darling River) in November 2008. If the automated infrared system proves to be an accurate and cost effective way of counting fish in fishways, it may provide an attractive option for the long-term monitoring of fish passage.



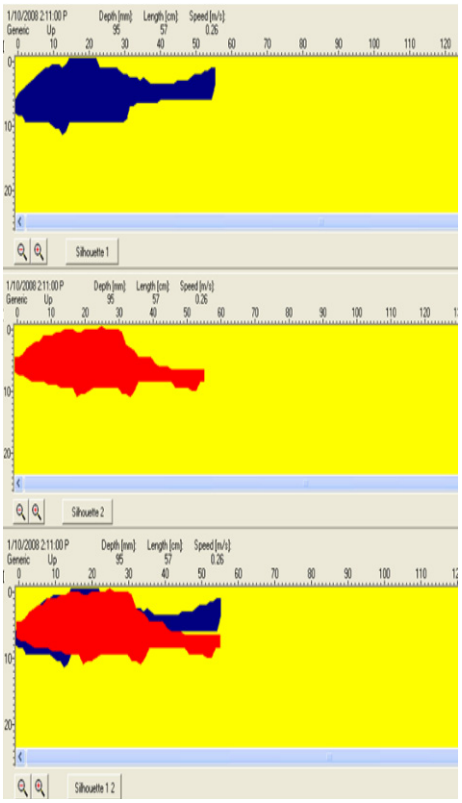


Figure 1. A diagrammatic representation of the scanner unit demonstrating the connections to the control unit. A cone was used to guide fish through the scanner unit. (Left)

Figure 2. Example of output from the control software. The software interprets information received from the scanner unit and presents individual fish detections as a silhouette. The output estimates the length and depth of the fish based on how the fish interacts with the beams. The average ground speed is also detected. These images were obtained from a Silver perch Bidyanus bidyanus used in this study. (Right)

Summary of findings

Turbidity trials

Turbidity trials were undertaken with adult Silver perch and were carried out in 2,000L tanks in the hatchery facility at the Narrandera Fisheries Centre. The trials sought to determine if the operation of the Vaki Riverwatcher unit was compromised by increased turbidity levels. The project team undertook experiments at manipulated turbidity levels 0, 50, 100, 150, 200 and 250 nephelometric turbidity units (NTU). The team also tested manipulated migrations rates to determine if the unit operated under peak levels of fish migration. Experiments were performed at each level of turbidity where different numbers of fish were passed through the unit (1, 5, 10). Each combination of fish number and turbidity was replicated 5 times. The total number of fish reported by the Vaki Riverwatcher and the estimated length of fish was recorded.

Data analysis is yet to take place, however, in general the Vaki Riverwatcher was successful in detecting fish under a range of conditions. The unit was particularly precise at low turbidity and during periods of low-moderate fish passage. The detection distance decreased as turbidity increased and fish were occasionally missed by the unit. The unit also failed to count all fish when many fish passed through the unit simultaneously. If used in the field, this could result in underestimation of fish passage. Once analysed, data will be used to estimate the degree of error and comment on applicability for wider applications.

Field trials

Field trials took place at Lock 10 in late 2008. Work involved installing two DIDSON units, a Vaki Riverwatcher and a split-beam hydroacoustic unit at the exit of the Lock 10 fishway. The units were set up to monitor fish passage past the last baffle. The fish trap was used intermittently to validate Vaki Riverwatcher readings and to also validate length data obtained by the Vaki Riverwatcher. Work was labour intensive and required the use of 4 laptops and three software platforms to record the data. More than 400 hours of data were logged and project staff now need to review all data (time for time) to interpret the results in a fish passage context. Field observations were generally better than predicted from laboratory trials. The site was characterised by high turbidity arising from high inflows from the Darling River at the time. Despite this turbidity, the Vaki Riverwatcher was successful at providing information on several hundred migratory fish. Vaki Riverwatcher information was validated by trap catches and overall discrepancies between automated counts and actual captures were low.

Key messages

- The Vaki Riverwatcher presents a useful technique to automatically count fish migrations
- The system worked well but was limited when turbidity was high
- There was some evidence of fish avoidance which may be overcome by removing the phototunnel

Management / Research Recommendations

A long-term installation should take place within a fishway in the Murray-Darling Basin to monitor upstream and downstream migrations to prevent physical interference with individuals from trapping and manual handling.

Acknowledgments

This study was funded by the Murray-Darling Basin Authority under the Native Fish Strategy's 'Innovative Fish Counting' initiative. A Fish Passage Task Force comprising representatives from several jurisdictions acted as a 'pseudo' steering committee for the project. The authors gratefully acknowledge guidance received from M. Mallen-Cooper, I. Stuart, J. Barrett, B. Dyer, B. Cooper, A. Berghuis, B. Erdmann, R. Alia. We would like to thank staff from Lock 10 including N. Boyd, J. Pappin and D. Bourke for assistance with field trials. Technical support was provided by A. Pickworth, G. Hackett and I. Magraith. All work was undertaken in accordance with Animal Care and Ethics Permit (ACEC 01/15).

Impacts of Weirs on Downstream Movement of Native Fish in the Murray-Darling Basin

Lee Baumgartner, Mick Bettanin, Jonathon Doyle, Justin Stanger

NSW Department of Industry and Investment

Objectives / Background

Two major weir designs, undershot and overshot, are constructed on Australian waterways. Undershot weirs are usually operated via steel gates and water is released underneath the weir. Overshot weirs are usually constructed from concrete or wood and water cascades over the weir crest. Many weirs that were constructed in the early 1900's were of overshot design and are currently being upgraded to undershot designs to comply with OH&S requirements and to minimise maintenance. NSW DPI recently undertook some small scale experiments, using Murray cod and Golden perch larvae, on a low-level weir in an experimental channel and determined that undershot weirs caused the death of 95% (Golden perch) and 52% (Murray cod) larvae that passed under the weir. In contrast, mortality due to overshot weirs was only 1.5%. These results demonstrate potentially catastrophic effects of undershot weirs on native fish populations but further research is needed to determine if such mortalities are equal across all species and size classes of native fish.

To obtain results that are more widely applicable to the management of other structures throughout the Murray-Darling Basin, NSW DPI and the Murray-Darling Basin Authority have recently commenced a more comprehensive, 3-year research project. The project, being undertaken at the Narrandera Fisheries Centre, will assess downstream movements of native fish through both types of weir but under a wider range of flows and river conditions. Specific aspects of weir operation, such as discharge and tailwater depth, will be manipulated to determine any adverse effects on fish. Researchers will do trials with more species to try and develop general weir operating protocols that minimise the risk of injury or mortality. Additional species will include Australian smelt, Unspecked hardyhead, Murray rainbowfish and Carp gudgeon.

Work is being undertaken at Balranald Weir on the Murrumbidgee River (Figure 1). In 2003, a fishlock was constructed at the weir which incorporates an adjustable internal weir. The internal weir can be manipulated over a variety of heights (0-3m) and be configured as either overshot or undershot by simply changing the position of adjustable drop-boards. The fishlock also has manually operating upstream and downstream gates which permits discharge and tailwater level to be accurately controlled at the weir. The operational flexibility of this structure, and the close proximity to Narrandera, provided an excellent experimental facility to undertake experiments seeking to quantify injuries and mortality of downstream migrating fish.

The overall objectives of this work are:

- To understand the effects of undershot and overshot weirs on species of MDB fish
- To document the survival of different species and size classes as they pass through different weir configurations.
- To develop techniques to improve the survival of these fish as they pass through the structures

- To identify current management practices used to ameliorate any potential impacts of dams and weirs
- To provide management recommendations for future construction and operation of dams and weirs, especially for structures to be constructed under the living Murray.

Summary of findings

Murray cod, Silver perch and Golden perch

Field trials have provided relatively consistent results for different life history stages of these species. Larvae of Silver perch were extremely intolerant to passage through undershot weirs with greater than 90% mortality (Figure 1). Mortality rates reduced substantially when discharge decreased and was further reduced when water was discharged through a small gate opening into a deep tailwater. This observation suggests that limiting undershot gate discharge during times of expected larval drift could improve survival for these species. Mortality associated with overshot weir passage was substantially lower for all three species. Mortality was greatest when high discharges occurred into a shallow tailwater, possibly due to physical contact with the downstream apron. Survival is substantially higher during overshot passage into a deep tailwater.

Juvenile Golden perch were impacted by passage through both undershot and overshot weirs during high discharges into shallow tailwater. Mortality associated with passage into deep tailwater was low suggesting that the provision of a deep downstream plunge pool could be a useful management technique to increase the survival of juvenile life history stages. Passage of adult fish showed consistent results among species where extremely low mortality rates were observed irrespective of undershot or overshot weir. Although few fish died, many exhibited injuries such as lateral compression, when fish were physically impinged beneath the gates. Overshot weir passage resulted in lacerations and bone damage arising from physical contact with the downstream apron.

Small-bodied species

Impacts of overshot and undershot weirs were remarkably similar among species of small-bodied fish. Mortality of Australian smelt and Unspecked hardyhead was substantial during passage through high discharge undershot weirs irrespective of tailwater level (> 90%; Figure 2). Similar patterns existed for undershot weir passage of Carp gudgeon and Murray rainbowfish although the average mortality was much lower. These four species were particularly resilient to passage through overshot weirs. Overshot mortality was lower overall, although small discharges into shallow tailwater were problematic for Unspecked hardyhead and Australian smelt (Figure 3).

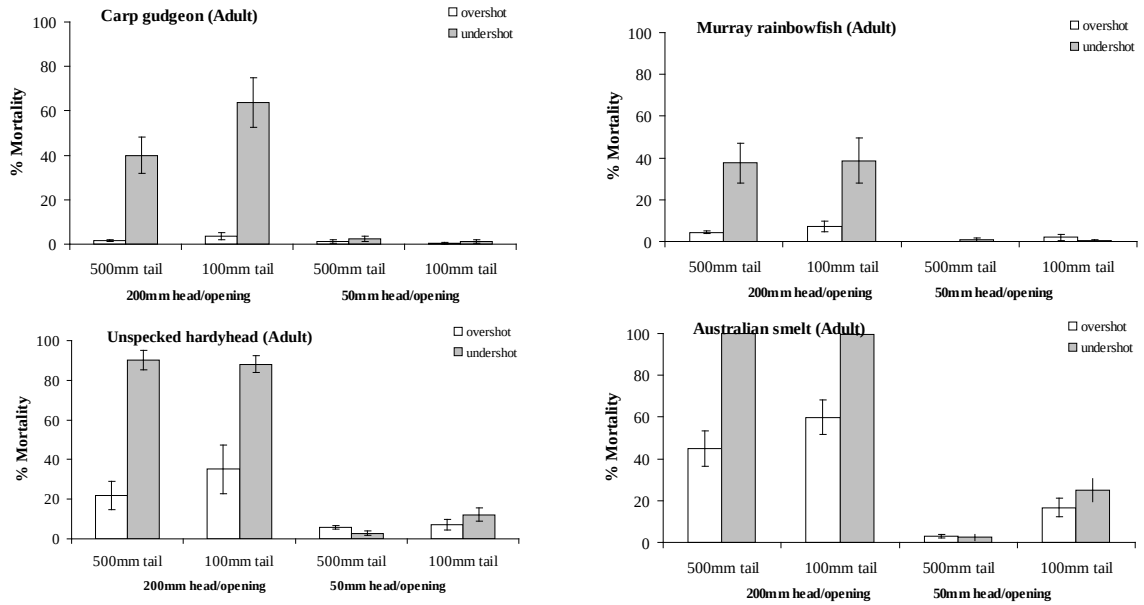


Figure 3. Mortality associated with undershot and overshot passage for adult individuals of small-bodied species.

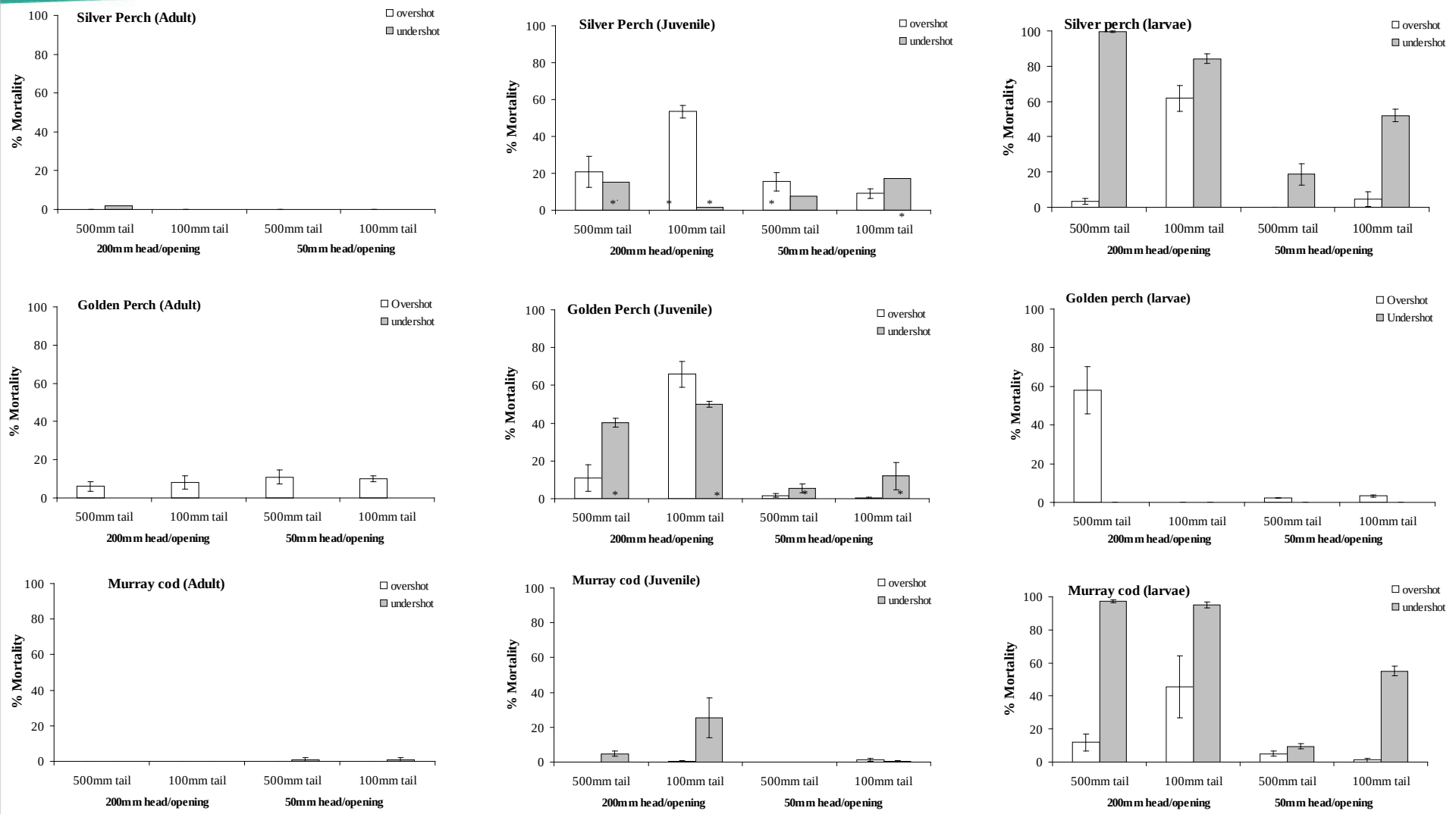


Figure 2. Summary of average mortalities for Murray cod, Golden perch and Silver perch (adult, larvae and juvenile) passing through undershot and overshot weirs.

Hydraulic bumper testing

Two physical hydraulic modifiers were retrofitted to undershot weirs to try and reduce injury and mortality. The first was a 'bumper' to be added to the base of the undershot gate to reduce shear at the gate edge (Figure 4). The second solution was a sloped dissipater sill (Figure 4) which will aim to slow the velocity of water on the downstream side of the weir. Both of these modifiers were simultaneously retrofitted to undershot gate at Balranald Weir and then assessed for improvements in survival. Trials were undertaken on juvenile and larval fish as previous work determined these were the most susceptible to mortality.

Work focused on juvenile life history stages which were deemed most susceptible to injury and mortality through undershot weirs. The hydraulic bumper and the sloping sill were retro-fitted to the undershot weir. Water was released into the experimental area and fish were introduced after 10 minutes. Fish were given another 10 minutes to pass through the facility. The experiment was then terminated and fish were processed. Data were plotted for both juvenile golden and Silver perch. In both cases, the presence of the hydraulic bumper actually increased mortality during high discharges. Passage through the unmodified undershot gate provided low mortality of Silver perch (<20%) but moderate mortality for Golden perch (<50%). When the hydraulic bumper was retrofitted, mortality in both Golden perch (>90%) and Silver perch (>50%) was substantial (Figure 5). The presence of the bumper was also associated with increased mortality during low discharges, but only when tailwater was low; a likely effect of the sloping dissipater sill.

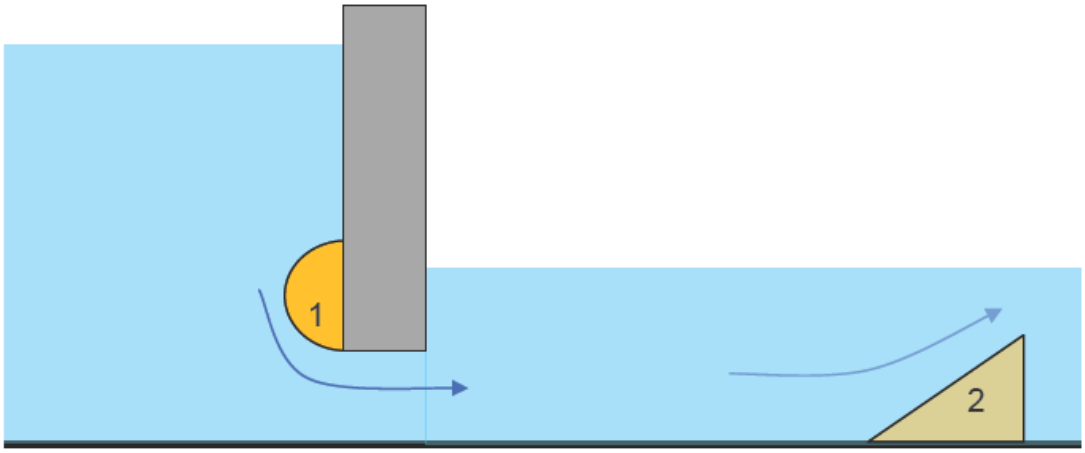


Figure 4. Diagrammatic representation of the hydraulic bumper (1) and dissipater sill (2) assessed for reducing mortality associated with downstream passage.

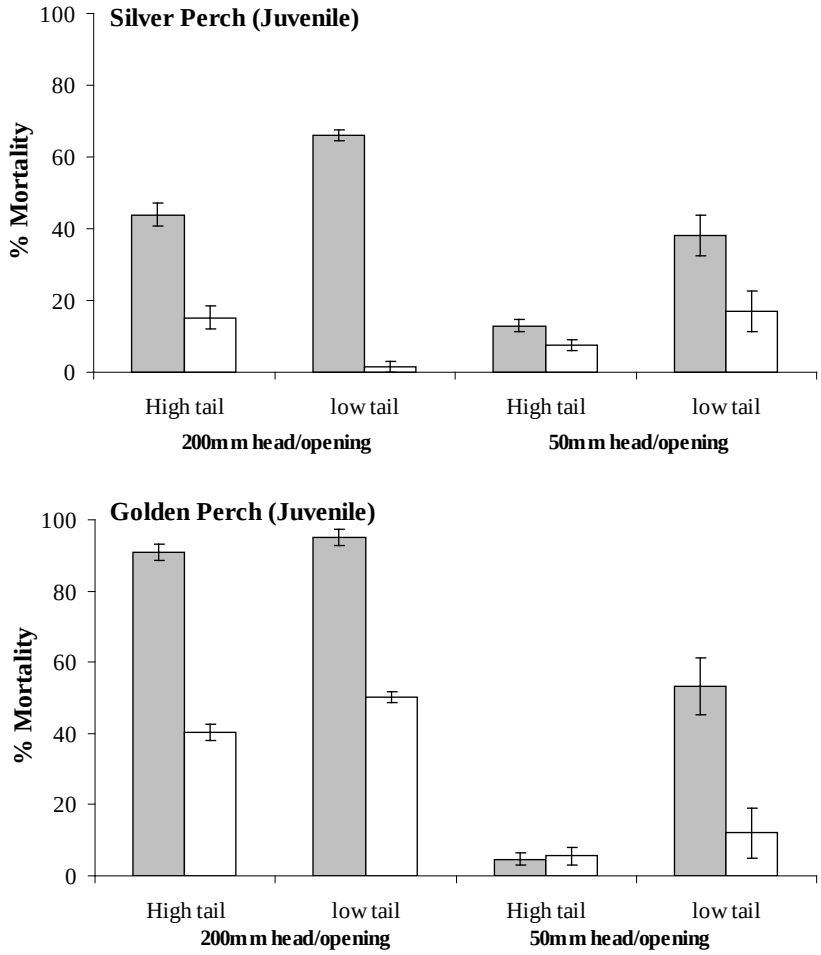


Figure 5. Comparison of mortality rates of juvenile Silver perch and Golden perch during 'normal' passage through an undershot weir (white) and through the hydraulic bumper (grey).

During low tailwater the sill is exposed and creates a 'ramp' effect. Water cascades over this ramp with high laminar velocities which likely disorients fish and creates a high risk of physical strike as the fish cannot maintain equilibrium. When tailwater is elevated, the 'ramp' effect is reduced as water levels inundate the sill (Figure 4). These observed increases in mortality initially suggest that the hydraulic modifiers are unsuitable as a mitigation method for undershot weirs. Low mortality rates during passage through overshot weirs continue to suggest that operational solutions will provide more effective mitigation techniques than mechanical retrofits. Final analysis of this data will yield some useful solutions that can be applied at a basin-wide scale.

Key messages

- Undershot weirs cause substantial injury and mortality of larval and juvenile fish
- Overshot weirs can also cause injury, especially when tailwater levels are low
- Initial trials to mitigate the impacts of undershot weirs have been unsuccessful
- Low discharges into deep tailwater was associated with low mortality for most species

Management / Research Recommendations

- Overshot weirs with deep plunge pools seem suitable for improving the survival of downstream migrating fish
- Further engineering options to reduce larval and juvenile mortality should be investigated, particularly for undershot weirs

References

Baumgartner LJ, Gilligan DM and Reynoldson N (2006). Mortality of Murray cod (*Maccullochella peelii peelii*) and Golden perch (*Macquaria ambigua*) associated with downstream passage through a low-level weir. Marine and Freshwater Research, 57: 187-191.

Acknowledgments

Funding for this project was provided by the Murray-Darling Basin Authority through the Native Fish Strategy and NSW Department of Industry and Investment. The project was supported by a steering committee comprising Martin Mallen-Cooper, Adam Vey, Heath Robinson, Brenton Zampatti, Stephen Thurstan, Jocelyn Karsten and Nathan Reynoldson. Jamie Hutchison, Jarrod McPherson, Chris Smith, Duncan McLay, Peter Heath, Les Rava, Peter McLean, Garry Graf and Leo Cameron assisted with fieldwork. Uarah and Silverwater fish hatchery both provided adult fish for use in the trial. Work was conducted under Animal Care and Ethics Permit ACEC 03/10.

Mitigating the Impact of Irrigation Offtakes

Craig Boys, Garry Giddings, Cameron Lay & Lee Baumgartner,
Industry and Investment NSW

Objectives / Background

Recent research by NSW Department of Primary Industries (Baumgartner et al. 2007) has shown that the physical extraction of native fish through irrigation pumps and bulk water diversion into irrigation canals is having a major impact upon the health of fish communities in inland rivers. In particular, large irrigation pumps were found to extract up to 200 native fish per day. The study conducted in the Namoi and Murrumbidgee Rivers showed that fish are either experiencing direct physical injury or mortality through interaction with pump turbines. Furthermore if they survive the extraction process, many fail to return to the source river and are effectively 'lost' from the main population.

The Murray-Darling Basin Commission, Industry and Investment NSW (I&I NSW, formerly NSW DPI) and Western CMA subsequently commenced a project which aimed to develop, implement and assess modifications to irrigation pump systems to mitigate these observed impacts on fish communities. The Namoi CMA and Cotton, Community and Catchment CRC have joined the project as additional funding partners, allow an expansion of the initial project.

The project specifically aims to:

- Document the range of existing technologies available internationally for reducing the loss of fish through irrigation pumps and assess their potential for adaptation to Australian conditions;
- Refine a list of potential pump modifications in conjunction with irrigation industry stakeholders and landholders, utilising their experience and expertise;
- Construct/purchase and install the range of preferred pump modifications at selected sites within inland river systems;
- Assess the effectiveness of different pump modifications (treatments) at reducing the loss of native fish over two irrigation seasons (2009/10 and 2010/11);

Summary of findings

The project is now at the completion of the scoping phases and is now entering the trial phase.

Scoping phase

A focus Group meeting with irrigators and project representatives from I&I NSW was held at the Australian Cotton Research Institute on the 1st April 2009 to finalise screen design. The stakeholders who were present and contributed included cotton growers, Lower Namoi Cotton Growers Association, Namoi Water, Gwydir Valley Irrigators Association, engineers and I&I NSW Irrigation Officers.

The meeting provided the project team with some excellent information regarding design issues and potential logistical constraints that would be associated with the trial. Important feedback from industry representatives included:

- Discussion regarding the maintenance requirements associated with the trial and the target velocities to prevent debris accumulating on the experimental screens.
- Issues of depth and submergence of the experimental screens and the ability to find suitable sites with sufficient depth to trial the screening options.
- Input regarding the choice of materials and the suitability of certain mesh products for the task.
- Advice that the irrigation industry would accept the results from a trial that involved a smaller pump (i.e. 16 inch) than the initial proposal (i.e. 20 inch). This improves the manageability of the experimental set-up without compromising the validity of the results within the irrigation industry.

- Willingness of pump suppliers and manufacturers to become involved in the development of the screens and experimental pump set-up.
- Willingness of cotton growers to provide access to their properties for experimental site.
- Communication brochure to be produced by NSW DPI outlining the major objectives of the offtakes project.

The scoping phase has resulted in a screen design that will allow stainless steel panels of various mesh sizes (5mm, 10mm and 20mm) to be trialled (Figure 1). Removable screens will allow the research team to adjust the aperture of the mesh, whilst also being able to adjust the surface area of the screen. This was essential because the velocity experienced at the screen is a function of both the mesh size (permeability of screen) and the surface area of screen. The surface area of the screen can be adjusted using blank panels (zero permeability).

Figure 1: Final screen design showing removable mesh panels that will allow both the aperture size to be changed and the surface area of screen to be adjusted.

Trial phase

The last 12 months have been spent refining the trial design in close consultation with the steering committee to ensure that both the screen design and the experimental trial design complement each other and can produce results which are both ecologically relevant and acceptable to the irrigation industry. Under the original proposal, the Murray-Darling Basin Authority and Western CMA agreed to fund a Before/After/Control/Impact (BACI)-style trial in the Darling River near Bourke. At the inception meeting (28th May 2008) of the project steering committee it was decided that a Darling River-focused study would lack geographic scope. Additional funding by the Namoi CMA and Cotton CRC has allowed an expansion of the trial into the Namoi River. The study now encompasses both the Bourke to Brewarrina and Namoi Demonstration reaches.

The original research proposal involved the testing of pump modifications on existing irrigation pumps. Therefore the success of any trial was contingent upon irrigators being able to pump at a level to satisfy the trial. Given the prevailing drought conditions, the risk posed by restricted pumping conditions was recognised from the outset and a review point was built into the workplan. At this review point, and subject to consultation with the steering committee, the trial would be delayed if flows were inadequate, until river conditions improved. Irrigator entitlements in the 2008/09 season were so low (0-10% in most areas) that those with an entitlement pumped for as little as two days. This was obviously insufficient to allow a replicated trial to be run.

It became apparent that little would be gained from delaying the trial in its current form. This is because after a 12 month scoping phase, the research team were unable to find a sufficient number of standardised fixed pump sites in the study areas to satisfy the experimental design. This problem was further exacerbated by the fact that many irrigators are risk averse during drought conditions and reluctant to allow un-trialled technologies to be used on their pump systems during what little time they do have to pump. Finally, the logistical and OH&S constraints of having researchers modify fixed pump intakes underwater during elevated irrigation flows were unanticipated and unsurmountable.

In response to these constraints, which made the original design and work plan untenable, an independent biometrician (Wayne Robinson USC) was engaged to assist in developing an alternative experimental design which circumvented these constraints and would allow a trial to be undertaken. The BACI design was replaced by a 'latin square' design which utilises a mobile pumping station (Figure 2) and allows the trial to be undertaken independent of irrigators and pumping rules. Without this design change the project was at very high risk of failure. The design change has since been endorsed by the steering committee and contract variations have been approved by the MDBA and Cotton CRC. Additional operating costs have been incurred as a result of this change, to cover the lease of the pump and cover consumables associated with the pumping station (e.g. skids, pipes, flanges, diesel and transport). These costs have been met through additional Native Fish Strategy funding.

5mm, 10mm and 20mm mesh will be trialled. It was decided that with current technologies, it would not be feasible to trial aperture sizes capable of screening larval fish and thus the trial will focus on juvenile and adults. Modelling using data obtained from Baumgartner's earlier offtakes project suggest that 5mm mesh may result in a 100% reduction in entrainment of juvenile and adult Golden perch, Bony herring and Carp, but only modest reductions in small bodied species such as gudgeon and smelt. In the end, it was not feasible to trial any aperture smaller than 5mm as this would require the screen to be made bigger, a scenario that was unacceptable to irrigators from both a logistical and financial standpoint.

As already explained, as aperture size changes, so does the velocity profile of the water surrounding the intake. This will affect both the discharge of water that can be pumped, and the subsequent surface area required of the resultant screen. The decision has been made to standardise water velocity at the screen among different treatments at two levels: 0.1m/sec (world standard for fish screens) and the more conservative 0.5m/sec.

The Steering Committee noticed that with the original design, the project will not be able to ascertain the following:

1. How many fish are getting entrained on the screen but not passing through into the net (mortality and injury may be underestimated)?
2. How is the velocity profile different among different treatments?
3. What are threshold velocities for the entrainment for different species and size classes and how do fish behave under different velocities?
4. How can entrainment be further reduced by altering variables other than aperture size of screen?
5. How does pump performance and velocities at the screen change throughout the trial as a result of screen fouling?

Being able to answer the above questions will enhance our understanding of the mechanisms and thresholds for entrainment of fish at screened and un-screened intakes and assist in developing better screens and being able to assure irrigators that pump performance will not be unduly affected.

These questions will now be answered using a combination of Acoustic Doppler Current Profiler (ADCP) measurements and subsequently cross referencing these to real-time observations of fish behaviour using DIDSON. Once key behaviours and velocity thresholds have been ascertained,

Computational Fluid Dynamics (CFD) modelling can be used to run various design scenarios to enable screen designs to be fine tuned without the need to construct and trial additional treatments in the field, thus leading to substantial improvements in outcomes with a relatively small increase in investment. Such an approach was recently employed with great success at Torrumbarry Fishway to gauge the relative effect of different bay treatments on turbulence and fishway performance.

A pilot trial was run in mid August to refine the experimental protocol. The trial proper will begin in September on the Namoi and move to the Darling next year. The DIDSON and Acoustic trials will be conducted in season two.

Figure 2: Experimental pumping station being tested during the pilot trial.

Key messages

- One screen design and a variety of mesh apertures (5mm, 10mm, 20mm) will be trialled. This approach has been developed with direct consultation with the irrigation industry. Something that will be essential in maximising the potential for later industry adoption of technologies.
- The trial proper will begin this September and run for 1 month in the Namoi River. The trial will then move to the Darling River in the following year.
- The original BACI-type design has been replaced by a latin square design to be conducted on a mobile pumping station.
- Velocity at the screen among different mesh treatments will be trialled at both 0.1m/sec (world standard for fish screens) and the more conservative 0.5m/sec.
- The trial will now utilise a combination of Acoustic Doppler, DIDSON and CFD technologies to better understand the mechanisms and thresholds for entrainment and impingement of fish at screens.

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Acknowledgments

Thanks to the project steering committee, including Martin Mallen-Cooper, Janet Pritchard and Guy Roth. Wayne Robinson has played a large part in helping to refine the trial design and conduct power analyses. A big thanks to Colin Barnes and the boys from BnB Engineering Narrabri for helping design and construct the experimental pumping station, as well as setting it up and moving it between trial sites. Thank you to all those irrigators and industry members who participated in the scoping phase. Last but not least, thank you to Dennis Smith, Ken Fraiters and all of the other landholders in Narrabri that have been most accommodating by allowing the trial to be undertaken on their property this year.

The Williams' Carp Separation Cage: New Innovations and a Commercial Trial

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Objectives / Background

Non-native Carp (*Cyprinus carpio*) are highly migratory and are expected to benefit from fishways being constructed to facilitate native fish passage as part of the 'Sea to Hume Dam fish passage program' (Barrett and Mallen-Cooper 2006). The Mark IV Williams' Carp separation cage has proven effective for separating adult Carp from native fish as they passed upstream through Torrumbarry fishway (Stuart et al. 2006) where the native fish are automatically released unharmed. However, the Williams' cage system has not been tested under conditions of high Carp biomass, such as those expected to occur at fishways in the Lower Murray River. Additionally, the Mark IV design requires application in a straight narrow fishway channel, which limits its broad applicability to other fishway types or areas where high numbers of Carp cannot be held in narrow channel confines.

The objective of this study was to design and test two modifications to the Williams' cage, these were:

1. At Lock 10 fishway, test the Mark V Williams' cage for application at the exit in the static weir pool.
2. At Lock 1 fishway, test the Williams' cage under a co-operative arrangement with commercial fishers and conditions of high Carp biomass.

Summary of findings

Mark V Williams' cage trial at Lock 10

To date, both trials of the Mark V Williams' cage have proven very effective. In 2008, the Mark V cage design by Alan Williams' (Goulburn Murray Water), proved successful in its weir pool commissioning at Lock 10. This latest innovation will enable broad application of the Mark V Williams' cage in weir pool environments with four improvements over the Mark IV design:

1) cage not limited by fishway type,
2) Carp are held in static water,
3) no restrictions on space,
4) native fish are automatically released into the weir pool rather than the fishway.

Consequently, the Mark V Williams' cage design has broad application and is recommended as the preferred system for fishways (Stuart 2008). Furthermore, a Mark V Williams' cage was recently installed on the Lachlan River with support from the Lachlan CMA and State Water.

Commercial Williams' cage trial at Lock 1

At Lock 1, the Williams' Carp cage was tested, by licensed commercial fishers and SA Water, from late 2007 when the new vertical-slot fishway began operation. To date, the Williams' cage has successfully removed 80 tonnes, or approximately 32,000, adult Carp from the fishway (up to 2,705 kg/day), demonstrating its success under conditions of high Carp biomass. Despite record low flows and water levels during the study, the Lock 1

project has been an effective on-ground cooperative Carp control effort and represents the largest ongoing and successful best practice Carp control initiative in the Murray-Darling Basin.

Incremental design improvements

The Lock 1 trial was the first time the design team and commercial fishers had the opportunity to observe Carp entering a Williams' cage and their subsequent behaviour. Visual and DIDSON sonar observations resulted in four important modifications:

1) angling the jumping baffle to improve Carp separation success;
2) modifications to the funnel entry to reduce Carp escapement;
3) use of perforated metal sheet (instead of wire mesh) and angular roofs on the Carp holding cages to improve fish holding conditions and the commercial value of the Carp;
4) incorporation of vertical-bar mesh to restrain Carp but allow constant passage of small and medium sized native fish.

Carp biology and more effective control

The Lock 1 trial was also an opportunity to examine Carp size, sex and reproductive status. The data indicated that the majority (72%) of migrating Carp were large pre-spawning females (Figure 1). The abundance of Carp migrating varied temporally and was related to changes in water temperature and reproductive status, peaking in October/November 2008 (Figure 2). Carp separation efficiency also varied temporally with highest monthly efficiencies (77%) coinciding with peaks in migration (Figure 3). Specific trials revealed that Carp entered the trap and jumped more readily during the day than at night. Moreover, separation efficiencies were also improved by allowing Carp the maximum daylight time in the jumping area prior to tipping to release native fish.

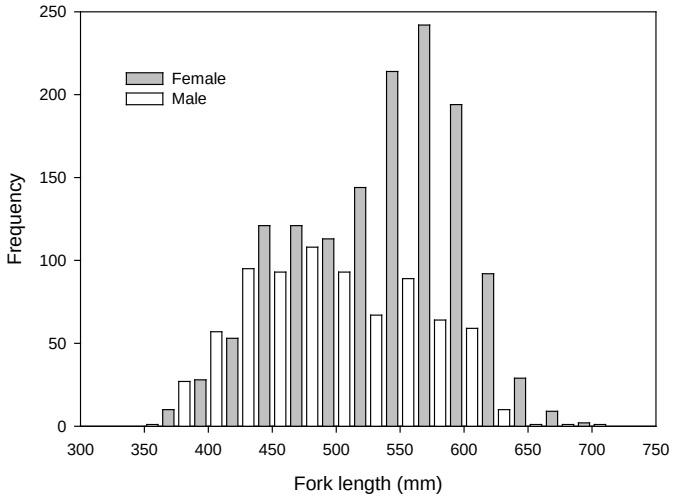

Figure 1: The length frequency distribution of male and female Carp collected at Lock 1 from late 2007.

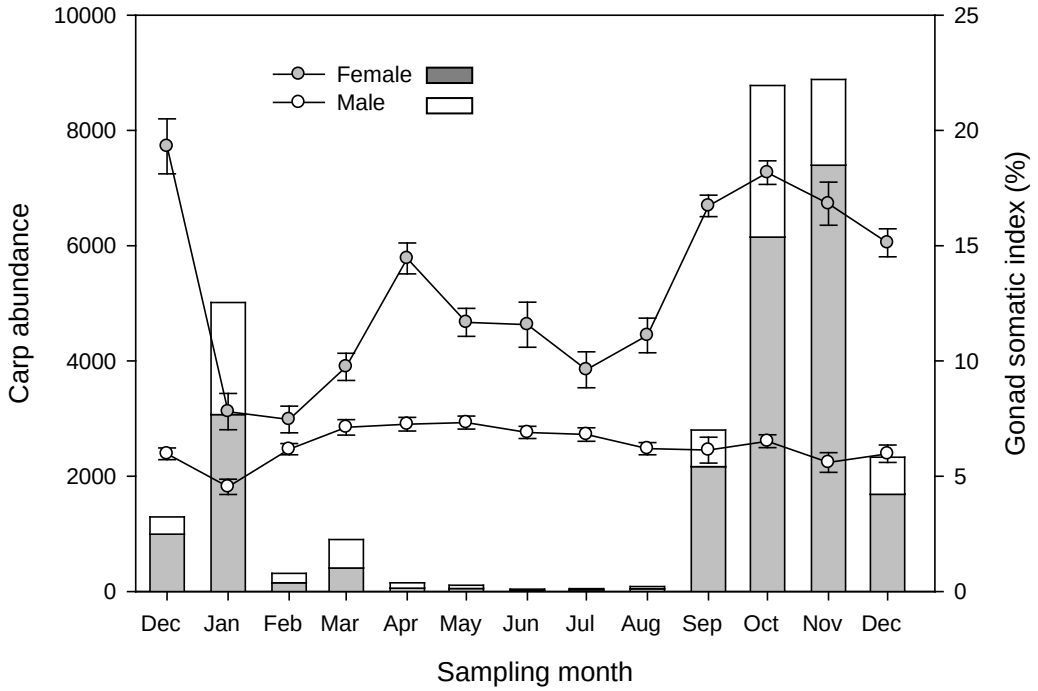

Figure 2: Summed monthly catch and gonad somatic index (± standard error) of male and female Carp collected at Lock 1 from December 2007-2008.

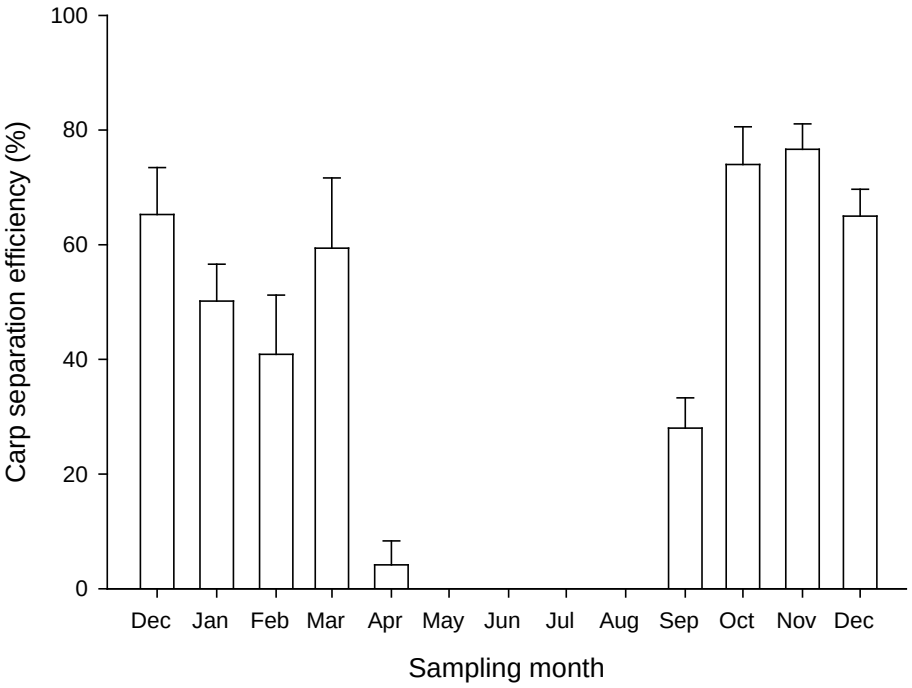

Figure 3: Mean monthly separation efficiency (+ standard error) for Carp collected at Lock 1 from December 2007-2008.

Improvements to the native fish release system

To enable, constant passage of small and medium sized native fish a vertical bar mesh (42 mm internal bar spacing) was incorporated into the Lock 1 Williams' cage. Two weeks of trials in January 2008, allowed unimpeded passage of 98% of the abundant native fish Bony herring (n = 647), all Golden perch (n = 30) and numerous small-bodied native fish (e.g. Murray rainbowfish, Australian smelt, Unspecked hardyhead). The remaining large native fish can be automatically tipped (at the end of daylight) and released as per the original Mark IV Williams' cage. Additionally, the vertical-bar mesh restricted passage of 95% (>300 mm total length) of broad bodied adult Carp (n = 3,047) during the trials.

Does the Williams' cage impact on Carp populations?

This is a key question for the long-term Native Fish Strategy goals of Carp management and native fish recovery. At Lock 1, the removal of 80 tonnes of pre-spawning Carp is expected to impact on the adult population abundance but further work is required to determine its significance. Part of this question might be answered by the Tri-State fishway team's PIT tagging and boat electrofishing program which will indicate the percentage of Carp populations that migrate through fishways (Baumgartner et al. 2008). We suggest further development of long-term integrated Carp management programs with a suite of environmental indicators. The information from Lock 1 will help target application of the Williams' cage to maximise effectiveness on pre-spawning Carp whilst facilitating native fish passage.

Key messages

- The Mark V Williams' cage has proven effective in trapping and separating migrating Carp from native fish and the new design is flexible for weir pool application in various fishway designs across the Murray-Darling Basin.
- The Williams' cage technology was effective at separating and removing large biomasses of Carp from fishways in a commercial application.
- Native fish by-catch within the Williams' cage continues to be minimal and the technology has been tailored to maximise constant passage of native fish species.
- The Lock 1 project highlights an effective on-ground Carp control effort which utilised a co-operative arrangement between researchers, commercial fisherman and lock operations staff and represents an ongoing and successful best practice Carp control initiative.

Management / Research Recommendations

- Continue technical development and roll-out of the Mark V Williams' cage at Lock 1 and the new Murray fishways, and formulate Standard Operating Procedures to minimise impacts on native fish and other relevant criteria.
- Mark V Williams' cage should incorporate angled jumping baffles and modified holding cages.
- Install and monitor a PIT tag reader on the Lock 1 Carp separation cage.
- Integrate Carp control efforts and maintenance/training programs along the Murray River with central co-ordination.
- Design a Carp monitoring program to determine the population level effects of Williams' Carp cages.
- Continue research into the GSI, sex ratios, seasonal aggregation, and diurnal activity of Carp and native fish in relation to Williams' cage catch rates and separation efficiency.

- Using the process developed for the engagement of commercial fishers at Lock 1, continue to utilise local commercial fishermen to undertake harvesting and Carp disposal operations at other locks and weirs in the SA Murray-Darling Basin.

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Application of Carp Trapping Technology at Wetland Inlets: Lake Bonney as a Test Case

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Background

The Williams' Carp separation cage has proven highly successful in separating large tonnages of adult Carp from large-bodied native fishes, as they migrate longitudinally to upstream areas through river fishways (Conallin et al. 2008). Carp also undertake predictable, seasonal, lateral migrations towards shallow wetlands, where they aggregate en masse after winter to forage and spawn (Stuart and Jones 2006; Smith et al. 2009a; Thwaites et al. 2009). Thus, over the past few years, several research projects (including two PhD research projects) have investigated and tested design requirements/improvements for applying Williams' type Carp trapping technology at wetland inlets, and evaluating likely impacts on native biota. This paper briefly describes the key findings from those projects and outlines a SARDI Aquatic Sciences design for an 'optimised' wetland Carp cage and lifting infrastructure set-up that has been professionally engineered to ensure that the design:

1) is operable by just one person,
2) complies with all relevant Australian design and OHS&W standards
3) is vandal- and bullet-proof (as far as possible) and
4) will be transferable amongst wetland sites throughout the Basin.

The first prototype installation is to occur by end September 2009 at Lake Bonney, South Australia, as a test case.

Lake Bonney as a test case

Lake Bonney, located 221 km north east of Adelaide at Barmera, is a 1,700 ha shallow (max depth ≈5 m) freshwater (10,000-20,000 EC) lake fed from the Murray River. In mid-2007, Lake Bonney was disconnected from the River Murray main channel by an earthen levee, to reduce the amount of water lost to evaporation. Subsequently, water quality gradually deteriorated until the latter half of 2008 when significant kills of small-bodied fishes and large-bodied Murray cod, Golden perch, bony herring and Carp occurred. As such, the lake received a partial water refill allocation of 10 GL, which succeeded in reducing salinities and preventing further fish kills. Interestingly, the filling event also created a large aggregation of resident Carp at the inflow point, possibly attracted to the sensory cues provided by the inflowing water (scent, flow, and sound). This aggregation formed quickly, persisted for the entire filling event (approx. 1 month) and comprised large numbers of adult Carp vigorously attempting to migrate from the lake. Around 30 tonne of aggregating Carp (but virtually no native fishes; 30 bony herring and one Golden perch) were manually harvested by commercial fishers and a further 5 tonne by the general public. The commercial harvest, however, was extremely labour intensive, and the harvest by the general public (including bows and arrows, pitchforks, spearguns etc) was unethical, unsafe and uncontrolled.

Before the end of September 2009, delivery of another 26 GL of environmental water is to be delivered to the lake to avoid another fish kill over the summer months, and Carp are again expected to aggregate en masse. Given that 2.5 times more water is to be delivered to the lake this year, combined funding from the SA MDB NRM Board, the MDBA and IA CRC has been secured to design, construct, install and monitor an optimised wetland Carp separation cage and lifting infrastructure at the Lake's entrance to streamline the harvest of Carp. Regular fish monitoring over the duration of the fill, combined with known numbers of tagged fish in the Lake, will also enable evaluations of the:

- Population extent of key large-bodied native fish in Lake Bonney including Carp, Murray cod, Golden perch, Silver perch and Catfish.
- Movement patterns and requirements of Carp and large-bodied native fish during the proposed times of filling (early spring) – therefore the need to accommodate the passage of

large-bodied native fishes under proposed management regimes (refilling of wetlands during the cooler months to minimise evaporative losses).
- Species diversity, abundance, size structures and sex ratios of captured fish (Carp and large-bodied native fishes).
- Effectiveness of the cage in terms of the proportion of the total Carp population removed and any required design improvements.

Summary of findings

A new push trap element for incorporation into Carp separation cages & Carp exclusion screens

A new Carp push trap element, which exploits Carp's innate pushing abilities, has been successfully tested under laboratory and field conditions (Thwaites et al. 2007, 2009; SARDI Aquatic Sciences, Unpub. Data). In brief, the push trap element has been designed for installation in Carp exclusion screens, or to work in combination with the traditional jumping element of a William's Carp separation cage. It consists of a series of weighted one-way steel 'fingers', hinged from individual sleeves over a supporting shaft suspended within a frame. To push through the element, Carp must push (lift) at least one finger far enough to create an aperture that will enable it to either swim directly underneath the lifted finger or between the lifted and adjacent fingers. Once a Carp has pushed through, the finger(s) then fall shut entrapping the Carp within a holding cage positioned behind the trap element. Based on the morphology and pushing ability of Carp:

- Finger apertures (31-mm) have been designed to catch all Carp ≥250-mm total length (TL) (>90% of all Carp found migrating through river fishways and wetland inlets), whilst allowing the passage of >98% of small bodied native fish (<250 mm TL at maturity, which comprise the majority of fish in wetlands), >98% of bony herring (which comprise the majority of large-bodied native fishes using wetlands) and the juveniles of large-bodied native fish (e.g. Golden perch).
  NOTE: The 31 mm apertures between jail bars accords with recent recommendations for the design of 'optimised' Carp exclusion screen mesh. This jail bar mesh enables the passage of significantly more native fish than existing screen mesh designs (Hillyard et al. in press, in prep).
- Finger weights (pushing force required to lift to 90° = 440 g) have been designed to allow the passage of Carp ≥250 mm TL but discourage the passage of large-bodied native fish of the MDB. However, <22% of Carp's known pushing capacity is needed to push through the 'fingers', so finger weights can be increased if future testing reveals that large native fishes are also able to push through the fingers – this is yet to occur.

Use of wetlands and wetland inlets by native and alien fishes

Surveys of fishes in 74 wetlands and six wetland inlets in South Australia have been conducted during 2004-7 to, inter alia, identify other aquatic fauna that may be impacted by the use of Carp management technologies at wetland inlets. Those studies revealed:

- As well as Carp, there is a diverse (32 species, including 27 native and five alien invasive) and abundant (≈325,000 individuals) fish community utilising wetlands and wetland inlets, including the majority of fishes known from the MDB.
- Catches vary amongst wetlands
- Catches are typically dominated by several small-bodied native fishes (Australian smelt, Carp gudgeons, unspecked hardyhead, small-mouthed hardyhead; ≈98% of catch) but a handful of larger fish species dominate the biomass (common Carp & Bony herring ≈40% each, Golden perch ≈8%).
- Species of conservation significance are generally found in few wetlands and low abundance (hence their conservation status).
- Catches for most species comprise individuals from all age, size and reproductive classes, providing clear evidence of the importance of lateral connectivity to the aquatic community.
- The passage requirements of ≈98% of small and medium sized native wetland fishes (<250 mm TL) would be unaffected by the use of Carp exclusion screens and traps made from optimised 'jail bar' mesh with 31 mm apertures between the bars. However, understanding and avoiding possible impacts on the remaining 2% of fishes is critical!
- Turtles are the only other large-bodied aquatic fauna that may be impacted by Carp trapping technology at wetland inlets – although design amendments can be incorporated to minimise any impacts/accommodate their passage.

Trials of a wetland Carp cage at Banrock Station

Trials of a Williams'-type wetland Carp separation cage, incorporating jumping and pushing trap components, were undertaken over six months (June to Dec 08) in the inlet and outlet creeks to Banrock Station wetland. Approximately 8 tonnes of Carp and very few large native fishes were captured. Results also confirmed:

- Carp show a similar preference to jump as they do to push. Thus, the Carp push trap is a successful new management technology that should be incorporated into existing Carp management infrastructure (Carp cages and Carp exclusion screens).
- Carp >250 mm TL are the focus of trapping, and are the fish most likely to migrate to wetlands to spawn, or to respond to attractant flows/odours/sounds.
- The likely impacts of Carp management technologies on native fishes (generally low), and the diversity, abundance and size-range of native and alien fishes that undertake lateral migrations (generally high)
- Design, operational and OH&S considerations for applying Carp trapping technologies at wetland inlets. In particular, suitable infrastructure (gantry) to safely and efficiently lift and empty a wetland Carp cage is mandatory, and is considered essential for the long-term success of this technology.
- There was a distinct temporal separation between the peak Carp migration (mid Sept) and native fish migration (late-Nov / early Dec).

Lake Bonney as a test case – current status

- The final engineering drawings for the optimised wetland Carp cage and lifting infrastructure (gantry) has only recently been received from the engineers. Quotes for the construction and installation of the cage and gantry are now to be confirmed.
- Fish monitoring will begin once the cage is installed and the water begins to flow.
- Cage management will be dictated by the presence/absence and capture of native fishes e.g. If only Carp are being captured (expected until at least early-Nov): the internal jump/push trap elements will be unnecessary and removed to maximize Carp capture rates. Once (if) native fish begin to be captured, the push/trap elements will be re-instated to separate Carp from native fish.

Key messages

- Carp trapping technology for use at river fishways and wetland inlets, has made significant advances in recent years. Importantly, new trapping elements, new cage designs, new supporting infrastructure and new management approaches have been developed/suggested to maximise Carp trapping rates, whilst minimising impacts on native fishes.
- Site selection is the key criterion for the successful application of Carp trapping technology. A forthcoming publication entitled 'Draft decision support package for the selection and implementation of Carp management options at wetland inlets; a test case for South Australia' will help to inform that process (Smith et al. 2009b) – and can be adapted to other jurisdictions.
- The combined data suggest that vertical jail-bars, with 31 mm apertures between the bars, should be used as the principle mesh on all existing and new Carp separation cages and Carp exclusion screens within the MDB. The optimum diameter of the jail bars is yet to be determined but thinner diameter bars might result in better passage for fish as they would represent less of a barrier.
- Carp push traps should be considered for incorporation into Carp screens and traps, especially at Carp recruitment 'hotspots'.
- Designs for the optimised Carp cage and lifting infrastructure can be made available to interested stakeholders - subject to consultation with SARDI staff and the 'draft decision support package'.

Management / Research Recommendations

- Prior and ongoing assessment and monitoring of all new installations to confirm effects on large-bodied native fishes and to continue to develop and refine the trapping technology - especially under higher flow regimes.
- Cost-benefit analyses regarding the use of wetland Carp traps – could returns from the sale of captured Carp ever pay for the installation and ongoing maintenance of wetland Carp traps? How long would it take?
- Work closely with stakeholders regarding the on-ground application of the technology, and in assessing and improving the draft Decision Support Package.
- Incorporate all design improvements identified during the Lake Bonney trial of the prototype trap/lifting infrastructure, and develop operational and training protocols for community groups from this work.
- Work with statisticians/biometricians to develop a cost effective, simple, yet scientifically robust and universally applicable trap monitoring program. In this way, the utility of the technology across varying locations can be evaluated in a replicated manner.
- Work to instate a 'Carp Management Advisory Committee (CMAC)' to oversee, advise, record and therefore centralise the deployment and management of new Carp management technologies. This group should included representatives from fisheries, NRM, research, policy etc.
- Work with fisheries in an attempt to develop trap specific fishing licences - if possible. This may aid in community groups gaining a return on their investment through sales as well as give CMAC power to revoke licences if the traps are being misused.

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Carp Harvest and Disposal at Murray River Fishways

Peter Jackson
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Objectives / Background

In March 2001, the Murray-Darling Ministerial Council adopted a River Murray structural works program to provide fish passage from the sea to Hume Dam, a distance of 2,225km (Barrett ed. 2008). The program is due for completion in 2010/11 and involves the construction of 14 new fishways and is one of the most ambitious programs to be undertaken anywhere in the world and has involved close cooperation between engineers and fish biologists to achieve world's best practice in fishway design, construction and monitoring.

The primary aim of the construction of these fishways is to improve fish passage for native fishes, however they will also facilitate the movement of non-native species, in particular Carp (*Cyprinus carpio*). Reports of large numbers of Carp below some barriers (e.g. Lock 1) suggest that there may be opportunities to remove significant numbers of Carp and peak migration periods. Recent data (Conallin et al. 2008) indicates that these accumulations consist mainly of pre- spawning adults so removal of these fish may significantly impact on Carp breeding cycles.

Until recently, removal of Carp from fishways has only been possible by traditional trapping methods, requiring manual separation of Carp. The development of Williams' Carp separation cages (Stuart et al. 2003, Stuart et al. 2006) offers a potentially effective way of removing Carp from fishways without significantly impacting on native fishes.

To progress the harvest and removal of Carp from Murray River fishways, River Murray Water commissioned this study to ascertain the best way forward. The specific objectives of the study are:

- To identify options available for the ethical and cost effective removal of Carp from fishways in the River Murray using Carp separation cages and the issues that may arise harvesting Carp.
- To provide recommendations for the deployment of Carp separation cages in Murray River fishways.
- To provide recommendations on the harvest of Carp from cages and the ethical means of use/disposal of the harvest.

At the same time as this project was undertaken a parallel study was carried out to trial harvesting of Carp using a Williams' separation cage at Lock 1 and the engagement of a commercial fisher to dispose of the Carp (Conallin et al. 2008, Conallin et al. In Prep). The results of the Lock 1 study have informed this study.

Summary of Findings

Carp in the Murray River and Carp Control

Carp occur throughout the Murray River with large accumulations being observed below Locks 1,2 and 3 (Zampatti, pers. comm.). Pre-spawning adults commence spawning migrations in mid August and migrate mostly during the day. There are a number of recruitment "hotspots" identified along the Murray River but more work is required particularly in the Lower Murray. The most prominent "hotspot" appears to be at Barmah/ Millewa but these are others (e.g. Euston Lakes, Darling Junction) (Gilligan pers. comm.). Carp harvesting at River Murray fishways should be seen as part of an integrated Carp management program and should target pre-spawning adult migrations and wherever possible should link in with control programs related to "hotspots".

Carp Harvesting at Fishways (Williams' Separation Cages)

The Mark V Williams' cage can be regarded as a prototype that can be used at all fishways on the Murray River. It has the following advantages: It can operate on the exit of any fishway type and exit configuration; it can hold a large biomass of Carp in lower water velocity conditions and native fish

are exited into the weir pool rather than the fishway (Stuart 2008). The design was trialled in a high Carp biomass situation at Lock 1 in 2007 and 2008 (Conallin 2008) although low flow conditions reduced the number of Carp entering the fishway and significantly higher Carp biomasses may be expected in a “normal” flow year.

There have been significant improvements in Carp cage design since its inception in 2000; however a continuous improvement program should be implemented with designs being modified as more information becomes available in Carp biology and any impacts on native fishes. The rollout of cages in River Murray fishways should be accompanied with appropriate research and monitoring. To ensure the cages are designed to the latest standard, a construction and design team should be formed. This team should also produce an operation and maintenance manual.

Carp Harvesting Outside the Fishway

Carp may enter fishways at very high numbers during peak migration times. In high biomass areas such as at Lock 1 they may physically exclude native fishes from migrating. There is a need to consider the impacts of this on native fishes. Do these high biomass events coincide with important migratory periods for native fishes and are there alternatives for capturing Carp before they enter the fishway? Carp could be captured below the fishway using a number of methods such as electrofishing, passive traps, netting etc. All jurisdictional Fisheries agencies would consider such activities provided there were no impacts on native fishes. Trials would have to be undertaken to gauge the impacts on native fish. They could be undertaken at Lock1.

Carp Disposal (Commercial Fishers)

All jurisdictions allow the capture and sale of Carp under license or permit and would expect commercial collectors to be given first option for harvest and disposal. However, the commercial industry is only marginally viable with a limited number of active fishers. It is strongest in South Australia. In NSW the commercial fishers do not target known aggregations of Carp in the state and are unlikely to participate in Carp harvesting and disposal at fishways without being paid a “fee for service”. The only industrial market that has potential for expansion at the moment is for crayfish bait and fertilizer.

A commercial fisher would need to harvest about 40 or 50 tonnes of Carp per annum for the operation to be commercially viable (Gary Warwick pers. comm.). It may be possible to obtain such a biomass at Lock 1 during a good flow year but it is more likely that a commercial operator would have to continue to fish other sites or incorporate a number of fishways into their operation.

During the Lock 1 trial, the lock operators harvested the Carp and kept them in a commercial freezer until there were sufficient numbers for the commercial operator to collect. It is likely that freezers will have to be installed at other locks if the role of commercial fishers is to be expanded beyond Lock 1.

The engagement of commercial fishers should be undertaken in co-operation with jurisdictional fisheries agencies.

Carp Disposal (Non-Commercial)

At sites where commercial collection is not viable, alternative measures will need to be investigated. Other options include; burial (the most common method), cremation (can cause highly visible air pollution) and composting. All methods would have to comply with state EPA and local council requirements. Composting is favoured in this report as it is utilising a resource. There are commercial composting options available (e.g BioBins) that have composting bins for hire including regular removal and replacement of bins.

The use of alternative disposal methods should be investigated on a cost/benefit analysis basis with the benefit based on the likely impact of removing the fish on Carp populations.

Animal Ethics
The handling and euthanasia of Carp must be done in an ethical manner. Animal welfare is primarily a state responsibility. All states apart from South Australia include fish under animal welfare legislation. All scientific research requires ethics clearance via animal ethics committees however all treatment of animals is subject to welfare legislation and prosecutions can occur.

Guidelines should be compiled and adhered to for the handling and holding of live Carp during harvest operations. Recommending euthanasia techniques is more difficult. The Australian guideline for euthanasia of fish for scientific purposes recommends the use of anaesthetics and does not support the use of ice slurries. However there remains some debate on whether the use of ice slurries is in fact an acceptable alternative for warm water species. They are used by commercial fishers and provide a more practical approach than the use of anaesthetics when large numbers of fish are involved. The use of anaesthetics could be considered when small numbers of fish are to be euthanased.

Implementation of a program to harvest and dispose of Carp at fishways in the Murray River
This study recommends a coordinated and staged approach to harvesting Carp with the emphasis on Carp control and utilising separation cages at fishways as another tool in an integrated Carp management program.

The following essential steps should be taken:
- Establish a coordinator position of oversee the program.
- Establish a design and construction team for separation cages.
- Compile all relevant manuals (e.g. cage maintenance and operation, IH&S, Animal ethics).
- Change duty statements of lock staff to reflect their role in Carp harvest.
- Develop and implement a communications plan to inform the community the reasoning behind the staged program implementation. Communications could build on the successes at Lock 1.
- Construct cages as part of the fishway construction program.
- Develop a Research and Monitoring Plan.

The program should be rolled out as follows:
- It should be a staged process with ongoing trials. Engagement of commercial fishers as first priority.
- The Lock 1 trials should continue including trial to investigate capture of Carp before they enter the fishway.
- The harvest of Carp should be expanded beyond Lock 1 with preference being given to South Australian sites. There are efficiencies in expanding operations upstream from Lock 1 as Locks 1 to 9 all fall under SAWater control.
- Look at other options at key sites for Carp control where commercial fishing is not viable. Composting as a preferred option.

Identification of sites for Carp harvest should be based on the following factors and in the first instance should be chosen at a workshop involving commercial fishers, fish biologists, state fisheries agencies and lock staff:
- Expected Carp biomass.
- Attraction flows
- Travel distance (for commercial fishers), access, infrastructure, resources.
- Fate of migrating Carp, likely upstream recruitment “hotspots”, access to tributaries, floodplain wetlands etc.
- Linkages with other Carp management and research projects.

Key Messages

- Williams' Carp Separation Cages provide a viable method of harvesting Carp from fishways on the Murray River.
- Commercial fishers can be involved in disposal of Carp at some of the fishways and should be given first option.
- Engagement of commercial fishers cannot be achieved on a cost or resource neutral basis. It is likely that lock staff will have to be involved in the harvesting and possible storage of fish. Freezers may have to be installed at key sites.
- There are other options to disposal of Carp that will have to be looked at where commercial disposal is not viable. Composting is the preferred option as it utilized Carp as a resource.
- A harvest and disposal program for fishways on the Murray River should be rolled out in stages with appropriate monitoring.
- A coordinator should be appointed to oversee the implementation of the program.
- A communication plan should be formulated and implemented to accompany the roll out of the program.

Management and Research Recommendations

- The MDBA implement a coordinated and staged program to utilize Williams' Carp Separation Cages to harvest Carp at key fishways on the Murray River.
- The program should be accompanied with appropriate research and monitoring.

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Appendix 1:

Native Fish Forum Program

Albury Entertainment Centre, Swift Street, Albury

Day 1. Tuesday 1st September

0900 - 0925:	Registration, coffee	
0925 - 0930:	Housekeeping	
0930 - 0940:	Welcome to Country	Pastor Darren Wighton
0940 - 0950:	Welcome to the forum	Jason Alexandra

Session 1. Retrospective

Session Chair:	*Janet Pritchard*	
0950 - 1015:	A Lost World of native fish: What are we trying to restore?	Will Trueman
1015 - 1045:	Native Fish Strategy highlights	Jim Barrett
1045 – 1100:	An engaging time	Adrian Wells
1100 – 1120:	***Morning Tea***	
1120 - 1150:	Findings from the 5th year review of the NFS	Peter Cottingham

Session 2. Broadening the fish perspective

Session Chair:	*John Koehn*	
1150 – 1215:	Overview of TLM icon site works	Ben Dyer
1215 – 1235:	MDBA Basin Plan	David Winfield
1235 – 1305:	How successful are environmental flows?	Alison King
1305 – 1325:	If I were the River God….	Terry Hillman
1325 – 1415:	***Lunch***	

Session 3. What has been demonstrated by Demonstration reaches?

Session Chair:	*Melissa Morley*	
1415 – 1430:	Overview of progress with Demonstration reaches	Peter Jackson
1430 – 1450:	Getting organised	Mike Harper & Jonathan McPhail
1450 – 1510:	Monitoring to demonstrate outcomes	Craig Boys
1510 – 1530:	One thousand and one cups of tea and the NFS: Engaging with the community	Fern Hames & Wayne Tennant
1530 – 1550:	Indigenous engagement	David Cordina & Phil Duncan
1550 – 1610:	***Afternoon Tea***	
1610 - 1630:	From small things big things grow: Building partnerships in Demonstration reaches	Kevin Graham & Stephanie Challen
1630 – 1645:	Demonstration reaches - Where to now?	Peter Jackson

Session 4. High conservation value habitats

Session Chair:	*Heleena Bamford*	
1645 – 1710:	Where to next for Habitat Management Areas?	Bill Phillips

Session 5. a) How to tell the difference between a stocked and wild caught fish?

b) Unearthing secret fish business with the Vaki Riverwatcher

c) NFS coordinators and communications display

1730 – 1930: a) David Crook and Stephen Thurstan will give a hands on demonstration of the new technique for marking hatchery fish
b) Lee Baumgartner will demonstrate the Vaki Riverwatcher (an infrared fish counter) with real-time footage of fish moving through fishways
c) NFS coordinators will host a display of communication materials

Day 2. Wednesday 2nd September

Session 6. In the face of doom and gloom…

Session Chair:	*Zafer Sarac*	
0830 - 0900:	Drought and threatened species	Janet Pritchard
0900 – 0930:	Understanding ecosystem resilience to drought disturbance & protecting & managing drought refugia	Dale McNeil
0930 – 1000:	Bushfires and threatened species	Fern Hames & Jarod Lyon
1000 - 1030:	Assessing inland acid sulfate soils	Dean Ansell
1030 – 1050:	***Morning Tea***	

Session 7. Breakout sessions – The next five years in native fish management

Facilitator: *Bill Phillips*
1050 – 1150 Breakout groups with clear structure to discuss 4 or 5 key topic areas of relevance to native fish management in the Basin that people can input and rotate through e.g. research priorities, communication needs, demonstration reaches, emerging area of concern (3-4 key common questions to each topic area; 3x20minute rotations with 'floating' facilitators to assist with keeping discussions on track)
1150 – 1220: Synthesis session
1220 – 1320: ***Lunch***

Session 8. Pipes and plumbing… Potential to improve native fish management through infrastructure design and operational changes

Session Chair:	*Craig Copeland*	
1320 - 1350	Sea to Hume Fishway program	Matthew Jones
1350 - 1410	Impacts of weirs on downstream movement of native fish in the MDB	Lee Baumgartner
1410 - 1430	Mitigating the impact of irrigation offtakes	Craig Boys
1430 - 1450	The Williams' Carp separation cage: new innovations and a commercial trial	Ivor Stuart & Anthony Conallin
1450 - 1510	Application of Carp trapping technology at wetland inlets: Lake Bonney as a test case	Ben Smith
1510 – 1530:	Carp harvest and disposal at Murray R. fishways	Peter Jackson
1530 – 1540:	Wind up and close	Jim Barrett
1540 – 1600:	***Afternoon Tea***	

Appendix 2:

Breakout session synthesis: The next five years in native fish management

Session Facilitator: Bill Phillips, RiverSmart

Six breakout stations were established to discuss topics of relevance to native fish management in the Basin for the next five years. Forum delegates provided input and rotated through the stations 'speed-dating style', moving every ten minutes and adding to the discussion points of previous groups. The following notes were collated from this feedback session.

Please note that the following points represent the 'unfiltered' view of individuals present at the forum, not necessarily a consensus view, or the views of the Murray-Darling Basin Authority. The feedback and suggestions collated from this session will be submitted for the consideration of the MDBA Native Fish Advisory Panel, and beyond them to jurisdictional partners. Supported recommendations will be incorporated into future Native Fish Strategy planning and work programs where feasible.

1) Monitoring recovery

(Group Facilitator: Craig Boys)

a) How do we improve monitoring and evaluation of the targets of the NFS?

- Move from aspirational to quantitative targets.

b) What to monitor?

- People – for a program where community engagement is highly valued and important, this is a noticeable absence – uptake, interest, how are stakeholders on-selling the NFS, who are the major champions? Recreational anglers seem to be disenchanted with the NFS but on paper they should be one of the major supporters of NFS outcomes.
- The overall NFS target of 60% recovery of native fish populations within 50 years is a great aspirational goal but a difficult target to precisely define and measure. How scientific do we really need to be to demonstrate how we are tracking towards this goal? Can we show trajectory of change and signs of recovery through "a lines of evidence" approach rather than large-scale and costly scientific monitoring programs? (e.g. decline in fish numbers moving through Euston weir was a major line of evidence for native fish decline when starting the Strategy). Maybe by measuring native fish movement through the new Sea to Hume fishways we can gain information about recovery and changes in native fish movements).
- Resilience is a key issue to include in monitoring – how close is a species to key tipping points? (crossing ecological thresholds that result in major community change). How do species 'bounce back' from threats? We should be setting targets on an individual species level relating to resilience.

- Iconic and alien species focus? – do we only look at indicator species and set targets for these? Potentially attractive, but dangerous given the NFS approach of achieving whole assemblage outcomes.
- Set a range of targets over different temporal and special scales.
- Smaller set of quantitative targets for individual driving actions of the NFS needed for the next five years.

c) Current research and adoption monitoring opportunities in the NFS

- Automated fishway counting systems show great potential for yielding long-term fish movement data (Passive Integrated Transponder systems). Lock keepers could potentially be trained to run this system.
- Recreational anglers can contribute information – this has been seen with angler involvement in the MDBA resnagging program, but this needs to be enhanced and expanded.
- The MDBA NFS looks to the MDBA Sustainable Rivers Audit program (SRA) to provide information about the overall condition of native fish populations through time. However, the basin scale at which the SRA operates may not be of sufficient resolution and the standardised sampling technique misses some fish species, and particularly those in low abundance. The NFS may need to supplement its reliance on information from the SRA with other lines of evidence on native fish response to works undertaken.

d) What monitoring is the NFS missing?

- A centralised website/area to access and store data (data warehouse and information management system).
- Synthesis of information generated over the past five years.
- Strategic review of direction for the next five years.

2) Demonstration reaches

(Group Facilitator: Peter Jackson)

a) What is working?

- Strong grassroots support – demonstration reaches give long term focus and commitment for action within a waterway.
- Working closely with catchment management authority (CMA)/ natural resource management (NRM) groups is great.
- Community engagement, education and awareness is well developed.
- Clear focus on monitoring to assess trajectory of change and outcomes – monitoring is now starting to ‘demonstrate’ some positive changes.
- Adaptive management approach (learning through doing) is appreciated.
- Seed funding from MDBA essential.
- Creates good publicity for MDBA.
- Good way of engaging partners.
- Supports active engagement and linkages across jurisdictions.
- Reconnects people with riverscapes.

b) What is not working?

(note not all points relevant for all Demonstration reaches)

- Access to funding - opportunities for driving/supporting sources of money drying up (regionally through CMAs and nationally through Caring For Our Country).
- Engagement good, but community empowerment not yet working (learning but then doing).
- Management of recreational fish take is not being adequately addressed.
- Lack of engagement with peak angling bodies.
- Little indigenous involvement.
- Need communication between indigenous communities, not just groups in isolation.
- Steering committees don't always work (but some are a key success!).
- MDBA Demonstration Reach Steering Committee should include a social researcher.
- Demonstration reaches are sometimes viewed as agency-driven instead of community-driven initiatives.
- Lack of information on how to go about starting and setting up a demonstration reach – and how would new reaches fit in with established reaches?
- Focus on monitoring / demonstrating – can be difficult to show quick results given prevalent drought conditions overlaid with the time needed for some aspects of ecology to respond (e.g. successful fish recruitment may take several years).
- Not selling the value of Demonstration reaches enough.

c) Supporting the future

- Ensure continued funding stream – reduced money means reduced momentum and risks community disenchantment.
- Caring for Our Country – no recent funding for freshwater fish projects, need to encourage an improved Commonwealth understanding of the value of native fish.
- Apply demonstration reach results/momentum to other parts of catchment.
- Promote positives and sell the benefits and value of Demonstration reaches.
- Provide more information and regular updates on demonstration reach progress.
- Recognise that focus on fish also delivers wider ecosystem health outcomes.
- Logical places to deliver environmental flows.
- Habitat rehabilitation – delivers benefits to landholders.
- Communication between indigenous communities to be supported.
- Need a social researcher on MDBA Demonstration Reach Steering Committee.

- Intervention monitoring essential, but be cautious, need to ensure sufficient replication and design power to test results.
- More reaches - one in each catchment? (but noting need to balance with resources available).
- Are we missing some key areas? (e.g. upland catchments)
- Not enough local knowledge being utilised.
- Suspicion/fear from some angling communities needs to be addressed.

d) Demonstration reaches need to continue to foster partnerships:

- Local groups within reaches.
- Between reaches and across state boundaries.
- Communities beyond the river margin.

e) Identifying potential for Demonstration reaches to relate to the MDBA Basin Plan:

- Aim to demonstrate tangible benefits of a restored environment.
- Could be useful for optimising use/delivery of environmental water.
- Demonstration reaches are ecological, social and financial assets to the Murray-Darling Basin community (don't be afraid to put in a dollar value).

f) The value of Demonstration reaches as a marketing tool for wider ecosystem management:

- Communities strongly identify with fish (fish are often the aquatic ecology 'bits' that get people interested in their river and its health).
- Broader scope – Landholders beyond river margin (fish are a great way to engage about the environment).
- Deliver flows through reaches (holistic river health and social outcomes).

3) Risks

(Group Facilitator: Mark Lintermans)

a) What are the risks?

- Aliens. Gambusia, Tilapia. (Redfin don't get as much attention as they should).
- Lack of water.
- Water quality.
- Acid sulfate soils.
- Lack of clearly defined responsibilities (Salami effect – lots of little slices, each agency with responsibility for one small part of the whole).
- Poor inter-agency communication (silo effect) and sheer scale (catchment).
- Ad hoc crisis management – are we actually learning lessons and improving how we manage rather than knee-jerk reacting?
- Planning for recovery is critical.
- Changing land use.
- Continuing drought (climate change).
- Risk assessment lacking, and if it does happen is generally informal, not rigorous.

- Lack of ongoing monitoring information: fish, habitat, water quality (pesticides).
- NFS future in the MDBA Basin Plan and under the Water Act.
- Lack of engagement with recreational fishers, industry, policy-makers etc.
- DEWHA Caring for our Country funding – where are the fish projects? Not on the funding radar.
- Typical single species approach to management versus community assemblage or ecosystem approach may be a risk.

b) Responsibilities for managing these risks?

- Responsibility for ecosystem health shared across multiple community and government levels - this is a major risk. No one group has the mandate to act.
- Don't expect CMA's and community groups to carry the can.
- Where is industry involvement? – how do we get them on board?
- Recreational fishing, riparian clearing, illegal water extraction – lack of enforcement is a real issue.
- Commercial fisheries for aliens in South Australia.
- Fisheries managers: management of stocking, temporary closures.

c) How can the Native Fish Strategy help?

- Integrate fish issues into the MDBA Basin Plan and national mindset (e.g. CFOC funding).
- Need to develop better links with DEWHA – national recovery plans get written for threatened species/communities but get little traction for on-ground improvements and implementation.
- Develop issues paper to brief upper levels of the Commonwealth (like the drought paper resulting from the Drought Expert Panel).
- We are doing well and the NFS coordinators in each of the jurisdictions are vital to this.
- Knowledge brokers would help with promotion of success/knowledge transfer up and down.
- Continue to be bold, with long term vision. Be champions.
- Recognise consumptive users and improve relationship/dialog with conservation management and recreational angling groups.
- More activity in encouraging corporate involvement.

4) Managing and restoring native fish habitat
(Group Facilitator: John Koehn)

a) What are we covering well?

- Fish passage and prioritisation of barriers – but note still a lot of work to keep doing.
- Starting on fire/drought impacts on habitat, but need to urgently consider climate change.
- Demonstration reaches are going well.
- Fish habitat needs have been highlighted.
- New scientific knowledge being generated is valuable and pragmatic for management.

- Identifying drought refuges has started.
- Protection of environmental water and how best to use environmental flows has just started.
- Some cold water pollution (CWP) scoping studies have been completed, but now is the time to invest in major infrastructure (multi-level offtakes) while dam levels are so low with the drought and before CWP becomes a major issue again when levels are higher.

b)What are we missing?

- History – context for what the habitats and fish populations in the Basin used to be like.
- Research and activities to improve management of upland habitats.
- Non-drought ecological data to provide context for the scientific results that have been obtained over the past ten years or so.
- Smaller fish and stream ecology and habitat information.
- In-stream habitat restoration measures other than snags (large wood items) e.g. restoring macrophytes.
- Landscape scale issues – habitat and threat mapping and prioritisation across the Basin.
- Protection of wetland, floodplain and riparian habitats.
- Protection of environmental flows.
- Best use of environmental water – multiple outcomes for the same water through 'clever' application.
- Climate change – large scale, big issues, need a clear direction.
- Cold water pollution – it will return as an important issue when water builds up in dams again. Now is the time to roll out infrastructure modifications.
- Commitment to maintenance of fishways and other riverine infrastructure (locks and weirs).
- Recognise the value of artificial habitats as potential refuges (farm dams, urban stormwater-fed habitats, etc).
- Take advantage of opportunities to increase habitat e.g. sourcing snags from road works.

5) Protecting native fish habitat
(Group Facilitator: Fern Hames)

a)What can the NFS do?

- Use NFS Coordinators – keep them connected especially with CMA's.
- Ensure responsible organisations understand and implement their legislative responsibilities.
- Support legislative back up.
- Educate community and stakeholder organisations and bring relevant people together.
- Plan with a strategic view and direction.
- Get better and broader distribution/dissemination of research outcomes/learnings (nb: success of regional CMA TV ads).
- Improve NFS pages on MDBA website.

- If possible, align priority native fish habitats as key environmental assets within the MDBA Basin Plan.
- Establish a mentoring program and succession planning to make sure that change in staff does not derail initiatives and progress.

b) Which areas do you choose to protect first?

- Be aware of the trade-offs between focusing on single sites "high value conservation areas" and getting whole system health. Note – triage approach doesn't work well for rivers due to connectivity and reliance on upstream/downstream – individual high value sites will die if the river dies!
- Potential criteria for identifying priority areas– presence of threatened species, intact vegetation communities, drought refuges, good instream habitat condition, previous investment in onground works (e.g. revegetation, snags), life histories of resident fish, connectivity in the system, social environmental and economic values.
- Where you can get co-operative landholders/stakeholders and ongoing management. (Discussion: not a primary driver but is an important consideration).
- Consider multiple values and scales.
- On a basin-wide scale, consider native fish hotspots (the bits whose ecology is still working), resilience and key drought refugia.

c) What are the risks and how do we ensure positive engagement?

- Not implementing what we decide. Inaction despite evidence, reports and legislation that sit on shelves.
- Inadequate resources, including lack of recurrent funding.
- Managing expectations.
- Managing scale. Too small scale (or too big), landscape vs scattering. Ecosystem vs site.
- Clarity of scope/vision.
- Early engagement.
- Critical stakeholder support, including political (lack of early support greatly increases risk).
- Lack of legislative back up for habitat and political will.
- No water!
- Get the size right in engagement groups – keep it focussed but include the relevant people.

6) Communication and Engagement
(Group Facilitator: Adrian Wells)

a) What has been working well?

- Keep doing what the NFS Community Stakeholder Taskforce (CST) is doing.

b) Where has communication and engagement broken down?

- Recreational anglers are not effectively involved or getting the messages.

c) There has not been enough communication with Native Fish Australia, conservation groups and state recreational fishing management organisations.

d) Ideas for the future.

- Establish better links to CMA's, NRM agencies and aim for greater coordination on all activities.
- Foster better links with Fisheries Inspectors, and those involved with recreational fishing competitions. Make sure they are well supplied with information about the NFS.
- Develop more links to recreational anglers.
- Explore opportunities to link with corporate and business interests.
- Heightened media profile needed.
- CST to underpin communication initiatives – the community relates very strongly to the CST who are community members, not paid employees or bureaucrats.
- We measure water, monitor fish, etc, but are we measuring people and communities and their changing attitudes? A strong social research element is needed.
- Measure engagement, community and people to make sure the NFS is engaging the "right people".
- More focus is needed in the northern Basin.
- Knowledge broker is needed – huge repository of native fish scientific and technical knowledge has been generated, but this needs to be translated into 'user friendly' information available to a much wider audience.
- Repository of knowledge is needed to house all this information – a central location to find out about native fish and their management in the form of an information management system.
- Need a coordinated approach to school education rather than ad hoc visits. An education package that links to the curriculum would be valuable.
- Mentoring programs.
- Identify native fish champions.
- National native fish day?
- Use technology to more effectively distribute information and materials.
- Interpretive signage on waterways – already good examples around, use existing ideas, but also consider bi-lingual or multi-lingual elements.
- Adopt a fish program?
- Encourage undergraduates and the university sector to work on fish issues.
- Establish links to recreational fishing groups – consult and acknowledge (newsletter, presentations to go to members).
- Provide basic biology information on native fish species for interested anglers.

e) General comments

- Stories about native fish issues are powerful communication tools – people relate well and are interested.
- Get youth interested in their environment through fish. This is especially true for high school kids, as many people target their information at upper primary school levels and neglect the needs of teenagers and young adults.
- Make sure communication is properly targeted and relates to the audience.
- Don’t reinvent the wheel.
- Less beer more tea…
- Continue looking for good stories and celebrate successes.

Appendix 3: Forum Delegates

Name	Organisation
Adam Vey	Industry and Investment NSW
Adrian Wells	Murray-Darling Association
Alan Williams	Goulburn-Murray Water
Alison King	Arthur Rylah Institute
Alistair McBurnie	Industry and Investment NSW
Andrew Chalklen	Department of Environment, Water, Heritage and the Arts
Andrew Sanger	Industry and Investment NSW
Anneke Rimmer	University of Sydney
Anthony Conallin	SARDI Aquatic Sciences
Anthony Townsend	Industry and Investment NSW
Anthony Wilson	North East Catchment Management Authority
Arkellah Hall	Department for Environment and Heritage (SA)
Ben Broadhurst	University of Canberra
Ben Dyer	Murray-Darling Basin Authority
Ben Smith	SARDI Aquatic Sciences
Bill Phillips	RiverSmart
Brad Hollis	South Australian Murray-Darling Basin NRM Board
Brett Smith	Industry and Investment NSW
Cedric Washington	Border Rivers Gwydir CMA
Changhao Jin	Arthur Rylah Institute
Charles Todd	Arthur Rylah Institute
Chester Merrick	Industry and Investment NSW
Chris Beale	South West Anglers Association
Chris Bice	SARDI Aquatic Sciences
Christine Reid	Murray-Darling Freshwater Research Centre
Clayton Sharpe	Murray-Darling Freshwater Research Centre
Craig Boys	Industry and Investment NSW
Dale McNeil	SARDI Aquatic Sciences
Darryl Girling	South West Anglers Association
Dave Ward	Industry and Investment NSW
David Cordina	Industry and Investment NSW
David Crook	Arthur Rylah Institute
David Hohnberg	Murray-Darling Basin Authority
David Sharley	Arthur Rylah Institute
David Winfield	Murray-Darling Basin Authority
Dean Ansell	Murray-Darling Basin Authority
Denise Morgan	Yorta Yorta
Dos O'Sullivan	NFS Community Stakeholder Taskforce
Fern Hames	Arthur Rylah Institute
Fin Martin	Lachlan Catchment Management Authority
Fiona Gavine	Fisheries Victoria
Fiona Gilbert	BMT WBM Pty Ltd
Gary Backhouse	Department of Sustainability and Environment (VIC)
Gavin Butler	Industry and Investment NSW
Grant Gunthorpe	Industry and Investment NSW
Heleena Bamford	Murray-Darling Basin Authority
Iain Ellis	Murray-Darling Freshwater Research Centre
Ian Wooden	Industry and Investment NSW
Ivor Stuart	Kingfisher Research
Jacqueline Giles	Department of Environment and Heritage
Jade Miller	Yorta Yorta
James Maguire	Department of Environment and Climate Change (NSW)
Jamie Hutchison	Industry and Investment NSW
Jamie Kaye	Water Technologies
Jane Frances	Industry and Investment NSW
Janet Pritchard	Murray-Darling Basin Authority

Jarod Lyon	Arthur Rylah Institute
Jarrod McPherson	Industry and Investment NSW
Jason Alexandra	Murray-Darling Basin Authority
Jason Lieschke	Arthur Rylah Institute
Jason Thiem	University of Canberra
Jim Barrett	Murray-Darling Basin Authority
John Douglas	Fisheries Victoria
John Hawkins	Albury City Council
John Koehn	Arthur Rylah Institute
John Robertson (QLD)	Department of Employment, Economic Development and Innovation
Jonathan McPhail	Department of Primary Industries and Resources of South Australia
Jonathon Doyle	Industry and Investment NSW
Joy Becker	University of Sydney
Joy Sloan	Fisheries Victoria
Karen Weaver	Fisheries Victoria
Karl Pomorin	KarlTek
Kate Scanlon	Murray-Darling Basin Authority
Katherine Cheshire	SARDI Aquatic Sciences
Kathleen Beyer	SARDI Aquatic Sciences
Katie Ryan	University of Canberra
Keith Ward	Goulburn Broken Catchment Management Authority
Kelly Crosthwaite	Department of Primary Industries and Resources of South Australia
Kevin Graham	Condamine Alliance
Kevin Smith	Chair of the Katfish Reach Steering Group
Kylie Hall	Department of Primary Industries (VIC)
Lara Suitor	Department of Environment and Heritage
Leah Beesley	Arthur Rylah Institute
Lee Baumgartner	Industry and Investment NSW
Libby McIntyre	Industry and Investment NSW
Lisa Barnwell	Department of Environment, Water, Heritage and the Arts
Louise McIntosh	Department of Water, Land and Biodiversity Conservation
Lowri Pryce	Ocean Watch Australia
Luke Johnston	ACT Parks Conservation and Lands
Luke Pearce	Industry and Investment NSW
Malcolm Davis	NSW Aboriginal Land Council
Mark Lintermans	University of Canberra
Mathew Jones	Arthur Rylah Institute
Matthew Beitzel	ACT Parks Conservation and Lands
Matthew Maclellan	Industry and Investment NSW
Matthew O'Connell	North East Catchment Management Authority
Matthew Vogel	Murray-Darling Freshwater Research Centre
Meaghan Rourke	Industry and Investment NSW
Melissa Morley	Murray-Darling Basin Authority
Michael Hammer	Aquasave Consultants
Michael Harper	Department for Environment and Heritage (SA)
Michael Hutchison (QLD)	Department of Employment, Economic Development and Innovation
Michelle Kavanagh	Murray-Darling Freshwater Research Centre
Mick Bettanin	Industry and Investment NSW
Milly Hobson	Industry and Investment NSW
Neville Atkinson	Goulburn Broken Catchment Management Authority
Nicole McCasker	Charles Sturt University
Paul Childs	Department of Environment and Climate Change (NSW)
Paul Hardiman	Department of Environment, Water, Heritage and the Arts
Paul Humphries	Charles Sturt University
Peter Cottingham	Consultant
Peter Gehrke	SMEC Australia
Peter Jackson	Independent Scientist, Native Fish Strategy
Peter Kind (QLD)	Department of Employment, Economic Development and Innovation
Peter Taylor	NFS Community Stakeholder Taskforce

Peter Teakle	NFS Community Stakeholder Taskforce
Phil Duncan	NFS Community Stakeholder Taskforce
Ray Ahmat	Department of Sustainability and Environment (VIC)
Rebecca Chapman	Industry and Investment NSW
Rhian Clear	University of Canberra
Richard Ping Kee	NFS Community Stakeholder Taskforce
Richard Whittington	University of Sydney
Rick Stoffels	Murray-Darling Freshwater Research Centre
Rob Loats	VR Fish
Robyn Watts	Charles Sturt University
Rodney Price	Industry and Investment NSW
Rohan Rehwinkle	Murray-Darling Freshwater Research Centre
Ron Lewis	Native Fish Australia
Russell Grant	Western CMA
Sam Davis	Industry and Investment NSW
Sandra Leigh	SARDI Aquatic Sciences
Shane Papworth	Goulburn-Murray Water
Sharon Molloy	Industry and Investment NSW
Shaun Morrison	Industry and Investment NSW
Simon Kaminskas	Department of Environment, Water, Heritage and the Arts
Simon Rowe	Ocean Watch Australia
Stacey Kopf	Charles Sturt University
Stephanie Challen (QLD)	Department of Employment, Economic Development and Innovation
Stephen Thurstan	Industry and Investment NSW
Stuart Richardson	Goulburn-Murray Water
Stuart Rowland	Industry and Investment NSW
Sze Flett	Arthur Rylah Institute
Terry Hillman	
Terry Holt	Goulburn-Murray Water
Terry Korodaj	Murray-Darling Basin Authority
Terry Maloney	South West Anglers Association
Tim Allen	Department of Sustainability and Environment (VIC)
Tim Knox	Queensland Murray-Darling Committee
Todd Wallace	Murray-Darling Freshwater Research Centre
Tom Zouch	Murray-Darling Basin Authority
Tracey Brownbill	Murray Catchment Management Authority
Travis Dowling	Fisheries Victoria
Troy Lancaster	NSW Aboriginal Land Council
Veronica Lanigan	North East Catchment Management Authority
Wayne Robinson	University of the Sunshine Coast
Wayne Tennant	Goulburn Broken Catchment Management Authority
Will Trueman	
Zafer Sarac (QLD)	Department of Employment, Economic Development and Innovation
Zeb Tonkin	Arthur Rylah Institute

Acronym List

CMA	Catchment Management Authority
NRM	Natural Resource Management
CST	Community Stakeholder Taskforce
NFS	Native Fish Strategy (MDBA program)
MDBC	Murray-Darling Basin Commission
MDBA	Murray-Darling Basin Authority
CWP	Cold Water Pollution
SRA	Sustainable Rivers Audit (MDBA program)
TLM	The Living Murray Initiative