

Murray-Darling Basin Commission
May 2003

Native Fish Strategy for the Murray-Darling Basin 2003-2013

Companion Document:
Recommended Actions

The overall goal of this Strategy is to rehabilitate native fish communities in the Murray-Darling Basin back to 60 per cent of their estimated pre-European settlement levels after 50 years of implementation.

Introduction

The *Native Fish Strategy* provides a response to the key threats to native fish management in the Murray-Darling Basin. These range from flow regulation, habitat degradation, lowered water quality, man-made barriers to fish movement, the introduction of alien fish species, fisheries exploitation, the spread of diseases and translocation and stocking of fish. Native fish populations in the Basin's rivers have declined under these threats with experts estimating that current levels are about 10 per cent compared to pre-European settlement.

The vision of this Strategy is to ensure that the Basin sustains viable fish populations and communities throughout its rivers. The goal of this Strategy is to rehabilitate native fish communities in the Basin back to 60 per cent of their estimated pre-European settlement levels after 50 years of implementation.

The *Strategy* will address its goal and targets through strategic actions designed to achieve the 13 objectives directed at improving the status of native fish populations in the Basin. This Companion Document describes these strategic actions.

The following recommended actions to achieve the objectives of the *Strategy* will be integrated into an annual operating plan which sets priorities on a three-year rolling cycle and takes into consideration the sequencing of projects and inter-relationship among them.

Actions are set with priorities, timeframes, ease of achievement and the responsible agencies assigned. Targets set criteria by which progress can be measured over set timeframes. These are aligned with the overall thrust of this Strategy which is to ensure an integrated management approach to restore native fish populations and communities to acceptable and sustainable levels. Three additional performance criteria allow assessment of progress:

- *process (empowerment) indicators*, which allow measurement of the information, resources and opportunities available for the Basin's communities to manage their natural resources in a sustainable way;
- *implementation indicators*, which allow measurement of the extent to which natural resource managers in government agencies and communities have actually used and understood the information, resources and opportunities for on-ground works; and
- *resource condition indicators*, which show improvement in the condition of natural resources – hence the sustainability of the ways in which the resource has been managed and used.

As well as the co-operation of the various agencies listed, the future of the Murray-Darling Basin River system is dependent on empowerment of the community and their strong participation in all levels of the *Strategy*.

Legend

Priority	Timeframe	Ease
Low	Immediate (<1 year)	Easy
Medium	Medium Term (1-5 years)	Moderate
High	Long term (5+ years)	Hard

Agencies with responsibility for progressing and/or reporting on progress

SWMA	State water management agencies
SLMA	State land management agencies
SF&C	State fisheries and conservation management agencies
MDBC	Murray-Darling Basin Commission
R&DC	Research and development corporations
CRC	Cooperative research centres
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWLT	Commonwealth government agencies
UNI	Tertiary institutions
EPA	State environment protection authorities
COAG	Council of Australian Governments
LGA	Local government associations
CMO	Catchment management organisations

Objective: To repair and protect key components of aquatic and riparian structural habitat that sustain native fish.

Suitable habitat is essential for the survival of all native fish species. Key components of habitat include home sites, spawning sites, provision of shade, shelter from certain water velocities and predators, and a variety of feeding sites and water depths. A diversity of habitats is needed for a diversity of species and life stages. In-stream and riparian habitats within the Basin have been severely degraded.

Sub-objective: To protect important areas and attributes of in-stream structural habitat and, where necessary, rehabilitate native aquatic vegetation and other structural features of habitat to maintain fish-habitat diversity.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Collate and publish all known Murray-Darling fish-habitat requirements, and undertake research with Basin-wide application to determine habitat requirements of native fish	High	Currently underway	Mod	MDBC, SF&C, R&DC, CRC
<i>Operational</i>				
Provide regulatory mechanisms to protect in-stream habitats	High	Immed	Mod	MDBC, SLMA, SWMA, SF&C, EPA
Establish a representative system of protected areas for each recognised habitat type	Med	Med	Mod	MDBC, SWMA, SF&C
Develop and trial principles and guidelines for in-stream habitat creation and repair for river care groups	High	Currently underway	Mod	MDBC, SWMA, SLMA, CMO, R&DC, CRC
Develop a Basin-wide program of in-stream habitat rehabilitation	Med	Med	Mod	CWLT, MDBC, R&DC
Develop and trial resnagging techniques, promote snags as important habitat, prevent removal and realignment, promote resnagging, realignment back to previous state and replanting	Med	Med	Mod	MDBC, SWMA, SF&C, CMO
Include an in-stream habitat component in all river care on-ground works	High	Long	Easy	CMO

Identify habitats that are needed to conserve native fish communities and protect remaining in-stream fish-habitat attributes	Med	Med	Mod	SWMA, SLMA, CMO
<i>Investigation and monitoring</i>				
Undertake a fish-habitat inventory of the Basin	Med	Currently underway	Mod	MDBC
Undertake scoping study on role of aquatic vegetation in providing fish habitat	High	Med	Mod	R&DC, CRC

Sub-objective: To protect important areas and attributes of riparian habitat and, where necessary, rehabilitate riparian vegetation and other structural features of riparian habitat to maintain fish-habitat diversity.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Provide information on the location and status of all riparian zones of the Basin's rivers, streams, wetlands and floodplain channels in relation to protection or rehabilitation requirements	High	Immed	Easy	MDBC, R&DC
<i>Operational</i>				
Develop and review best management practices and options for rehabilitating, managing and protecting riparian zones of rivers throughout the Basin	High	Immed	Mod	MDBC, SLMA, SLWA, R&DC
Protect remaining riparian habitat attributes, prevent further devegetation of riparian zones of river courses, wetlands and floodplain channels	High	Med	Mod	SWMA, SLMA, CMO
Develop a Basin-wide program of riparian vegetation protection and rehabilitation	High	Immed	Mod	CWLT, MDBC, R&DC
<i>Investigation and monitoring</i>				
Develop an inventory of riparian zone plants, their life histories, methods of propagation, ecological features and areas in which they should be planted	High	Med	Mod	R&DC, CSIRO
Monitor riparian zone management and rehabilitation projects as part of a wider approach to natural resource management so as to provide feedback for adaptive management	High	Long	Mod	SLMA, SLWA, LGA, CMO

	Target	Timing
Resource condition	<i>An increase in aquatic structural habitat values of 20%.</i>	2010
Management Action	<i>Implement at least one rehabilitation program in each Sustainable Rivers Audit (SRA) river process zone by 2004 and an additional one per year thereafter.</i>	2010
	<i>Addition of large woody debris through a reach of at least 100km in each river in which historical desnagging has occurred</i>	2005
	<i>Publish and promote principles and guidelines for in-stream habitat protection and repair across the Basin</i>	2004
	<i>Establish and implement an auditing program for aquatic structural habitat</i>	2004
	<i>A basin-wide structural habitat rehabilitation plan agreed to by each jurisdiction.</i>	2004
	<i>Increase the protection of riparian zone by 30% through 30m wide stock exclusion strips</i>	2005
	<i>'Alteration of natural flow regimes' listed as a threatening process under relevant legislation in all jurisdictions</i>	2004

Evaluation and performance criteria

Empowerment

- Community participation and appreciation of the importance of riparian zones for fish and management methods by which to retain/enhance these zones; and
- Identification of techniques required for the maintenance and rehabilitation of aquatic habitats.

Implementation

- Removal of riparian or in-stream habitat only undertaken where impact is not detrimental to fish; and
- Protective measures developed for existing fish habitat.

Resource condition

- Audits undertaken on the extent or quality of riparian zones; and
- Audits undertaken on the extent or quality of in-stream habitat.

Objective: To rehabilitate the natural functioning of wetlands and floodplain habitats for fish, and revive the linkages between wetlands and rivers.

Floodplains and wetlands play a significant role in the ecological functioning of riverine systems. They provide important habitats for fish and other plants and animals, including those on which fish are dependent for food. They are important for carbon-cycling, uptake of excess nutrients and sediment stabilisation. Substantial areas of floodplain have become degraded in the Basin and cut off from the river system.

Sub-objective: To implement best management practices for floodplains and wetlands, incorporating planning principles for ecologically functional riverine corridors at all scales.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Identify high-priority floodplain habitat types and locations for conserving fish populations	High	Med	Mod	MDBC, R&DC, SLMA, LGA
<i>Operational</i>				
Investigate buy-back options for floodplains as important river conservation areas	High	Med	Hard	SLMA, SWMA
Identify fill heights for key wetlands	Med	Med	Easy	SLMA, SWMA
Map all structures which may affect management actions on the floodplains	Med	Med	Easy	SLMA, SWMA
Reconvene interstate committee to assess all levee banks, remove redundant or inappropriate levee banks.	Med	Immed	Mod	MDBC
<i>Investigation and monitoring</i>				
Document the extent, location and history of floodplain alienation	Med	Med	Easy	SLMA, SWMA, R&DC, MDBC
Document the ecological roles of inundation of floodplains, temporary channels and wetlands	High	Immed	Mod	MDBC, R&DC

Sub-objective: To provide knowledge needed to revive ecological processes in floodplains, temporary channels and wetlands for the benefit of native fish.

Action	Priority	Timeframe	Ease	Agency
<i>Investigation and monitoring</i>				
Provide data on the location and condition of floodplain, temporary channel and wetland habitats important to fish, and their ecological and hydrological functions	High	Med	Mod	MDBC, SF&C
Develop improved regimes for inundation, grazing and land management on floodplains to benefit native fish	Med	Med	Easy	SLMA, SWMA, LGA, CMO
Develop criteria and measures for monitoring the attributes of wetlands, temporary channels and floodplains which benefit native fish	Med	Med	Mod	CWLT, R&DC, CRC
Involve the community in management and monitoring of floodplains, temporary channels and wetlands	High	Immed	Mod	SWMA, CMO, SF&C, EPA

	<i>Target</i>	<i>Timing</i>
Resource condition	<i>Functional processes and river floodplain linkages re-established for 80% of remaining wetland habitats through improved flow management</i>	2010
Management Action	<i>15% grazing lease buy-back or covenants on private land for conservation purposes</i>	2010
	<i>No further alienation of floodplain habitats</i>	2005

Evaluation and performance criteria

Empowerment

- Community participation;
- Identification of major threats impacting on fish use of floodplains and wetlands; and
- Agreed policy on the provision of appropriate inundation regimes of floodplains for the benefit of native fish.

Implementation

- Implementation of agreed inundation regimes for the benefit of fish;
- Implementation of fish guidelines in floodplain/wetland developments and improvements.

Resource condition

- No further reduction in floodplains or wetlands important to native fish.

Objective: To improve key aspects of water quality that affect native fish.

The Basin's native fish are facing a number of water quality problems including changed temperatures, increased salinities, pesticides, heavy metals and turbidity. For example, reduced water temperatures or dissolved oxygen levels can prevent fish spawning and reduce metabolic rates. Poor water quality is generally associated with poor river regulation and land management practices.

Sub-objective: To prevent and mitigate the impact of poor water quality on native fish in the Basin.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Collate data, identify and map regions, landscapes, land uses and industries that are important causes of water quality problems in the Basin	Med	Long	Mod	SWMA, EPA, MDBC
Establish monitoring and feedback programs to indicate the impact of water quality changes on the status of fish populations	Med	Med	Mod	EPA, SF&C, SRA
Develop a Basin-wide protocol for reporting fish kills	High	Immed	Easy	SF&C, MDBC
<i>Thermal Pollution</i>				
Give formal recognition within each jurisdiction of the Basin to the problems being caused by thermal pollution, and develop policy principles and strategic and research frameworks for addressing the problems	High	Immed	Easy	SWMA, SF&C
Reduce cold-water pollution below storages through revised operating procedures	High	Immed	Easy	SWMA, MDBC
Avoid introducing thermal pollution to currently unaffected rivers	High	Immed	Easy	SWMA, MDBC
In rivers currently unaffected by thermal pollution, develop future water infrastructure and management with appropriate thermal mitigation measures	High	Immed	Easy	MDBC, SWMA
Design and construct thermal mitigation structures on all storages where they are required	High	Immed	Mod	SWMA, MDBC
Document and map the scale, severity	High	Immed	Easy	MDBC,

and distribution of cold-water pollution throughout the Basin				EPA, SWMA
Complete a scientific assessment of the benefits of mitigating thermal pollution, monitoring the recovery of biota and ecological processes in various jurisdictions of the Basin	Med	Med	Mod	MDBC, SF&C
Develop standardised principles and procedures for monitoring thermal pollution, implementing these through the Sustainable Rivers Audit.	Med	Med	Easy	MDBC, SWMA, EPA
Establish priority-setting procedures and criteria for thermal mitigation which account for all environmental, social and economic issues	High	Immed	Easy	MDBC, SWMA, EPA, SF&C
Where responsibility for dam or river management is spread across multiple authorities, develop mechanisms to ensure cooperation in mitigating thermal pollution	High	Immed	Easy	MDBC, SWMA
Review legislation and policies relating to thermal pollution, and their implementation; identify and correct areas where legislation or policies could be improved	High	Immed	Easy	MDBC, SWMA, CWLT, EPA, SF&C
Review existing Basin programs supporting integrated catchment and natural resource management to ensure that mitigation of thermal pollution is integrated with river rehabilitation activities	High	Immed	Easy	MDBC, SWMA, CWLT, EPA, SF&C
List 'thermal pollution' as a threatening process under relevant legislation in all Basin jurisdictions	High	Immed	Easy	CWLT, EPA, SF&C
Identify streams where water temperatures are increased through loss of riparian vegetation and reduced water flows and develop remedial actions	Med	Long	Mod	SWMA, SLMA, CMO
Implement dam-release procedures to minimise fish mortality and behavioural impacts from thermal shock	Med	Immed	Easy	SWMA, MDBC
<i>Flow management</i>				
Minimise the impact of hypoxic floodwaters and 'blackwater' flows	Med	Med	Easy	SWMA, MDBC
<i>Salinity</i>				
Develop and implement revised flow manipulation strategies to prevent	Med	Med	Mod	SWMA, MDBC

increases in river salinity levels				
Develop and implement revised strategies for disposal of saline water to reduce river salinity levels	Med	Med	Mod	SWMA, SLMA, CMO
Determine the impact of increased salinisation on fish communities	High	Immed	Mod	SF&C, SLMA, CRC, MDBC
<i>Sediments</i>				
Identify areas where sediment and turbidity are impacting on fish	Med	Med	Mod	SWMA, MDBC, CRC
Minimise sediment inputs and clay turbidity from agriculture, roads, forestry and carp	Med	Med	Hard	SLMA, EPA, SWMA, LGA
Develop and implement revised flow manipulation strategies to prevent bank erosion and sedimentation	High	Med	Mod	SWMA, MDBC
<i>Contaminants</i>				
Minimise release of point source and diffuse sources of nutrients (phosphorus and nitrogen)	High	Med	Mod	CMO, SWMA, SLMA, LGA
Require reticulation of water used after pesticide application	Med	Med	Hard	SLMA, LGA, EPA
Determine effects on fish of pesticides and metals used in the Basin and implement remedial programs	Med	Med	Mod	SF&C, CRC, EPA, SWMA, MDBC
Monitor all pesticide and residue levels in the Basin's waterways	Med	Long	Hard	EPA

Sub-objective: To raise community awareness about the role and importance of water quality and its ecological significance for native fish

Action	Priority	Timeframe	Ease	Agency
<i>Operational</i>				
Develop best management practices for land managers to minimise water quality effects on fish	Med	Med	Easy	SF&C, EPA

	Target	Timing
Resource Condition	<i>All water quality criteria to meet ANZECC guidelines for 95% of the Basin</i>	2010
	<i>Rehabilitate 90% of thermally polluted waters to at least ANZECC guidelines</i>	2010
	<i>Spawning temperatures met for all native species at 95% of thermally impacted sites at appropriate times 9 out of 10 years</i>	2010
	<i>In addition to ANZECC guidelines, meet Basin Salinity Management Strategy targets</i>	2005
Management Action	<i>Abatement plan for the priority water quality issues in each river process zone commenced</i>	2005
	<i>'Thermal pollution' listed as a threatening process under relevant legislation in all Basin jurisdictions</i>	2004
	<i>The spatial extent of thermal pollution documented</i>	2004
	<i>Implement thermal mitigation measures on all thermally polluting storages, with a large, medium and small impoundment examples by 2005</i>	2010
	<i>Impact and risk of salination to native fish and to ecosystem components identified</i>	2006
	<i>80% of irrigation drains discharging into natural waterways comply with best management practices for interception of pollutants</i>	2008
	<i>Water quality problems associated with reduced flows decreased by 10% per year</i>	2004
	<i>Monitoring and auditing system in place for assessing success in implementing water quality actions and achieving objectives.</i>	

Evaluation and performance criteria

Empowerment

- Improved community participation and awareness; and
- Adoption of best management practices for nutrients, pesticides, salinity and erosion that minimise adverse impacts on native fish by managing authorities and stakeholders.

Implementation

- Reduction in nutrient loads discharged into riverine environment;

- Reduction in pesticide loads discharged into riverine environment;
- Reduction in salinity levels discharged into riverine environment; and
- Reduction in turbidity levels in the riverine environment

Resource condition

- Improvement in water quality according to water quality objectives identified for native fish.

Objective: To modify flow regulation practices so that they facilitate native fish rehabilitation.

Regulation of water through storages and off-stream extraction has vastly changed the natural flows of water in the Basin's rivers, causing widespread degradation. Restoring more natural flows to the Basin's rivers will reduce such degradation and help rehabilitate fish populations. A range of processes is already in place attempting to address the issues of flows on many rivers. The objectives of this Strategy need to be incorporated into these processes.

Sub-objective: To protect riverine ecological functions necessary to sustain native fish communities by reinstating flow regimes that mimic natural hydrographic patterns.

Actions	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Develop principles and guidelines for environmental flow management and implement procedures for environmental flows to be documented in operating rules for each dam, weir or regulating structure.	High	Med	Mod	SWMA, MDBC
<i>Operational</i>				
Where current environmental flow allocations do not account for seasonal and yearly variation below impoundments, implement 'transparent dam' and 'translucent dam' rules as an interim measure, ensuring that suitable minimum flows are fully protected	High	Immed	Easy	SWMA, MDBC
Where weirs have removable gates, develop procedures to allow as much natural flow-variability as possible downstream and in weir-pools. Gates should be lifted when diversions are not needed	Med	Med	Mod	SWMA, MDBC
Augment flows below impoundments with dam releases during natural high-flow events in spring/early summer to maximise fish recruitment success and migration.	Med	Med	Mod	SWMA, MDBC
Following high flows, reduce rate of gate shutdown or weir re-instatement to smooth recession and minimise stranding of fish	Med	Immed	Mod	SWMA, MDBC
Develop operating rules to extend the height and duration of flood peaks to	Med	Med	Mod	SWMA, MDBC

maximise native fish recruitment success				
Conserve flood events by ending the practice of making pre-releases from impoundments	Med	Med	Mod	SWMA, MDBC
Implement operating procedures that minimise constant flow releases to reduce bank erosion and sedimentation, and provide fluctuating flows to mimic natural variation	High	Immed	Mod	SWMA, MDBC
Protect low flows downstream of impoundments to conserve fish refuges in dry periods	High	Immed	Easy	
Review operating procedures at all structures to incorporate actions which will improve environmental performance	Med	Med	Easy	MDBC, SWMA
Develop and apply flows Decision Support System central repository for trigger-flow information for use by managing authorities	Med	Med	Easy	MDBC
Where off-allocation extraction occurs, cap a maximum volume of water that can be extracted in a given period and a minimum river flow below which water must not be extracted	High	Med	Mod	SWMA
<i>Knowledge transfer</i>				
Involve the Basin community and stakeholders in setting environmental flows	High	Currently underway	Mod	SWMA, CMO, SF&C, EPA

Sub-objective: To increase the availability of water to the environment.

Actions	Priority	Timeframe	Ease	Agency
<i>Operational</i>				
Eliminate costs of delivering environmental water allocations	Med	Immed	Mod	SWMA, MDBC, COAG
Determine the impact of the expansion of the irrigation industry on water for the environment	High	Med	Easy	SWMA, MDBC, CWLT
Investigate options for potential water savings from more efficient on-farm	Med	Med	Mod	R&DC, MDBC,

use, better transfer systems and reduced leakage and evaporation				SWMA
Investigate advantages of a tiered pricing structure of water purchase based on volume and environmental benefit	Med	Immed	Mod	SWMA, MDBC, COAG
Ensure water efficiency savings are returned to the environment	High	Immed	Easy	SWMA, MDBC, COAG
Determine the effects of interbasin transfers on environmental flows	Med	Med	Easy	SWMA, MDBC, COAG
Identify any consequences of water trading on the environment	High	Immed	Easy	SWMA, MDBC, COAG
Identify the effects of large-scale tree planting on environmental flows	High	Immed	Easy	SWMA, MDBC, COAG, LWMA
Predict the effect of global climate change on environmental flows	High	Immed	Mod	SWMA, MDBC, COAG
Determine the consequences for environmental availability of water from development of farm dams, water storages, block-banks and levees, channels and groundwater bores and recommend management actions	High	Immed	Mod	SWMA, SLMA, LGA, MDBC, CWLT

Sub-objective: To maintain and reinstate flow regimes that will improve the timely watering of targeted wetlands and river zones to rehabilitate and maintain native fish communities.

Action	Priority	Timeframe	Ease	Agency
<i>Operational</i>				
Incorporate appropriate wetting and drying regimes on wetlands and floodplains into environmental flow determinations	High	Med	Easy	SWMA, SF&C, MDBC
<i>Investigation and monitoring</i>				
Assess the process for and ecological value of retaining floodwaters with regulators on floodplains at Chowilla, Barmah, Peel, Macquarie Marshes, Gwydir Wetlands and Great Cumbung Swamp at times to suit native fish	Med	Immed	Mod	SWMA, RD&C, MDBC

recruitment and growth				
Assess the process for and ecological value of retaining floodwaters on floodplains by enhancing flood peaks with dam releases from Hume, Burrendong, Buffalo and Wyangala dams	Med	Immed	Hard	SWMA, MDBC
Further develop and apply the Lower Murray Floodplain Inundation Model to assist in flow determinations for Lower Murray floodplains	High	Immed	Easy	SWMA, MDBC, CMO
Emphasise the importance of floodplain channels and anabranches in plans for wetland and floodplain inundation	High	Med	Easy	SWMA, MDBC, LGA

	Target	Timing
Resource condition	<i>Major elements of the natural flow regime that are important to sustain native fish reinstated</i>	2010
Management Action	<i>Key ecologically significant elements of the flow regime reinstated to 80% of their natural occurrence</i>	2010
	<i>Daily, seasonal and episodic natural flow variability reinstated to 80% of natural levels.</i>	2010
	<i>Connections of river flows and floodplain reinstated to 80% of their natural occurrence</i>	2005
	<i>Ensure water trading and water efficiency savings contribute substantial benefits to the environment</i>	2004
	<i>Water available to the environment increased by 2 % per year</i>	2004
	<i>The ecological importance of flooding to the recruitment of five key native species documented</i>	2005
	<i>Monitoring and auditing system in place for assessing performance of water management and success in implementing actions and achieving objectives</i>	2004

Evaluation and performance criteria

Empowerment

- Community participation;
- Agreement on the cap on diversions and the development of new best practice techniques to satisfy the water requirements of both the environment and resource users;
- Agreed Basin-wide policy on the provision of flows for the benefit of native fish; and
- New flow regimes determined and operating rules adopted, in

consultation with responsible agencies, stakeholders and the community that better suit the native fish of the riverine environment.

Implementation

- Implementation of agreed flow regimes which improve water operations for maximum native fish benefit.
- A maximum volume of water that can be extracted in a given month or season; and a minimum flow rate, below which water cannot be

extracted, determined for all rivers in the Murray-Darling Basin; and

- Releases below impoundments and weirs at a constant flow avoided. Instead releases should mimic the pattern of natural discharge events in the catchment. When this is not possible some flow variation should be introduced with the amplitude of

this variation around a desired level of $\pm 20\%$ in terms of river height;

Resource condition

- Variation in the daily hydrographic regime of rivers in the Murray-Darling Basin should mimic the natural daily flow pattern expected without regulation or extraction.

Objective: To provide adequate passage for native fish throughout the Basin.

Barriers such as dams, weirs, levees, causeways, culverts and road crossings can stop the natural migration patterns of many native fish species within the Basin. Such barriers prevent native fish from completing key components of their lifecycle. State agencies have recognised more than 3 600 barriers in the Basin, and only a small number have implemented engineering works or operating procedures to mitigate their impacts on fish movements.

Sub-objective: To reinstate fish passage in both upstream and downstream directions and in all seasons at artificial barriers throughout the Murray-Darling Basin.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Develop a Murray-Darling Basin Fish Passage Program through the Fish Passage Reference Group to integrate State fishways programs, complete the barriers database, design whole-catchment fish migration strategies, establish Basin-wide priorities for fish passage works and pursue technological advances in fish passage	High	Currently underway	Mod	SF&C, MDBC, SWMA
Create a Murray-Darling Basin Fishways Database, including assessment of the effectiveness of all fishways and improvements required	High	Immed	Easy	MDBC, SF&C, SWMA
Extend NSW weirs review to other states, review the need for all weirs and target for removal those deemed redundant	High	Immed	Easy	SWMA, MDBC
<i>Operational</i>				
Implement a fishways construction program to prioritise, design, construct and assess the performance of new fishways under the Basin Fish Passage Program	High	Immed	Mod	MDBC
Adopt the fish-passage priority-setting scheme developed by CRCFE for objectively determining fishway-site priorities	High	Immed	Easy	MDBC, SF&C, R&DC
Adopt criteria for effective fishways specifying successful passage of 95% of native fish seeking passage for 95% of the time	High	Immed	Easy	MDBC, SF&C, R&DC

Develop a fishways rehabilitation program to identify and rehabilitate all ineffective fishways, and assess subsequent performance	High	Immed	Mod	MDBC, SWMA, SF&C
Build experimental bypass and Deelder fishways and assess their performance, cost-effectiveness and suitability for other Basin sites	High	Immed	Easy	MDBC, SF&C, R&DC
Build experimental fishways for high structures (barriers over 6m high) and assess their performance	High	Med	Mod	SWMA, MDBC, SF&C
Develop and institute an operational plan for managing each Basin fishway	High	Immed	Easy	SWMA, SLMA, SF&C, MDBC
Revise operating procedures for weir-gate manipulation, navigation-lock operation and drown-out flows to optimise fish passage pending fishway construction for low barriers (under 6m height)	Mod	Immed	Easy	SWMA, MDBC
Modify weir removal and reinstatement procedures to increase periods of open river	High	Immed	Easy	SWMA, MDBC
Identify and protect anabranches and other channels that can act as migration pathways around barriers	Med	Immed	Easy	SWMA, MDBC
<i>Investigations and monitoring</i>				
Undertake economic analyses of Basin fishways	Mod	Immed	Easy	SWMA, SLMA, SF&C, MDBC
Quantify the spatial and temporal extent of fish diversion into irrigation systems from rivers and storages and identify requirements for management	High	Immed	Mod	MDBC, R&DC, CRC
Improve knowledge on the effects of barriers on downstream movement of juvenile and adult fish	High	Current activity	Hard	MDBC, SF&C, R&DC
Complete research to evaluate low cost and innovative fishway designs, to optimise fishway designs and to assess the needs for fishways on both banks of major streams	High	Immed/current	Mod	SWMA, MDBC, SF&C, R&DC,
Quantify the discharges and durations of drown-out flows needed for fish passage at a series of representative weirs	Med	Med	Mod	SWMA, MDBC

Review legal and licensing arrangements in each jurisdiction and provide benchmark best practice	Med	Med	Easy	SWMA, SLMA, SF&C, MDBC
Assess the implications of removing barrages from the Murray River mouth	Med	Med	Easy	SWMA, MDBC
Assess the efficiency of operation of current fishway designs	High	Immed	Easy	CRC, MDBC, SF&C, R&DC
Assess the suitability and efficiency of current fishway designs for passing large fish (e.g., Murray cod, Mulloway)	Med	Med	Easy	CRC, MDBC, SF&C, R&DC
Monitor fish passage at a representative series of fishways to provide population-recovery and stock-assessment data	High	Immed	Mod	SWMA, MDBC

Sub-objective: To reinstate and maintain fish passage in both upstream and downstream directions at environmental impediments in all seasons throughout the Murray-Darling Basin.

Action	Priority	Timeframe	Ease	Agency
Identify and assess behavioural barriers such as thermal or water-chemistry changes and include separately in barriers database	Med	Med	Mod	SWMA, MDBC, SF&C, EPA
Develop management plans to mitigate behavioural barriers	Med	Med	Mod	SF&C
Identify and protect anabranches and other channels that can act as migration pathways around behavioural barriers	High	Med	Easy	SF&C, LGA

	Target	Timing
Resource Condition	<i>Reinstatement of 50% of migration pathways and passage restored to 50% of all native-species' habitats that are currently obstructed by artificial barriers</i>	2010
Management Action	<i>80% of existing fishways assessed as passing 95% of fish seeking passage for 95% of the time</i>	2010
	<i>Effective fish passage restored at 20 most-significant barriers as judged by priority-setting scheme</i>	2010
	<i>Removal of 20 of the most significant redundant barriers as judged by the State Weir reviews</i>	2010
	<i>Two high-level fishways completed and meeting performance</i>	2005

	<i>criteria</i>	
	<i>Assessments completed for innovative designs, passage for large species and passage downstream</i>	<i>2005</i>
	<i>One experimental bypass and one Deelder fishway built and assessed</i>	<i>2004</i>
	<i>No barriers to fish migration caused by altered flows</i>	<i>2004</i>

Evaluation and performance criteria

Empowerment

- State-based fishways programs continue to be supported; and
- Basin-wide support for integration of State-based fishways achieved.

Implementation

- Removal or modification of structures impeding fish movement; and

- Fishways built and assessed as performing effectively.

Resource condition

- Passage for fish should continually be improved; and
- Monitoring should show populations recovering.

Objective: To devise and implement recovery plans for threatened fish species and communities.

A number of the Basin's native fish are listed on various national/State lists as being endangered, and there is potential for the extinction of some species in the future. Risk-management strategies are needed to reverse this trend of endangerment, for both individual species and fish communities. A comprehensive, adequate and representative network of fish conservation reserves needs to be established.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Establish a series of comprehensive, adequate and representative river conservation management zones	High	Immed	Mod	MDBC, LGA, SF&C, SLMA, SWMA
Identify and protect areas of high conservation values	High	Immed	Mod	MDBC, CWLT, SF&C, SLMA, SWMA
Identify and alleviate major threatening processes, particularly those affecting multiple native fish species	High	Immed	Hard	MDBC, CWLT, SF&C, SLMA, SWMA
<i>Operational</i>				
Support the writing of nominations for listing threatened species, communities and threatening processes under all relevant legislation	High	Med	Easy	SF&C, CWLT
Establish representative scientific reference areas	Med	Med	Easy	SF&C, CWLT
Commission ASFB Threatened Species Committee to review status of all native fish species within Basin	Med	Immed	Easy	CWLT, SF&C, MDBC
Prepare and implement Species Recovery/Threat Abatement Plans/Action statements for threatened species and communities and threatening processes under all relevant legislation	High	Med	Easy	SF&C, CWLT
<i>Investigation and monitoring</i>				
Create an inventory of critical habitat areas for threatened species and communities	High	Immed	Mod	SF&C, CWLT

	Target	Timing
Resource condition	<i>Population declines in all threatened species and communities halted or reversed</i>	2010
Management Action	<i>A comprehensive, adequate and representative network of river conservation management zones established in each river catchment.</i>	2005
	<i>90% of key threatening processes leading to endangerment halted or reversed</i>	2010
	<i>Legislation and compliance procedures to prevent the introduction of alien and non-endemic Australian fish species into the Basin established in all jurisdictions</i>	2004
	<i>Conservation status of native fish in the Basin reviewed</i>	2004
	<i>Recovery programs funded and implemented for all threatened fish species and communities in the Basin</i>	2005

Evaluation and performance criteria

Empowerment

- Community participation;
- Identification of major threats impacting endangered species;
- Review of the status of native fish species in the Basin; and
- Preparation of recovery plans for threatened species in the Basin.

Implementation

- Removal or reduction in the impact of threatening processes;

- Implementation of recovery plans for threatened species and communities; and
- Areas of high conservation value identified and protected.

Resource condition

- No further native species or ecological community being listed as extinct, endangered or vulnerable;
- Improved viability of native species listed as endangered or vulnerable; and
- Degree of impact of threatening processes decreased.

Objective: To create and implement management plans for all non-threatened fish species and communities.

Substantial declines have occurred in populations of many native non-threatened species. Such declines may be rapid or masked by other factors. The cost and effort of maintaining healthy populations are far outweighed by the resources necessary to reverse the conservation status of threatened species. Appropriate management arrangements for all fish need to be implemented.

Action	Priority	Timeframe	Ease	Agency
<i>Operational</i>				
Accommodate non-threatened species within fish community recovery plans	High	Immed	Easy	CWLT, SF&C
Develop management plans with clear objectives for all fish species	Med	Med	Easy	CWLT, SF&C
Create and implement fisheries management plans for all recreationally or commercially exploited fish in the Basin	High	Med	Easy	CWLT, SF&C
<i>Investigation and monitoring</i>				
Establish facilities and procedures for monitoring the abundance, distribution and population structure of all fish species in the Basin	High	Med	Hard	CWLT, SF&C, MDBC
Predict future trends of all fish species using monitoring data and population modelling	Med	Med	Mod	SF&C

	Target	Timing
Resource condition	<i>No additions to the threatened fish conservation listings by Commonwealth, State, professional or NGO agencies</i>	2010
	<i>No long-term contractions in the range or abundance of any native species</i>	2010
Management Action	<i>Potential and current threats to non-listed species identified</i>	2004
	<i>Fisheries management plans in place for all exploited species</i>	2005

Evaluation and performance criteria

Empowerment

- Develop fish community recovery plans.

Implementation

- Implement fish community recovery plans; and
- Implement fisheries management plans.

Resource condition

- No further native species or ecological community listed as extinct, endangered or vulnerable; and
- Improved viability of native species; and
- Degree of impact of threatening processes decreased.

Objective: To control and manage carp and other alien fish species effectively.

The Basin already contains at least 11 alien fish species in the wild, some in pest proportions, and further introductions are inevitable over time. Both the abundance and attributes of some alien fish including carp continue to cause damage to habitats and populations of native species. Management needs to minimise the risk of future introductions and seek to tackle the problems of existing introductions.

Sub-objective: To implement strategies to control or eradicate existing alien species.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Develop database and maps of alien fish species in the Basin including data on the location, impacts and status of key species	High	Immed	Easy	SF&C
<i>Operational</i>				
Develop management plans that identify and rank areas for action on pest alien species, implement regional control strategies in these areas	High	Med	Mod	SF&C
Implement the goals and strategies of the <i>National Management Strategy for Carp Control</i>	High	Immed	Mod	MDBC, CWLT, SF&C, CMO
Develop management plans for controlling alien pest species, using pest management principles and risk management strategies	High	Immed	Mod	SF&C
Ensure consistent legal status and approach to alien species management across the Basin	Med	Immed	Easy	SF&C
Identify major donor regions, recruitment areas and dispersal pathways for all alien species	High	Immed	Easy	SF&C
Prepare national management strategies and research plans for all existing alien species other than carp	Mod	Med	Easy	SF&C
Identify areas which are currently free of alien species and protect them from future invasion	Mod	Immed	Hard	SF&C, CMO, MDBC
Test the effectiveness of existing carp eradication and control techniques	High	Immed/current	Mod	SF&C, CMO, UNI
Review existing angling regulations to maximise the impacts of fishing on	Med	Med	Mod	SF&C

undesirable alien species

Investigation and monitoring

Develop and implement a research strategy to support research to show the impacts of alien fish species	Med	Med	Mod	SF&C, MDBC
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Develop monitoring facilities and procedures to assess the success of pest management actions	Med	Med	Mod	SF&C, MDBC
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Sub-objective: To prevent the introduction and establishment of new alien species and to develop strategies for management.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Implement risk management strategies to limit the potential for new fish species to invade the Basin, especially through the aquarium trade	High	Immed	Easy	CWLT SF&C
Establish procedures to prevent the introduction of alien and non-endemic Australian fish species into the Basin	High	Immed	Easy	SF&C, CWLT, MDBC
<i>Operational</i>				
Develop a rapid response system for new pest species in the Basin	Mod	Immed	Easy	SF&C
Develop a contingency plan for eliminating tilapia following invasion of the Basin	High	Immed	Easy	SF&C
Develop management options that utilise best management practices for the assessment and development of risk management strategies for potential pests	Med	Med	Mod	SF&C
Prepare contingency plans and outbreak control strategies for anticipated alien species	Med	Med	Mod	SF&C
Review the potential for new fish species to invade the Basin, especially through the aquarium trade and predict the impacts of such invasions	High	Immed	Easy	CWLT, SF&C, UNI, CRC
Develop and implement risk management procedures to minimise the risks of invasion through the import of aquarium species	Med	Med	Mod	CWLT, SF&C

<i>Investigation and monitoring</i>				
Review existing controls on imports, movement, security and potential escapes within the ornamental fish trade	Med	Med	Mod	CWLT, SF&C
Assess the likely ecological impacts of alien fish species identified as threatening invasion of the Basin	Mod	Immed	Easy	CRC, SF&C, CSIRO

Sub-objective: To prevent the escape of aquaculture species by ensuring that all aquaculture facilities are secure.

Action	Priority	Timeframe	Ease	Agency
Develop and enforce minimum-requirements legislation for secure containment of all aquaculture species and facilities	Med	Med	Mod	SF&C
Prepare contingency plans to cope with potential security breaches	Med	Med	Easy	SF&C

	Target	Timing
Resource condition	<i>The distribution and abundance of selected alien species reduced by 30% at selected locations</i>	2010
Management Action	<i>Control measures for alien pest species implemented across 90% of the Basin</i>	2010
	<i>Priority sites for pest species control identified in each jurisdiction</i>	2004
	<i>Legislative and policy measures in each jurisdiction implemented and complied with to prevent future introductions and restrict range expansions</i>	2004
	<i>Basin communities informed of the problems and threats from alien species and supporting management actions</i>	2004

Evaluation and performance criteria

Empowerment

- Development of threat abatement plans for alien pest species across the Basin;
- Development of pest management principles and management options for the aquatic environment; and
- Improved understanding and community participation.

Implementation

- Implementation of pest management/control programs for the riverine environment; and
- Agreed Basin-wide policy on the control and eradication of pest species.

Resource condition

- Reduction in the number, distribution and abundance of alien pest species in the Basin.

Objective: To increase understanding of fish diseases and parasites and to protect native fish from them.

Both exotic and endemic disease outbreaks have potentially devastating effects on native fish populations. However, our knowledge of fish diseases and parasites is far from complete. The potential sources and risks of disease outbreak need to be determined. Attention also needs to be paid to the mechanisms that transfer diseases and parasites across the Basin.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Promote and support research on endemic and threatening diseases and parasites of all fish species in the Basin	High	Long	Mod	SF&C, CWLT, MDBC
Prepare a detailed review and recommendations on fish-health issues in the Basin	High	Immed	Easy	SF&C, CWLT, CRC,
<i>Operational</i>				
Develop contingency plans for exotic disease outbreaks	High	Immed	Easy	SF&C
Establish risk assessment as an integral part of all aquaculture developments	High	Immed	Easy	SF&C
Implement a comprehensive scheme for hatchery accreditation	High	Immed	Mod	SF&C
<i>Investigation and monitoring</i>				
Complete the screening of aquatic fauna to assess their significance for managing the viral disease, epizootic haematopoietic necrosis (EHNV)	Med	Med	Mod	CWLT, SF&C
Assess the health risk to Basin fish from Barramundi picorna-like virus (BPLV)	Med	Med	Easy	CWLT, SF&C
Complete a health-risk assessment of the practice of inter-basin water transfers	Med	Immed	Easy	SF&C
Assess fish-health implications from water-quality changes such as black-water flows, cold water pollution and summer releases from Lake Victoria	Med	Med	Mod	SF&C, MDBC, CRC, UNI

	<i>Target</i>	<i>Timing</i>
<i>Resource condition</i>	<i>No introduction or outbreak of detrimental native fish diseases or parasites</i>	<i>2010</i>
<i>Management Action</i>	<i>Basin-wide risk management procedures implemented for preventing and managing outbreaks</i>	<i>2004</i>
	<i>Fish health review completed and recommendations adopted</i>	<i>2004</i>
	<i>Hatchery certification scheme functioning in all jurisdictions</i>	<i>2004</i>
	<i>Hatchery accreditation scheme functioning in all jurisdictions</i>	<i>2004</i>

Evaluation and performance criteria

Empowerment

- Development of risk management plans for disease outbreaks;
- Establishment of effective monitoring processes; and
- Development of Basin-wide procedures for preventing and controlling disease outbreaks.

Implementation

- Agreed Basin-wide protocols for minimising disease outbreaks; and
- Accreditation procedure implemented for hatcheries and aquaculture industry.

Resource condition

- No significant reduction in the population distributions, abundances or numbers of native fish species due to disease outbreaks.

Objective: To manage recreational and commercial fisheries in a sustainable way.

The exploitation of fish by both the recreational and commercial sectors, together with illegal activities, has made substantial impacts on the viability of native fisheries in some regions of the Basin. Fish populations need to be returned to a viable, sustainable status to provide for ecologically sustainable fisheries in the future.

Sub-objective: To protect riverine fish populations from the adverse impacts of fishing.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Assess stocks of native fish and the levels of exploitation by recreational, commercial and illegal fishing	High	Med	Mod	SF&C, CWLT
<i>Operational</i>				
Develop ecologically sustainable development indicators for commercial fisheries in the Basin	Med	Med	Mod	SF&C
Protect fish aggregations below impoundments from fishing	High	Immed	Easy	SF&C, MDBC, SWMA
Provide adequate regulatory enforcement in key areas, including inter-jurisdiction cooperation where necessary	Med	Immed	Mod	SF&C
Investigate potential mechanisms for community based enforcement	Med	Med	Easy	SF&C
Review regulation and compliance in the marketing of freshwater fish in both centralised and regional markets	Med	Immed	Easy	SF&C, CWLT
Implement five-yearly reviews of the sustainability of fishing for native fish, including all stakeholders and community groups	High	Med	Easy	SF&C, CWLT, CRC, UNI
<i>Investigation and monitoring</i>				
Assess the level, distribution and impacts of illegal fishing in the Basin	High	Immed	Mod	SF&C, CWLT
Investigate best-practice catch and release techniques for anglers and assess hooking injury and post-release mortality rates associated with various	High	Immed	Mod	SF&C, CWLT

techniques

Develop fishery-management plans for impoundments to relieve fishing pressure on river fish populations Med Med Easy SF&C

	Target	Timing
Resource condition	<i>Native fish populations are able to support a selective harvest of 20% of biomass without adverse impacts on population structure and ecology in rivers</i>	2010
	<i>Total take of native fish is sustainable in each jurisdiction</i>	2010
Management Action	<i>First review of fishing sustainability throughout the Basin completed</i>	2005
	<i>Illegal take of fish is less than 10% of total take</i>	2010
	<i>80% of Basin fishers understand and support fishing regulations</i>	2010

Evaluation and performance criteria

Empowerment

- Development of agreed Basin-wide guidelines for commercial and recreational fishing;
- Revive inter-jurisdiction council for fisheries enforcement; and
- Increased community awareness and participation.

Implementation

- Regular audits on the sustainability of fishing for native fish.

Resource condition

- Declines in fish populations not a function of commercial, recreational or illegal fishing.
- Improvement in native fish populations associated with fishing controls.

Objective: To protect the natural species composition, population structure, genetic integrity and diversity of native fish communities from the adverse effects of fish translocation and stocking.

The composition of native fish populations can be threatened by the liberation of fish from outside their natural range or from hatcheries. The impact of fish from hatcheries can have enormous impacts on the viability and evolutionary potential of native fish populations. Appropriate guidelines to minimise such risks are required.

Action	Priority	Timeframe	Ease	Agency
<i>Overarching actions</i>				
Establish common Basin-wide policy, procedures and guidelines which complement and ensure adherence to the National Translocation Policy ⁵⁷	High	Immed	Easy	SF&C
<i>Operational</i>				
Develop a central register of translocations and stockings within the Basin, incorporating all jurisdiction databases	Med	Med	Easy	SF&C
<i>Investigation and monitoring</i>				
Review the impact of translocations and stockings on all native fish populations	High	Immed	Easy	SF&C, CRC, UNI
Develop protocols to maximise the efficiency and benefits of conservation stocking programs	Med	Med	Mod	SF&C, CRC, UNI
Investigate the efficiency and benefits of all fish stocking programs	Med	Med	Mod	SF&C, CRC, UNI
Complete a risk assessment of potential fish translocations	Med	Immed	Easy	SF&C, CRC, UNI
Trial the use of natural lakes as rearing areas for young native fish which can then be released for stocking riverine populations	Low	Long	Mod	SF&C, MDBC

	<i>Target</i>	<i>Timing</i>
<i>Resource condition</i>	<i>Threats to native fish populations by the translocation or stocking of native or alien species removed</i>	<i>2010</i>
<i>Management Action</i>	<i>Rigorous procedures for managing native fish translocation and stocking implemented in each jurisdiction</i>	<i>2010</i>

Evaluation and performance criteria

Empowerment

- Improved community participation and awareness; and
- Identification of the benefits and threats to native fish of translocation and stocking programs.

Implementation

- Agreed Basin-wide policy, procedures and guidelines established for translocation and stocking.

Resource condition

- No detrimental impact on native fish populations from translocation and stocking programs.

Objective: To ensure that native fish populations benefit from aquaculture.

Apart from releases of alien fish, natural populations of native fish are threatened by the potential release of genetically restricted material from native fish aquaculture operations using limited brood stock. The release of such material has potential to reduce the genetic fitness and hence viability of fish populations.

Action	Priority	Timeframe	Ease	Agency
<i>Operational</i>				
Develop hatchery techniques for producing genetically diverse fish for stocking and conservation	High	Med	Easy	SF&C
Develop quality-control procedures for hatcheries to prevent disease, adverse genetic effects and inadvertent translocations	High	Immed	Easy	SF&C, CWLT
Implement a comprehensive scheme for hatchery accreditation, including compliance measures, to be consistent with the National Translocation Policy	High	Immed	Mod	SF&C
Manage some aquaculture resources for conservation purposes	Med	Med	Easy	SF&C
Develop guidelines and create an Interstate Agreement to regulate the use of non-native species for aquaculture in the Basin	Med	Med	Easy	SF&C, MDBC, CWLT
<i>Investigation and monitoring</i>				
Document the genetic composition of hatchery-produced native fish	Med	Med	Mod	SF&C

	Target	Timing
Management Action	All native fish hatcheries accredited and following environmental safeguard protocols	2005
	95% of hatcheries following sound production and distribution practices	2010

Evaluation and performance criteria

Empowerment

- Development of protocols for producing genetically diverse fish for stocking and conservation purposes; and
- Development of protocols and accreditation for hatcheries to prevent disease outbreaks, inadvertent translocations or the release of genetically restricted native fish.

Implementation

- Agreed Basin-wide protocols and accreditation for hatcheries to prevent

disease outbreaks, inadvertent translocations or the release of genetically restricted native fish in the Murray-Darling Basin; and

- Agreed guidelines on which non-native species can be used for aquaculture in the Murray-Darling Basin.

Resource condition

- No adverse impact on native fish populations from the stocking of native fish species; and
- No inadvertent translocations of native or alien species due to the aquaculture industry

Objective: To ensure that the community and stakeholders understand and support the Native Fish Strategy.

As fish are hidden under water, the general community understanding of issues relating to native fish is often less than that for more visible and identifiable terrestrial animals. There is a clear need for the community to be made more aware, participate in programs, and provide local expertise and skills in relation to native fish, their status, importance and threats to them. The use of demonstration reaches and actions is an important way to illustrate the value of rehabilitation actions.

Sub-objective: To engage the community and stakeholders with implementation of the Native Fish Strategy through an effective communication strategy.

Action	Priority	Timeframe	Ease	Agency
Target water managers, land holders, stakeholders and the community with an education program on best management practices to restore native fish populations	Med	Med	Easy	SLMA, CMO, SWMA, MDBC, SF&C
Develop and implement a communications strategy on the risks from alien species, to target CMOs, indigenous, fishing, aquarium and conservation bodies and other relevant community groups	High	Immed	Easy	MDBC, SF&C
Implement a communication strategy that ensures public recognition of fish as an important component of biodiversity and gives support to the implementation of the <i>Strategy</i>	High	Med	Mod	SWMA, SF&C, MDBC, CMO, CRC
Implement a strategy to ensure that managers and the public recognise the need for decisions to be based on good scientific knowledge	High	Med	Mod	SWMA, SF&C, MDBC, CMO, CRC
Develop and implement an education program to raise community awareness of risks and benefits of fish stocking and translocation	Mod	Immed	Easy	SF&C, MDBC
Develop and implement an educational program to raise community awareness of conservative recreational fishing practices	High	Immed	Easy	SF&C, CWLT
Develop and implement an education program to raise community awareness of the impact of illegal fishing on native	High	Immed	Easy	SF&C, MDBC, CWLT

fish				
Alert the public to the danger of the spread of existing introduced fish species	High	Immed	Easy	SF&C, MDBC, CWLT
Develop and implement an alien species communications strategy to target CMOs, indigenous, fishing, aquarium and conservation bodies and other relevant community groups, identifying those species that are pests, undesirable, or acceptable within present limits	High	Immed	Easy	MDBC, SF&C
Develop and provide resource material to ensure the <i>Strategy</i> is included in all relevant planning processes	High	Immed	Easy	SLMA, MDBC, LGA, CMO
Collate, publish and widely disseminate all known Murray-Darling fish-habitat requirements	High	Med	Easy	MDBC, SF&C, R&DC, CRC
Raise community understanding of habitat requirements of in-stream fauna and habitat values as river-health indicators and promote the community's role in management through field days, seminars, videos, pamphlets, etc.	High	Immed	Mod	CWLT, MDBC, SWMA, SLMA
Promote snags to the public as important habitat	Med	Med	Easy	MDBC, SWMA, SF&C, CMO
Facilitate inclusion of best management practices for riparian zones into planning processes by local government, communities and agencies as part of an integrated approach to natural resource management in riverine corridors	High	Med	Mod	SLMA, SLWA, LGA, CMO
Develop and implement an education program on the importance of floodplains, temporary channels and wetlands	High	Med	Mod	SWMA, SF&C, MDBC, CWLT, CMO
Target land managers with an education and extension program on best management practices and the impact of poor water quality on fish	Med	Immed	Easy	SLMA, CMO, LGA
Form a broadly based working group to guide the community-awareness program	Med	Immed	Easy	SF&C, MDBC, EPA
Develop and distribute resource material	High	Immed	Easy	SLMA,

to ensure water quality management is included in planning processes				MDBC, LGA, CMO
Develop and implement an environmental flows education program for the general public and water managers	High	Immed	Easy	SWMA, SF&C, MDBC, CWLT
Promote the values of the Murray-Darling Basin Fish Passage Program among stakeholders and the Basin community	High	Immed	Easy	SWMA, MDBC
Ensure barriers database information is available to the community and promote involvement of catchment groups in developing an inventory of barriers for incorporation into State databases	Med	Long	Mod	SWMA, CMO
Develop and implement a fish passage communications strategy to target CMOs, indigenous, fishing, agricultural and conservation bodies and other relevant community groups	High	Mod	Easy	CRC, MDBC, SWMA
Educate the community about all threatened and non threatened native fish species	High	Immed	Easy	SF&C, CWLT, MDBC
Develop fish habitat guidelines and incorporate them into floodplain and wetland planning and management at Commonwealth, State, regional and local levels, including guidelines for 'fish friendly' development on floodplains	High	Immed	Easy	SLMA, LGA, CMO, CWLT
Promote floodplains to managers and the public as areas that need flooding	High	Immed	Mod	SLMA, SWMA, LGA

- **Sub-objective:** To initiate relevant scientific research which will provide new knowledge to support management actions in an adaptive context.

Action	Priority	Timeframe	Ease	Agency
Determine the ecological relationships between fish species.	High	Med	Mod	SWMA, SF&C, MDBC, CMO, CRC
Undertake research with Basin-wide application to determine habitat	High	Med	Mod	MDBC, SF&C,

requirements of native fish				R&DC, CRC
Enhance scientific understanding of riparian zone-groundwater interactions, linkages of the riparian zone with in-channel and floodplain components, and physical and ecological processes and functions of riparian zones in streams	Low	Med	Mod	R&DC, CRC, MDBC, CSIRO
Enhance scientific understanding of the ecological processes and functions of floodplains, temporary channels and wetlands	Med	Long	Hard	MDBC, R&DC
Develop and apply forecasting and modelling techniques to predict threatened fish population trends and responses to management	Med	Med	Mod	CWLT, SF&C
Promote and undertake targeted research into ecology and conservation requirements of threatened species	High	Med	Mod	CWLT, SF&C, SWMA
Undertake basic taxonomic and ecological studies	High	Immed	Mod	SF&C, CRC, UNI
Investigate the ecological implications of irrigation flows during natural low flow periods	Med	Immed	Easy	R&DC, CRC, MDBC
Assess and quantify the requirements for flows to maintain in-stream habitat condition in representative reaches across the Basin	Med	Med	Mod	SWMA, MDBC, CRC
Undertake research to fill knowledge gaps about the ecological role across the Basin of stream flow in fish spawning, recruitment and migration	Med	Med	Mod	SWMA, MDBC, CRC, R&DC, CWLT
Assess the ecological impacts of all alien fish species currently in the Basin	Mod	Med	Mod	CRC, SF&C, CSIRO, UNI
Investigate potential biological control techniques for tilapia, redfin perch and gambusia	Mod	Med	Med	CRC, UNI, CSIRO, SF&C
Determine the effects of alien species on native species	Mod	Med	Hard	SF&C
Assess the potential effectiveness and practicality of carp eradication and control techniques including biological control	High	Immed	Mod	SF&C, CSIRO, CRC, UNI
Make a scientific assessment of	High	Med	Mod	SF&C,

ecological and fish population responses to rehabilitation

CRC,
UNI,
CWLTL

- **Sub-objective:** To ensure that the objectives, actions and targets of the *Strategy* are monitored and evaluated to measure its success and provide a basis for adaptive management.

Action	Priority	Timeframe	Ease	Agency
Ensure that monitoring and evaluation is included as a critical component of all management actions	High	Immed	Easy	SF&C, CRC, UNI, CWLTL
Undertake monitoring and regular audits on the environmental benefits obtained by new water resource management actions	Med	Immed	Mod	SWMA, MDBC

Sub-objective: To demonstrate recovery of native fish through comprehensive rehabilitation of the key factors degrading demonstration river reaches.

Action	Priority	Timeframe	Ease	Agency
Identify in each Basin jurisdiction a prominent, large river reach requiring comprehensive rehabilitation to act as a demonstration reach	High	Med	Easy	SWMA, SF&C, MDBC, CMO
Implement in each reach a program to restore the values of key habitat, ecosystem and human-dimension factors such as river flows, barriers to fish passage, thermal pollution, riparian condition, pest species, salination, catchment condition, fishing and contamination	High	Med	Mod	SWMA, SF&C, MDBC, CMO, CRC
Implement a knowledge transfer program, promoting the rehabilitation reaches as demonstration sites showing the responses to repair of rivers and native fish communities	High	Med	Easy	MDBC, SF&C, CMO, SLMA, SWMA
Integrate the rehabilitation program with existing catchment and river management programs	High	Med	Easy	SWMA, SF&C, MDBC, CMO, SLMA

	Target	Timing
Management Action	90% of identified stakeholders engaged and 50% recognition by, and 80% support by the Basin community for the Native Fish Management Strategy.	2010
	An ongoing research program initiated and supported	2003
	50% or priority knowledge gaps filled	2010
	A minimum 10% of total budget allocation dedicated to monitoring and evaluating each implemented action.	2005
	One river rehabilitation reach in each jurisdiction rehabilitated to ecological functionality and sustainability.	2010

Evaluation and performance criteria

Empowerment

- Production and extensive distribution and promotion of the Native Fish Strategy; and
- New knowledge to allow managers to make decisions with greater understanding and certainty.

Implementation

- Establishment and comprehensive rehabilitation of demonstration river reaches;

- Implementation of ecological and fisheries assessment procedures in rehabilitation reaches; and
- Incorporation of NFMS in works and planning functions of all relevant agencies, authorities and stakeholder groups.

Resource condition

- Improvements in the status of the Basin's native fish communities; and
- Recovery of ecological and fisheries values in rehabilitation reaches.



GLOSSARY

Adaptive management: “learning by doing”.

AFFA: Agriculture, Fisheries and Forestry – Australia.

Algae: Single celled, colonial or filamentous aquatic plants, distinct from vascular plants.

Alien: A plant or animal introduced from another country and established in the wild.

Alluvial plain: An area of fairly flat land where a river has deposited silt.

Anabranch: Diversion channel which returns to the main river channel.

Anoxic: An absence of oxygen.

Aquaculture: The farming of fish or other aquatic organisms under artificial conditions.

Basin: An area in which the ground level dips from all directions towards a common central point. A river basin is the area drained by a river and its tributaries.

Benthic: Living on or in the bottom of a water body, bottom living.

Benthivorous: Animals that feed on the animals from the benthos.

Biomass: The weight of living material. The total weight of all organisms in a particular habitat or area.

Biota: All living organisms, usually used for all the living organisms in a place (for example, the Australian biota).

Biotic: A description of the living components of ecosystems.

Bloom: Temporary rapid increase in the population of aquatic photosynthetic micro-organisms (for example, phytoplankton or cyanobacteria) to the extent that the water becomes discoloured and, if the micro-organisms are toxin producers, unfit for drinking.

Brackish: Water with a salinity greater than fresh water but less than sea water, usually found in estuaries.

BRS: Bureau of Rural Sciences.

Carp: The common carp, *Cyprinus carpio*, including the decorative koi strain and other less colourful strains.

Catchment: The area from which a river, stream, lake or other body of water receives its water.

Catadromous: Describes fish that migrate from fresh water as adults to spawn at sea (for example, eels).

Channel: The part of a stream or river confined between banks, or a deeper passage through a lake or harbour.

Clay: A fine particle of sediment. Finer than sand.

Community: All organisms inhabiting a common environment and interacting with one another.

CRC: Cooperative Research Centre

Cyprinidae: The taxonomic family including common carp *Cyprinus carpio* and other species such as goldfish *Carassius auratus*, roach *Rutilus rutilus*, tench *Tinca tinca*.

Dam: A wall or other structure holding water back.

Demersal: Living on or near the bottom of the ocean.

Detritus: Organic debris from decomposing material.

Detritivore: A consumer organism that directly consumes dead organisms and the cast-off parts and organic wastes of organisms (for example, vulture, jackal, earthworm, termite, millipede, ant, and crab).

Discharge: Flow of a river, usually measured in megalitres per day.

Ecologically Sustainable Development (ESD): Defined in 1992 Brundtland Report by the World Commission on

Environment and Development as 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs'.

Ecology: The study of the interactions of organisms with their physical environment and with one another, including results of such interactions.

Ecosystem: A term used to encompass all the organisms (biotic) in a community together with the associated physical environment (abiotic) factors with which they interact (for example, a rockpool ecosystem, a forest ecosystem, a wetland ecosystem).

EHNV: Epizootic haematopoietic necrosis virus. A viral disease of introduced fish that affects native fish.

Emergent vegetation: Vegetation growing or protruding above the water surface.

Endemic: Used to describe a species that is naturally restricted to a particular region (although it may be able to establish in another region if introduced).

Ephemeral: A term used for organisms with short life cycles, usually adapted to making rapid use of favourable environmental conditions.

Epifauna: Fauna associated with the substrate surface.

Erosion: The act or process of eroding, especially the wearing away of the land surface by sun, wind, water, frost or ice.

Eutrophication: An increase in the nutrient content of a body of water, occurring either naturally or as a result of human activities. Eutrophication leads to a rapid increase (bloom) in growth of algae.

Euryhaline: Able to live in a wide range of water salinities.

Exotic: A plant or animal that is not native to the area referred to..

Feral: The description given to an animal species that is normally domesticated (for example, koi carp,

cats, goats, pigs, horses, camels, and goldfish) but which have reverted to a wild state.

Fish ladder: A type of fishway.

Fish passage: The directed movements or migration of fish past a point in a stream; free passage implies absence of impediments to movement.

Fishway: A structure which provides fish passage past an obstruction in a stream.

Food chain: Pathway of energy.

Food web: The linking and inter-linking of many food chains, as may be found in a complex ecosystem (for example, river, lake, forest) with several trophic levels.

Freshes: Flushes of fresh water through the aquatic system, for example, due to rain or flood.

Groundwater: Water that is found beneath the surface of the ground, usually in porous rock known as an aquifer.

Habitat: The place normally occupied for at least part of the life cycle by an organism, group or population of a species (for example, nesting habitat, freshwater habitat).

Herbivore: An organism that eats plants or other photosynthetic organisms to obtain its food.

Hybrid: Individual resulting from interbreeding of two species, for example, carp and goldfish. A hybrid needs to be infertile for the two parents to be regarded as two species.

Hydrology: The study of water on, or under, land.

Hypoxic: Deficient in oxygen.

Indigenous: Native, although not necessarily restricted, to an area.

Inorganic: Not forming part of the substance of living bodies.

Invertebrate: An animal without a backbone (for example, worms, insects).

In-stream use: Ways of using water which do not require it to be removed from the river or wetland system.

Lentic: Still water systems (for example, billabongs, lakes, wetlands).

Lotic: Flowing water systems (for example, rivers).

Macroinvertebrate: An animal without a backbone (for example, worms, insects) visible to the naked eye.

Macrophyte: Large aquatic plant.

MDBC: Murray-Darling Basin Commission

NRMS: Natural Resources Management Strategy.

Organism: Any living thing, animal, bacterium or plant, whether one celled or many celled.

pH: A measurement to indicate the level of acidity or alkalinity of a solution where pH 1 is highly acidic, pH 7 is neutral and pH 14 is highly alkaline.

Phytoplankton: Free floating, single celled or colonial algae.

Piscivore: Feeds on fish.

Plankton: Free floating, mostly microscopic, aquatic organisms — can be divided into phytoplankton and zooplankton.

Population: A group of animals of a particular species occupying an area where they are subject to the same broad environmental or management conditions.

Precautionary Principle: ‘to avoid wherever practicable, serious or irreversible damage to the environment, and an assessment of the risk-weighted consequences of various options’. And, when dealing with ‘threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.’

Predator: An organism that captures and feeds on another organism.

Reservoir: A place for storing water, or the water that is stored.

Riffle: Relatively shallow, fast flowing section of a stream.

Riparian: Of or on the river-bank.

River: A large permanent stream flow of water in a natural channel with banks, which flows into the sea, or a lake.

Saline: Of or containing salt.

Salinity: The concentration of various salts dissolved in a volume of water.

Salmonids: Trout and salmon species.

Silt: An earthy deposit laid down by a river, lake, or other water body, which is finer than sand but coarser than clay.

Spawn: In aquatic animals, to produce or deposit eggs and sperm.

Species: Group of interbreeding individuals not breeding with another such group and which has the characteristics which distinguish it from other groups.

Stratum: A horizontal layer of any material, especially a layer of sedimentary rock, usually one of several parallel layers (plural is strata).

Stream: A small river. First-order streams have no tributaries, second-order streams are formed by the confluence (flowing together of two streams) of two first-order streams, third-order streams from the confluence of two second-order streams, etc.

Substrate: The solid bottom of a water body to which an animal may be attached, on which it moves about or with which it is otherwise associated.

Sustainable Rivers Audit: a monitoring program being developed to assess sustainability.

Swamp: An area of soft, permanently or intermittently wet ground, often with coarse grasses or reeds. Also called a marsh or wetland.

Taxon: A unity of biological classification, such as species, genus or

class; a group of organisms sharing common characteristics (plural taxa).

Taxonomy: The science of classification of animals and plants.

Turbid: Not clear or transparent — water muddy with suspended silt or sediment.

Turbidity: A measure of the amount of suspended solids (usually fine clay or silt particles) in water and thus of the degree of scattering or absorption of light in the water; level of cloudiness in the water.

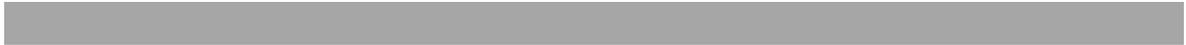
Watershed: A boundary between areas drained by different river systems.

Water table: The top level of water in the ground that occupies spaces in rock or soil and lies above a layer of impermeable (non-porous) rock.

Weir: A dam across a watercourse, over which the water may flow.

Wetland: An area of soft, permanently or intermittently wet ground, often with coarse grass or reeds. Also called a marsh or swamp.

Zooplankton: The animal constituent of the plankton, small floating herbivores that feed on phytoplankton; a collective term for non-photosynthetic plankton.



APPENDICES

Appendix 1: Freshwater fish species of the Murray-Darling Basin

Common Name	Scientific name	Comments
Native species		
Short-headed lamprey	<i>Mordacia mordax</i>	lower Murray-Darling Basin
Pouched lamprey	<i>Geotria australis</i>	lower Murray-Darling Basin, rare
Short-finned eel	<i>Anguilla australis</i>	lower Murray-Darling Basin, rare
River blackfish	<i>Gadopsis marmoratus</i>	minor angling species, lower Murray-Darling Basin and cooler regions
Two-spined blackfish	<i>Gadopsis bispinosus</i>	Upland species, lower Murray-Darling Basin
Common galaxias	<i>Galaxias maculatus</i>	lower Murray only
Climbing galaxias	<i>Galaxias brevipinnis</i>	recently introduced into Murray-Darling Basin
Spotted galaxias	<i>Galaxias truttaceus</i>	recently introduced into Murray-Darling Basin
Flat-headed galaxias	<i>Galaxias rostratus</i>	threatened species, lowland and lower Basin
Mountain galaxias	<i>Galaxias olidus</i>	upland areas
Barred galaxias	<i>Galaxias fuscus</i>	threatened species, upland, lower Murray-Darling Basin
Tupong	<i>Pseudaphritis urvillii</i>	restricted to lower Murray
Murray Cod	<i>Maccullochella peelii peelii</i>	angling species, widespread, declining
Trout cod (Bluenose cod)	<i>Maccullochella macquariensis</i>	threatened species, two known populations, one of which is a translocated population
Golden perch	<i>Macquaria ambigua</i>	angling species, widespread and common
Macquarie perch	<i>Macquaria australasica</i>	threatened species, angling, restricted distribution

Silver perch	<i>Bidyanus bidyanus</i>	threatened species, angling, declining
Southern pygmy perch	<i>Nannoperca australis</i>	lower Murray-Darling Basin, uncommon
Yarra pygmy perch	<i>Nannoperca obscura</i>	lower Murray-Darling Basin, uncommon
Australian smelt	<i>Retropinna semoni</i>	widespread
Freshwater catfish	<i>Tandanus tandanus</i>	angling, declined, was widespread
Bony herring	<i>Nematalosa erebi</i>	widespread
Hyrtl's tandan	<i>Neosilurus hyrtlii</i>	northern Murray-Darling Basin
Rendahl's tandan	<i>Porochilus rendahli</i>	northern Murray-Darling Basin
Southern purple spotted gudgeon	<i>Mogurnda adspersa</i>	threatened species, once widespread, restricted to upper basin in QLD/Northern NSW
Western carp gudgeon	<i>Hypseleotris klunzingeri</i>	a species complex, widespread
Murray-Darling carp gudgeon	<i>Hypseleotris sp. 3</i>	patchy in the Murray-Darling Basin
Midgeley's carp gudgeon	<i>Hypseleotris sp. 4</i>	
Lake's carp gudgeon	<i>Hypseleotris sp. 5</i>	
Spangled perch	<i>Leiopotherapon unicolor</i>	common, mid to upper Murray-Darling Basin
Flat-head gudgeon	<i>Philypnodon grandiceps</i>	widespread, common
Dwarf flat-head gudgeon	<i>Philypnodon sp. nov.</i>	lower Murray-Darling Basin and Murrumbidgee and Murray rivers
Murray-Darling rainbowfish	<i>Melanotaenia fluviatilis</i>	widespread
Darling River hardyhead	<i>Craterocephalus amniculus</i>	threatened species, restricted distribution
Fly-specked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>	widespread, declining
Murray hardyhead	<i>Craterocephalus fluviatilis</i>	threatened species, restricted distribution
Olive perchlet	<i>Ambassis agassizii</i>	threatened species, declining in lower Murray-Darling Basin

Alien species		
Brown trout	<i>Salmo trutta</i>	angling, upland areas
Brook char	<i>Salvelinus fontinalis</i>	angling, stocked, upland areas
Rainbow trout	<i>Oncorhynchus mykiss</i>	angling, upland areas
Atlantic salmon	<i>Salmo salar</i>	angling, stocked upland areas
Carp	<i>Cyprinus carpio</i>	pest, widespread
Roach	<i>Rutilus rutilus</i>	recently introduced into lower Murray-Darling Basin upper reaches of VIC streams
Tench	<i>Tinca tinca</i>	lower Murray-Darling Basin upper reaches of VIC streams
Goldfish	<i>Carassius auratus</i>	widespread
Redfin perch (English perch)	<i>Perca fluviatilis</i>	angling, widespread
Gambusia (Mosquitofish)	<i>Gambusia holbrooki</i>	pest, widespread
Oriental weatherloach	<i>Misgurnus anguillicaudatus</i>	aquarium species, lower basin

Derived from Cadwallader and Lawrence 1990; Harris *et al.* 1998; T. Raadik, NRE, Victoria, pers. comm.; D. Moffatt, NRE, Queensland, pers. comm.; B. Pierce, SARDI, pers. comm.; P. Humphries, pers. comm. The taxonomy of several groups, including the hardyheads and gudgeons, is under revision and could result in the identification of further species.

Appendix 2: Conservation status of fish species found in the Murray-Darling Basin

Species	IUCN		National		Vic	ACT	NSW	Qld	SA
EPBC ANZECC ASFB									
Short headed lamprey								EW	
River blackfish					DD				E
Two-spined blackfish						V			
Flat-headed galaxias	V		V	V	DD				
Mountain galaxias					DD				
Barred galaxias	CE	E	E	CE	CE, FFG				
Murray cod					V, FFG				
Trout cod	E	E	E	CE*	CE, FFG	E	E, P		P
Macquarie perch	DD	E	E	E	E, FFG	E	V, P		P
Silver perch	V		E	E	CE, FFG	E	V, P		
Southern pygmy perch							V		P
Yarra pygmy perch	V	V		V					P
Freshwater catfish				V	V, FFG		P		P
Southern purple spotted gudgeon				E	CE, FFG		E		P
Flat head gudgeon					FFG				
Murray-Darling rainbowfish					FFG				
Murray hardyhead		V	V	E	E, FFG		E		
Darling River hardyhead	V			V					
Olive perchlet	DD				FFG		E		P

The list presented has been prepared using the IUCN Species Survival Commission for incorporation into the 1996 IUCN Red List, Federal Endangered species listings, NSW threatened species listing, listings under the ACT Nature Conservation Act, determinations made by recovery teams (*) and Pierce (1989) (for South Australia). FFG = listed under the Flora and Fauna Guarantee Act, Victoria. See Appendix 3 for IUCN categories. P = NSW Protected Species (i.e., no take); (P) = Protected from commercial take.

Appendix 3: Red List categories (International Union for the Conservation of Nature)

Ex = EXTINCT A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EW = EXTINCT IN THE WILD A taxon is Extinct In The Wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range.

CE = CRITICALLY ENDANGERED A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

E = ENDANGERED A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future.

V = VULNERABLE A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

LR = LOWER RISK A taxon is Lower Risk when it has been evaluated and does not satisfy the criteria for any of the categories Critically Endangered; Endangered; or Vulnerable. There are three sub-categories:

- 1) **Conservation Dependent** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
- 2) **Near Threatened** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
- 3) **Least Concern** Taxa which do not qualify for Conservation Dependent or Near Threatened.

DD = DATA DEFICIENT A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and / or population status.

NE = NOT EVALUATED A taxon is Not Evaluated when it has not yet been assessed against the criteria.

Note: For full definitions and details of the criteria used for each of the above categories, the reader should consult the IUCN Red List Categories, prepared by the IUCN Species Survival Commission (1994).

Appendix 4: Guiding principles for this strategy

Ecological principles

1. Protection of biodiversity

In 1992, industry, environmental groups and all three levels of Government in Australia committed themselves to a *National Strategy for Ecologically Sustainable Development*. One of the three core components of this national strategy is the protection of biological diversity. To accomplish this protection *The National Strategy for Biodiversity* was signed in 1996. Biodiversity was defined as ‘the variety of all life forms - the different plants, animals and micro-organisms, the genes they contain and the ecosystems of which they form a part’. Clearly, fish species of the Murray-Darling Basin and the ecosystems they inhabit are an important and integral part of Australia’s biodiversity.

2. Restoration

A general protocol for the restoration of regulated rivers was published by Stanford *et al.*¹. It provides some useful guidance for the *Native Fish Management Strategy* through its focus on the ecological functions of rivers on which fish populations rely for their survival. The protocol should be viewed as an hypothesis derived from the principles of river ecology. Through the management of processes that maintain normal habitat conditions and by allowing the river to do most of the work, it aims to recover some of the lost capacity of rivers to sustain native biodiversity and production. A summary of key objectives includes: restoring peak flows; stabilising base flows; reconstituting seasonal temperature regimes; maximising fish passage;

¹ Stanford, JA, Ward, JV, Liss, WJ, Frissell, CA, Williams, RN, Lichatowich, JA and Coutant, CC (1996). A general protocol for restoration of regulated rivers. *Regulated Rivers: Research and Management* 12: 391-413.

instituting a management belief that relies upon natural habitat restoration rather than artificial propagation; installation of artificial in-stream structures for predator control; and practising adaptive ecosystem management.

A National Framework for River Restoration provides a step by step process for prioritising, undertaking and monitoring river restoration activities incorporating the community.

3. River ecology

Ward and Stanford² provide a series of perspectives on the developments in regulated river ecology, including single and multiple dam and floodplain perspectives for different reach types, channel patterns and habitat types. They also discuss a river conservation perspective, which has a holistic approach to river conservation and restoration practices and for which biodiversity is the integral measure.

4. Conceptual frameworks

Hobbs and Norton³ identified a number of key processes which they considered essential to restoration ecology:

- identify processes leading to the degradation or decline;
- develop methods to reverse or ameliorate the degradation or decline;
- determine realistic goals for re-establishing species and functional

² Ward, JV and Stanford, JA (1997). Changing perspectives in the ecology of regulated rivers. Pp. 37-51 in: *Current Issues in Limnology*. 36th Congress of Australian Society for Limnology, Albury-Wodonga, September 1997.

³Hobbs, RJ and Norton, DA (1996). Towards a conceptual framework for river restoration. *Restoration Ecology* 4(2): 93-110.

ecosystems, recognising both the ecological limitations on restoration and the socioeconomic and cultural barriers to its implementation;

- develop easily observable measures of success;
- develop practical techniques for implementing these restoration goals at a scale commensurate with the problem;
- document and communicate these techniques for broader inclusion in land-use planning and management strategies; and
- monitor key system variables, assess progress of restoration relative to the agreed-upon goals and adjust procedures if necessary.

These processes were identified for general restoration ecology, but are applicable to the restoration of fish populations.

Several key points should be observed:

- biodiversity conservation is a central pillar to ecologically sustainable development;
- conservation is best undertaken within the species' natural habitat;
- there is the need for a comprehensive and adequate system of ecologically viable protected areas;
- conservation is enhanced by knowledge and understanding of species, populations and ecosystems. Hence, there is a need to continue to develop knowledge and understanding of species and ecosystems; and
- it is more cost effective to conserve now than restore later.

Management Principles

1. Ecosystem management

Maltby⁴ proposed ten principles of ecosystem management:

- management objectives are a matter of social choice.
- ecosystems must be managed in human context.
- ecosystems must be managed within natural limits.
- management must recognise that change is inevitable.
- ecosystems management must be undertaken at the appropriate scale.
- ecosystems management needs to think globally but act locally.
- ecosystems management must seek to maintain and enhance ecosystem character and functioning at an appropriate level for social choice.
- decision-makers should be guided by appropriate tools derived from science.
- ecosystem management must act with caution.
- a multi-disciplinary approach is needed.

2. Risk Management Principles

The 'Precautionary Principle' agreed to by Australia under Principle 15 of the *Rio Declaration on Environment and Development* suggests two main ways to deal with the uncertainty and risk involved in managing biological systems to maintain biodiversity:

- when contemplating decisions that will affect the environment, applying the Precautionary Principle involves careful evaluation of management options 'to avoid wherever practicable, serious or irreversible damage to the environment, and an assessment of the risk weighted

⁴ Maltby, E (1997). Ecosystem Management: the concept and the Strategy, *World Conservation* 3/97.

consequences of various options’;
and

- when dealing with ‘threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.’

A risk management strategy involves assessing risks to biological values, regularly recording the state of those values, and developing and implementing proactive and risk-minimising options. In addition to the Precautionary Principle, the *National Biodiversity Strategy* applies the following two risk management principles:

- prevention is better than cure. Protecting ecosystems is far more cost effective than attempting rehabilitation once the damage is done. Some such changes can never be rectified, emphasis must be given to the prevention.
- the causes of a significant reduction or loss of biodiversity must be anticipated, attacked at source, or prevented.

3. Adaptive management

Understanding of biological systems and their functioning is imperfect, creating uncertainty. Adaptive management or ‘learning by doing’ operates on the basis that it draws on the best available scientific knowledge while recognising this uncertainty in scientific understanding. This means that implementation of the *Strategy* can proceed immediately without further extensive studies. The evaluation procedures built into it enable its progressive refinement in the light of information produced by its implementation. If management actions are properly designed, learning from both successes and mistakes can add to the knowledge base.

Adaptive management is particularly important given the diversity of situations encountered. The multitude of causal factors responsible for the decline of native fish populations requires that remedial action be undertaken simultaneously on a number of fronts. The *Strategy* identifies twelve of these issues as its objectives and develops milestones to be achieved for each objective.

Appendix 5. Infrastructure required for implementation

To guide and implement the *Strategy* it is suggested that two committees are formed that draw together representatives of all major stakeholders and managers. The model proposed is that which is currently being used to facilitate carp management throughout Australia. This consists of a community liaison group and a scientific and management committee.

Both groups may be established under the MDBC Community Advisory Committee and overseen by this committee. Terms of reference should be developed for each group with a memorandum of understanding between the two.

Suggested features of the Community Stakeholder Group

Aim: to engage political and public support for the restoration of fish populations within the Basin.

The Group should:

- use the National Carp Task Force as a model;
- have an independent chair;
- contain community, conservation, indigenous community, recreational and commercial fishing, scientific and other relevant stakeholder representation;
- have a representative member on the Science and Management Committee;
- have operating funds to conduct meetings and operate a small executive;
- conduct forums to inform and give and receive feedback from the community; and

- provide feedback to the Science and Management Committee.

Suggested features of the Murray-Darling Fish Science and Management Committee

Aim: To provide direction and advice on priority restorative actions for fish populations within the Basin.

The Committee should:

- be convened by the MDBC as an expansion of their Fish Working Group, and have an executive managed by the MDBC;
- have an independent chair;
- comprise a mixture of academic and State agency scientists and management personnel from fisheries and other agencies, with a balance between State agency expertise and structural representation (use CCCG as a model);
- provide formal government representation;
- have operating funds to conduct meetings and run a small executive of support staff;
- have a representative member on the Community Stakeholder Group;
- report to the Fish Management Project Board;
- have reporting lines to all ministerial councils and sub councils; and
- provide a method of review for this *Strategy*.

Under the auspices of this committee, task-based working groups could be formed to address key objectives or areas of concern, for example, legislation, flows and barriers. These groups could

be based around committee members and co-opt additional expertise as required. In order to minimise transaction costs, these groups may interact opportunistically and

meet electronically or adjacent to the main committee meetings.



Appendix 6. Group approaches and community participation

Fish occur in public waters; a cooperative approach to their management is vital and should be encouraged at all levels. Implementation of native fish management does not rest solely with fisheries agencies, but involves government agencies, regional catchment groups and a wide range of community groups.

A coordinated group approach to fish management is essential to:

- make effective use of skills and resources;
- enable the problem to be tackled over a large area and facilitate more strategic management;
- encourage ownership of the problem by the group through the cohesiveness that develops;
- allow underlying conflicts to be raised, openly discussed and often resolved;
- recruit/influence others who may be reluctant to be involved;
- promote a greater interest and awareness within the group and local community of the problem and the potential solutions.

Empowerment of both the community and water managers to undertake native fish management is essential for the success of the *Strategy*. Education is a key to involvement in the management process so that participants are better informed and feel able to actively contribute. Successful examples of strong community involvement in national management initiatives include the Landcare and Waterwatch Programs, both of which strive to develop successful partnerships between volunteers and local agencies.

Group formation

Because fish populations are widespread and waterways continuous, it is important for interested community groups to interact to share information and experiences from different areas. Involving groups of people with a range of skills and expertise in the planning process encourages group ownership of management decisions and will facilitate participation in implementing the *Strategy*.

Ideally, groups would be made up of people with a mixture of skills and interests in native fish management, including scientists, technicians, naturalists, fishermen, landholders and local interest groups as well as managers. Representatives from public authorities and organisations with responsibility for managing public waters and water storages also need to be involved.

There should be a flow of information between all agencies and groups with an interest in fish management and aquatic systems in the Basin, and integration of strategies across states, shires, boards, government departments and authorities. Catchment management organisations are often an effective level at which to coordinate local management. They may be responsible for directing or guiding others to undertake projects, and can take an active role in obtaining funding.

Other broad community groups are concerned with water and habitat issues. These groups are either organised from individuals with the same interest (for example, Landcare groups) or are facilitated at the government level. They form locally and, as stakeholders in an area, contribute to decision making and assist in the action.

Other community groups such as Field and Game Associations, Field Naturalists, Native Fish Australia and local schools are concerned with management action in a local situation and work as volunteers.

Group maintenance

The formation and maintenance of groups can be difficult. At least some group members need to have good leadership, chairperson, negotiation and conflict resolution skills. Government can assist by providing extension officers trained in communication skills; their role is to act as facilitators and coordinators for management groups and associated stakeholders as well as to provide information and advice. Facilitators help groups make best use of people both within the group and between the group and outside sources of information and assistance. Most facilitators are skilled listeners, asking the right question of the right people at the right time and they are often critical to guiding meetings to a successful outcome.

Coordinators tend to work at the local scale. They sustain the momentum of the group, help to keep members interested and involved and ensure that management is implemented. They also organise meetings, lead the planning and management of group projects and locate sources of advice and assistance.

Meetings can be informal, in a shed or around a kitchen table, or more structured when they concern many players from a wide area. A useful way to structure the meeting is the 'problem specification workshop process'.

Problem Specification Workshop Process (based on Braysher & Barrett 2000)⁵

- The first step in the process is a meeting of specialists to assess the relevant scientific and technical information and determine legal and other constraints to local fish management.
- Next a facilitated workshop is held, involving key stakeholders, to determine the problem and identify solutions. Workshops generally last for two days. However, there is no formal modeling process.
- Techniques such as historical profiles are used to identify key elements of the problem and how these might change in the short- to mid-term.
- Pinboarding, decision tree and mind mapping exercises are used to examine opportunities for improving management and to identify likely constraints.
- Participants then conduct a needs analysis of the key issues and develop action plans for obtaining necessary additional information, reducing constraints and mechanisms and approaches for managing the problem.
- Feedback to the participants is essential, both immediately after the workshop and then regularly as the local management program is developed and implemented. A monthly low key newsletter containing a mixture of hard information and interesting snippets about participants and their achievements is one method for ongoing feedback.

⁵ Braysher, M and Barrett, J (2000). *Ranking Areas for Action: A Guide for Carp Management Groups*. Murray-Darling Basin Commission: Canberra.

The role of extension

In recent years the role of government funded extension activities has expanded from simple dissemination of knowledge to such tasks as:

- raising awareness and developing understanding of the issue of native fish management;
- changing attitudes toward the issue;
- explaining and encouraging adoption of new practices;
- facilitating communication between policy makers, land managers and others with an interest in fish management;
- taking into account the regional needs, skills and tools;
- offering a range of options rather than dictating what should be done; and
- providing a framework for making management decisions built on broader-based information combined with local observation.

Extension workers take a participatory learning approach that allows local groups/individuals ownership of the problems and solutions. They need to understand the goals, motivation and constraints that fish managers work within as well as the ecological issues. Extension information can be communicated through pamphlets, talks and field days, or electronically, linked with a decision support system.

Appendix 8. River Murray Targets

To illustrate the process and application of targets to specific river reaches, examples are provided for two reaches of the River Murray. The reaches selected are Hume Reservoir to Lake Mulwala and Lake Mulwala to Torrumbarry. Hume Reservoir to Lake Mulwala was considered to be well suited as a river rehabilitation reach, whilst Lake Mulwala to Torrumbarry was considered to be representative of river conditions in a more natural reach. The specific targets outlined below provide the basis for the measurement of the success of the Native Fish Strategy in these two example reaches.

Hume Reservoir to Lake Mulwala	Timing	Lake Mulwala to Torrumbarry	Timing
Aquatic structural habitat			
Increase structural habitat (snags) by 20%	2010	Increase structural habitat (snags) by 20% in lower 80 km	2010
Half riparian zone covered by stock exclusion covenant.	2010	Half riparian zone covered by stock exclusion covenant.	2010
Rehabilitation programs commenced for damaged riparian zones	2005	Rehabilitation programs commenced for damaged riparian zones	2005
Increase spatial distribution of aquatic vegetation by 20%	2010	Increase spatial distribution of aquatic vegetation by 20%	2010
Establish a river rehabilitation reach	2005	Develop a rehabilitation plan	2005
Undertake audit	2010	Undertake audit	2010
Designate 50km upstream from Lake Mulwala as a habitat management area	2005	Designate Lake Mulwala to Tocumwal as a habitat management area	2005
Protect 80% of riparian zone	2010	Protect 50% of riparian zone	2010
Floodplain and wetland habitats			
Buy-back covenant and restore 30% of important floodplain habitat	2010	Not required – Barmah Millewa Forest meets requirements	
Water Quality			
Mitigate thermal pollution from Lake Hume	2005	Investigate thermal impacts by Goulburn River	2004
		Investigate sediment inputs from Goulburn River and Broken Creek	2004
Flow regulation			
Rehabilitate flows	2004	Rehabilitate flows	2004
Fish passage			
Build high level fishway on Lake Hume	2005	Ensure effective functioning of Yarrawonga fish lift	2004

Assess and remedy all anabranch fish passage barriers	2010		
Threatened species, communities and conservation zones			
Targeted recovery programs for trout cod, Macquarie perch, freshwater catfish, flat headed galaxias and southern pigmy perch	2003	Targeted recovery programs for trout cod, freshwater catfish, flat headed galaxias and southern pygmy perch	2003
Non-threatened fish species			
A sustainable recreational fishery for Murray cod and Golden perch re-established	2010	A sustainable recreational fishery for Murray cod downstream of Tocumwal re-established	2010
Alien species			
Implement <i>National Management Strategy for Carp Control</i> within this reach	2004	Implement <i>National Management Strategy for Carp Control</i> within this reach	2004
Distribution and abundance of carp, goldfish, weatherloach and redfin reduced by 30%	2010	Distribution and abundance of carp, goldfish, weatherloach and redfin reduced by 30%	2010
		Priority sites for pest species control (Carp) Barmah-Millewa, Torrumbarry weir and Yarrawonga weir	2004
Fishing mortality			
Sustainable fishing levels determined and controls implemented following an audit of the stocks and take of Murray cod and Golden perch	2004	Sustainable fishing levels determined and controls implemented following an audit of the stocks and take of Murray cod and Golden perch	2004
Translocations and stockings			
All stocking unless in an agreed rehabilitation plan halted	2004	All stocking unless in an agreed rehabilitation plan halted	2004
Knowledge Exchange			
This reach used as a river rehabilitation reach	2004	This reach used to assess the performance of aquatic reserves	2004
A minimum 10% of total budget allocation dedicated to	2004	A minimum 10% of total budget allocation dedicated to	2004

monitoring and evaluation of each implemented action		monitoring and evaluation of each implemented action	
90% of identified stakeholders engaged and 50% recognition by, and 80% support, by the general public for the <i>Native Fish Strategy</i> in the regional area	2010	90% of identified stakeholders engaged and 50% recognition by, and 80% support by, the general public for the <i>Native Fish Strategy</i> in the regional area	2010