I have pleasure in presenting the second Native Fish Strategy Annual Implementation Report.

The Strategy is designed to bring communities and governments together to enhance native fish populations throughout the Basin over the next 50 years. The central purpose of the Annual Implementation Report is to provide a framework for the reporting of national and state progress towards implementation of the Strategy.

In the second year of the Strategy considerable effort continues to be focused on awareness activities; this work has been facilitated through the employment of state-based Native Fish Strategy coordinators. The development of the ‘Daughterless carp’ technology, the trialling of a number of fish counting devices, and several projects investigating various impacts of flows on native fish ecology, also proceeded at full pace.

On-ground achievements included the commencement of construction of vertical slot fishways at Locks 9 and 10, and the completion of several prototype fishways at the Barrages.

The Strategy’s Community Stakeholder Group undertook a very successful week-long ‘Darling River Tour’ in May 2005, meeting with local government, catchment management organisations, Indigenous people, recreational fishers, school children and the general public; a similar event is now planned for 2006 in the south-east NSW/north-east Victorian part of the Basin.

In June 2005, the Fish Management and Science Committee sponsored a workshop on ‘Fish in Wetlands’, which brought together scientists, managers, conservationists, and community groups to review the current state of knowledge on this issue, and recommend priority actions for future management.

State and territory governments have made significant progress in implementing the Strategy, especially in areas such as fish passage, habitat rehabilitation, and the maturation of the ‘demonstration reach’ concept. The cooperation of those governments was greatly appreciated in the preparation of this document.

Wendy Craik
Chief Executive Officer
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The Native Fish Strategy (NFS) was developed in 2002 to coordinate the recovery of the Murray-Darling Basin’s (MDB) decimated fish populations through amelioration of their major threats. This is the second Native Fish Strategy Annual Implementation Report. The document fulfills the Murray-Darling Basin Fish Management and Science Committee’s reporting commitment and provides a framework for the reporting of national and state progress towards implementation of the NFS.

In its second year of life, the NFS is still developing and consolidating, actively guided by the various committees. The Fish Management and Science Committee (FMSC) oversees implementation of the Strategy, assisted by the Community Stakeholder Group (CSG). NFS Coordinators carry out extension work and facilitate the NFS’s on-ground application, and the Fish Passage Reference Group (FPRG) provides advice on fishway design, location and monitoring. During the year, the Murray Cod Reference Group (MCRG) was established to provide expert advice and leadership on all matters relating to Murray cod and its management.

The year saw initiation of several new projects, preparations made for implementation of others, and established projects beginning to yield results. The FMSC initiated a major review of the ‘Sea to Hume Dam’ Fishway Program. This ambitious program aims to restore free passage to fish communities from Hume Dam to the sea, a distance of 2,225 km. To this end, the MDBC is constructing 15 fishways at 13 sites; at this stage, seven have been installed. Fish monitoring is helping to improve fishway performance and, excitingly, showing that the structures are allowing passage of large numbers of fish.

The fishways’ research has also resulted in significant advances in knowledge of the ecology of native fish, fishway design and monitoring technology. The program has received much support from the four participating States and garnered considerable international interest because of the unique design intent of restoring passage to whole fish communities.

Trial resnagging is proving successful for a variety of fish species and can be targeted at particular species. Several sites have been selected for restoration of instream and riverine habitat. The Demonstration Reach concept is progressing towards implementation, with the identification of several suitable sites across the States that will benefit from intervention and be used to demonstrate how threats to native fish populations can be managed. A demonstration reach manual is in preparation.

During the year, consideration was made of the value of Habitat Management Areas for the protection of freshwater fish and their habitats, and a study initiated on the existing system and the need for additional measures. In recognition of the poor protection currently afforded the threatened Murray Crayfish, the FMSC initiated a knowledge scoping study for that species. Projects are underway on the identification of barriers to movement and significant habitat for the threatened Murray cod.

Among the many new projects is a review of the impacts of native fish stocking on fish within the Basin. At the same time techniques are being investigated that will allow discrimination of released stock from wild fish. Fish survey information from around the MDB is being collated, and innovative techniques identified and implemented to analyse the data, to provide an overview of the status of native fish in the Basin and trends in abundance and distribution. Other studies are tackling the impact of managed flows on native fish, and the incidence of entrainment of fish into off-stream habitats by irrigation practices.

The MDBC-funded ‘Daughterless carp’ Project comprises seven sub-projects to test the hypothesis that male-bearing Carp could drive down the population across the Basin. Results to date indicate that the daughterless approach is technically feasible and would be acceptable to the public. Other progress towards control of invasive fish species includes the development of rapid response plans and their trialing. Not least, the award-winning Carp separation cage (the ‘Williams’ separation cage’) was fully automated with no loss of efficiency, and the design was finalised in 2005.

Executive Summary
Indigenous involvement continues, and a report is in preparation that condenses information on the significance of Murray cod to Aboriginal people, and documents the species’ contemporary and historical significance recorded directly from the people themselves.

As part of their ongoing commitment to the NFS, substantial reports against the six driving actions of the NFS have been received from the five states and territories with a stake in the Basin: New South Wales, the Australian Capital Territory, South Australia, Queensland and Victoria. They appear in the CD attached to this document.

The securing of adequate, long-term funding and the setting of priorities remain challenges to the implementation of the NFS. The task is daunting, yet there is wide support to reverse damage to the Basin’s aquatic systems for the benefit of their native fish. Rehabilitation work, guided by research, has begun and is proving successful, but there is a long road ahead.
1. Introduction

The Native Fish Strategy (NFS) is a response to the key threats to native fish populations in the Murray-Darling Basin (MDB), which range from flow regulation, habitat degradation and lowered water quality, to man-made barriers to fish movement and the introduction of alien fish species. Under these threats native fish populations in the Basin’s rivers have declined to an estimated 10 per cent of pre-European levels.

The NFS is built around 13 objectives, outlined below. These have been condensed into six driving actions, designed to catalyse investment in the Strategy.

The Native Fish Strategy has 13 objectives:
- repair and protect key components of aquatic and riparian habitats
- rehabilitate and protect the natural functioning of wetlands and floodplain habitats
- improve key aspects of water quality that affect native fish
- modify flow regulation practices
- provide adequate passage for native fish
- devise and implement recovery plans for threatened native fish species
- create and implement management plans for other native fish species and communities
- control and manage alien fish species
- protect native fish from threats of disease and parasites
- manage fisheries in a sustainable manner
- protect native fish from the adverse effects of translocation and stocking
- ensure native fish populations are not threatened from aquaculture
- ensure community and partner ownership and support for native fish management.

and six driving actions:
- rehabilitating fish habitat
- protecting fish habitat
- managing riverine structures
- controlling alien fish species
- protecting threatened fish species
- managing fish translocation and stocking.

This document, the Native Fish Strategy Annual Implementation Report, details progress towards achieving the Strategy’s objectives. It begins with an overview of developments towards achieving each of the six driving actions and is completed by the five State and territory reports. In 2004–2005, the second year of implementation, the Strategy gained momentum and made significant progress, as summarised in Table 1.
### Table 1: Summary of significant achievements made toward the objectives of the Native Fish Strategy during 2004–2005

<table>
<thead>
<tr>
<th>Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>• response of endangered Trout cod to resnagging downstream of Yarrawonga</td>
</tr>
<tr>
<td>• progress on several aspects of the ‘Daughterless Carp’ technology</td>
</tr>
<tr>
<td>• establishment of the Murray Cod Reference Group</td>
</tr>
<tr>
<td>• Darling River Tour</td>
</tr>
<tr>
<td>• installation of PIT tag readers in all new fishways</td>
</tr>
<tr>
<td>• construction of fishway at Lock 9</td>
</tr>
<tr>
<td>• refinements in the Williams carp separation cage</td>
</tr>
<tr>
<td>• progress with the establishment of several demonstration reaches</td>
</tr>
<tr>
<td>• trials of several new fish counting technologies</td>
</tr>
</tbody>
</table>

Monitoring has shown response of Trout cod to resnagging on the Murray River
2. Background

Many factors have contributed to the deterioration of fish habitat and native fish populations. These include changes to water flow, thermal pollution and the introduction of alien fish species. An expert panel convened by the Murray-Darling Basin Commission (MDBC) in 2001 estimated that present levels of native fish communities in the Basin are about 10 per cent of those pre-European settlement. Without intervention, populations are likely to fall to near five per cent in the coming 40 to 50 years.

To address this crisis, the Native Fish Strategy (NFS) was developed. Rehabilitation of aquatic ecosystems is fundamental to achieving the Strategy’s objectives and, therefore, a holistic approach to implementation is essential. The NFS provides direction for investment in on-ground management activities and associated research. It is a working document for the next decade and expected to be the basis for future strategies. Implementation of native fish management actions involves government agencies, regional catchment organisations and a wide range of community groups. Aesthetic, conservation, cultural, recreational and commercial values will all be taken into account.

The NFS has been developed and enhanced through extensive consultation with agencies, interest groups and individuals, particularly in regional areas. Various government organisations, through representatives on the MDBC’s technical groups, have contributed. It was circulated for expert consultation and is now a very inclusive document that shows the way ahead, as conceived by the key partners in the Basin.

Implementing the driving actions of the NFS requires a targeted and sustained effort by governments, catchment management organisations and communities. It is imperative to define the actions and associated responsibilities required within each catchment.

State governments have the prime responsibility for managing rivers. Many of the in-stream interventions needed to improve conditions for fish in rivers will require funding from the States. This will also be so for any interventions on State-owned land. However, in the case of the Murray and lower Darling Rivers, the MDBC has specific responsibilities (e.g. management and operation of structures for water supply) and can provide direct resources (both human and financial) to achieve resource management outcomes, as well as recommending policies to be adopted for the wise management of those rivers by all relevant jurisdictions.

In order to facilitate the uptake and implementation of the Native Fish Strategy, both an Investment Plan for the Basin and an Implementation Plan for the River Murray have been developed. The Investment Plan is guided by the Integrated Catchment Management (ICM) Policy principles relating to investment:

- the economic, environmental and social benefits of the investment must be greater than the costs
- government investment will be used to stimulate private investment, and to prevent unacceptable levels of resource degradation
- alternative investments will be considered and evaluated
- joint-venture partnerships with the community will be the preferred government investment approach
- on-ground investment will be supported by strong institutional arrangements, knowledge, sound planning, and adequate monitoring, evaluation and reporting systems.

2.1 Linkages with other Basin initiatives

The targets for the NFS will be formulated so they are consistent with the Sustainable Rivers Audit (SRA), the ICM Policy Statement and ‘The Living Murray’ initiative. Targets for river health and fish populations will be coordinated with monitoring, which will be undertaken for the SRA.

2.1.1 Integrated Catchment Management

The NFS has been developed and will be implemented within the context of the MDBC’s ICM Policy. This policy reflects a commitment by the community and governments to do all that needs to be done to manage and use the resources of the Basin in an ecologically sustainable manner.
The partnership approach implicit in ICM depends on the commitment of individual landholders, Indigenous communities, Landcare groups, catchment management organisations, waterway managers, urban and rural community groups, local, State and Commonwealth Government agencies, as well as the MDBC. A substantial reallocation of funding will be needed by governments and the community to implement the NFS.

2.1.2 The Living Murray

Implementation of the Native Fish Strategy on the River Murray will be highly dependent on the outcomes of ‘The Living Murray’ initiative, and on decisions regarding development and maintenance or upgrading of structures on the river. The Living Murray Environmental Works and Measures Program is designed to implement structural and operational changes in the River Murray System to achieve positive ecological outcomes. The benefits of this Program to the River Murray System will include:

- improved fish passage and habitat
- improved floodplain health
- better management of the Murray Mouth, Coorong and Lower Lakes
- increased capacity to enhance flows to deliver ecological outcomes and improved water quality for all river users.

As part of improving fish management, The Living Murray Environmental Works and Measures Program is funding the ‘Sea to Hume Dam’ fishways program.

2.1.3 Sustainable Rivers Audit

The SRA has been developed to monitor the environmental health of the Basin’s rivers and provide more information to resource managers and the community on the location and extent of degradation. The Audit is seen as a logical extension of the Cap on Diversions and a means of providing a stronger scientific base for debate in relation to ecological, environmental and social considerations associated with water management in the Basin.

The SRA involves regular measurement and reporting on river health, and the reports are independently audited. The health of fish populations is used as one of the outcome-based indicators of river health, with measures of current fish populations compared to a baseline reference condition to give a general assessment of fish health. Over time, the SRA reports will reflect the impact of management initiatives (such as the Native Fish Strategy) on the direction and rate of change in the health of fish populations.

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The SRA will provide consistent, Basin-wide information on the health of rivers to enable and enhance sustainable land and water management by: developing a common reporting framework using comparable information, through time and across catchments; and reporting against a consistent and scientifically robust set of river health indicators.

The SRA is proceeding to implementation of three themes: fish, macroinvertebrates and hydrology. A cost sharing arrangement has now been agreed by partner governments which includes funding for further development of indicators in the following thematic groups: physical form, riparian vegetation and floodplain health. Fifty per cent of the program will be paid for within the Murray-Darling Basin Commission budget, and the States and Australian Government will contribute an additional 25 per cent each. The outcomes of the Pilot Audit have now been publicly released by way of five technical reports, one covering each thematic group of indicators trialed in the Pilot.
3. The year in review

3.1 Driving actions

3.1.1 Rehabilitating fish habitat

Downstream Yarrawonga resnagging evaluation

The concept for this project grew from previous MDBC-funded research projects which investigated the habitat and movement requirements of fish by radio-tracking and the distribution and abundance of snags in the Murray River (the Pilot Snag project). One of the many critical findings of these projects is the dependence of certain fish species (Murray cod, Trout cod and Golden perch) on snags as instream habitat. Nearly all Murray cod reside within or at snags, and after their annual spawning migration almost all fish return back to the same snag. The residency, site fidelity and homing behaviour documented by this project, in conjunction with the already understood significance of snags as velocity shelters and food providers, established beyond any doubt the absolute dependence of these fish on snags. The Pilot Snag Project quantified snag characteristics, distribution and abundance and provided a template for re-snagging.

Re-snagging is one of the more obvious habitat management actions highlighted in the NFS. Recent funding for re-snagging of sections of the Murray River has seen this management option become a reality and provides an important chance to test and evaluate the benefits of resnagging. The effects of snag (large woody debris) management have been widely studied overseas and re-snagging has been used as a rehabilitation tool, where its viability has been established through on-ground experience. Since 2002, the evaluation of the sites that were resnagged below Yarrawonga has been supported by the Resnagging Evaluation Project. The results confirm the positive response that can be expected from native fish to resnagging.

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A secondary component of this monitoring program has been the establishment of a mark-recapture dataset that will provide estimates of the growth rates and population statistics of Murray cod, Trout cod and Golden perch. This has already been used to assist with advancing the management of Murray cod in the MDB. However, another three years of data collection is necessary before the dataset will have the statistical power required to allow its inference to apply to other regions in the MDB (the utility of this data will have direct relevance to demonstration reaches in the area). The data will also provide the opportunity to confidently identify variation in the use of resnagged sites by different size classes of fish (these data provide the foundation for investment decisions with regard to resnagging in the region).

In 2005, the Arthur Rylah Institute (ARI) sampled 40 sites on the Murray River between Yarrawonga and Tocumwal to complete the mark-recapture dataset that will allow estimates of population statistics for Murray cod, Trout cod and Golden perch to be made. ARI also sampled resnagging sites on the Murray between Yarrawonga and Cobram to estimate the variance in use of resnagged sites by different size classes of fish.

Results indicate that fish use logs restored to streams, and that sites can be optimised for particular species. The response is unequivocal for the critically endangered Trout cod, with a biologically important increase in the number of Trout cod following resnagging. For the other species the results are more variable, indicating that other habitat variables may also be necessary to increase the number of occupants. These results demonstrate the importance of longer term monitoring to quantify restoration responses. They also highlight the value of testing restoration predictions.

Hume to Yarrawonga: riparian and instream rehabilitation

During 2004–2005, ‘The Living Murray’ project ‘Resnagging and Riparian Restoration – Hume Dam to Yarrawonga’ made significant progress including:

- monitoring of 58 sites to establish a baseline dataset of large-bodied fish distribution and the development of a comprehensive monitoring strategy
- mapping of location, size and complexity of woody habitat in the main stem and anabranches
- development of a stakeholder and community consultation and Indigenous engagement strategy
- revision of the restoration plan to include compliance issues and identification of three priority sites for resnagging
development of a feasibility study to examine costs, implementation methods and sourcing of appropriate woody habitats
establishing an agreement with VicRoads to source large woody habitats from the current Albury bypass
preparation of a draft investment proposal for Commission approval.

During 2005–2006, the following tasks will be undertaken to begin implementation of the resnagging program:

- completion of the investment proposal, MDBC and agency approval process
- development of detailed work-plans for each of the priority resnagging sites
- modelling the effect of resnagging on flow to anabranches and upstream water levels
- continued stakeholder and community consultation and Indigenous engagement
- continued sourcing of woody habitat for the priority resnagging sites and possible stockpiling, dependent upon funding availability
- further monitoring of existing fish distributions.

An additional Living Murray project, ‘Resnagging and Riparian Restoration – Hume Dam to Yarrawonga – Refuge Habitat’, was initiated in 2004–2005 to investigate the role of backwaters and anabranches in relation to the survival of native fish. The project monitored fish movements in five backwater areas during rising, static and falling river water levels. Two sites were identified for establishing artificial refuge areas to investigate increased survival and growth of native fish when refuge is provided from predation, cold water pollution and high flows. An investment proposal was developed for one of the trial refuge sites, located on private land at Boiling Downs Creek, including regulator design and review of environmental factors. The investment proposal was approved by the MDBC, but the project has been deferred until 2006–2007 due to limited availability of funds.
Boiling Downs monitoring
The Boiling Downs section of the River Murray meets the criteria for a Demonstration Reach, in that it is:
- degraded but considered able to demonstrate results from rehabilitation
- in close proximity to population centres and resources of Albury/Wodonga, Howlong and Corowa
- likely to gain strong community support because it is accessible and visible to the public
- already the target of several rehabilitation projects
- affected by several threats and ecological issues
- adjacent to a suitable downstream river reach for testing scientific hypotheses and assessing results.

A number of major projects/programs have listed the western part of the reach (Boiling Downs Reach) as a priority under ‘The Living Murray’ Implementation Program. These are the:
- Hume to Yarrawonga Waterway Management Plan’s river stabilisation works
- resnagging and riparian restoration under ‘The Living Murray’ Environmental Works and Measures Program
- refuge habitat project under ‘The Living Murray’ Environmental Works and Measures Program.

The potential therefore exists to expand on these activities/programs to form a demonstration reach.

In order to explore this potential it is necessary to understand the current state of the fish population in the reach. Accordingly, sites were sampled throughout the Boiling Downs Creek system and in the nearby main channel of the Murray River. Only sections near the upstream entrance and downstream exit of Boiling Down Creek in the main Murray River were sampled, due to navigation hazards blocking access to the mid sections of the Murray River. The survey design allowed comparison of the standardised catch, longitudinal trends and species and size class differences.

A total of 3,358 native fish and 233 introduced fish were recorded in the survey. The native fish count was dominated by smaller bodied species (97 per cent of the count). These species included Flat-headed gudgeon, Australian smelt and Unspecked hardyhead. Carp (97 per cent) dominated the introduced species count.
The sampling did not detect the presence of 10 native species previously recorded in the region: Macquarie perch, Bony bream, Freshwater catfish, Southern pygmy perch, Carp gudgeon, Crimson spotted rainbowfish, Murray hardyhead, Murray jollytail, Mountain galaxias and Short-headed lamprey. Macquarie perch, Bony bream, and Freshwater catfish have not been recorded for at least 20 years and may be functionally extinct in this region of the Murray River.

This snapshot of the fish population indicates that the Boiling Downs Creek region may be suitable for a demonstration reach for the following reasons:

- there appears to be a small but resident population of Murray cod in the region
- Trout cod are present in small numbers and may be re-establishing in the reach
- Golden perch, Silver perch, Australian smelt, Unspecked hardyhead and Flat-headed gudgeons were detected in the region
- Carp gudgeons, Murray jollytail and Mountain galaxias have been recorded in the region by other recent surveys and are likely to occur in Boiling Downs Creek
- the catch per unit effort for fish overall is low in comparison to less degraded sections of the Murray River (e.g., below Yarrawonga Weir to Barmah Forest) indicating that there may be potential for population increase due to restoration.

**Progress summary on Native Fish Demonstration Reach Project**

In 2004, consultants were contracted to engage and inform the communities of a number of catchments in the MDB about the generic concept of demonstration reaches. Investigations were carried out at six potential sites for native fish demonstration reaches. The investigations involved field visits and structured interviews.

**Macintyre River reach in the vicinity of Goondiwindi**

- The site offers considerable potential for a demonstration reach and meets many of the critical criteria. There are two potential local champions and a local home (regional NRM organisation); the reach is proximate to a large population centre; in reasonable condition; and interventions that could impact on habitat and fish populations are not unrealistic. There are no critical risks. MDBC involvement would be welcomed and appreciated.
- Queensland DPI is interested in developing a demonstration reach in the vicinity.
- There is a need to consolidate disparate research data relating to the river and to build the baseline data.

**Darling River near Bourke**

- The reach from Bourke to Brewarrina is the site of a Western CMA funded project being implemented by New South Wales DPI. Consultations in the region indicated that the choice of site was influenced by the source of the funds (National Action Plan for Salinity and Water Quality). Key stakeholders were not familiar with the project and many suggested that the selected site was not the most ideal in the region. The project is large and the Western CMA stated that if additional investment was available (e.g., through MDBC) it would prefer to see it spent in a downstream reach.
- The reach offers less potential than the Macintyre in relation to community engagement and education outcomes of a demonstration reach.
- The reach is technically suited to a demonstration reach.

**Murrumbidgee Catchment**

- Murrumbidgee CMA is funding a number of projects relating to riverine health and habitat. One is a demonstration reach project, being implemented by New South Wales DPI. The site is Old Man Creek—an anabranch of Tarcutta Creek.
- The site is technically suited to a demonstration reach and is reasonably proximate to a large population centre (Wagga), but the land is almost all privately held and there is very limited public access along the reach.
- Landholder engagement is uncertain. Of about 20 fringing landholders, 80 per cent have expressed interest but are concerned about being actively involved. There are concerns about ongoing maintenance of riparian fencing and stock water access.
- Current investment (around $200,000) is not sufficient to achieve the integrated aims of a demonstration reach.
• The CMA is proposing an extension of the project and further funding.
• The involvement of the MDBC would be appreciated and welcomed. The types of support could include assistance with promotional material to boost the engagement and publicity outcomes of the demonstration reach. Assistance with Carp control would also be appropriate.

**Hume Dam to Yarrawonga, Murray River**

• The Hume to Yarrawonga reach enjoys excellent benchmark information on native fish populations and habitat quality. This provides ample scope for countable targets in managing a demonstration reach. Remnant populations of native fish (including threatened species) provide a platform for the future. On top of this, good populations of large-bodied fish in the practically unregulated Ovens River provide opportunities for recruitment.
• Ongoing investments in river management practices are significant. Resource management agencies have the capacity to finetune this investment. For marginal costs, significant native fish benefits can be brought together. There is a critical mass of resource management expertise in the region. This is coupled with a sound history of interagency and cross-border cooperation, and there is strong community support for work in the Murray River.

**Broken River**

• The Victorian Government has invested a lot of money and effort into changing flow regimes in the Broken River. The proposed decommissioning of Lake Mokoan is providing the catalyst for a range of actions that will help to improve native fish habitat thereby favouring native fish populations over alien species.
• There is some scope for the MDBC to work with Goulburn Broken CMA and State agencies to help communicate tangible benefits from these activities in terms of their benefits for native fish populations. However, given the political currency already invested at the State level in demonstrating the overall benefits of making what are perceived to be radical changes in the way the system operates, the best way for the MDBC to help is to use the findings from the interview process to inform the communication strategies of the State agencies.
South Australia

- South Australian interest in developing a demonstration reach is high. The immediate priority is to facilitate a consensus on the best way forward. There are several contending sites. Several small sites around Murray Bridge enjoy strong community and agency support. Interest is high in the Lower lakes and Coorong, but there are questions about how well this would help demonstrate the concept for other parts of the Basin.

- Katarapko Creek, which is close to the population centres of Berri, Barmera and Loxton, offers significant opportunities to alter flow regimes and fish passage. Baseline information is needed and work is required in building community engagement. However, these tasks could be done in parallel.

- Chowilla enjoys good baseline data, and current investments in managing environmental flows are being finetuned to optimise native fish outcomes. The reach is already in good condition from the perspective of the NFS. Nonetheless, the Local Area Action Plan (LAAP) Group is confident that local knowledge and further community input would yield dividends.

Demonstration reach papers/presentations

Raising the awareness of the demonstration reach concept among the community and partner governments is critical to its success. Accordingly, papers were presented at key conferences in 2004–2005, including the 7th International Riversymposium in Brisbane, September 2004, the Fourth Australian Stream Management Conference in Launceston, October 2004, and the Fourth National Waterwatch Conference in Melbourne, February 2005.

Demonstration reach manual

A demonstration reach manual is being developed to provide catchment management organisations, local communities and other interested parties with a toolkit of technical and practical information on how to plan, establish and measure the effectiveness of a demonstration reach. Contributions are being sourced from experts on key management issues such as thermal pollution mitigation, alien species control, environmental flows, and experimental design. The document is due for completion in 2006.

State and territory highlights

New South Wales is establishing a 26 km demonstration reach for Trout cod in the upper Murrumbidgee. Preparations have begun, with willow poisoning completed, and fencing and replanting underway. The engineering works will commence as soon as conditions are suitable. To improve knowledge of the effectiveness of the rehabilitation work, the DPI Aquatic Ecosystem Research Group has completed replicated sampling of fish communities at three sites slated for rehabilitation, three paired control sites and three Murrumbidgee River sites, to be repeated post rehabilitation. Conservation Volunteers are doing some of the replanting works, and the project has received wide media coverage. The Murrumbidgee CMA has approved the development of a second demonstration reach at Old Man Creek, an anabranch of the Murrumbidgee River. Landholder engagement has commenced, and fish monitoring and habitat mapping are underway. A resnagging feasibility study has been completed and several sites have been selected for investigation near Wagga Wagga. The 2005–2006 Recreational Freshwater Fishing Trust Fish Habitat Grant Program has been launched with $200,000 available for freshwater projects.

To progress the demonstration reach concept in the Queensland Murray-Darling Basin, a one-day workshop was held in May at Stanthorpe. The workshop set in motion a process for the establishment of demonstration reaches in Queensland. Regional NRM groups are prioritising sites suggested at the workshop. Once sites have been chosen, a steering committee in each NRM region will be formed to develop the management plan for the proposed sites. QMDC’s Indigenous Landcare Officer discussed prospective collaborative projects with Aboriginal communities in the region, some of which have commenced: the Yumba project focuses on revegetation of a section of riverbanks on the Maranoa River; at Dirranbandi, the Old Camp project is stabilising a kilometre of eroding riverbanks; and the Aboriginal rock wells will be restored and re-fenced at Weengallon.
In South Australia, following appointment of a River Care officer by Greening Australia (SA), four restoration sites—Terrington wetland complex and lakeshore on Lake Alexandrina; Paiwalla wetland upstream from Murray Bridge; Hart Lagoon at Waikerie; and Gurra Gurra Creek and Lake—were established with assistance from landowners, community volunteers, Indigenous groups and others. On the Chowchilla Floodplain, red gums at thirteen sites were watered; preliminary results indicate that the watering improved the aquatic habitat for fish, macro-invertebrates, crustaceans, frogs and birds. At the Murray Mouth, sand pumping operations have improved water flow and connectivity between the ocean and the Coorong, reducing salinities and providing fish passage. In the absence of flows over the Barrages, sand pumping is the most effective way of keeping the Murray Mouth open and is expected to continue until greater river flows occur. The establishment of Riverine Management Zones in the South Australian section of the River Murray moved closer with the completion of several investigatory projects. The program aims to develop policy and planning frameworks to integrate delivery of environmental flows with other floodplain rehabilitation initiatives.

Following the 2003 Canberra bushfires, monitoring of water quality in Cotter Reservoir revealed significant problems with low dissolved oxygen levels. As the reservoir contains a significant population of the threatened Macquarie perch and is used as a source of domestic water, a solar-powered de-stratification system was installed in December 2004. The system considerably reduced the seasonal pattern of oxygen depletion at the 3 m, 6 m and 9 m depths. In the lower Cotter catchment, a program of riparian restoration has commenced following the loss of most of the pine plantations that dominated the area before the fire. Riparian buffers of native vegetation are to be planted along streams and, in preparation, work has commenced to clear burnt pines.

Victoria’s ten Catchment Management Authorities are developing their own Regional River Health Strategies (RRHS), three of which were released for public comment in 2004–2005. As each RRHS sets out five-year implementation targets for on-ground actions and ten-year resource-condition targets for the overall improvement of river health, there is much scope to ensure that the driving actions of the NFS are appropriately reflected in these plans. A large-scale river restoration
A project has commenced to improve the flow and habitat values of the Broken River. The Goulburn Broken Catchment Management Authority (GBCMA) received almost $1 million from the Victorian Government as part of the ‘Our Water Our Future’ action plan to develop the project. Over the next three to five years habitat restoration works are planned which are hoped to significantly improve native fish habitat and fish passage. The Broken River project complements the proposed decommissioning of Lake Mokoan and restoration of the Winton wetlands complex. An interesting development is the ‘River Tender’ pilot project, a first attempt to quantify the benefits that landholders can provide to the environment through financially supporting their management of riparian areas. The Ovens River pilot explores the use of this market-based incentive program to assist landholders in the protection and enhancement of riparian zones to achieve river health benefits. The project has been given a promising start, with $900,000 of funding allocated so far for the Victorian Government Water Trust Healthy Rivers Initiative, with an additional $500,000 allocated for 2005–2006. Encouragingly, monitoring in 2004–2005 has shown that a resnagging trial undertaken from 1999–2002 in the Murray River between Yarrawonga and Tocumwal has provided habitat for many species of native fish. The project was particularly successful for the critically endangered Trout cod, which has increased markedly since resnagging.

3.1.2 Protecting fish habitat

Protected areas are widely employed as management tools in the conservation of biodiversity, particularly with respect to terrestrial, and to a lesser extent marine, biodiversity. Despite widespread acknowledgement of the potential benefits of habitat protection to aquatic biodiversity conservation, it is often overlooked or deliberately excluded in protected area management, and few dedicated freshwater protected areas exist. Instead, freshwater systems are commonly offered incidental protection when situated within terrestrial protected areas.

The inadequacy of the protection incidentally afforded freshwater systems through inclusion in terrestrial protected areas is being increasingly recognised. To this end, and in the face of global degradation of freshwater systems and resultant losses of aquatic biodiversity, calls for the establishment of freshwater protected areas are now widespread. The NFS recognises this deficiency and provides for the establishment of Habitat Management Areas (HMAs) in the Basin.

Adequacy of terrestrial protected areas project

The need for the establishment of HMAs, freshwater reserves or protected areas, for the protection of freshwater fish and their habitats is well documented. Indeed, the NFS recommends such measures through the establishment of a system of HMAs. However, in presenting to the community the need for the adoption of such measures, it has become evident that there is a lack of data to justify such an approach. For example, there is a need to answer questions such as why the current terrestrial reserve system provides insufficient protection to aquatic habitats within its boundaries.

To address this deficiency, the MDBC has commenced a review of the adequacy of the protection afforded native fish by the current protected area network. The review seeks to: i) quantify the protection afforded native fish by the existing protected area network; and ii) identify opportunities to expand management arrangements in specific protected areas or the system as a whole to better accommodate the needs of native fish. It is anticipated that the exercise will: iii) highlight the inadequacy of the current reserve system in protecting freshwater fish and their habitats; iv) provide statistics to justify claims for the establishment of habitat management areas; and v) provide recommendations for the alteration of current management regimes of selected protected areas. The expected outputs of the exercise include a database of information regarding fish in protected areas in the MDB, as well as a paper to be submitted to a scientific journal and presented at one or a number of conferences.

An international review of freshwater protected areas for aquatic biodiversity conservation

This project involves an international and national desktop literature review of
the use of freshwater protected areas for biodiversity conservation. It is anticipated that the project will enhance knowledge of the social, political, legal and biological issues surrounding the management of freshwater protected areas; identify potential barriers to the establishment of a system of HMA's in the Murray-Darling Basin; and, identify informed management options for the establishment of these areas in the Basin. From this a 'game plan' will be developed that examines the costs and benefits of developing a system of HMA's across the Basin, which will be reviewed by a panel of experts.

In 2004–2005 the majority of the literature phase was completed and the early developmental work on the 'game plan' undertaken. The project report, when completed in 2005–2006, will address issues such as how to apply multiple-use management frameworks, how to work with existing arrangements for protected areas (in the broadest sense), how to use science to prioritise areas for consideration, the range of options and tools available, and the impediments and challenges to moving forward.

**Riversymposium presentation**

At the 7th International Riversymposium in Brisbane, September 2004, a paper was presented titled 'A System of Fish Habitat Management Areas in the Murray-Darling Basin', which detailed the concept of HMAs under the NFS, and described the potential linkages with other initiatives in the Basin such as 'The Living Murray'. Continued discussion with both the scientific community and the general public will be crucial in moving the HMA concept forward.

**State and territory highlights**

The NSW Government has pledged $13.4 million towards the $26.8 million ‘Wetland Recovery Plan’, a suite of projects developed to deliver long term and permanent benefits to ecologically significant wetlands through water efficiency projects, water buy-back and projects to improve wetland management in the Macquarie Marshes and Gwydir Wetlands over a minimum of four years.

The Queensland Murray-Darling Committee (QMDC) has developed a landscape and social process to achieve biophysical outcomes and cooperation across sub-catchments, which has resulted in more than 2.4 million hectares being covered by sub-catchment planning during 2004–2005. Nine sub-catchment plans, that will improve land management, including riparian zones, and assist in the protection of riverine health, have been approved. In addition to approximately $2 million provided, landholders have more than matched this figure with their own investment of time and money. During 2004–2005 QMDC delivered 18 water-based workshops with 151 landholders representing 65 properties and 76 km (6487 ha) for changed riparian management (typically fencing and de-stockling). More locally, at a workshop in May, sponsored by QMDC and the Australian Government’s Natural Heritage Trust (NHT), Goomeroi Elders recognised those who have been involved in the protection of their sacred site, Boobera Lagoon, for the past thirty-five years. During 2004–2005, QMDC’s Landcare Indigenous Officer played a major role in negotiating the protection of the site from grazing and recreational pursuits.

In 2005, the South Australian Government released two key strategies for public comment. ‘Environmental Flows for the River Murray’ is a draft strategy which establishes a framework for collective action to restore river health, while the draft ‘Estuaries Policy & Action Plan’ aims for ‘healthy estuaries for the benefit of present and future generations’. Interim Asset Environmental Management Plans have been developed for the Lower Lakes, Coorong and Murray Mouth and the Chowilla Floodplain (including Lindsay–Wallpolla) Significant Ecological Assets (SEAs). Advisory groups were established for each Asset to assist with the development of ecological objectives, targets and environmental flow management actions. A new project was initiated to determine the condition and management requirements of the aquatic habitats and fish communities in the Chowilla anabranch, funded under ‘The Living Murray’ Environmental Works and Measures Program. The objectives and targets will contribute to the development of a flow management plan for the Chowilla floodplain. A Weir Pool Manipulation Steering Committee was established to assist with the undertaking of a project in 2005–2006, if conditions permit. The Committee made significant progress in preparing
South Australia to be ‘event ready’ and South Australia is now in a better position to capitalise on any flows to the State above entitlement for weir pool manipulation activities.

In the Australian Capital Territory, the 2003 bushfire impacts and prolonged drought over much of southeastern Australia prompted the local water authority to commission a series of studies into future water supply options for the ACT. Three water supplies involving 14 options were shortlisted for further investigation, and a review of the potential impacts on fish and crayfish populations was carried out. The major issues identified were the potential transfer of alien fish and diseases, impediments to fish passage, inundation of threatened fish spawning sites, and construction impacts.

The Victorian Government has committed $225 million to water projects over four years as part of the 2004 ‘Our Water Our Future’ White Paper Action Plan to secure Victoria’s water future. The environment will receive $100 million to protect and repair major rivers and groundwater sources. In 2004–2005, the Wimmera Catchment Management Authority made significant progress in how it manages flows for environmental benefit, receiving over $100 million in assistance from the Victorian Government. A ten-year plan for the Wimmera-Mallee Pipeline Project (WMPP) was approved in 2004–2005. A $501 million initiative, WMPP is a three-way partnership with the considerable task of converting 16,000 km of open channels into a pipeline system that will reticulate water to about 10,000 rural properties and 40 towns; savings from evaporation and leakage may deliver 83,000 ML to the environment (to be shared predominantly between the Wimmera and Glenelg rivers). In the lower Campaspe River, the use of a temporary change in delivery path demonstrated that rural water authorities can manage water supplies to achieve ecological objectives whilst still maintaining the efficient delivery and supply of water to their customers. Given the extreme low flow conditions during 2004–2005, Goulburn-Murray Water worked with the Department of Sustainability and Environment’s Water Sector Group to ensure that native fish habitat and water quality were maintained, by providing a 20 ML/day inter-Basin transfer of water. A pilot scheme in the Mallee area highlighted the cooperation that can occur between landholders, water authorities and natural resource management agencies to achieve environmental outcomes. Irrigators were allowed to temporarily transfer unused water to deliver an environmental benefit to local areas, and the transfer fees that would normally apply were waived. Individual farmers volunteered to donate 1,300 ML of unused water entitlements to enhance the 4,000 ML environmental flow allocated by the Victorian Government for red gums in Hattah Lakes and other locally significant sites.

3.1.3 Managing riverine structures

‘Sea to Hume Dam’ Fishway Program

Fishways at the River Murray Barrages

In 1940, five tidal barrages, with a combined length of 7.6 km, were completed near the mouth of the Murray River.
These reduced the extent of the estuary by approximately 90 per cent. Freshwater flows are now highly regulated and during periods of reduced rainfall within the Murray-Darling Basin catchment (e.g., the period between 2001–2005) little freshwater is allowed to pass into the Coorong estuary via this network of barrages. Consequently, the Murray mouth has closed, further fragmenting freshwater, estuarine and marine habitats.

The vision of the MDBC is to restore passage between the Southern Ocean and the Murray River as far as Lake Hume. Hence, in 2004 the MDBC funded two experimental fishways at Tauwitchere Barrage on the Murray River and research to assess their effectiveness. In January/February 2005, over 107,000 native fish of 16 species were captured in 16 days of trapping at the top and bottom of the vertical-slot fishway. Small-bodied fish (<100 mm long), mostly Small-mouthed hardyhead, dominated the catch.

Although the experimental fishways proved effective for facilitating passage of freshwater fish in general, their effectiveness for small-bodied fish species was limited, mainly because the headwater range was greater than anticipated. There is a need to expand the operational range of the fishways, reducing the internal head loss and also the turbulence within the fishway. Several more fishways are planned for the five tidal barrages near the Murray mouth and the new assessment data generated from the present short-term study will be critical in facilitating the design and operational success of these. Further research will be necessary to demonstrate this success and ensure appropriate fishways are constructed in the future.

Importantly, the assessment has generated a number of new design parameters likely to improve passage success at the Murray barrages; these include automation of the fishways in response to the fluctuating upstream and downstream water levels. Furthermore, the tri-State monitoring team has developed several new innovations and operating protocols that can facilitate fish passage within the confines of limited freshwater discharge. During periods of low flows, it is possible to limit freshwater discharge from a full-time fishway, for small-bodied fish, to 5 ML/d or less.

At the Murray mouth, freshwater flows have been greatly reduced and water conservation is a key issue for the present program of restoring fish passage at all five barrages. A specific environmental allocation of water for the fishway is needed to sustain fish passage during low flows and this will likely be one of the most important steps toward restoring biodiversity in the lower River Murray.

Fishways at Locks

On the Murray River there are two high dams and 13 weirs that obstruct the passage of native fish. To improve fish passage the MDBC is constructing fishways at all barriers on the Murray River between the sea and Hume Dam, a distance of 2,225 km.

The MDBC Murray Fishway Assessment team, comprising freshwater research staff from New South Wales Department of Primary Industries (NSWDPI), Victorian Department of Sustainability and Environment (DSE) and South Australian Research and Development Institute (SARDI), was established in 2001 to address four major questions—namely whether the fishways at locks are:

- reducing accumulations of fish downstream of barriers
- allowing passage of the full range of size classes and species of fish
- contributing to positive changes in abundance and diversity of native fish in the river
- optimally designed, located and operated.

A major aim of the project is to monitor changes to riverine fish communities post-fishway construction. Over the first three years of sampling (2002–2005), the tri-State team sought to demonstrate accumulations of fish below Locks 1, 2 and 3 and obtain a ‘before construction’ estimate of fish community composition. The team collected over 60,000 fish, from 15 sampling occasions, and effectively established that weirs were obstructing the migration of fish in the lower Murray River.

Excitingly, the fishways constructed on the Murray River are now allowing passage of large numbers (over 50,000 fish in total so far), of various species (12 species) and a wide range of sizes (60 mm to 1000 mm long). Further testing will track how fish communities are responding to fishway installation.
Electrofishing on the Murray River

The early success of the fishways sets new standards for the restoration of freshwater ecosystems. Overseas, fishways are usually designed to pass only a few large-bodied, economically important fish species. In contrast, the Murray River fishways are unique in their design intent of restoring the passage of whole communities. This more holistic approach to fishway design has set a worldwide benchmark, and generated great interest from international experts from France, Belgium, USA, South Africa, Sweden, Germany, Austria and the United Kingdom.

The fishways research has also resulted in several substantial advances in the knowledge of native fish species within the Murray-Darling Basin. For example, small fish species, such as Carp gudgeon, Murray rainbowfish and Fly-specked hardyhead, were previously thought not to be migratory, but are turning up in their thousands in the fishways.

Advances have also been made in monitoring technology. The Murray Fishways Assessment Team has invested a considerable amount of effort in developing, installing and maintaining six cutting edge remote Passive Integrated Transponder (PIT) tag reader systems at Lock 7, 8, 9, 15, 26 and Yarrawonga Weir. This system constantly monitors the fishways for any of the 4,700 fish tagged in the lower Murray River. To date over 350 fish have been detected migrating through the fishways using the PIT tag system, providing new information on behaviour within the fishway and migration patterns between weirs. Interestingly, one tagged fish moved from below Lock 1 to Torrumbarry Weir, approximately 1,400 km, whilst many others frequently move over 400 km in relatively short periods of time. A tagged fish can now be tracked up and down the Murray River for its whole lifetime, providing ecological data that can be used to refine fishway design, and inform river and habitat management, environmental flow, and optimisation of weir operation to enhance fish passage.
Community members inspect the fishway at Lock 8 on the Murray River

New experiments in Spring 2005 will focus on optimising the passage of small fish with innovative methods that also reduce construction costs. These experiments will use the latest ideas generated by the design and research teams and signal an exciting new direction in the development of fishways for whole migratory fish communities.

The Murray River fishways constructed thus far have met their unique design requirement of passing both small and large fishes (from 60 to 1000 mm long). Assembling a tri-State assessment team, with broad scientific and technical expertise, has been critical in demonstrating this success and identifying innovative ways to improve future fishways. Importantly, for the first time in Australia, ongoing monitoring is likely to show a change in riverine fish communities post-fishway construction. The results indicate that the vision of the MDB to restore fish passage from the sea to Lake Hume is well underway, but further research under guidance from the Fish Passage Reference Group (FPRG) is likely to lead to more efficient and cheaper fishway designs and a greater understanding of native fish populations.

PIT tagging
Since inception in 2001, the tri-State team has implanted PIT tags into all Murray cod, Golden perch, Redfin perch, Bony herring, Silver perch, Common carp and Goldfish over 200 mm collected during routine sampling. Presently, there are several thousand tagged fish at liberty within the Murray-Darling Basin. Automated four-antennae PIT tag reader systems have been installed at all newly completed fishways. At each site antennas have been installed at the entrance, exit and two midpoints to provide detailed information on the movements of large fish within the fishways. This information is continuously logged via a laptop and data obtained can be used to help refine the design of future fishways in the Basin.

Prototype fish pump fishway
This project addresses NFS objectives relating to the development of improved fishway designs. It aims to develop and test a novel design that adapts airlift pumping technology. The concept relies on the longstanding use of airlift pumps for transporting fish in the aquaculture industry and it may have the potential to
overcome several ongoing problems of standard fishways.

The prototype design involves a downstream entrance connected through an airlift pump to an upstream exit via a transfer chamber. Water is gravitated into the system from the storage. Yanco Weir on the Murrumbidgee River near Narrandera has been chosen as a test site and trials are planned for late September 2005. The prototype will be installed then mechanically tested and refined as necessary. Fish-passage performance will then be assessed, with replicated trials to monitor the prototype’s ability to capture and relocate the full range of potentially migrating fish species and sizes, and the occurrence of injuries or mortalities among transported fish.

The testing program will be brief, involving demonstration of the physical functioning of the prototype, then evaluation of its fish-passage performance. A report on the project will be presented to MDBC, detailing the design and operation of the prototype, the results of field trials and recommendations for future development.

Yarrawonga exit fate project

In October/November 2004 a PIT reader was installed at Yarrawonga fish lock. Aerials were placed on all four entrances, two entrances to the vertical chamber, and three locations on the exit channel (bottom, middle and exit of the new steel flume). Cooperation from Goulburn Murray Water (GMW) staff and divers was critical to successful installation.

Following this, a study of fish exiting the Yarrawonga fish lock was conducted. A total of 45 fish were surgically implanted with mini transmitters (3.5 g; maximum battery life 20 days). These included 26 Golden perch (305–511 mm long), 12 Murray cod (462–1015 mm), five Silver perch (352–367 mm) and four Trout cod (391–472 mm). After surgery the fish were held in the exit channel overnight and released the following morning, and their positions manually and automatically tracked.

At the time of the exit trial the power station was running at 10,000 ML/d (max. load before Barmah floods) and the Victorian channel was discharging 2,200 ML/d (max 3,100 ML/d). All Golden perch and Murray cod exited safely. One Silver perch went down the irrigation channel and one Trout cod swam near the turbine trash racks (ultimate fate unknown); another Trout cod did not exit and was caught under a trash screen. Further study is needed before the evidence is conclusive, but initial findings include:

- There was a behavioural inhibition for all species to exit the flume, possibly due to high cross velocities.
- Adult and larger sizes of juvenile Golden perch and Murray cod exit safely.
- More trials with Silver perch and Trout cod are planned (tentatively slated for November 2005).
- There were large numbers of Smelt in the vertical lock chamber.
- Fish used three different tracks after exiting the fishway flume: many used the low water velocities adjacent to weir near gate 10; Murray cod dived to the bottom; other species swam along the log barrier.
- Most fish rapidly left the lock area and swam well upstream into Lake Mulwala.
Recommendations include:

- The PLC system, including telemetry, is outdated and in need of upgrade.
- The exit race water velocity needs to be at least 14 per cent (>1 m/s) so that fish can exit.
- The fish lock should not be operated if gate 10 is open.
- Some fish were caught under a screen in the exit channel floor—minor modifications are needed.

**Menindee Lakes**

In 2004–2005, an Environmental Impact Statement for the proposed structural works at Menindee Lakes was completed by the NSW Department of Infrastructure, Planning and Natural Resources. Five fishway options were investigated, two of which were located within the Lake system at:

- the site of a new regulating structure between Lakes Menindee and Cawndilla
- the proposed enlarged regulator at the Lake Menindee outlet.

The remaining three options examined provision of fish passage on the main stem of the Darling River as an offset to providing fishways associated with the new regulating structures within the Lakes system. The three offset fishway options included construction of vertical slot fishways at:

- Main Weir (44 bays), at an estimated cost of $6.8 million
- Lake Wetherell Outlet (53 bays), at an estimated cost of $8.5 million
- Lake Pamamaroo Outlet (53 bays), at an estimated cost of $10.2 million.

The preferred option, as indicated in the Environmental Impact Statement, was the Lake Wetherell Outlet. The site is the location of the original Darling River channel, which provides a deep pool for fish refuge, and an attracting flow past the entrance for the majority of time caters for fish passage for the full height between a low Darling River and a full Lake Wetherell.
Vertical slot fishway innovations/
Lock 8 experiment

The vertical-slot fishways being designed and built for the locks on the Murray River are world-class in functionality, passing a diversity of migratory fish species and a wide size range from 60–1000 mm in length. However, they are costly and their broad-scale application across the thousands of barriers throughout the Basin is unlikely to be practical.

A major factor in the capital cost of vertical-slot fishways is the slope of the fishway channel, which determines the total length of the fishway. The following experiments examined innovations in the vertical-slot fishway design that are most likely to lead to increasing the slope while retaining all, or some, of the functionality of the new vertical-slot fishways on the Murray River.

The main fish migrating during the experiment were small (20–50 mm) Australian smelt, Rainbowfish, Carp gudgeons and Flyspecked hardyhead. While preliminary analysis indicates that bristles and Denil baffles improve the passage of small fish compared with the standard 0.3 m wide slot, the difference was not statistically significant, especially with Australian smelt which had large sample sizes. Further replication of the experiment may reduce variability and detect significantly greater fish passage through the baffles. There are also other designs of Denil fishways that may be more efficient at passing fish in narrow slots. At present, however, the results suggest that even though the bristles and the Denil baffles appeared to create low velocity zones, small fish are unable to use them to any greater extent than a narrow slot.

The experiment yielded four major findings that are likely to lead to reduced cost and improved performance of fishways throughout the Murray-Darling Basin. Each of these has specific recommendations:

- The Denil baffle in the vertical-slot design has significant potential to improve fish passage.
- Turbulence in the fishway pool may be more limiting for the passage of small fish than the high water velocity in the slot of the vertical-slot baffle.
- The sharp-edged narrow-slot appeared to provide improved velocity distribution.
- The biomass of small migrating fish was much greater than expected.

The results show that refining the vertical-slot design can improve fish passage performance, but further research is needed before design changes can be applied with confidence to new fishways. Some of the required research will be completed by the Murray River Fishways Assessment Team, but the remainder will need additional funding. Significantly, the design approach with the most potential to reduce cost is to separate the function of passing small fish and large fish, as well as allowing for differential passage in high and low flows as has already been applied with cost savings to the Lock 10 fishway.

Resistivity experiment

Fish have a natural electrical conductivity which can be detected in many cases in the resistance readings of wire loops under favourable conditions. This method of detecting fish has been used in the United Kingdom and Ireland for many years. The method of fish counting is a relatively simple, low cost, low technology approach which avoids the need to capture and handle the fish. The detection is however sensitive to water conductivity (ie. salinity), size of fish and its proximity to the wire loops.
The need for a simple and reliable fish ‘counter’ in fishways in the Murray-Darling Basin has been identified. Recent laboratory work by Adelaide University has been sufficiently encouraging for it to be engaged with ‘seed funding’ from the Commission to develop a prototype fish counter to trial in the River Murray. The University has recently achieved significant improvements to the laboratory prototype and field tests are scheduled prior to the end of 2005.

**DIDSON sonar trial**

As part of the NFS, the trial of a powerful underwater sonar to remotely study the migration patterns of native fish was an Australian first. The dual-frequency identification sonar (DIDSON) uses acoustic lenses to produce quality, high definition underwater images. It is particularly useful in dark and turbid conditions where conventional optical systems are ineffective.

The unit was originally developed in the USA for military applications, such as detecting mines or locating military equipment. However, in more recent years it has been used successfully in the USA for more specific applications, such as underwater surveillance, rescue operations and fish migration studies. For fish studies in particular, the DIDSON has capabilities that permit the tracking of fish movements (including directionality), determine the depth of fish in the water column, provide continuous observations of fish behaviour and automatically estimate the size of migrating fish.

Initial trials of the system were performed within fishways at Yarrawonga Weir, Lock 8 and the Murray mouth barrages. Additional ‘ground truthing’ trials were undertaken at the Narrandera Fisheries Centre. The trials revealed that the unit was able to record the migration patterns of fish as they approached, entered and negotiated each fishway. In some cases, fish were observed to physically avoid certain flow conditions (and objects), and accumulations of schooling fish in the vicinity of weirs were directly observed for the first time.

Such observations could potentially enable fisheries managers and engineers to better optimise fishway design criteria such as the location of entrances and exits. The ability to collect this type of data makes the DIDSON an exciting new tool for the monitoring of fish migration, and further trials are being planned.

**State and territory highlights**

In New South Wales, a DPI and Worldwide Fund for Nature managed project on redundant weirs was completed. The outcomes of the project included the removal of three instream barriers to fish passage. Three case study documents and a brochure have been published and distributed across NSW and other interstate agencies. In the Macquarie River, fishway construction is complete at Duck and Crooked Creeks. 2004–2005 was the first year of monitoring and early results indicate that the fishways were passing small-bodied native fish species. Works have also been completed at Warren and Gunningbar Weirs, and this first year of monitoring indicated that both fishways are passing fish.

In 2004 the MDBC funded Queensland Department of Primary Industries and Fisheries (DPI&F) to undertake a pilot study into the application of hydroacoustics for monitoring fish passage. Following the success of the study the DPI&F has purchased a hydroacoustics system and is exploring options for the identification and sizing of migrating fish detected acoustically. During 2004–2005 an investigation began into the possible removal of a redundant weir on the Maranoa River, near the town of Mitchell. A Local Council initiative with strong community support, this could be the first weir to be removed in the Queensland Murray-Darling. The community of Mitchell is applying for a Community Water Grant, to carry out an assessment of the condition of the weir, the threats downstream if it is removed (such as transport of sediment and parthenium seeds) and the benefits of removal.

In South Australia, a desk-based study to identify and prioritise barriers to fish-passage between main-channel and off-
channel habitats above Wellington was completed. Approximately 300 barriers to fish passage were identified between main-channel and off-channel habitats.

The five yearly review of the Australian Capital Territory Environmental Flow Guidelines was conducted and, as a result of the Canberra bushfires in 2003 and the prolonged drought, the environmental flow regime was modified in 2004–2005 to reduce the environmental flow volumes released from domestic water storages. An adaptive management approach was adopted to monitor the impacts of reduced flows on aquatic ecosystems, and the results demonstrated that reduced flows still had substantial environmental benefits. This has resulted in modification to the environmental flow guidelines, which will be finalised in 2005–2006. Ad hoc reports in 2004 of Macquarie perch upstream of Vanity’s Crossing, a high-level ford, indicate that the fishway installed in 2001 has been successful in passing adult fish. The requirement for fish-friendly road-crossings of streams has been recently incorporated into the roading plans for ACT Forests. A significant number of forestry roads have been decommissioned following the destruction of plantations by the 2003 fire, and a number are being realigned or upgraded. Where road crossings of significant streams are part of this process, fish-friendly options are being pursued.

In Victoria, a new vertical-slot fishway is nearing completion on the Broken River after a 1998 agreement between the Victorian Government and the Goulburn-Broken CMA. The ‘Sea to Hume Dam’ fish passage program is in full swing with new vertical-slot fishways completed in 2004–2005 at Lock 7 and under construction at Lock 9 and 10 near Mildura. As an example of the new fishways’ success, at Lock 8 an average of 500 fish use the fishway every day. These range from large Murray cod over 900 mm in length to small Smelt around 30 mm. Other fishways further upstream on the Murray River are also helping reconnect native fish populations. The new Denil fishway at Euston weir has passed large Murray cod up to 1 m long and the fishway at Torrumbarry Weir recently recorded a 300 mm Trout cod, the furthest downstream record of the species for decades. The installation of remote tagging technology also continues to spread, with the Torrumbarry Weir and Yarrawonga Weir fishways fitted with PIT-tagging sensors in 2004–2005.

3.1.4 Controlling alien fish species

Daughterless Carp

The MDBC-funded ‘Daughterless Carp’ Project comprises funded seven sub-projects to test the hypothesis that male-bearing Carp could drive down the population across the Basin. The project is managed by the Pest Animal Control CRC. Besides the lead genetics project, pest fish population responses to management have been modelled, and investigations of the ecology of Carp and of public attitudes to Carp and genetic control have been conducted, in addition to an extensive communications campaign.
All projects to date indicate that the ‘Daughterless’ approach is technically feasible. Extensive modelling shows that ‘Daughterless’ technology is the most promising technique for the control of a hypothetical fish population.

Social research indicates that the application of the ‘Daughterless’ technology would not be constrained by public attitudes. Benefits and concerns of using ‘Daughterless’ technology were sought from the Australian public and analysed through a sophisticated survey technique developed by Valuemetrics Australia. The analysis took benefits and concerns and weighed them against each other to determine a relative impact. The survey and analysis showed that the Australian public (rural and urban areas were tested) support the use of ‘Daughterless’ technology for control of Carp in Australia.

Laboratory experimentation in 2005-2006 will continue to test the genetic constructs in the model species, the Medaka, or Japanese rice fish.

Other developments of the program include:

- Ecological investigations of the Murray-Darling Basin revealed there are a limited number of wetland sites which are responsible for the majority of Carp recruitment in the Basin. These should be targeted for control, and do not require to wait for new technologies to be developed.
- Two students have been contributing valuable scientific knowledge in the program.
- A highly effective communications and public engagement strategy involving more than 60 public presentations has developed an excellent rapport, with many communities embracing the ‘Daughterless’ technology in the Murray-Darling Basin.
- A user-friendly modelling package (CARPSIM 2) has been developed to monitor and inform the release of ‘Daughterless’ technology in the Basin.

The ‘Daughterless Carp’ project aimed to test a bold initiative to manage Australia’s worst pest fish through genetic control. The final report on Stage 1 of the project records technical success and gives a ‘green light’ for continuation, while recognising that much needs to done beyond the initial 2.5 year project. Knowledge of the ecology of Carp gathered warrants immediate targeted control campaigns in areas providing recruits, and offers fisheries managers a new tool for Carp management.

**Carp separation cage (the ‘Williams’ separation cage’)**

The automated Carp cage at Lock 26 successfully releases native fish from the trap with 100 per cent efficiency while sub-adult/adult Carp are separated at 88 per cent efficiency (Table 2). With minor tweaking of the automated release system (to release in the evening rather than morning) it should be possible to separate up to 95 per cent of Carp. The technology continues to be of interest around Australia and internationally.

Other fishways have been prioritised for new Carp traps, including Locks 1, 7, 9, 15, 26 and Kerang Weir.

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Number in fishway</th>
<th>Number that jumped</th>
<th>Percentage that jumped</th>
<th>Size range (mm)</th>
</tr>
</thead>
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<tr>
<td>Carp</td>
<td>421</td>
<td>370</td>
<td>88</td>
<td>244–710</td>
</tr>
<tr>
<td>Silver perch</td>
<td>6033</td>
<td>0</td>
<td>0</td>
<td>92–505</td>
</tr>
<tr>
<td>Golden perch</td>
<td>1712</td>
<td>1</td>
<td>0.06</td>
<td>94–560</td>
</tr>
<tr>
<td>Bony bream</td>
<td>236</td>
<td>3</td>
<td>1.3</td>
<td>145–302</td>
</tr>
<tr>
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<td>48</td>
<td>0</td>
<td>0</td>
<td>123–930</td>
</tr>
<tr>
<td>Trout cod</td>
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<td>0</td>
<td>0</td>
<td>301</td>
</tr>
<tr>
<td>Freshwater catfish</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>250</td>
</tr>
</tbody>
</table>
The Williams’ Carp separation cage

Carp seminar at Narrandera
The MDBC, in conjunction with NSW DPI, hosted a public seminar on the NFS and the control of Carp at the Narrandera Fisheries Centre in August 2004, which was attended by around 40 people. Speakers included the NFS Manager and the Chairperson of the CSG.

National framework for invasive species management
The Australian Government Department of Agriculture, Fisheries and Forestry requested the MDBC’s input into the development of a national framework for invasive species management in Australia. The purpose of this framework is to support a coordinated and strategic approach to manage pest species already present, as well as to prevent the establishment of significant new pests. The MDBC supported the establishment of the framework, and suggested that the Native Fish Strategy and the National Management Strategy for Carp Control be considered during its development. A number of issues were also highlighted, such as the need for development of rapid response plans for new aquatic incursions, the need for complementarity and consistency in policies and programs between the jurisdictions and for ensuring that agencies are adequately resourced to implement alien species control.

Tilapia Response Plan
The invasive pest species, Tilapia, is present in a number of water bodies in south-eastern Queensland, such as North Pine Dam and parts of the Brisbane River system. The species is now in drainage systems adjacent to the Queensland Murray-Darling Basin and there is a risk that it may be translocated into the Basin. Queensland is looking at ways to reduce this risk and to be in the best position to respond if an infestation does occur.

In spring 2005 a new phase is planned to test the system under the weir at Lock 1 (i.e. in a non-fishway situation). The conditions of mass Carp migration at the weir, which no longer occur at Torrumbarry, will be of great benefit to finalising design.
A number of Fisheries staff have been trained in the effective and safe use of rotenone.

The ability to successfully eradicate an infestation depends on how rapidly the infestation is recorded. Once an infestation has entered and spread in a river system eradication is usually impossible. In order to maximise the chances of early detection, DPI&F will form a community network covering both the already infested catchments in south east Queensland and the non-infested catchments of the Queensland Murray-Darling. This network will assist with education and extension programs and will help identify ‘hot spots’, or areas where Tilapia are most likely to be released. The intention is that DPI&F will undertake regular surveys of these areas to maximise the chances of early detection. Funding will be critical to the execution and success of these activities.

State and territory highlights

In May, the New South Wales DPI in conjunction with the Pet Industry Association of Australia released a brochure entitled ‘Don’t Dump That Fish’, which aims to educate pet owners about the dangers of releasing fish into local waterways. The brochure is being distributed through pet shops and aquarium suppliers, DPI offices and at community events.

Queensland took steps in 2004–2005 to ensure that it is able to respond quickly and effectively to reports of new alien fish outbreaks. Of particular concern is the possibility of Tilapia being released into the Basin. DPI&F has obtained a restricted permit from the Australian Veterinary and Pesticides Review Committee for the use of rotenone, a fish poison. A manual has been developed and staff trained in the use of the poison. In a trial in the Bremer catchment, a potential source of invasion, Tilapia were successfully removed and the lake has been stocked with native species. Early in 2005, QMDC collaborated with Carp Busters Inc. to organise four ‘Carp Buster’ fishing events over the next three years. While these competitions will not significantly impact on Carp populations, they alert the wider community to the Carp problem and allow recreational anglers to raise money for restocking purposes.

As part of the Pest Animal Control CRC’s ‘Daughterless Carp’ Program, Dr Ben Smith (SARDI) completed a comprehensive review of Australian Carp ecology, producing a report titled ‘The State of the Art: A Synopsis of Information of Common carp in Australia’. The draft ‘Strategic Approach to the Management of Ornamental Fish in Australia’ has been also completed and released for comment.

In the Australian Capital Territory, two separate records of the Red-eared slider turtle were received. The Red-eared slider turtle is listed by the IUCN as one of the
worst 100 invasive species worldwide, and has established feral populations in a number of countries, including part of Australia. The Canberra records were within the Murray-Darling Basin, where the species is not known to have established. A publicity campaign to alert the community to the impacts of this species and seek further records was conducted, as well as sampling of dams in the vicinity of the sightings. No Red-eared Sliders were encountered and further surveys are planned. The ACT was a participant in the National Ornamental Fish Policy Working Group, which drafted the document ‘A Strategic Approach to the Management of Ornamental Fish in Australia’, released for public consultation in late 2005. The ACT was also involved in a project proposal that has been approved by the new Invasive Animals Cooperative Research Centre, to prepare Rapid Response Plans for new alien fish incursions into Australia and conduct field trials, to commence in 2006. The Territory was also a contributor to a major review of the human-assisted dispersal pathways for alien freshwater fish, published in the New Zealand Journal of Marine and Freshwater Research. The review identified 12 major pathways involved in the dispersal of freshwater alien fish in Australia, and found that the aquarium trade was implicated in the establishment of 22 of the 34 alien species currently established in Australia.

In Victoria, a recent outbreak of Carp in the Glenelg River Catchment, formerly one of the few large Carp-free rivers in southeastern Australia, triggered the development of a Carp management plan by the Glenelg Hopkins CMA, and active pursuit of new technologies to contain the problem. In August 2004, the Williams’ Carp-separation cage for removing migrating Carp as they negotiate fishways received a second major award, the Eureka Prize for Water Research. In 2004–2005 further testing and design improvements of the Williams’ Cages were undertaken at Torrumbarry Weir; full automation was achieved without loss of effectiveness. The design has now been finalised and meetings are underway to discuss the installation on the new fishways on the Murray River. A PhD has been initiated at the University of Melbourne (2004–2007) to investigate the impacts of Oriental weatherloach in Murray-Darling waterways.

3.1.5 Protecting threatened fish species

Loss of fish in irrigation offtakes project

The entrainment of native fish into offstream habitats has long been a suspected consequence of irrigation practices. However, a lack of empirical data detailing the extent of such processes is currently precluding the implementation of effective management practices to reduce any possible environmental effects. In September 2004, the New South Wales Department of Primary Industries was engaged to undertake a 2-year investigation to provide estimates of the numbers of fish annual extracted, and the fate of these fish in irrigation systems.

Given the diversity of irrigation practices used within the MDB, two separate investigations are being conducted in Southern (Murrumbidgee catchment) and Northern (Namoi catchment) reaches of the MDB. Sampling is being undertaken to determine the effects of irrigation practices over a wide range of species and life history stages. To this end, a combination of electrofishing, netting and larval sampling are being performed, both night and day, to provide estimates of the number of fish involved.

Irrigation canal sampling

Sampling in Bundigerry Creek (an open canal system) commenced in November 2004, using electrofishing and larval sampling, to determine similarities in the structure of fish communities among sites from the Murrumbidgee River, Bundigerry Creek and Murrumbidgee Irrigation Area (MIA) canal. Two weeks of electrofishing and five weeks of larval sampling (day and night) were completed. Subsequently, a majority of irrigation canals will be drawn-down and all electrofishing sites will be re-sampled, including any deeper pools, to determine the fate of any fish that may be trapped by the reduced water levels.

Irrigation pump sampling

A study on irrigation pump systems, in the Namoi River catchment, commenced in January 2005. Collaborative relationships have been established between the Australian Cotton Research Institute (ACRI) and Auscott Pty Ltd, who have generously provided access to their pumping facilities.
Fine mesh nets were set (day and night) in the main river channel, and at the outlet of pumping systems, to quantify the amount of larval fish removed from the main river channel. In addition, electrofishing was undertaken to provide a comparison of fish communities in the main river channel and storage dams. This sought to determine species most likely to survive the pumping process. Finally, customized fyke nets (5 m drop, 6 mm mesh) were set (day and night) at the outlet of pumping systems to quantify the amount of larger-bodied fish that are being removed from the main river. A total of four trips were completed during the pumping season. Sampling is due to recommence in November 2005.

Communication and education

A brochure was designed detailing the objectives and anticipated outcomes of the project. Copies will be available from NSW DPI and the MDBC in late 2005.

Murray Cod workshop proceedings

The proceedings of the Management of Murray cod in the Murray-Darling Basin workshop, held in Canberra in June 2004, were produced during the year. The document contains papers and key recommendations emanating from the event. This led to the establishment of the Murray Cod Reference Group, for which the recommendations will become an important work plan.

The significance of the Murray cod to Aboriginal communities

Aboriginal people have had a close association with the Murray and Darling Rivers for tens of thousands of years. The rivers and their tributaries have provided water, hunting and gathering grounds, raw materials, movement routes, and a strong spiritual dimension to the lives of countless generations. Many Aboriginal people continue to live along or near the rivers and in neighbouring towns and regions. Their historical, cultural and spiritual connections to the river environments remain very important. The Murray cod is a central part of these associations. However, the traditional, historic and contemporary associations and significance of this iconic fish for Aboriginal people across the Basin have been poorly documented.

The June 2004 Management of Murray cod in the Murray-Darling Basin workshop recommended that the significance of this species in Aboriginal culture and oral history should be documented. In May 2005 the Commission contracted Sydney-based Gondwana Consulting to

Children learning about native fish in the Warrego River

Photo: Arthur Mostead
undertake a 9-month project to carry out the work. The project will include a review of published and unpublished literature as well as discussions with relevant government agencies and experts. It will generate a report comprising a synthesis of information on the significance of Murray cod to Aboriginal people, with the species’ contemporary and historical significance recorded directly from the Aboriginal people themselves.

The project will provide improved knowledge of the significance of Murray cod to Aboriginal people. It will also enhance awareness and participation by Aboriginal people in relevant activities under the NFS, as well as being of use to State/Territory fisheries management agencies and the Commission’s Fish Management and Science Committee.

Protection and enhancement of Murray cod populations

This project, which is being carried out by the Arthur Rylah Institute, is examining the importance of anabranches on the Murray River to Murray cod populations by assessing movements of cod into and out of these systems. During 2004-2005, a large number of fish in the Mullaroo and Ulupna Creeks and surrounding areas of the Murray River were fitted with radio-transmitters. Antennas fitted with remote data loggers have been installed at strategic locations on each anabranch, allowing the investigators to remotely download data which details the location and direction of travel of individual fish. Temperature data loggers have also been installed to monitor variation in water temperature in order to assess its importance as a determinant of Murray cod use of anabranches.

A second component of this project is an assessment of barriers to fish passage on the Broken Creek system. The investigators are in the process of compiling information on the physical attributes of each of these barriers and will make recommendations for their modification and/or improved management to facilitate passage of fish such as Murray cod. This will be a vital contribution to the protection and enhancement of Murray cod populations in the Barmah-Millewa Forest, one of ‘The Living Murray’s’ six Significant Ecological Assets (SEAs). It will also provide information for the improved management of cod in the other SEAs of the River Murray, as well as other river systems.

Scoping the knowledge requirements for Murray crayfish

Murray crayfish are the second largest freshwater crayfish in the world, reaching weights of 3 kg and are estimated to live for up to 50 years. Murray crayfish populations have undergone significant declines and are classified as a threatened species in the ACT and SA, and Vulnerable under the 2004 IUCN Red List. At its December 2004 meeting, the Fish Management and Science Committee agreed that the crayfish be considered under the auspices of the NFS. This came in recognition of the fact that there was a paucity of funding available for the species, despite its conservation status. At this meeting, it was also decided to initiate a review of existing knowledge on the species in order to identify and prioritise knowledge gaps. The project, which was awarded to a team led by New South Wales Department of Primary Industries (Fisheries), has commenced and is in the process of reviewing the literature and discussing knowledge requirements with researchers experienced in Murray crayfish biology and ecology. The primary output will be a prioritised list of research requirements which will facilitate improved management and conservation of the species.

Three key aspects of the review combine to give an overview of current knowledge of Murray crayfish: (a) a review of past and current work on Murray crayfish; (b) analysis and reporting of unpublished data from a significant study undertaken by the New South Wales Department of Primary Industries (then New South Wales Department of Agriculture) between 1981 and 1985; and (c) developing an understanding of the Traditional Ecological Knowledge (TEK), historical uses and cultural roles of Murray crayfish in Aboriginal communities.

The review is on track for completion in early October 2005; a draft is currently being edited and finalised. The Aboriginal community consultation process to develop an understanding of the TEK, historical uses and role of Murray crayfish in Aboriginal culture is being completed following a week of community interviews in the Murray and Murrumbidgee catchments (Albury, Wagga Wagga, Narrandera, Deniliquin, Echuca,
Barmah and Balranald) in early September. These consultations have proved rewarding and the outcomes are currently being summarised and a report is in preparation.

Due to the large scale of the work undertaken by New South Wales Agriculture in the 1980s, analysis and reporting of the complete dataset will be unfeasible under the current project. Instead, the extent of the dataset, details of the methods used and the sites sampled will be fully documented, and key aspects of the data summarised in the project report. Further, the raw data will be transferred to an electronic database. Formal presentation as scientific papers will be forthcoming.

Effects of environmental water allocations on the lateral movements of native fish in the Barmah-Millewa forest

A project on the effects of Environmental Flow Allocations (EWA) on lateral movements of native fish in the Barmah-Millewa Forest is in its third year of funding. This project is aimed at understanding the timing (flow/temperature) of fish movements to and from floodplain (lateral) areas, particularly around regulators.

Understanding when, how and why native fish move laterally into off-channel habitats, particularly during flow events, is essential for management. Similarly, safe passage of native fish to and from wetland systems such as the Barmah-Millewa forest is likely to play a significant role in maintaining healthy native fish populations.

Results to date suggest that a variety of native fish (large and small), for example Murray cod, Trout cod, Golden perch, Silver perch, gudgeons, Australian smelt and hardyhead, utilise offstream areas within the Barmah-Millewa forest. Results also suggest that both large and small-bodied native fish become stranded in regulated offstream areas. Gonad staging of large bodied fish stranded behind regulators has found that spawning was likely, but was interrupted by regulator operations, that is, closure. This phenomenon needs further investigation.

Interestingly, radio-tracking of Murray cod and Golden perch in an unregulated system has revealed that they regularly move between mainstream and offstream areas with changes in flow, without becoming stranded. For example, they move into the Murray River mainstream with decreasing flows and into offstream areas, such as creeks, with increasing flows. This result appears to be in contrast to regulated areas.

A trial radio-tracking experiment has also found that once flows return to regulated offstream areas Golden perch will move to escape the area in which they have been stranded and return to deeper refuge areas such as the Murray River. So far all fish have moved downstream in order to escape to deeper refuge waters—upstream movements were hindered by a partially closed regulator. It is hoped that the experiment can be repeated with a fully opened regulator, which will not hinder upstream movement.

The lack of an EWA during the life of the project has meant that the effects of targeted water on native fish movement (to and from offstream areas) remain unknown. Such information needs to be documented so that EWAs can be effectively targeted whilst maintaining native fish passage. The results will be applicable to floodplains throughout the Murray-Darling Basin.
Metadata analysis
This project aims to collate all fish survey information, including metadata, from around the MDB, and to identify and implement innovative techniques to analyse the data to provide a broadscale overview of the status of native fish in the MDB and trends in abundance and distribution. The project is being undertaken in three phases:

1. Assemble all available datasets and metadata.
2. Analyse data for common trends at Basin, State, and catchment scales as permitted by data quality.
3. Report trends at appropriate spatial scales to relevant stakeholder groups.

To date, over 100,000 data records have been collated from State agencies, museums, commercial fisheries records and hard copy reports.

Data have been reviewed and formatted for entry into an Access database. The review indicates that data are of a fairly high quality and contain few abnormalities. Examples of abnormalities encountered include unusual length records and records of estuarine species.

A brief review of statistical techniques suitable for analysing available data has been undertaken and a detailed report is being prepared. While a significant quantity of data is available there is little data on specific catch effort. Some data provide information on gear type, number of nets employed, soak time or electrofishing time and for these records catch effort can be calculated. Effort data are more likely to be recorded for recent surveys and there is little information on catch effort or abundance from historical data. This makes it difficult to undertake quantitative analysis of trends in abundance using classical statistical techniques. At this stage it appears that an approach can be developed based on ranked abundance. A range of criteria will be used to assign abundance based on, for example, the total number of catch records in a particular location, the frequency of occurrence of individual species as a proportion of the total catch, or number of surveys. Categorical abundance will be assigned for each species across a range of spatial and temporal scales determined by the available data. A range of statistical techniques will then be used to identify any trends or patterns in abundance or distribution at a range of scales.

Tasks required to complete the project are a workshop to present and discuss statistical techniques, followed by statistical analysis and mapping of trends in abundance and distribution.

Spatial distribution of MDB fish project
Fish distribution data for the Murray-Darling Basin is available in a number of disparate locations including individual State agency databases, museums, native fish society records, scientific papers, technical reports and research thesis. SKM has collated this data in conjunction with its other current project for the NFS, the metadata analysis project.

SKM has designed a MS Access database and a data entry tool, which will be presented for review at the planned workshop. The collated data are currently being loaded into the database, and on completion of this task the data records will be georeferenced (i.e., located in a GIS dataset, and the coordinates recorded in a single common format). A half-day workshop is planned for October 2005, to be run in conjunction with the metadata analysis project.

State and territory highlights
The Lachlan CMA and NSW DPI are planning a project to rehabilitate degraded Macquarie perch habitats in the upper Lachlan and Abercrombie catchments. The project involves documenting the distribution of Macquarie perch in both rivers, identifying their key habitat requirements, and increasing the quality of these habitat features in degraded reaches. The NSW Trout cod draft recovery plan was publicly exhibited from June 2005 to July 2005. Public submissions have been assessed and the recovery plan is currently being finalised and should be released in the near future.

In comparison with some other parts of the Basin, the Queensland Murray-Darling supports healthy native fish populations. Queensland recognises its responsibility to protect these populations. In 2004–2005, long-term monitoring programs in the Warrego and Condamine Rivers captured Eel-tailed catfish and Murray cod, which are threatened in other parts of the Basin.
The Action Plan for Freshwater Fish in South Australia is progressing well. The Southern pygmy perch recovery monitoring continued at core sites over autumn 2005. Numbers were erratic due to unusual climatic conditions and continuing threats to local habitats (e.g., streams being pumped dry and introduced fish).

In the Australian Capital Territory, action plans for five threatened fish species (Trout cod, Macquarie perch, Silver perch, Two-spined blackfish, and Murray crayfish) are to be amalgamated into a single Aquatic Species and Riparian Zone Conservation Strategy. Drafting of the Strategy was largely completed in 2004–2005 with public consultation to be conducted in 2005–2006. Monitoring of fish populations in the Cotter River continues. As part of the post-fire review of Canberra’s water supply, Cotter Reservoir was brought back on-line as a component of the long-term domestic water supply infrastructure for the ACT. This reservoir had not been used since the late 1960s, and contains the last remaining viable population of the threatened fish Macquarie perch in the Territory. As part of the recommissioning of Cotter Reservoir, the potential impacts on Macquarie perch of use of the reservoir are being investigated.

A workshop on Epizootic Haematopoietic Necrosis Virus (EHNV)—which has adverse impacts on a range of native fish species, including the nationally endangered species Silver perch and Macquarie perch—and its ramifications for future water supply options for the ACT was held in Canberra in August 2004. The lack of recent research into the virus, particularly its effects on wild fish populations was highlighted, and a funding proposal will be prepared in 2005–2006.

In Victoria, sampling in early 2005 indicated that fish populations were generally recovering, and fish abundances had returned to pre-bushfire numbers at some sites in the healthier rivers, following the severe Alpine fire of 2003. Whereas at Broken Creek, two years after the November 2002 fish kill of unknown cause, the abundance of several native fish species is still low and it is likely that it will take many years for native fish in the affected area to fully recover. However, even with a decade of significant investment in recovery actions for the threatened Barred galaxias, as of 2004–2005 the remaining populations remain threatened. Unless populations can be significantly expanded, their small size and extreme isolation increase the risk of extinction through local catastrophic events, while predation by the substantial Trout populations below the instream barriers also remains a threat. In 2004, a three-year project to determine the role and value of anabranch systems for Murray cod was initiated; early results indicate that anabranch habitats are significant refuges...
for Murray cod broodstock. In 2004–2005 recovery actions were undertaken for all five remnant populations of Murray hardyhead in Victoria. Surveys in 2004 raised fears that the Lake Elizabeth population may have become extinct and there is the risk that an increasing focus on improving water efficiencies will place the Murray hardyhead at further risk. ‘Top-up’ environmental flows at Lake Elizabeth, Round Lake, Cardross Lakes and Lake Hawthorn were delivered in 2004–2005 in order to dilute the increasingly saline water and to increase water levels to provide habitat for Murray hardyhead. In the Mallee, a snapshot survey of Murray crayfish to determine the current distribution of this once widespread species found that populations downstream of the Wakool River junction were poor. Trial stockings of adult Murray crayfish were recommended.

3.1.6 Managing fish translocation and stocking

Review of the impacts of native fish stocking on fish within the MDB

Fish stocking has been practised worldwide for centuries, but it is only recently that the environmental and ecological risks have been recognised. Stocking has largely been undertaken in the Murray-Darling Basin either to enhance recreational angling or to aid conservation of a species (e.g., threatened species recovery plans). Regardless of the objective, appropriate and effective management of stocking activities is required as there are a number of risks, which are not always well understood. However, it has been noted that stocking (and translocation) of fishes is a potent factor contributing to species extinction, declining genetic diversity and homogenization of plant and animal assemblages. Limited research has been done to fully evaluate efficacy of stocking native fish for conservation.

Whilst each State or Territory in the Basin has a stocking program for both native and alien fish, the impacts of such stocking on native fish species and communities is not well known. The workshop ‘Managing Fish Translocation and Stocking in the Murray-Darling Basin’ held in 2002 acknowledged this fact and recommended that ‘impacts at both the stocking site and in adjacent aquatic habitats need to be considered, with a review and consolidation of the information describing these impacts required urgently’. To this end, the MDDBC has contracted Adelaide Research and Innovation to undertake a review of the impacts (both positive and negative) of stocking native fish. This review is deliberately focussed on stocking of native species as another project currently underway, funded by the Australian Government, is investigating the impacts of stocking salmonids on fish.

The MDDBC-funded project will identify fish species or communities that require further work to accurately assess actual or potential impacts of fish stocking, and identify areas where improved management practices may reduce the adverse impacts of stocking and increase the success of threatened species stocking and translocation programs. Furthermore, it is intended that the project will identify research needs or knowledge gaps that are currently inhibiting improvements in fish stocking practices or management.

Discrimination of stocked and wild native fish project

Fish are commonly used as biological indicators in river health assessment programs, such as the Sustainable Rivers Audit. A continuing problem for fisheries agencies, however, is the difficulty of discriminating stocked fish from wild fish in monitoring and assessment programs. As part of the NFS, the MDDBC has funded a project titled ‘Improved methodology for discrimination of stocked and wild native fish’, which aims to evaluate and develop methods for the identification of fish produced in hatcheries. The project is being conducted by a collaborative research team from three organisations: Arthur Rylah Institute for Environmental Research (ARI); the University of Adelaide; and the New South Wales Department of Primary Industries.

Initially, a review of literature relating to existing and proposed methods for discriminating hatchery and wild-bred fish was completed to allow for the evaluation of promising options. Several methodological approaches have since been trialed over the past year. Injection of female brood stock Golden perch with Barium during the hormone injection stage.
Initial chemical analysis has shown that there are elevated levels of Barium in the otoliths of treatment fish compared to control fish, suggesting that the method has potential as a practical and cost effective means of marking hatchery produced fish. Further analysis is currently being undertaken to confirm the early results. Trials of an ‘osmotic induction’ method of mass marking Golden perch fingerlings with the fluorescent compounds Calcein and Alizarin Red S were completed in 2005 at the ARI. Early results showed that externally visible marks and otolith marks could be applied to large numbers of fish within 20 minutes with little or no associated mortality. Experiments were also conducted in April 2005 at the University of Adelaide to determine whether immersion of fish in solutions containing rare earth elements (lanthanides) and enriched isotopes of Barium and Strontium can be used to batch mark Golden perch fingerlings. These experiments have examined the effects of pH and alkalinity on the uptake of chemical marks, allowing for an assessment of whether manipulation of water chemistry in hatcheries would be necessary for mass marking fingerlings using this method. The fish from the marking trials are currently being grown out in aquaria to determine mark retention and any effects of the marking procedure on long-term growth and mortality.

State and Territory highlights
The NSW ‘Freshwater Fish Stocking Fishery Management Strategy’ (FMS) has been approved by the Minister for Natural Resources and gazetted by the Minister for Primary Industries. The FMS introduces changes to administrative and regulatory provisions relating to the stocking of native and alien species in NSW. Approximately 105 delegates, representing freshwater fish stocking associations, freshwater hatcheries, recreational fishing bodies, regional NRM groups and the DPI&F, attended the 2005 Queensland Southern Freshwater Fisheries workshop. These workshops are held to foster feedback from community-based stocking associations involved in the Queensland Government’s Freshwater Fish Stocking Program. The 2005 workshop presented an opportunity to increase awareness of the NFS implementation plans, and gave the regional NRM groups the opportunity to interact with a new group of stakeholders. DPI&F reported on progress with an Ecological Sustainable Development (ESD) assessment of Queensland fish stocking program. Stocking groups were supportive of the approach and recognise that stocking must be undertaken under appropriate sustainability guidelines. Following the completion of a review of Trout stocking in South Australia in 2003–2004, changes were recommended to Cabinet. Stocking of Trout has now been altered such that six rivers will continue to be stocked, three of which are in the SA MDB: the Finiss, Hindmarsh and
Currency Creeks. All other rivers of the SA MDB will be closed to the stocking of Trout immediately. Stocking of the approved rivers will be reviewed after 10 years, based on the results of monitoring and research programs.

In the Australian Capital Territory, 79,355 fish were stocked into ACT waters as part of the urban lakes recreational fish stocking program. Murray cod were released into Lake Tuggeranong and Yerrabi Pond and Golden perch were released into Lake Burley Griffin and Gungahlin Pond. Fry of the endangered Trout cod were stocked at Angle Crossing on the Murrumbidgee River in December 2004. The Two-spined blackfish is declared vulnerable in the ACT, and now only occurs in the ACT in the Cotter River. It was present in the Murrumbidgee and the Paddy's rivers in the ACT until the early 1960s. In an attempt to re-establish a population in Paddy's River, Two-spined blackfish were translocated from the Cotter River. Monitoring of the survival of released individuals will be conducted in 2005–2006.

A trial re-introduction of sub-adults of the endangered Trout cod was conducted in the Murrumbidgee and Cotter Rivers in the ACT in late 2004. Fish were fitted with radio-transmitters to monitor their movements after release. In an unexpected result, the sub-adult fish suffered considerable mortality over a period of six months after release, with predation by birds and/or water rats suspected as significant causes of mortality. Further investigation into measures to minimize predation or educate fish in predator avoidance is planned.

In Victoria, almost $1 million from recreational fishing licence fees is being used to fund dozens of projects to enhance recreational fishing throughout the State. These projects include $85,000 for fish stocking projects in addition to the one million fingerlings Fisheries Victoria stock annually. A continuing problem for waterway managers is the difficulty in discriminating stocked fish from wild fish. To monitor the effects of river improvement works, or assess changes in the status and trend of native fish populations through time, there is a need to quantify the numbers of stocked individuals and their effects on the rest of the fish community. Further, fisheries managers face increasing demands from anglers to enhance recreational fisheries via stocking programs. Two complementary projects are under way to address these issues. An ARC funded project is comparing population structures and abundances between stocked (Murrumbidgee and Edwards Rivers) and unstocked rivers (Murray River and Billabong Creek), and investigating a range of methods to mark hatchery-bred fish. An NFS MDBC project is examining the potential of various marking techniques, evaluating marking methods that will be viable for government and commercial hatchery operations, and identifying non-lethal methods to detect stocked fish after their release into rivers. Following a literature review, two marking methods were trialed in the laboratory—glow in the dark fish and creating unique chemical fingerprints—both are promising.

3.2 Other projects and activities

Mesoscale movement patterns

The aim of this project is to investigate mesoscale movements of fish species and/or life history stages for which there is little existing information. The project commenced in September 2004. Key achievements in 2004-2005 included completion of the pilot study, formation of a steering committee, selection of sites, preparation of a press release about the project, completion of a draft literature review, commencement of the main study and tagging of 5,000 fish.

The draft literature review was completed in April 2005. It identified existing knowledge
on movements of freshwater fish species, methods for studying movements, and knowledge gaps. A copy of the final version will be posted on the MDBC website when completed. Based on knowledge gaps identified in the literature review, the following species and life history stages were selected for movement studies. Carp gudgeon, Murray River rainbowfish, hardyheads, Glass perchlet, Spangled perch, Hyrtl’s tandan, Eel-tailed catfish, Bony bream, juvenile Golden perch, and juvenile Murray cod. These include both common and threatened species, widespread species and some species restricted to the northern Basin.

The pilot study involved both tank and field-based experiments. These investigated tag retention, post-tagging survival and the potential to recapture tagged fish. Tagging systems trialed were visible implant elastomer (VIE) tags in Bony bream and small species such as gudgeons and hardyheads, and passive integrated transponder (PIT) tags in larger species such as Spangled perch and Hyrtl’s tandan. Approximately 5,000 fish have already been tagged (including all of the species listed above). Carp gudgeons, Rainbowfish, Bony bream, Spangled perch and juvenile Golden perch represent the bulk of fish tagged.

The pilot study enabled the researchers to develop an efficient, mobile, field-based tagging system for handling large numbers of fish. It involves minimal handling and transport. Fish are kept in floating cages in the river prior to tagging. All tagging is done adjacent to the release site. An inverter connected to a research vehicle battery powers the tagging machines. Compressed air for the VIE tagging machine injection systems is provided from SCUBA tanks. A short video showing capture and tagging of fish in the field has been produced.

**Impacts of managed flows project**

This project is investigating the impact of managed flows on native fish species. The native species which persist in regulated rivers tend to be those that spawn over an extended period (protracted spawners), whereas those that spawn for a short time (brief spawners) tend to be under-represented. This has led to the suggestion that, because of altered flows, conditions for recruitment in regulated rivers have changed and the larvae of many ‘brief’ species now rarely encounter favourable conditions. On the other hand, ‘protracted’ species produce larvae for many months, and it is possible that a portion of those larvae encounter favourable conditions and are able to be recruited.

Thus, the aims of this project are to investigate the timing of recruitment of species which spawn over an extended period and compare this with recruitment of species which have a brief spawning period. To determine whether the patterns are consistent between regions for the same species, these investigations will be carried out in a regulated and an un-regulated river in each of the upper Murray-Darling Basin (MDB), the middle MDB and the lower MDB.

The first step is to describe the patterns in recruitment of a protracted species and determine whether recruitment is even throughout the spawning season or if there is differential recruitment. Australian smelt were selected as the model species, since previous work has shown that it can spawn for up to seven months of the year.

Sampling of newly-hatched larvae will take place monthly from September to February in each of 2005–2006 and 2006–2007 in the three parts of the Basin. In February, recruitment will be estimated by sampling juvenile fish, ageing them and back-calculating to determine when they hatched. Comparison of the abundance of newly-hatched larvae with the abundance or recruits will enable the researchers to determine whether recruitment is proportional to larval abundance or not. Physico-chemical variables and the abundance of planktonic and benthic prey will also be monitored to determine patterns in recruitment and potential influencing variables.

**Native fish and wetlands workshop**

The NFS recommends the rehabilitation and protection of the natural functioning of wetlands and floodplain habitats for native fish and aims to revive the links between terrestrial ecosystems, wetlands and rivers. The FMSC sponsored a workshop, ‘Native Fish and Wetlands’, in Canberra on 7–8 June 2005.

Wetlands and fish have not had a close association in the public eye. In most States and Territories those agencies working to
see inland wetlands protected or managed for long-term sustainability have done so in isolation of fisheries agencies. Native fish should be seen as intrinsic natural assets of wetlands so that both fish and wetlands can be better off. Indeed, a little known trigger for declaring wetlands as internationally significant under the RAMSAR Convention is the presence of ecologically important fish populations.

The workshop explored in detail some of the more pertinent issues relating to fish and wetlands, including the significance of floodplain wetlands for Murray-Darling Basin fish species, the impact of invasive fishes on wetland ecosystems in the Basin, and the need to take more integrated approaches, involving regional and catchment groups, private landowners, anglers, NGOs, big business and government. There was also a case study approach to managing ephemeral wetlands for native fish, linking fish ecology to regulatory structure design and operation.

**Australian Society for Fish Biology sponsorship**

The MDBC again continued its support of fish and fisheries science through sponsorship of the Australian Society for Fish Biology's 2004 conference, which was held in Adelaide on 23–24 September 2004. This sponsorship also supported the National Symposium on Ecosystem Research and Management of Fisheries which was held also in Adelaide, on 21–22 September 2004.

**Assessing the effectiveness of environmental flows on fish recruitment in Barmah–Millewa**

This project, which commenced in 2003, aims to assess the timing and extent of fish breeding and recruitment in response to flow, temperature and management regimes in the Barmah–Millewa forest. Two small flood events occurred during 2004–05 in the region, in mid September and February respectively.

More than 13,000 fish were sampled, representing 15 species – 10 of which were native. Though additional sampling will be carried out in 2005–06, results so far indicate the importance of Barmah–Millewa as a breeding and recruitment area for a number of native fish species. The project will aid in optimising environmental watering strategies for fish in the region and other floodplain wetlands in the system.
3.3 Infrastructure

3.3.1 Fish Management and Science Committee

During 2004–2005, membership of the Fish Management and Science Committee comprised:

- Mr Scott Keyworth, MDBC (Chairperson)
- Mr Jim Barrett, MDBC
- Mr Paul Bennett, DSE
- Ms Deb Callister, DEH
- Mr Craig Copeland, NSW DPI
- Dr Peter Jackson, Qld DPI
- Dr John Harris, consultant
- Mr John Koehn, DSE
- Mr Mark Lintermans, Environment ACT
- Ms Emma Lowe, DEH
- Mr Alex McNee, DAFF
- Mr Jon Presser, PIRSA
- Mr John Pollock, Qld DPI
- Dr Qifeng Ye, SARDI

The FMSC met on three occasions: 3 August 2004, 14 December 2004 and 27 April 2005 (all in Canberra). Major outcomes of these meetings included:

- advancements on a consistent approach to fish kill protocols
- the establishment of the Murray Cod Reference Group
- initiating a project on Murray crayfish;
- development of a policy on the adequacy and limitations of provisions for dealing with noxious fish
- initiating a project to review and quantify the adequacy of the protection afforded to native fish under the current network of protected areas
- initiating a review of the ‘Sea to Hume Dam’ fishway program.

Fish Management and Science Committee

Terms of Reference

Provide high level advice to the MDBC on fish conservation, rehabilitation and management issues in the Basin, especially in relation to the implementation of the NFS.

Under the broad direction of the Commission, undertake a leading role in coordinating the holistic management and rehabilitation of rivers in terms of protecting and restoring fish habitat; pursue a consistent approach across State boundaries in freshwater fish issues, and legislation; provide the conduit for information exchange and public awareness activities. In particular:

- identify emerging or potential issues in fish conservation and management that may be applicable to MDB fish communities
- prioritise and coordinate actions that need to be undertaken, under the umbrella of the Strategy’s objectives and driving actions
- assess and advise on the suite of resources necessary for implementing the NFS within jurisdictions, and provide a mechanism for the securing of those resources to meet Basin objectives
- instigate actions for the effective integration of fish issues under the ICM framework, and in particular the incorporation of fish management issues in regional and catchment management plans
- promote the integration of Basin-wide fish management and conservation issues across the range of departments, agencies and policies
- coordinate and advise on the establishment and implementation of demonstration reaches in the MDB
- provide advice, as required, to other, issues-based working groups (such as the FPRG and the CSG)
- provide an annual consolidated Basin report on the implementation of the NFS.
3.3.2 Community Stakeholder Group

In late 2001, the MDBC established a Community Stakeholder Group (CSG) as one of three groups to assist the Commission with the development and implementation of its anticipated NFS. The group is drawn from a range of stakeholders including Local Government, recreational and commercial fishers, the conservation movement, the Indigenous community, the National Carp and Pest Fish Task Force, catchment management, tourism and the Commission. During 2004–2005, membership of the CSG comprised:

- Mr Adrian Wells, local government/community (Chairperson)
- Mr Dean Ansell, MDBC
- Mr Jim Barrett, MDBC
- Mr Simon Bennison, aquaculture
- Mr Paul Donatiu, conservation
- Mr Phil Duncan, Indigenous
- Mr Craig Ingram, Native Fish Australia
- Mr Henry Jones, commercial fishing/conservation
- Mr Graham Pike, recreational fishing
- Mr Richard Ping Kee, recreational fishing
- Mr George Sossi, tourism
- Mr Peter Taylor, recreational fishing

The CSG annual implementation report for 2004–2005 is on the CD attached.
3.3.3 The Fish Passage Reference Group

The FPRG met on three occasions, namely 23–24 August 2004 (Mildura), 6–7 December 2004 (Adelaide) and 15 June 2005 (Canberra). Other than progressing the construction of fishways (and monitoring their effectiveness) at Locks 9 and 10 and the Barrages, major outcomes of these meetings included:

- liaison with Carp fishers re control options and infrastructure at Lock 1
- liaison with the Commission’s GIS and IT experts re the establishment of a centralised database for PIT readers
- the drafting of a progress report on the first four years’ operation of FPRG activities
- investigating innovations in the vertical-slot fishway design
- a proposal to host an international symposium on fish passage in 2007
- operating manuals, and training of site staff on fish identification and tagging
- investigations into a prototype fishway at Lock 11
- the establishment of a trial for using a fish pump as a novel means of passing fish over an obstruction.

During 2005–2006, membership of the FPRG comprised:

- Jim Barrett, MDB (Convenor)
- Mr Andrew Berghuis, Southern Fishway and Fish Communities Team, Queensland DPI & Fisheries
- Dr Lee Baumgartner, NSW DPI (Fisheries)
- Mr Cameron Lay, NSW DPI (Fisheries)
- Mr Brian Cooper, NSW DPWS, Dams & Civil
- Mr Brenton Erdmann, SA DWLBC
- Mr Darryl Jones, SA Water
- Dr Martin Mallen-Cooper, consultant
- Mr Tim O’Brien, VIC DSE (ARI)
- Mr John Prentice, RMW
- Mr Angelo Rossi, SA Water (Project Manager, Locks 1, 7, 8, 9 & 10)
- Mr Brenton Zampatti, SARDI

Fish Passage Reference Group

Terms of Reference

On the premise that hydrology, hydraulics and biology are three essential and interrelated elements in developing fish passage, the MDB Fish Passage Reference Group will:

- on a Basin-wide level, integrate these disciplines at a broad, strategic level and at an individual site-specific level
- using these disciplines, ensure that appropriate fishway designs are used at particular sites, with consistency across the Basin
- in the context of the above, provide advice on fishway designs, including on-site advice at specific locations as required (and including low cost and/or innovative designs) and (joint) applications
- develop a Basin-wide fish passage program for priority structures
- provide an emphasis on river ecology and its relationship with fish passage
- ensure that there is an appropriate monitoring and evaluation component for each new fishway
- make recommendations on the above matters to the MDB FMSC and/or the RMW Board, as appropriate.
3.3.4 NFS Coordinators

The MDBC has contributed to the employment of Native Fish Strategy Coordinators in each Basin State. The role of the NFS Coordinators is to:

- raise the general awareness of the NFS in the jurisdictions
- engage with stakeholder groups such as catchment management organisations, non-government organisations, Indigenous peoples, local government, fishing groups, landholders and industry
- ensure regional natural resource management plans properly reflect the objectives and priorities of the NFS
- develop project briefs for NFS-related projects in the jurisdictions, including through the major Commonwealth programs such as NHT and NAP
- prepare tenders and contracts for funded projects under the direction of relevant FMSC members; investigate and provide reliable information concerning the availability of funds, including alternative sources of funding
- assist FMSC members and the community prepare proposals for the development and implementation of demonstration reaches
- ensure a consistent approach to implementation of key actions under the NFS's objectives across the Basin
- undertake formal liaison with the MDBC and associated groups.

During 2004–2005, the NFS coordinators were:

New South Wales—Ms Sharon Molloy, Mr Mark Neeson and Ms Milly Hobson
South Australia—Mr Jason Higham
Queensland—Ms Maria Bavins and Ms Natalie Baker
Victoria—Dr Janet Pritchard

The Coordinators met in July 2004 (Brisbane), November 2004 (Adelaide), and April 2005 (Canberra). In addition, they participated in the Darling River Tour in May 2005. Some of the major outcomes of these meetings included:

- development of detailed work plans for Coordinator activities
- identification of communication needs and development of educational material
- progression of the demonstration reach concept in each jurisdiction
- establishment of a database of funding sources within the MDB
- development of NFS Annual Implementation Reports.

For contact details of NFS Coordinators, please contact the MDBC.

3.3.5 Murray Cod Reference Group

The Murray Cod Reference Group (MCRG) was established as the result of a recommendation of the July 2004 workshop on Murray cod in Canberra. The MCRG includes representatives from the following interests: recreational fishing, indigenous, aquaculture, the conservation movement, Native Fish Australia, ecology, fish biologists, and enforcement, and is chaired by the Manager of the NFS.

During 2004–2005, membership of the MCRG comprised:

- Mr Jim Barrett, MDBC (Chairperson)
- Mr Dean Ansell, MDBC
- Mr Phil Duncan
- Mr Richard Ping Kee
- Dr Stuart Rowland
- Dr John Harris
- Mr John Koehn
- Dr Qifeng Ye
- Dr Michael Hutchison
- Mr Robert Loats
- Dr Dean Gilligan
- Mr Marc Ainsworth
- Mr Mark Lintermans
- Mr Ben Bowman
- Mr Peter Teakle
- Mr Les Kowitz
- Mr Ron Lewis

The MCRG met twice in 2004-2005, on 10 December 2004 and 8 April 2005. The Group considered matters such as:

- the national Murray cod recovery plan;
- stocking issues
- the development of a database of ‘cod’ projects
- the promotion of Murray cod as an icon species
- the NSW Government report on a hatchery quality assurance program.
1. Under the umbrella of the MDBC’s Fish Management & Science Committee (FMSC), provide regular advice through the FMSC to the Ministerial Council, the MDBC Community Advisory Group (CAC) and the NFS Community Stakeholder Group (CSG) on key issues such as:

- the identity, size, structure and dynamics of Murray cod populations
- the level of fishing catches from cod populations
- levels of recruitment
- impacts of stocking efforts
- impacts of, and mitigation options for, thermal pollution
- habitat management options and priorities
- community liaison and involvement in the management of Murray cod
- the incidence, severity, causes of, and responses to fish kills
- the adequacy of current management arrangements, including the impact of set lines on Murray cod populations; appropriateness of current bag and size limits and seasonal closures and future management options
- the feasibility, design and implementation of potential additional Murray cod management measures that are widely employed in the conservation of other freshwater and marine fisheries, such as closed areas, catch and release areas, identification, definition and declaration of critical habitats, and trophy fisheries
- measures to further promote Murray cod as an icon species.

2. Liaise with and provide advice to the Victorian Department of Sustainability and Environment regarding the National Recovery Plan for the Murray cod in consultation with relevant State and Territory agencies and other regional natural resource management groups and catchment management organisations, thus ensuring that the plan reflects the priorities in the NFS and any new research findings that address key knowledge gaps.

3. Identify, and develop project briefs for, research priorities to assist decision-making in the management of Murray cod.

3.4 Community engagement

During 2004-2005 the NFS team, including MDBC staff, NFS Coordinators and members of the CSG, dedicated significant time and resources to talking to communities in the Basin about the native fish issues they see as high priority and ways they can assist in recovery of native fish and their habitats. This involved presentations to schools, recreational angling clubs, landholders and community groups, attendance at field days, workshops and conferences, as well as many site visits. Details of the groups consulted and the events attended can be found in the individual reports on the CD attached to this report.

3.4.1 CSG Darling River Tour

The Darling River Tour was conducted from 16–20 May 2005 with great success and was attended by the CSG, NFS Coordinators, and MDBC NFS team. Travelling through Collarenebri, Walgett, Brewarrina, Bourke, Louth, Tilpa, Wilcannia, Menindee, Pooncarie, Wentworth and Mildura, the purpose of this tour was to engage Darling River communities, raise awareness of the NFS and to discuss local issues relating to native fish in the region. This tour was also designed to deepen the understanding of members of the NFS team of issues facing fish and their habitats in the Darling River, as well as the stakeholders.
The tour involved presentations to, and discussions with, local schools, angling groups, community groups, Indigenous people, catchment management authority representatives, Local Government councils, State natural resource management agency staff, landholders and other organisations (including Tourist Information Centres), as well as visits to sites relevant to native fish management (e.g., fishways, Menindee Lakes, Indigenous fish traps).

Overall, the community was very receptive and eager to share their views and concerns. Pervasive issues involved a strong interest in demonstration reaches, concern over magnitude of illegal fishing activity and perceived inadequacy of compliance efforts, and disenchantment about the lack of resources available to assist community groups to develop and implement on-ground projects. A number of communication gaps were also identified that require immediate attention, such as confusion over the benefits of large woody debris as habitat for fish. A report has been prepared by the Group, summarising the outcomes of the various meetings held, and the recommendations that the CSG has undertaken to progress.
3.4.2 Publications
During 2004–2005, the following publications were developed and made available through the MDBC office and/or website:

- ‘Fish n’ Chips’
  - a brochure that complements the ‘What is a fishway’ flyer by discussing why we microchip fish with PIT-tags and what this is telling us about where and when fish move. This topic directly links back to fishways as a means of assessing the performance and success of the new fishways.

- ‘The River Murray Barrages and Fishways’
  - a brochure that describes the ecology of the Coorong and Lower Lakes, details the history and purpose of the River Murray Barrages, and the design and operation of the fishways at the barrages.

- ‘Snags and restnagging’
  - a brochure that explains the role of large woody debris (snags) in the ecology of native fish.

- Proceedings of the Management of Murray cod in the MDB workshop.

- Proceedings of the Native Fish Habitat Rehabilitation and Management in the MDB workshop.

3.5 Knowledge generation
There is a lack of biological and ecological knowledge for many of the Basin’s fish species and communities. The Native Fish Strategy seeks to initiate scientific research that will provide new knowledge and thus facilitate informed management decisions and increase community awareness of fish conservation issues. Knowledge gaps are identified and prioritised for investigation by the Fish Management and Science Committee and reviewed yearly. Research undertaken during 2004–2005 is detailed below (Table 3). Note that this table contains only those projects funded solely by MDBC. For details of further research, see individual Implementation reports for each jurisdiction in the attached CD.
Table 3. Key knowledge generation projects funded by MDBC during 2003–04

<table>
<thead>
<tr>
<th>Project</th>
<th>Expected outcomes</th>
<th>Lead investigator(s)</th>
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</table>
| Effects of environmental flow allocations on the lateral movements of native fish in the Barmah-Millewa Forest | • Procedures/protocols for provision of fish passage devices in the Barmah-Millewa floodplain  
• Operational protocols to minimise impacts of regulators on movement of native fish and their larvae  
• Identify major entry and exit points to the floodplain and major barriers to movement  
• Determine significance of lateral movements onto the floodplain and management implications | Arthur Rylah Institute                    |
| Spatial distribution of fish in the MDB                                 | • Capacity to utilise fish distribution information in natural resource management programs  
• Capacity to visually display fish distributions for educational and interpretive programs | Sinclair Knight Merz                      |
| Meso-scale movement patterns of native fish                            | • Improved knowledge of movement requirements of native fish  
• Improved management of longitudinal and lateral connectivity of aquatic systems (eg floodplain and wetland connectivity, upstream and downstream movement requirements) | Queensland DPI&F                          |
| Impacts of managed flows on fish spawning and recruitment              | • Improved knowledge of the impacts on fish spawning and recruitment of flow management in river channels  
• Improved flow management practices and procedures to facilitate increased spawning and recruitment of native fish in river channels | Charles Sturt University                  |
| Assessing the effectiveness of environmental flows on fish recruitment in Barmah-Millewa | • Improved management of environmental watering strategies for the Barmah-Millewa Forest for native fish  
• Identify type and locality of significant nursery habitats within Barmah-Millewa Forest  
• Improved understanding of the importance of floodplain inundation to native fish recruitment | Arthur Rylah Institute                    |
| Daughterless Carp                                                       | • Laboratory-bred second generation daughterless Carp (proof of concept)  
• Significant progress on knowledge of carp population dynamics, integrated pest management considerations and logistical and statutory constraints | Pest Animal Control CRC                   |
<table>
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<tr>
<th>Project</th>
<th>Expected outcomes</th>
<th>Lead investigator(s)</th>
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</thead>
</table>
| Protection and enhancement of Murray cod populations | • Preparation of a weir pool operation guide to facilitate fish passage in the Broken Creek  
• Assessment of methods to achieve operational changes to flow regimes, including flow variability and timing, to enhance passage and spawning of Murray cod  
• A community based monitoring plan of Murray cod populations and aspects of water quality                                                                 | Arthur Rylah Institute              |
| Consultancy to develop the demonstration reach concept under the Native Fish Strategy | • Prepare a report which will outline community aspirations and reservations, risks and benefits, and a path forward in regards to developing demonstration reaches  
• Provide formal feedback to the Commission on (i) community expectations and acceptance of the demonstration reaches concept and (ii) a continuing reality check between the theory and a working example (e.g. Hume to Yarrawonga)  
• Organise and facilitate two regional community workshops.                                                                                                                                 | Griffin nrm                         |
| Exit fate of fish from Yarrawonga fishlock and effects of turbine passage | • Improved understanding of the fate of fish exiting from Yarrawonga fishlock  
• Identify significant impacts of turbine passage on freshwater fish  
• Describe flow patterns and fishlock operation methods needed to enhance safe exit of fish from Yarrawonga fishlock  
• Assess potential methods to determine timing and magnitude of downstream fish migration from riverine reaches above Yarrawonga Weir and recommend management/research strategies to minimise entrainment  
• Provide baseline data and recommendations for future fishlocks in the MDB and coastal rivers                                                                 | Arthur Rylah Institute              |
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<tr>
<th>Project</th>
<th>Expected outcomes</th>
<th>Lead investigator(s)</th>
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</thead>
</table>
| International review of freshwater protected areas for aquatic biodiversity conservation | • Enhanced knowledge of the social, political, legal and biological issues surrounding the management of freshwater protected areas  
• Identification of potential barriers to the establishment of a system of freshwater protected areas in the Murray-Darling Basin  
• Informed management options for the establishment of freshwater protected areas in the Murray-Darling Basin | Mainstream Environmental Consulting |
| Impacts of native fish stocking on fish in the MDB                      | • Improved knowledge of the impacts (both positive and negative) of native fish stocking  
• Greater success in rehabilitation programs for threatened species and populations  
• Improved fish stocking practices and policies in the Basin | Adelaide Research and Innovation |
| Significance of Murray cod to Aboriginal communities                    | • Improved knowledge of the significance of Murray cod to aboriginal people  
• Enhanced awareness and participation by aboriginal people in relevant activities under the Native Fish Strategy | Gondwana Consulting |
| Scoping the knowledge requirements of Murray crayfish                   | • Identification of knowledge gaps in Murray crayfish ecology and management  
• Priorities for research to address these knowledge gaps  
• Improved management options for maintaining or recovering Murray crayfish populations | NSW DPI and Environment ACT |
| Improved methodology for the discrimination of stocked and wild native fish | • Improved management of fish stocking programs  
• Improved capacity to accurately assess river health and status of native fish populations | Arthur Rylah Institute |
| Quantification of fish in water supply offtakes                          | • Improved knowledge of extent and patterns of loss of fish through water offtakes  
• Improved management options for reducing loss of native fish at water offtakes | NSW DPI |
| Development of a fish counter                                           | • Development of robust cost effective fish counter | Adelaide Research & Innovation |
| Development of prototype airlift pump fishway                            | • Development and testing of prototype airlift pump fishway | Harris Research |
### List of Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>NSW DPI AER</td>
<td>Aquatic Ecosystems Research</td>
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<tr>
<td>AEMP</td>
<td>Asset Environmental Management Plan</td>
</tr>
<tr>
<td>ACIAR</td>
<td>Australian Centre for International Agriculture Research</td>
</tr>
<tr>
<td>ANSA</td>
<td>Australian National Sportfishing Association</td>
</tr>
<tr>
<td>ARC</td>
<td>Australian Research Council</td>
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<tr>
<td>ARI</td>
<td>Arthur Rylah Institute for Environmental Research, DSE</td>
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<tr>
<td>AU</td>
<td>Adelaide University</td>
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<tr>
<td>BIA</td>
<td>Boating Industry Association</td>
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<tr>
<td>BMF</td>
<td>Barmah-Millewa Forum</td>
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<tr>
<td>BRCMA</td>
<td>Border Rivers Catchment Management Association</td>
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<tr>
<td>CA</td>
<td>Condamine Alliance</td>
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<tr>
<td>CAC</td>
<td>Community Advisory Committee</td>
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<tr>
<td>CAP</td>
<td>Catchment Action Plan</td>
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<tr>
<td>CCEAD</td>
<td>Consultative Committee on Emergency Animal Diseases</td>
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<tr>
<td>CMA</td>
<td>Catchment Management Authority</td>
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<tr>
<td>CMO</td>
<td>catchment management organisation</td>
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<tr>
<td>CRCCH</td>
<td>Cooperative Research Centre for Catchment Hydrology</td>
</tr>
<tr>
<td>CRCFE</td>
<td>Cooperative Research Centre for Freshwater Ecology</td>
</tr>
<tr>
<td>CSG</td>
<td>Community Stakeholder Group</td>
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<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>CW</td>
<td>Coliban Water, Urban Water Authority</td>
</tr>
<tr>
<td>DAFF</td>
<td>Department of Agriculture, Fisheries and Forestry</td>
</tr>
<tr>
<td>DEH (SA)</td>
<td>Department of Environment &amp; Heritage (SA)</td>
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<tr>
<td>DEH</td>
<td>Department of Environment &amp; Heritage</td>
</tr>
<tr>
<td>DIPNR</td>
<td>Department of Infrastructure, Planning and Natural Resources (NSW)</td>
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<td>DNR&amp;M</td>
<td>Department of Natural Resources and Mines (Qld)</td>
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<td>DSE</td>
<td>Department of Sustainability and Environment (Vic)</td>
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<td>DSE BNR</td>
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<td>DSE NW</td>
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<td>DSE WSG</td>
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<td>DWLBC</td>
<td>Department of Water Land and Biodiversity Conservation (SA)</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<tr>
<td>EPBC Act</td>
<td>Environment Protection and Biodiversity Conservation Act 1999</td>
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<tr>
<td>ESD</td>
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<td>ET</td>
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<td>EWA</td>
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<td>FCLM</td>
<td>Forests and Crown Land Management</td>
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<td>FFG</td>
<td>Flora &amp; Fauna Guarantee Act 1988</td>
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<td>FMAC</td>
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<td>Acronym</td>
<td>Explanation</td>
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<td>NSW DPI</td>
<td>New South Wales Department of Primary Industries</td>
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<td>ORL</td>
<td>Our Rural Landscapes Initiative</td>
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<td>PAC CRC</td>
<td>Pest Animal Control Cooperative Research Centre</td>
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<td>PIRSA</td>
<td>Primary Industries Research South Australia</td>
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<td>PIRVic</td>
<td>Primary Industries Research Victoria</td>
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<td>PIT</td>
<td>Passive Integrated Transponder</td>
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<td>PV</td>
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<td>QMDC</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<td>RCP</td>
<td>Regional Catchment Plan</td>
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<td>RFLT</td>
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<td>RHFF</td>
<td>Rex Hunt Future Fish Foundation</td>
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<td>RRHS</td>
<td>Regional River Health Strategy</td>
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<td>RMCWMB</td>
<td>River Murray Catchment Water Management Board</td>
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<td>RMW</td>
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<td>ROP</td>
<td>Resource Operations Plan</td>
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<td>RWA</td>
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<td>SA MDB NRM Board</td>
<td>South Australian Murray-Darling Basin Natural Resources Management Board</td>
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<td>SFMP</td>
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<td>SKM</td>
<td>Sinclair Knight Mertz Consultants</td>
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<td>SR</td>
<td>Streamline Research Pty. Ltd.</td>
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<tr>
<td>SRA</td>
<td>Sustainable Rivers Audit</td>
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<tr>
<td>TLM</td>
<td>‘The Living Murray’ Program</td>
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<tr>
<td>UC</td>
<td>The University of Canberra</td>
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<td>UWA</td>
<td>University of Western Australia</td>
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<td>VIE</td>
<td>Visual Implant Elastomer</td>
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<td>WCMA</td>
<td>Wimmera Catchment Management Authority</td>
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<td>WMPP</td>
<td>Wimmera-Mallee Pipeline Project</td>
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<td>WRP</td>
<td>Water Resource Plan</td>
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<tr>
<td>WWF</td>
<td>World Wildlife Fund</td>
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</table>
**List of Scientific Names**

- **Australian smelt**: *Retropinna semoni*
- **Barred galaxias**: *Galaxias fuscus*
- **Black bream**: *Acanthopagrus butcheri*
- **Bony bream (Herring)**: *Nematalosa erebi*
- **Brown trout**: *Salmo trutta*
- **Carp gudgeons**: *Hypseleotris spp.*
- **Common carp**: *Cyprinus carpio*
- **Crimson spotted rainbowfish**: *Melanotaenia fluviatilis*
- **Eel-tailed catfish**: *Tandanus tandanus*
- **Flat-headed gudgeon**: *Phyldnodon grandiceps*
- **Fly-specked hardyhead**: *Craterocephalus stercusmuscarum*
- **Freshwater catfish**: *Tandanus tandanus*
- **Glass perchlet**: *Ambassis agassizi*
- **Goldfish**: *Carassius auratus*
- **Golden perch**: *Macquaria ambigua*
- **Greenback flounder**: *Rhamboseola tapirina*
- **Hardyheads**: *Craterocephalus spp.*
- **Hyrtl’s tandan**: *Neosilurus hyrtlii*
- **Macquarie perch**: *Macquaria australasica*
- **Mountain galaxias**: *Galaxias olidus*
- **Mulloway**: *Argyrosomus hololepidotus*
- **Murray cod**: *Maccullochella peelii peelii*
- **Murray hardyhead**: *Craterocephalus fluviatilis*
- **Murray jollytail**: *Galaxias rostratus*
- **Murray River crayfish**: *Euastacus armatus*
- **Murray River rainbowfish**: *Melanotaenia fluviatilis*
- **Olive perchlet**: *Ambassis agassizi*
- **Purple spotted gudgeon**: *Mogurnda adspersa*
- **Rainbow trout**: *Oncorhynchus mykiss*
- **Red-eared slider turtle**: *Trachemys scripta elegans*
- **Redfin perch**: *Perca fluviatilis*
- **River blackfish**: *Gadopsis marmoratus*
- **River snail**: *Notopala sublineata*
- **Short-headed lamprey**: *Mordacia mordax*
- **Silver perch**: *Bidyanus bidyanus*
- **Small-mouthed hardyhead**: *Atherinosoma microstoma*
- **Southern pygmy perch**: *Nannoperca australis*
- **Spangled perch**: *Leiopotherapon unicolor*
- **Tilapia**: *Oreochromis mossambicus*
- **Tilapia**: *Macullochella macquariensis*
- **Trout cod**: *Gadopsis bispinosus*
- **Two-spined blackfish**: *Hypseleotris klunzingeri*
- **Unspecked hardyhead**: *Atherinosoma microstoma*
- **Western carp gudgeon**: *Aldrichetta forsteri*
- **Yellow-eye mullet**: *Aldrichetta forsteri*