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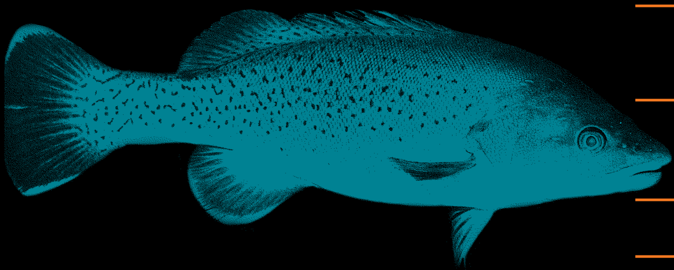

Setting Environmental Flows to Sustain a Healthy Working River

by Professor Gary Jones

Many people involved in the management and stewardship of Australia's rivers have pondered, indeed agonised over, the vexed problem of environmental flow allocations. Support for environmental flow allocations across river communities is often strong – a recent survey of one river catchment group showed 95% of all stakeholders agreed that their river needed more environmental water. The question facing river managers and communities is, how much water does a river need to remain healthy or to become healthy again?

In this edition of Watershed, we consider some of the key issues surrounding environmental flows, and propose a way forward – a starting point for deliberation – for establishing environmental flow allocations to sustain or restore a healthy working river.

So, what is a healthy working river? It could be defined as a river that has been brought into service for the benefit of human kind, while retaining an 'ecological character' that is generally accepted as being 'healthy'. Inside, Dr. John Whittington considers possible useful definitions of a healthy working river in more detail.

This leaves the challenge of proposing a way forward on environmental flow allocations. A small group of senior scientists from the CRC for Freshwater Ecology, the CRC for Catchment Hydrology and the NSW Parks and Wildlife Service recently met to discuss this issue. We agreed that environmental flows for a healthy working river must be considered at different geographic scales. Communities need information and understanding at the local scale about local flood-plains, forests, wetlands, or river reaches – that match

Cooperative Research Centre for Freshwater Ecology
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The Cooperative Research Centre for Freshwater Ecology improves the condition of Australia's rivers, lakes and wetlands

their responsibilities and experiences. Ecologists believe there are properties of large river systems that are also meaningful at the whole-of-river scale. These properties can be synthesised in five system-level categories:

- flow volume
- flow distribution or pattern
- flow variability
- connectivity (within and between the river, floodplain and their component parts)
- flow-related water quality

Each attribute category can be characterised by a limited number of hydrological indicators. These attributes and their indicators provide a description of the flow regime of the river, which is applicable at both a local and a whole-of-river scale.

There are many ways to cut a cake, and other river scientists may choose to describe flow regime in a slightly different way. They may choose to use several more indicators to fully describe each system-level attribute, ending up with numerous hydrological indicators, each of which may need to be evaluated at several locations along a river. It soon becomes apparent to any group – scientific or otherwise – that long lists of hydrological indicators can be more of a hindrance than a help. The challenge is to search for the most parsimonious and rigorous list of indicators that provide explicit and robust links to ecological outcomes at local and whole of system scales.

Professor Gary Jones
Photo: Lynne Sealie, CRCFE

Based on the available knowledge the expert working group arrived at the following position:

"There is a substantial risk a working river will not be in a healthy state when key attributes of the flow regime are reduced below two-thirds of their natural level."

The 'two-thirds natural' scenario could be considered as an 'interim flow guidance value' for a healthy working river. A simple risk assessment framework was developed around this value. It addresses the question "What is the likelihood (or probability) of supporting a healthy working river given a specified flow regime?" The derived risk, or probability categories are:

% of Natural Flow (for critical indicators)	Probability of having a healthy working river
Greater than two-thirds	HIGH
Greater than half	MODERATE
Less than half	LOW

If habitat conditions and water quality are being well managed at greater than two-thirds of natural flow, the probability of sustaining a healthy working river is high. When half the natural flow is restored the probability of a working river being healthy is moderate. Flow regimes of less than half-natural will mean that it is highly unlikely that a river will be capable of remaining healthy in the long-term.

Ultimately, whether the assessed risk for any environmental flows option is acceptable is up to the community to decide, not to a group of well-intentioned river scientists. This simple risk-based framework is a starting point – a rule of thumb – for consideration of environmental flows in any river valley. The validity of the framework should always be considered on a case by case basis using a combination of the best available scientific data and knowledge, and community experience and judgement.

Professor Gary Jones
Director of Knowledge Exchange

Working Rivers

by Dr John Whittington

healthy working river *n.* a managed river in which there is a sustainable compromise, agreed to by the community, between the condition of the natural ecosystem and the level of human use.

We have always made our natural environment work for us. We work our rivers to produce hydro-electric power, we divert their waters for town water, manufacturing and for irrigation and we farm the rivers' fertile floodplains.

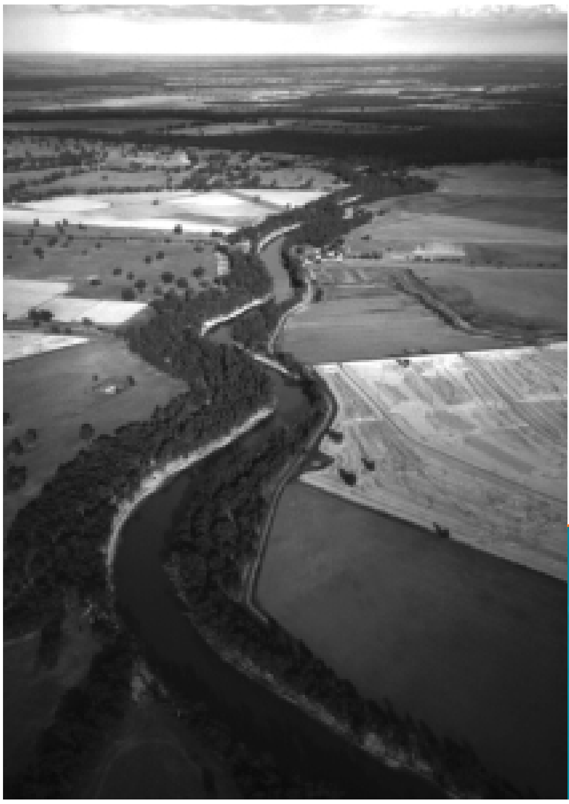
As we work the natural environment we modify it to better suit our purpose, or incidentally as a consequence of the work. By replacing natural deep rooted vegetation with shallow rooted pastures and crops we have significantly increased agricultural production but this has resulted in long-term changes to the movement of water, sediment and salt in the landscape into our rivers. Similarly, capturing and storing water from rivers in reservoirs and diverting this for irrigation has dramatically improved agricultural production, but has resulted in changes to the flow patterns and long-term changes to the types of plants and animals that live in the river.

Working rivers will not look like nor will they function in the same way as pristine rivers. There is a relationship between the type and level of work we make a river do and its naturalness. In general, the more work the river is made to do the less natural it becomes. By most definitions of river health, a loss of naturalness represents a reduction in river health.

As well as deriving benefit from the work we prescribe, humans also value services that are provided by a natural river ecosystem. Called ecosystem services, these include provision of clean water, nutrient cycling, sustaining river and coastal fisheries and providing an aesthetically appealing environment for tourism and recreation. In determining the amount of work a river is made to do, a compromise is struck between economic gains from the work and the loss of river health. This trade-off also needs to consider the associated reduction in ecosystem services.

We should not expect the same level of work from all our rivers

Healthy working rivers need not all look and function the same as each other. Their character – what they look like and how they function – will be determined by the type and level of work they are made to do. We should not expect the same level of work from all our rivers. A different compromise may be struck between the level of work and the loss of naturalness depending upon the values the community places on any river. For example, the community has decided to maintain Tasmania's Franklin River and Queensland's Cooper Creek in near natural condition rather than turn them



The River Murray, working hard to satisfy an ever increasing demand for water.
Photo: Bill Bachman

into working rivers. On the other hand, the compromise struck for rivers such as the Murray and the Murrumbidgee strongly favours economic gain rather than river health. Whether these are *healthy* working rivers is another matter.

It is not the role of the scientific community or those who work the river to decide upon the compromise between the competing values of production and the natural environment. Rather, it is for the community, through the political process, to determine this compromise. It is the role of the science community to identify the relationship between level and type of work and the loss of river health. Similarly, it is the role of river users to identify the levels and types of work that are socially and economically viable. Within these bounds, the community will determine what it perceives as an acceptable level of work and health for the river, and consequently the relative levels of economic production and river health. A major responsibility for the scientific community is to evaluate and monitor the sustainability of this compromise and warn the rest of the community if health is declining dangerously.

The River Murray, winding its way through red gum forests. Photo: Bill Bachman

A key component of the healthy working river concept is that the river is managed to sustain an agreed level of work and river health indefinitely. If the level of work reduces the health of the river below what the community desires it is not a *healthy* working river, regardless of the economic gains we may make in the interim. Therein lies a major difficulty in determining the trade-off between economic production and river health – economic returns can be immediate, or at least within the lifetime of the current generation, whereas the consequences of a loss of river health and ecosystem services may take decades to impinge on the human community.

The River Murray provides a poignant example, where river health at the current level of work is likely to decline for decades to come. The eventual level of health, when fully realised, is likely to be unacceptable to this generation, and disastrous to future generations.

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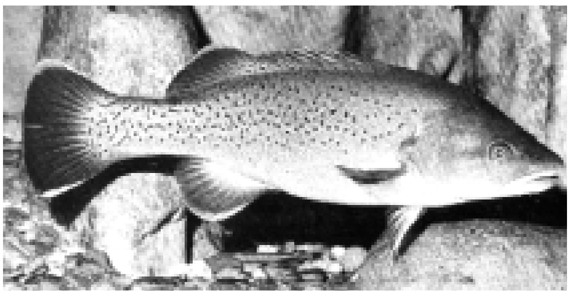


The creature feature for this issue is the trout cod

Family:	Percichthyidae
Genus:	*Maccullochella*
Species:	*macquariensis*

"Trout cod, once abundant throughout the southern part of the Murray-Darling Basin have suffered dramatic declines in the last 50 years, due to overfishing, habitat degradation, altered flow and temperature regimes and competition with alien fish. Trout cod are now listed as 'endangered' under the Environment Protection and Biodiversity Conservation Act 1999.

The Effects of Increasing Salinity on Wetland Sustainability

by Dr Daryl Nielsen and Dr Margaret Brock

Daryl Nielson checks the progress of some salinity trials.
Photo: J Biro

Within the sediment of wetlands and rivers exists a storehouse of seeds, eggs and fragments of aquatic and terrestrial plants. This "seed bank" is an important reservoir of biodiversity and an important store from which future communities are derived. How seedbanks respond to increasing wetland salinity is the focus of an associated project involving the Cooperative Research Centre for Freshwater Ecology and partners, the NSW Department of Land and Water Conservation, and the CSIRO Murray Darling Freshwater Research Centre.

The amount of land and freshwater affected by salinity is increasing in the Australian environment. The salinity audit (MDBC 1999) identified dryland salinity as a major cause of increasing aquatic salinity, particularly in wetlands. Wetlands are of particular ecological importance, providing a range of ecosystem services, such as clean water, biodiversity habitat and nutrient cycling.

Although some freshwater organisms may tolerate saline conditions, in general, freshwater biota do not extend into saline or slightly saline water. For many species, tolerance to salinity increases with maturity. Most research to date has focused on the response of post larval fish, mature aquatic plants and the aquatic stages of macroinvertebrates to lethal (may cause death) levels of salt.

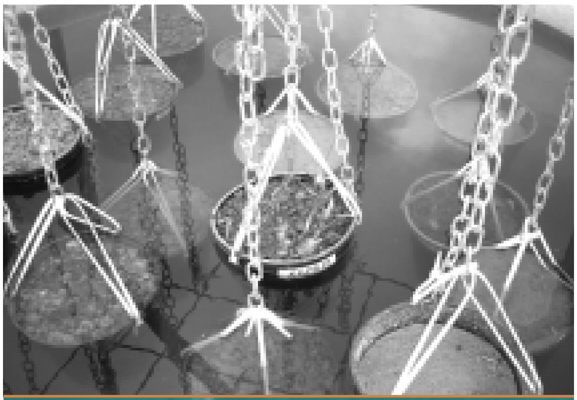
Sublethal levels of salinity may reduce the fitness of a species by reducing its ability to reproduce and survive to adulthood. This in turn may affect the viability and sustainability of future communities. Understanding the responses of immature life stages to sublethal salinity levels is essential if we are to develop protocols and tools that will help in the management of freshwater ecosystems affected by increasing salinity.

A decrease in the diversity and abundance of organisms within the "seed-bank" will have a significant impact on the biodiversity of wetland ecosystems and hence, on many of the ecological processes that they provide. Many animals such as birds and fish rely on the emergence of zooplankton (water bugs) and plants for food and habitat for breeding and their loss may affect the survival of the dependent biota. By knowing which plants and invertebrates are selected from the seed bank the structure and composition of communities could be predicted as salinity levels increase. It will also provide information that will assist future salinity audits and the setting of future environmental targets.

This "seed bank" is an important reservoir of biodiversity

This information in conjunction with other research being carried out at the CRCFE may form the basis of pro-active management decisions for future wetland communities.

The project is planned in three phases. Phase 1 asks *"What biotic components of wetland communities are selected by increasing salinity?"* Two wetland sites were



Germination is reduced when seeds and eggs are exposed to the saline conditions imposed in these artificial wetlands.
Photo: Glenn Wilson, CRCFE

chosen for the study, one a Murray River wetland and the other in the New England area.

The objectives of this initial project are:

A. To quantify the relationship between increasing salinity and the structure of biological communities that develop from dormant eggs and seeds.
B. To determine how the interaction between salinity and hydrology influences wetland biological communities.
C. Use ouputs from (A) and (B) to develop protocols for predicting the consequences of future salinity increases on wetland communities and use these as key indicators of wetland sustainability.

Phase 2 of the project asks: *"How sustainable are the components and processes in wetland communities under increasing salinity?"* And Phase 3: *"Can the aquatic communities of salt affected wetlands be rehabilitated by transplanting "seed and egg banks" selected for under saline conditions?"* These phases will be developed on completion of phase 1, subject to funding.

Preliminary data analysis suggests that increasing salinity reduces the number of plant and zooplankton species emerging and surviving. There was less diversity of aquatic plants germinating at salinities above 300 mg/L (450 EC) and a decrease in the total number of plants germinating at 5000 mg/L (750 EC). There was also a decrease in the diversity and number of zooplankton that were able to emerge and survive at 5000 mg/L (Figure 1).

This project will contribute to the information needed to assist in setting salinity targets for wetlands in a variety of catchments. It will also provide tools to aid the rehabilitation of wetlands affected by salinity. The CRCFE has several ongoing projects addressing the impacts of salinity on our rivers and wetlands that will inform the development of a broader strategy on salinity research.

Further reading:

Hart, B. T., Bailey, P., Edwards, R, Hortle, K., James, K., McMahon, A., Meredith, C. & Swadling, K. (1991). A review of the salt sensitivity of the Australian freshwater biota. *Hydrobiologia*, 210, 105-144.

Nielsen, D. L. & Hillman, T. J. (2000) *Ecological impacts of increasing salinity.* CRCFE technical report.

MDBC (1999). *The Salinity Audit*. Murray-Darling Basin Commission Canberra.

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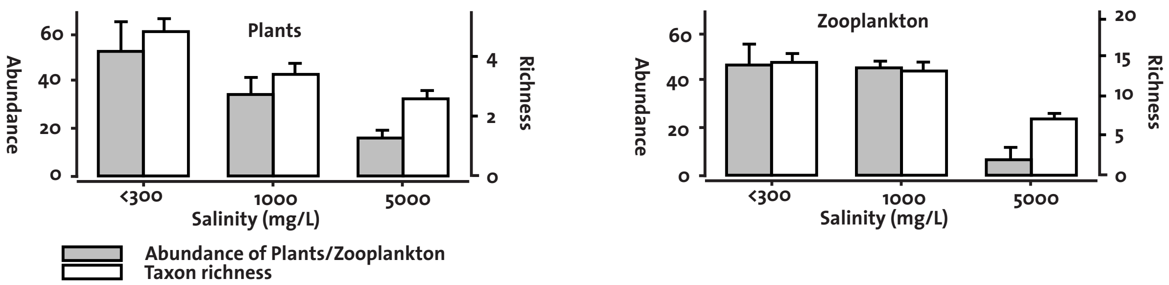


Figure 1. The abundance and taxon richness (or variety) of aquatic plants and zooplankton germinating and emerging from sediment exposed to different salinities.

Bringing Them Back: Returning Macquarie Perch to the Queanbeyan River, NSW

by Mark Lintermans

The future of Macquarie perch in the Queanbeyan River was severely threatened with the construction of Googong Reservoir in 1978. A reintroduction program funded by Environment ACT, and conducted as an associated project within the Cooperative Research Centre for Freshwater Ecology has seen the species successfully restored to the river.

Macquarie perch *Macquaria australasica* is considered a threatened species in all the State/Territories where it occurs. It is classified as endangered in the Australian Capital Territory and Victoria and as vulnerable in New South Wales. It is a moderately sized fish (maximum length 460 mm, maximum weight 3.5 kg) typically found in the cooler, upper reaches of the Lachlan, Murrumbidgee and Murray catchments.

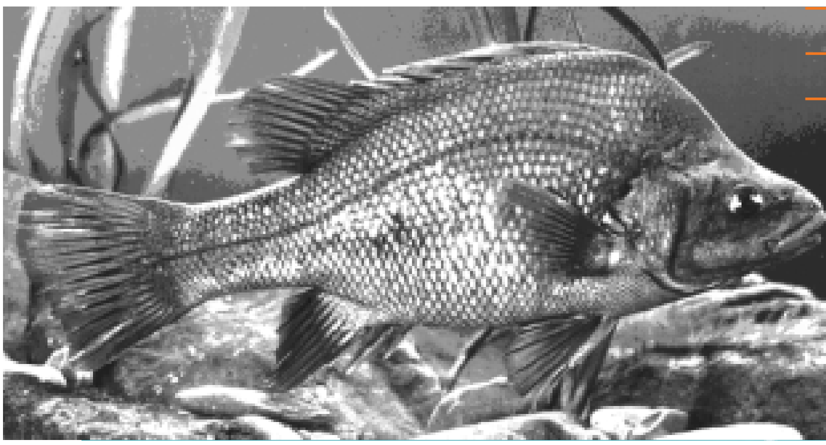
A small population of Macquarie perch was known to be in the Queanbeyan River prior to the construction of Googong Reservoir in 1978. The reservoir and some 5,212 ha of the surrounding catchment are managed to protect the water quality and nature conservation values in the reservoir and immediate catchment.

In 1978 a fish monitoring program for Googong Reservoir was established for the new impoundment and monitoring between 1978 and 1980 revealed that the fish, while present in the reservoir, were not reproducing, with the future of the population appearing grim.

Macquarie perch require flowing water to spawn, with fish depositing eggs above riffles or fast-flowing sections of river. The eggs are then washed downstream where they lodge in gravel or rocky areas until hatching. It is believed that the construction of the reservoir had flooded all available Macquarie perch spawning sites, with fish unable to access the river above the reservoir because of a natural barrier posed by a waterfall (Curleys Falls). The waterfall is at the upstream limit of the impounded waters and consists of a series of small (1-3m) drops through a small rocky gorge.

fish unable to access the river

In November 1980 a total of 57 adult Macquarie perch were netted from the reservoir and transported upstream, past the barrier of Curleys Falls, and released at two sites on the Queanbeyan River. It was



Macquarie perch have been returned to the Queanbeyan river following a successful reintroduction program from Googong Reservoir.
Photo: Environment Australia

Macquarie perch were unable to access remaining spawning sites above the reservoir because of a natural barrier posed by Curleys Falls. Photo: Environment Australia

hoped this action would allow the species to access suitable spawning sites and ensure the survival of the population in the Queanbeyan River.

Monitoring of the release sites between 1981 and 1985 did not detect the presence of Macquarie perch and it was feared the relocation attempt had failed. However, in 1985 an angler reported catching a Macquarie perch at one of the release sites with additional captures by anglers reported over the next few years. In March 1991 a preliminary survey of the Queanbeyan River revealed that there was a small population of Macquarie perch, with at least three age classes of fish present.

The population of Macquarie perch in the Queanbeyan River above Googong Reservoir was sampled in 1996 and 1997. Three sites were sampled each year using a combination of nylon multifilament gill nets, single-winged fyke nets, and bait traps.

A total of 289 fish from 4 species were recorded over the two years of sampling, (see table 1) including 187 Macquarie perch from a number of different size classes. The majority of Macquarie perch were caught in fyke nets in both years with most of these fish being young-of-year fish.

The results demonstrate the importance of using a variety of sampling techniques if you wish to sample a range of fish sizes and species. It is also important to note that a considerable period of time had elapsed before the results of the translocation attempt became apparent. No Macquarie perch were encountered for the first five years after the translocation with breeding only occurring some 7-10 years after translocation. Monitoring programs need to be long-term, and with fish or other long-lived species, you need to be patient.

The success of the translocation of Macquarie perch from Googong Reservoir provides another management option for conserving threatened fish species. The Googong translocation (relocation) involved adult fish as the impact on the donor population was not an issue (considered doomed due to lack of spawning sites). Where a translocation is to extend the range of a population, or to establish a new population without compromising the donor population, consideration should be given to using immature fish. Recent sampling has revealed another waterfall on the Queanbeyan River, approximately 15 km upstream of Curleys Falls, which is limiting the distribution of Macquarie perch. The feasibility of carrying out a further translocation past this waterfall is currently being investigated.

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	Gill Nets		Fyke Nets		Bait Traps	
	1996	1997	1996	1997	1996	1997
Macquarie Perch	13	20	57	95	2	-
Mountain Galaxias	-	-	-	-	24	18
Rainbow Trout	6	14	-	4	-	-
Brown Trout	13	19	4	-	-	-
Total per year	32	53	61	99	26	18
Combined Total	85	160	44			

Managing River flow using larval fish growth and survival?

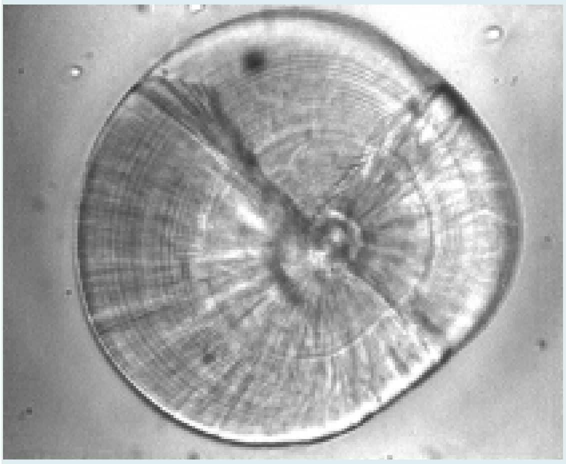
Kylie Peterson, PhD Student

Larval fish, because of their rapid growth rate and sensitivity to temperature and food availability, are useful indicators of environmental stress. However, the triggers associated with fish spawning and the conditions required for larval fish growth and survival are not well understood.

Kylie Peterson of the Cooperative Research Centre for Freshwater Ecology, under the supervision of Professor Robert Kearney is completing her PhD on the effects of coldwater (thermal) pollution and flow variability on spawning and recruitment (growth and survival) of several native and exotic freshwater fish. The research is supported by the CRCFE and the Fisheries Action Program through the Natural Heritage Trust.

The study was conducted during the first year of an environmental release from Burrinjuck reservoir, and provides a comparative study on the effects of changing water temperatures on a variety of fish species.

Larval fish were sampled over a two-year period from the unregulated Goodradigbee River and the regulated Murrumbidgee River (below Burrinjuck dam). Fish were identified and various measurements taken. One of the measurements used was that of 'otolith' growth. Otoliths are the ear bones of fish and their structure appears as a series of concentric rings, much like the growth rings in a tree.



Otoliths are calcium carbonate rich rings found in the inner ear and are valuable for measuring the age and growth rates of fish. This otolith is from a 40 day old mountain galaxias larvae. Photo: Kylie Peterson

Previously used in marine research otoliths provide an accurate way of aging fish. They also provide scientists with a measurement of growth (as the width of rings correlates to growth rate). In waters affected by sudden temperature variations, as occurs following releases from dams, growth can drop sharply.

This study suggests that coldwater releases have a greater negative impact on our larger native species such as Murray cod and golden perch than on smaller species such as mountain galaxias.

Large native species have complex spawning requirements including a combination of flow and temperature cues. Carp on the other hand may be less fussy. While their preferred spawning temperature lies within the range of those for Murray cod and golden perch, and high flows often result in abundant carp recruitment, carp do not appear to require the same flow cues that have been suggested as requirements for these larger natives.

Small native species, such as mountain galaxias appear to be stimulated to spawn after a flow peak and may also benefit from cooler water that is often associated with large irrigation releases.

Before river regulation native fish would have got the correct cues perhaps once every five years, sufficient to allow significant recruitment events to occur. Now these cues might only occur once a decade, or less. This places pressure on the ability of fish populations to remain self-sustaining.

These findings show the immense variation in environmental requirements and life-history strategies of a range of species. They also provide real-time indicators of the impacts of different water release strategies. Releases must occur at an appropriate time and temperature to provide the spawning cues that large native fish require. Management of flows after environmental releases is just as important in order to maximise the survival of newly hatched larvae. This study shows that larval fish can be useful for assessing the success of river flow management strategies in achieving environmental outcomes.

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Talking Point

by Professor Gary Jones

The community-based processes underpinning natural resource management in Australia provide a new challenge for scientists. A challenge that not all scientists may recognise, but one that is looming nonetheless. At its heart lies a view that for those whom it may affect, the community, the quality of research is no longer the only test of its validity and usefulness.

Historically, 'society' has allowed scientists to undertake research without imposing too many expectations or conditions, content with a steady stream of publications or the occasional brilliant theory or insight! The validity of the research – the benchmark for its defensibility – was applied by a critical audience of like-minded scientists. There may have been a sense of 'public good' about the research but this largely remained a matter of faith, rather than an operational goal. For the most part, the international scientific community was the true client for new scientific knowledge.

Today, those people who consider themselves as stakeholders in our research findings – water mangers, landholders, catchment coordinators, – are seen as important clients too. Ultimately they will judge whether the knowledge we produce is useful and credible. Scientific objectivity and rigour remain absolute requirements, but alone they are insufficient to ensure impact and adoption, if indeed they ever were.

Legitimisation of research by the community is becoming essential in many disciplines including natural resources science. This does not mean that the community must share our conclusions about the significance or the implications of our research. However, we need them to see the research process as objective, unbiased and transparent. Outcomes – how other people respond to our knowledge – become important under this scenario, not just our knowledge outputs.

Community trust can be slow to build, but it can be eroded rapidly. This is a challenge for all scientists. Building trust at an organisational or an individual level takes time and patience – time that scientists may prefer to spend doing research. It also requires scientists to undertake activities they may feel uncomfortable about, something they didn't know would be necessary when they decided to become a scientist – to allow the community to meet and debate the person behind the science.

Our knowledge brokers and scientific communicators carry a significant part of the effort by facilitating and undertaking much of the necessary stakeholder interaction. But, and here may lie the rub, the individual researcher must allocate some time to meeting and talking with the community. Time that will be spent not only in explaining the research project, its findings and potential applications, but in simply getting to be known. No matter how good the science, there is a significant risk that our knowledge will be marginalised if the scientist's role as an independent knowledge provider has not been validated and accepted by all community stakeholders.

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SideStream

New Director for the MDFRC

Dr Ben Gawne has been appointed Director of the Murray-Darling Freshwater Research Centre and also takes a position on the Executive of the CRC for Freshwater Ecology. Ben comes to the position with an extensive knowledge of the Basin's rivers and how they are managed. In announcing the appointment Professor Peter Cullen, Chief Executive of the CRCFE said he was confident Ben would build on the excellent reputation established by the Centre over the last 25 years.

New Technical Report

Lawrence I. 2001. *Integrated Urban Land and Water Management: Planning and Design Guidelines.* CRCFE Technical Report 1/2001. This report is available from the CRCFE website on www.freshwater.canberra.edu.au, look under publications, technical reports.

New Chief Executive sought for the CRCFE

The CRC for Freshwater Ecology is seeking to appoint a new Chief Executive. The appointee will replace Professor Peter Cullen who will be stepping down from the position at the end of June 2002, prior to his retirement from the University of Canberra.

This is a challenging post, to provide leadership to an organisation which has demonstrated its capacity to undertake ecological research, essential to the management of water resources in Australia and to deliver that knowledge in an effective way to agencies, politicians and the community.

An attractive salary package will be negotiated.

The position description and selection criteria are available on the CRCFE web site at http://freshwater.canberra.edu.au

Further information about the Centre and the position is available from the CRCFE web site, or from the Chair of the CRCFE Board, Dr John Langford, c/o Water Services Association of Australia, 8th Floor, 469 Latrobe Street Melbourne, VIC 3000 AUSTRALIA. Phone (03) 9606 0678

CRCFE web site:
http://freshwater.canberra.edu.au

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The CRCFE is a collaborative venture between:

- ACTEW Corporation
- CSIRO Land and Water
- Department of Land and Water Conservation, NSW
- Department of Natural Resources and Environment, Victoria
- Environment ACT
- Environment Protection Authority, NSW
- Environment Protection Authority, Victoria
- Goulburn-Murray Rural Water Authority
- Griffith University
- La Trobe University
- Lower Murray Water
- Melbourne Water
- Monash University
- Murray-Darling Basin Commission
- Natural Resources and Mines, Queensland
- Sunraysia Rural Water Authority
- Sydney Catchment Authority
- University of Adelaide
- University of Canberra

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