



The Murray-Darling Freshwater Research Centre:

Research Portfolio ~ November 2009

Current and Recently Completed Projects

(Version 4.8)

The Murray-Darling Freshwater Research Centre: Research Portfolio Current and Recently Completed Projects, November 2009

The Murray-Darling Freshwater Research Centre

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This report was prepared by The Murray-Darling Freshwater Research Centre (MDFRC). The aim of the MDFRC is to provide the scientific knowledge necessary for the management and sustained utilisation of the Murray-Darling Basin water resources. The MDFRC is a joint venture between the Murray-Darling Basin Authority, La Trobe University and CSIRO (through its Division of Land and Water). Additional investment is provided through the Australian Government Department of the Environment, Water, Heritage and the Arts.



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Brief History of MDFRC:

The Murray-Darling Freshwater Research Centre (MDFRC) was formed in October 1986 to generate and communicate the knowledge required to manage aquatic ecosystems, particularly iconic assets such as the Murray River. The MDFRC was formed as a joint venture between the former Australian Water Research Advisory Council (AWRAC) – now Land & Water Australia; CSIRO; the former River Murray Commission, later named the Murray-Darling Basin Commission (MDBC) – now the Murray-Darling Basin Authority and the Albury-Wodonga Development Corporation (AWDC) and was located at the existing AWDC laboratory facilities in Albury. The Centre was charged with the task of carrying out medium to long-term research that would be of benefit to the management of the water resources of the Murray-Darling Basin.

In 1993 MDFRC had a major role in establishing the CRC for Freshwater Ecology (CRCFE) with the head office being located at MDFRC in Albury. The MDFRC was vital to the success of the CRCFE because it was one of the few research organisations that had any experience in lowland river and floodplain ecology. MDFRC staff time allocations were 100% committed to the CRCFE and the MDFRC Board delegated most of its roles and responsibilities to the CRCFE Board.

In October 1996, the CRCFE enabled the MDFRC to expand its operation through the establishment of the Lower Basin Laboratory (LBL), located in Mildura. The LBL was an important landmark for MDFRC making it possible for the MDFRC to cover the free flowing sections of the Murray River and represented a major commitment by the Sunraysia community to the generation of ecological knowledge. The effective lobbying and fundraising by the Sunraysia community to help establish the LBL was another testament to the commitment of regional communities to the MDFRC.

In July 2000, CSIRO and the former Murray-Darling Basin Commission (MDBC) entered into a Participation Agreement establishing the unincorporated joint venture known as the Murray-Darling Freshwater Research Centre (the Original Centre), with CSIRO Land and Water acting as Centre Agent.

The CRCFE ceased operations in June 2005 and the institutional and operating environment for MDFRC changed significantly with MDFRC going from being committed 100% to the CRCFE to 30% to the eWater CRC. The Original Centre was terminated on 30 June 2006. In late November 2006 CSIRO and the MDBC entered into a Termination Deed to record the arrangements agreed between CSIRO and MDBC regarding the winding up and post-termination obligations of the participants in the Original Centre. However, CSIRO and the former MDBC wished to continue the work of the Original Centre beyond 30 June 2006 by establishing a new unincorporated joint venture between CSIRO, MDBC and La Trobe University (the Centre Members). The Centre Members entered into an agreement (Centre Agreement) on or about November 2006, under which they established the new unincorporated joint venture, which will also be known as The Murray-Darling Freshwater Research Centre (the Centre). The Centre Members have established MDFRC Pty Limited and have appointed the company as their agent, to carry out certain management functions related to the Centre.

Additional investment is provided by the Australian Government through the Department of the Environment, Water, Heritage and the Arts.



Australian Government
Department of the Environment,
Water, Heritage and the Arts

MDFRC Vision

The MDFRC has a vision of:
Healthy and productive aquatic ecosystems in the Murray-Darling Basin.

MDFRC Mission

In targeting this vision, the overarching mission of the MDFRC is:
The generation, synthesis and communication of freshwater ecological science fundamental to protection and enhancement of the natural assets of the Murray-Darling Basin while supporting sustainable use of the Basin.

Our Science supports governments, land and water resource managers, the water industry and the community in making informed decisions for the future management of the Basin.

MDFRC Values

In pursuit of this mission, the staff and management of the MDFRC are committed to a value set which espouses:

- ★ Excellent freshwater ecological science through initiative and creativity.
- ★ Accountability for the quality, integrity and objectivity of our research.
- ★ Collaboration with agencies to inform decisions based on sound ecological knowledge.
- ★ Developing expertise to inform decisions based on sound ecological knowledge.
- ★ Respect for our colleagues and personal accountability for our behaviour and actions.

MDFRC Research Themes

There are currently eight research themes that each MDFRC project is categorised under.

- **Assessment**
- **Biota**
- **Connectivity**
- **Education**
- **Habitat**
- **Knowledge Exchange**
- **Metabolic Function**
- **Review**

Assessment

A project that quantifies the environmental condition of an area to enable managers to determine appropriate actions to protect or restore the area.

Biota

A project that improves our understanding of species characteristics, including their capacity to disperse, their life history, cues for reproduction, breeding behaviour, salinity tolerance or metabolic requirements.

Connectivity

Connectivity is the exchange of material and organisms among habitat patches. Projects in this theme examine the movement of material among patches and the consequences of changes in patterns of connectivity.

The movement of material such as organic carbon, sediment and nutrients are critical ecosystem processes that influence habitat and productivity in receiving systems. Understanding the major pathways of movement and how management may have changed both the type and amount of material being moved are critical questions if we are to manage ecosystems.

Biota need to move in order to complete their life cycle, avoid disturbances or find food. Dispersal is also a critical determinant of the success of any rehabilitation activity as we cannot achieve our objectives if the organisms cannot colonise rehabilitated sites.

Education

A project undertaken by postgraduate students undertaking their PhD, Masters or Honours and undergraduate students undertaking Summer scholarships, work experience etc.

Habitat

Projects in this theme will help identify the key habitats (both spatial and temporal) of the major functional components of the ecosystem [primary production (in-stream and floodplain), invertebrates, fish, birds etc.] and quantify how they change in response to changes in flow, land use and climate.

Knowledge Exchange

A project that provides information and advice to government and non-government organisations, as well as the community via;

- expert panels
- consultancies
- publications
- presentations
- workshops

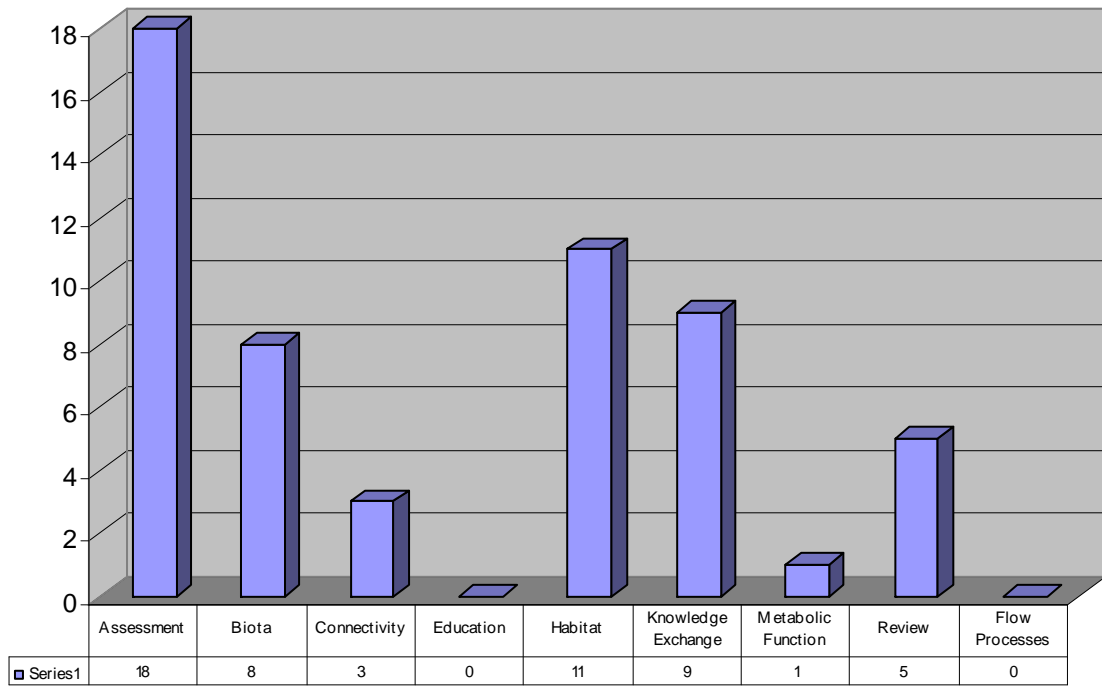
Metabolic Function

Metabolic Function refers to the transformation of organic matter through aquatic food webs. The transformations include critical processes such as primary production and decomposition, but also the consumption of plant material and predation. Processes such as primary production and decomposition have a significant impact on water quality and nutrient cycles that are of importance to managers. Projects in this theme also improve our understanding of food web processes thereby helping managers ensure that iconic species such as Murray cod have the food resources they require to survive and reproduce.

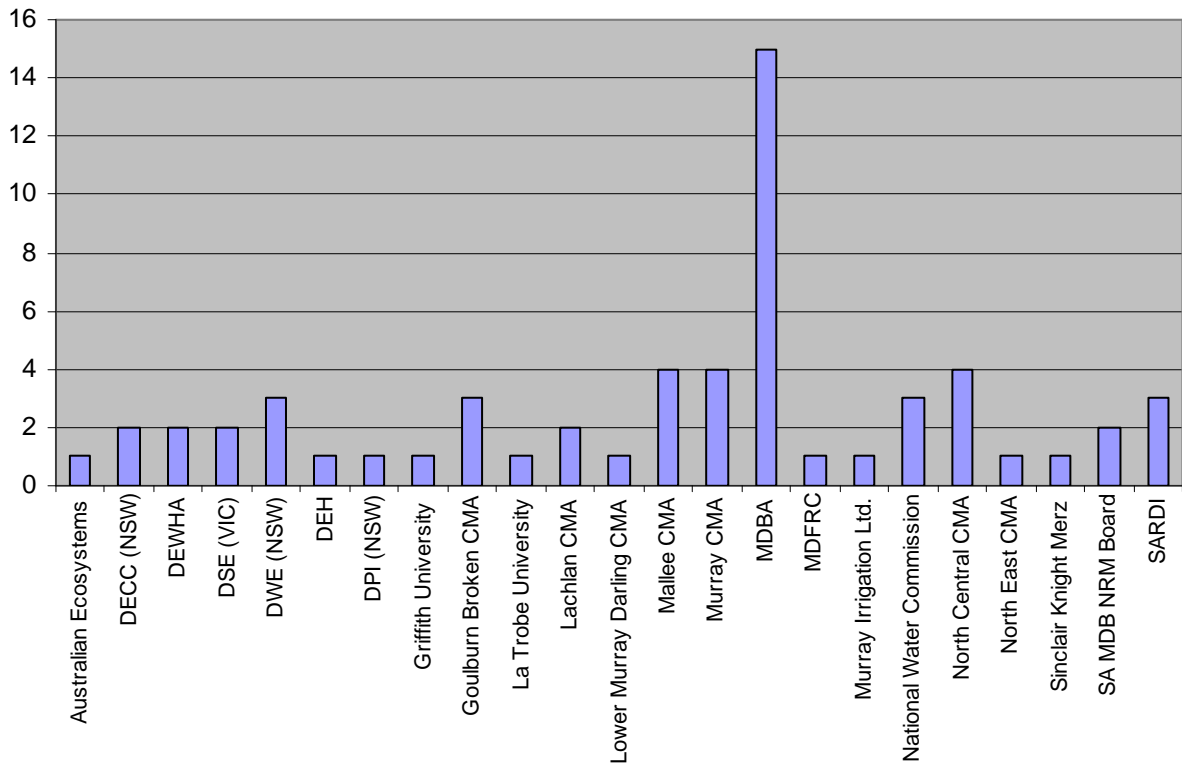
Review

A project that is a synthesis of existing, available data and information sources (published and unpublished), that will improve our understanding of aquatic ecosystems. Report format could be scoping study; literature review or desktop analysis. These projects may be used as a guide for research and monitoring that will fill knowledge gaps, understanding and assessment of areas and assets critical to the ecological health of a water body.

MDFRC Research Portfolio - Research Themes



MDFRC Research Portfolio - MDFRC Clients



MDFRC Researchers



Dr Ben Gawne - Director
Freshwater ecologist (Wodonga)
b.gawne@latrobe.edu.au

Aquatic ecosystem function including primary production, decomposition and the movement of organic matter through aquatic food webs. Effects of management on aquatic ecosystems, particularly flow regulation.



Dr Gavin Rees – Assistant Director
Microbiologist (Wodonga)
gavin.rees@csiro.au

Ecology of aquatic micro-organisms, including bacteria and fungi and the way in which they influence water quality and flow-related ecological processes. The role of micro-organisms in determining nutrient cycles and floodplain ecology.



Dr Todd Wallace – Officer in Charge (Mildura)
Aquatic ecologist (Mildura)
t.wallace@latrobe.edu.au

The effects of flow regulation on the ecology of riverine and floodplain habitats, particularly the effects on water quality and fish communities.



Dr Darren Baldwin
Aquatic biochemistry (Wodonga)
darren.baldwin@csiro.au

Examination of the effects of human activities on the way nutrients and energy move through aquatic ecosystems, particularly wetlands, floodplains and reservoirs. Current interests include hyper-drought and wetland acidification.



Dr Daryl Nielsen
Invertebrate ecologist (Wodonga)
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Ecology of aquatic invertebrates and plants in rivers and wetlands and the effects of flow on community ecology. Interested in the role of eggs and seeds within sediments in sustaining healthy plant and animal communities.



Dr Lorenzo Vilizzi
Fish ecologist and statistician (Mildura)
l.vilizzi@latrobe.edu.au

Modelling and statistical evaluation of fish-habitat relationships in riverine and wetland habitats. Conservation of native fish. Ecology of fish recruitment through a variety of interpretation methodologies and analysis.



Dr Rick Stoffels
Fish ecologist (Wodonga)
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Experimental, descriptive and modelling approaches to improve our understanding population structure and dynamics, Flow-demography relationships in freshwater fishes. Bioenergetics of freshwater fishes. Population biology of freshwater fishes.



Dr Bernard McCarthy
Invertebrate ecologist (Mildura)
b.mccarthy@latrobe.edu.au

Crayfish biology and ecology, the effects of changes in flow on riverine and wetland ecology, particularly the effects of weir pools in the Mallee.



Dr Giri Kattel
Aquatic ecologist (Mildura)
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Limnological and palaeolimnological investigations of lakes and floodplain ecosystems, ecology of microinvertebrates including the role of fossil Cladocera (water fleas) and ephyppia (the thick shell that protects the winter eggs of a cladoceran) in reconstruction of climate change, land use and cultural development.



Mr John Hawking
Aquatic ecologist (Wodonga)
j.hawking@latrobe.edu.au

Assessment, Knowledge Exchange and Macroinvertebrate Taxonomist.

Mr Clayton Sharpe, Fish ecologist (Mildura) c.sharpe@latrobe.edu.au - Fish population and community dynamics in regard to natural and imposed flow regimes. Habitat use throughout ontogeny, age and growth, reproductive physiology and recruitment ecology for Australian native fish.

Dr Mark Fraser, Aquatic biochemistry (Wodonga) m.fraser@latrobe.edu.au - Restoration and management of inland wetlands, focussing on the role of sulfidic sediments in the development of potential acid sulfate

Dr Sally Hladyz, Aquatic food web ecologist (Wodonga) sally.hladyz@csiro.au - Ecosystem functioning, freshwater food webs and interactions between terrestrial and freshwater ecosystems. Effects of changing flow on biological interactions and trophic interactions in lowland river systems.

Dr Amina Price, Fish ecologist (Wodonga) amina.price@latrobe.edu.au - Fish and shrimp ecology, recruitment ecology, riverine landscape ecology, interactions between flow, habitat and aquatic biota in rivers and wetlands of the Murray-Darling Basin.

Dr Susanne Watkins, Wetland ecologist (Wodonga) s.watkins@latrobe.edu.au - Wetland ecology including invertebrate community dynamics and the influence of flow modification, land use and riparian vegetation on food webs and wetland ecology.

Dr Jessica Wilson, Biogeochemist (Wodonga) j.wilson@latrobe.edu.au - Water and soil quality, ecological assessment, flow-related ecological processes, biogeochemistry of soils and sediments.

Mrs Lyn Smith, Senior aquatic research technician (Wodonga) lyn.smith@latrobe.edu.au - Bioassessment and macroinvertebrate taxonomy.

Mr Iain Ellis, Senior aquatic research technician (Mildura) i.ellis@latrobe.edu.au - Fish biology/ecology, threatened species management, lowland river and wetland ecology, aquatic ecosystem monitoring.

Ms Cherie Campbell, Vegetation ecologist (Mildura) c.campbell@latrobe.edu.au - Plant ecology, riverine, wetland and floodplain assessments.

Mr Rob Cook, Senior aquatic research technician (Wodonga) r.a.cook@latrobe.edu.au - Restoration and assessment.

TABLE OF CONTENTS

AUSTRALIAN ECOSYSTEMS	11
Gunbower Forest Outfall – Preliminary Flora and Fauna Assessment (M/BUS/311)	11
DEPARTMENT OF ENVIRONMENT & CLIMATE CHANGE (NSW)	12
Impacts of land use and water quality on organic matter dynamics and secondary production in floodplain (lower Murrumbidgee River) (M/BUS/260).....	12
DEPARTMENT OF THE ENVIRONMENT, WATER, HERITAGE AND THE ARTS (C’WEALTH)	13
Online guide to the Identification and Ecology of Australian Freshwater Invertebrates (M/BUS/34) and (M/BUS/300).....	13
Determining Watering Regimes to Protect Floodplains under Hyper-Drought Conditions (M/BUS/246)	14
DEPARTMENT OF SUSTAINABILITY AND ENVIRONMENT (VIC)	15
Living Murray Monitoring 2008-2009 Lindsay – Mulcra – Wallpolla Islands and Hattah Lakes (M/BUS/283)	15
Living Murray Monitoring 2009-2010 Lindsay – Mulcra – Wallpolla Islands and Hattah Lakes (M/BUS/323)	17
DEPARTMENT OF WATER AND ENERGY (NSW)	18
Determining the resilience of fish populations to drought in unregulated rivers (M/BUS/272).....	18
Reviewing information on the ecology of the purple–spotted gudgeon, <i>Mogurnda adspersa</i> (Eleotridae), in Australian rivers (M/BUS/297)	20
Integrated Monitoring of Environmental Flows – Freshwater Shrimp in Regulated Rivers (M/BUS/278)	21
DEPARTMENT FOR ENVIRONMENT AND HERITAGE	22
Interim maintenance and breeding of captive Murray hardyhead from Rocky Gully Wetland (Murray Bridge, South Australia) (M/BUS/310).....	22
GRIFFITH UNIVERSITY	23
National Climate Change Adaptation Research Facility (M/BUS/302).....	23
GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY	25
Broken River re-snagging monitoring 2008 2009 (M/BUS/285).....	25
Monitoring of Broken Creek: Water Quality and System Understanding - <i>Azolla</i> III (M/BUS/211-2)	26
Effects of Turbidity on native fish populations: an ecosystems-scale experiment (M/BUS/292)	27
LA TROBE UNIVERSITY	29
Australian Tourism in a Water Constrained Economy: Scoping Study (M/BUS/303)	29
LACHLAN CATCHMENT MANAGEMENT AUTHORITY	30
Spawning and recruitment of native fish in the Lachlan Catchment (M/BUS/295).....	30
Fish Spawning and Recruitment in the Lachlan River – Stage 2 (M/BUS/295)	31
LOWER MURRAY DARLING CATCHMENT MANAGEMENT AUTHORITY	32
Lower Darling River Fish-Habitat Investigation (M/BUS/301).....	32
MALLEE CATCHMENT MANAGEMENT AUTHORITY	33
Threatened Aquatic Species Management - Murray hardyhead 08/09 (M/BUS/284).....	33
Conservation of Murray hardyhead (<i>Craterocephalus fluviatilis</i>) 2008-2009 preliminary monitoring of translocation sites and expansion of the maintenance program (M/BUS/284) Part 2.....	35
Aquatic Vertebrate Surveys at Kings Billabong (M/BUS/308).....	36
Aquatic Vertebrate Surveys at Kings Billabong Part 2(M/BUS/322)	37
MURRAY CATCHMENT MANAGEMENT AUTHORITY	38
Assessing the Impacts of Recreational Boating Activities on River Bank Stability (M/BUS/226)	38
Interpretation of analysis data from perennial and ephemeral streams in the Murray Catchment (M/BUS/264)	39
Climate Change Monitoring in the Murray River Catchment using Macroinvertebrates (M/BUS/318).....	40
Understanding Blackwater Events and Managed Flows in the Wakool System – A Scoping Study (M/BUS/319)41	41
MURRAY-DARLING BASIN AUTHORITY	42
Macroinvertebrate Monitoring Program 2007/08 to 2009/10 (M/BUS/244).....	42
Mitta Mitta River Catchment Long-Term Monitoring Project: Continuation of the existing ecological monitoring of the river health below Dartmouth Dam and the additional of extra monitoring sites in the Upper Mitta Mitta Catchment (M/BUS/291)	43
Drought Contingency Monitoring of NSW Wetlands–Euston Lakes system (M/BUS/247)	44
Drought Contingency Monitoring of NSW Wetlands – Back Creek & Tumudgery Creek (M/BUS/250)	46
Drought Contingency Monitoring of NSW Wetlands – Salt Creek/Tareena Billabong (M/BUS/251).....	48
Implementing a systems approach to support adaptive management of river wetland health in the Murray-Darling Basin (M/BUS/248).....	49
Ecological Advisory Services related to the Northern Basin (M/BUS/265)	51
An ecological evaluation of the Environmental Watering of the Gunbower Wetlands ICON site in relation to the aquatic animal community (M/BUS/271)	52
Development of semi arid wetland conceptual models (M/BUS/275)	54
Ecological outcomes of managed flooding and control structures at Webster’s lagoon (M/BUS/293)	57

Literature review and experimental design to address retaining floodwater on floodplains and flow enhancement hypotheses relevant to native tree species (M/BUS/313)	58
Northern Basin Program Review (M/BUS/314)	59
Comprehensive review of the 1980 – 2008 Murray river monitoring data (M/BUS/330)	60
Comprehensive review of the Mitta Mitta 1998 – monitoring data (M/BUS/331)	61
Evaluation of local biological effects (Water Quality) (M/BUS/327)	62
THE MURRAY-DARLING FRESHWATER RESEARCH CENTRE	63
Drought Monitoring (M/BUS/214)	63
MURRAY IRRIGATION LIMITED	64
Murray Irrigation Area Aquatic Ecosystem Monitoring (M/BUS/86)	64
NATIONAL WATER COMMISSION	66
Minimising Environmental Damage from Water Recovery from Inland Wetlands: Determining water regimes to minimise the impact of sulfidic sediments (potential acid sulfate soils) (M/BUS/228)	66
Optimising Environmental Watering Protocols to Maximise Benefits to Native Fish Populations (M/BUS/229)	67
The Farms, Rivers and Markets Project: Catchment Scale Demonstration of Integrated Water Management (M/BUS/296)	69
NORTH CENTRAL CATCHMENT MANAGEMENT AUTHORITY	70
Gunbower Forest Fish Surveys (M/BUS/294)	70
Angler diaries for Gunbower Island: Community contribution to knowledge generation of fish distribution across Gunbower Island (M/BUS/320)	72
Status of freshwater catfish (<i>Tandanus tandanus</i>) populations in Gunbower Creek (M/BUS/321)	73
Wetland and waterway condition assessments (M/BUS/329)	74
NSW DEPARTMENT OF PRIMARY INDUSTRIES	75
Resnagging the Pomona Priority Habitat Reach, Lower Darling River (M/BUS/262)	75
NORTH EAST CATCHMENT MANAGEMENT AUTHORITY	76
Willows Monitoring (M/BUS/274)	76
SINCLAIR KNIGHT MERZ	78
Salinity Target Reviews (M/BUS/326)	78
SOUTH AUSTRALIAN MURRAY-DARLING BASIN NATURAL RESOURCES MANAGEMENT BOARD (SA MDB NRM Board)	79
Tree Health Monitoring for the Pike River Floodplain (M/BUS/299)	79
Fish and Fish Habitats of the Pike River Anabranch and Floodplain Complex (M/BUS/309)	81
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE (SARDI)	82
Integrated Pest Management (M/BUS/219)	82
The protection of drought refugia for native fish in the Murray-Darling Basin (M/BUS/286)	85
Ecosystem resilience and importance of refugia for native fish communities/populations (M/BUS/287)	86

MDFRC PhD Students

Paul McInerney	87
Nick Whiterod	88
Janice Williams	89
Clayton Sharpe	90
Nicole McCasker	91
John Hawking	92
Tegan Evans	93
Nirmala Wijeratne	94

Client	AUSTRALIAN ECOSYSTEMS
Project Title	Gunbower Forest Outfall – Preliminary Flora and Fauna Assessment (M/BUS/311)
Contact Officer	Mr Clayton Sharpe - c.sharpe@latrobe.edu.au
Project Duration	30 th March to 30 th June 2009
Research Theme	Assessment
Status	Completed

► Background

An investigation is currently underway to investigate how the North Central CMA can deliver water to the Upper Gunbower Forest to water critical floodplain areas. It has been identified that the majority of water delivered through the forest outfalls into Gunbower Creek at Chinaman's Bend. As such, an investigation is also underway to design a structure for the control of the outfall of environmental water released into Gunbower Forest to Gunbower Creek and the Murray River.

This project is to investigate the observed and expected Aquatic flora and fauna values at Chinaman's Bend on the Gunbower Creek, within a 1km radius of the outfall location proposed.

► Methodology

Fish Surveys (aquatic fauna)

Undertake standardised (550 sec) electrofishing (backpack) and, where deemed appropriate as to complement electrofishing (deeper pools) fyke netting, at 16 sites on the lower Gunbower Creek within 1 radial kilometre of the proposed affected area. Sites selected approximately every 200m along the lower Gunbower Creek between the Koondrook Weir and the Murray River / Gunbower Creek junction.

Habitat Surveys

AUSRIVAS Physical Assessment Protocol (habitat surveys) (Ladson and White 1999) conducted at nine sites within the 1km radius of the proposed affected area; three each at the upstream, middle and downstream fish survey sites.

► Reports

Sharpe C (2009) Gunbower Forest Outline: Aquatic fauna investigation of the Gunbower Creek at Chinamans Ben and the area of influence of the proposed Gunbower Forest outfall. Draft Report prepared for Australian Ecosystems, June, 21pp.

Bennetts K, Cook D, Jolly K and Sharpe C (2009) Flora and Fauna investigation of the proposed Gunbower Forest Outlet. Report prepared for North Central Catchment Management Authority by Australian Ecosystems and The Murray-Darling Freshwater Research Centre, July, 228pp.

Client	DEPARTMENT OF ENVIRONMENT AND CLIMATE CHANGE (NSW)
Project Title	Impacts of land use and water quality on organic matter dynamics and secondary production in floodplain (lower Murrumbidgee River) (M/BUS/260)
Contact Officer	Dr Susanne Watkins - s.watkins@latrobe.edu.au
Project Duration	1 st March 2008 to 30 th August 2009
Research Theme	Connectivity
Status	Completed

▶ Background

Models of floodplain ecosystem response to hydrological flows are based on an understanding of the effect of flooding regime, including timing and duration of flooding. While these “water quantity” considerations are of central importance, the role of a number of ameliorating factors is often overlooked.

The response of a floodplain to watering may be influenced by the quality of water inputs, and also local land-use practices which influence the quality of food being provided to lower-level herbivores and detritivores. In developing models of floodplain response to watering, the client seeks to incorporate land-use and water quality considerations into the predicted response to flow.

▶ Objective

Allow the refinement of models regarding the effect of water regimes (i.e. water quantity) on floodplain response by considering factors ameliorating these effects. These insights will be incorporated into models of floodplain response for the lower Murrumbidgee specifically, and deduced for other floodplain wetlands being studied under Rivers Environmental Restoration Program.

▶ Methodology

- A) The determination of the quality (C:N:P ratio), quantity and source of organic matter within wetlands of varying floodplain land-use types.
- B) Quantification of the abundance and richness of primary consumers within floodplain wetlands.
- C) Recommendations regarding management strategies for maximising the biodiversity of secondary producers.

▶ Reports

Watkins S, Nielsen D, and Gawne B (2008) Rivers Environmental Restoration Programme Milestone requirements: project development, selection of field sites and methodology. Progress Report to Department of Environment and Climate Change, August, 7pp.

Watkins S and Nielsen D (2009). Impacts of land use and water quality on organic matter dynamics and secondary production in floodplain wetlands. Final Report prepared for the Department of Environment and Climate Change by The Murray-Darling Freshwater Research Centre, September, 50pp.

▶ Notes

In July 2009 the NSW government advised that the Department of Environment and Climate Change would also take on the water responsibilities of the abolished Department of Water and Energy, forming the Department of Environment, Climate Change and Water.

Client	DEPARTMENT OF THE ENVIRONMENT, WATER, HERITAGE AND THE ARTS (C'WEALTH)
Project Title	Online guide to the Identification and Ecology of Australian Freshwater Invertebrates (M/BUS/34) and (M/BUS/300)
Contact Officer	Mr John Hawking - j.hawking@latrobe.edu.au
Project Duration	1 st February 2003 to 30 th January 2009
Research Theme	Knowledge Exchange
Status	Completed - On going maintenance funded through The Murray-Darling Freshwater Research Centre

► Background

This interactive guide to the “Identification and Ecology of Australian Freshwater Invertebrates” (Bug Guide) is designed to provide ecological and taxonomic information to enable community groups, students and scientists to readily identify inland aquatic invertebrates; this includes some invertebrates from saline waters. The bug guide is used at MDFRC and by Waterwatch Victoria and AUSRIVAS monitoring agencies.

General ecological information and images (habitat, life history, habit and distribution) are given, as available, for each of the major aquatic invertebrate groups. Successively more specific information and images are becoming available for four insect orders and one crustacean order to generic level, with other insect and crustacean orders to family level. Identification keys and information pages for the major groups of Bivalvia (mussels), Cnidaria (hydra, jellyfish), Gastropoda (snails), Hirudinea (leeches), Acaria (mites) and Platyhelminthes (flatworms) to family level are under construction. Colour digital images are used to illustrate the diagnostic characters used in the identification keys. A glossary, colour terminology images of actual specimens, and a list of information sources are also provided.

The Bug Guide, on the MDFRC website, went online on 25 September 2006. This online identification tool can be visited at: www.mdfrc.org.au/bugguide Please distribute the link to anybody you think would find the guide useful and ask them to send feedback via the bugsonline@mdfrc.org.au

► Reports

Hawking JH Smith LM and Le Busque K (2006 onwards). Identification and Ecology of Australian Freshwater Invertebrates. [www.mdfrc.org.au/bugguide]

Hawking JH Smith LM and Le Busque K (2006) Colour Web Guide to the Identification of Invertebrates from Australian Inland waters. First Progress Report to the Department of the Environment and Heritage, November, 9pp.

Hawking JH Smith LM and Le Busque K (2007) Colour Web Guide to the Identification of Invertebrates from Australian Inland waters: Testing of usefulness and user-friendliness. Progress Report to the Department of the Environment and Heritage, June, 20pp.

Hawking J and Smith L (2008) Colour Web Guide to the Identification of Invertebrates from Australian Inland waters. Final Progress Report to the Department of the Environment, Water, Heritage and the Arts, February, 9pp.

Hawking J and Smith L (2009) Colour Web Guide to the Identification of Invertebrates from Australian Inland waters: Project Completion Report. Report prepared for the Department of the Environment, Water, Heritage and the Arts, March, 17pp.



Client	DEPARTMENT OF THE ENVIRONMENT, WATER, HERITAGE AND THE ARTS (C'WEALTH)
Project Title	Determining Watering Regimes to Protect Floodplains under Hyper-Drought Conditions (M/BUS/246)
Contact Officer	Dr Darren Baldwin - darren.baldwin@csiro.au , Dr Gavin Rees - gavin.rees@csiro.au and Dr Todd Wallace - t.wallace@latrobe.edu.au
Project Duration	1 st July 2007 to 31 st May 2010
Research Theme	Habitat
Status	Current

▶ Background

Floodplains in semi-arid regions rely on periodic floods to maintain soil health – a key driver of ecosystem condition. River regulation and over-extraction of water resources has limited the frequency of small to medium floods, imposing a long-term artificial drought regime that has substantially impacted on floodplain condition. Because these floodplains are already stressed due to low soil moisture, they become more susceptible to drought-induced degradation than they would be under natural flow regimes (hence the term ‘hyper-drought’).

▶ Aim

The project will determine critical thresholds exist for maintaining soil health and ecological function. The knowledge generated can be used as ecological targets for restoration of these degraded ecosystems, and is of critical importance in the face of climate change.

▶ Methodology

The project will be carried out at three methodological scales. Small-scale laboratory experiments will be used to identify how floodplain soil processes (in particular carbon and nutrient dynamics) and soil biota respond to changes in soil moisture under different flooding and drying regimes (Soil health will be explored using a suite of techniques we have developed for examining biogeochemical processes and biotic community structure in aquatic sediments). Of particular importance is to identify (a) whether soil function responds reversibly to drying and flooding; and (b) if critical thresholds exists which, if exceeded cause either a hysteretic response or even irreversible change. Factors that can mitigate change (e.g. increased carbon content of the soil) will also be examined.

▶ Reports

Baldwin D, Pitman T, Rees G, Wallace T and Wilson JS2008). Milestone 2: Progress report examining soil response to wetting, drying and flooding and recommendations for second phase of the Hyper-drought project. Report prepared for the Department of the Environment, Water, Heritage and the Arts Commonwealth Environment Research Facilities, December, 26pp.

Wilson J, Baldwin D, Rees G, Pitman T, Wallace T and Zahra S (2009). Hyper-drought Project Milestone 3: Soil characteristic changes across different drying regimes in a semi-arid floodplain ecosystem. Report prepared for the Department of the Environment, Water, Heritage and the Arts, Commonwealth Environment Research Facilities by The Murray-Darling Freshwater Research Centre, June, 22pp.

Baldwin D, Wilson J, Rees G, Pitman T and Wallace T (2009) Progress Report 4 and Milestone Report 4: Determining Water Regimes to Protect Floodplains under Hyper-Drought Conditions. Report prepared for The Department of the Environment, Water, Heritage and the Arts by The Murray-Darling Freshwater Research Centre, December, 13pp.

Client	DEPARTMENT OF SUSTAINABILITY AND ENVIRONMENT (VIC)
Project Title	The Living Murray 2008-2009 Condition Monitoring Lindsay–Mulcra–Wallpolla Islands and Hattah Lakes (M/BUS/283)
Contact Officer	Mr Mark Henderson - m.henderson@latrobe.edu.au
Project Duration	1 st July 2008 to 30 th June 2009
Research Theme	Habitat
Status	Current, continuation from projects funded by Mallee Catchment Management Authority (M/BUS/87-4) Draft Final Reports have been submitted, awaiting finalisation (Helen Missen 6 th October 2009)

► Project Description

Lindsay–Mulcra–Wallpolla Islands

The overarching objective is to provide robust, scientifically defensible data on the environmental condition of the Lindsay-Mulcra-Wallpolla Islands component of the Chowilla Floodplain including Lindsay-Wallpolla Islands Icon site.

The outcome for the Chowilla Floodplain Icon site is to “*Maintain high biodiversity values of the Chowilla Floodplain*”; with the objectives

- (i) High value wetlands maintained.
- (ii) Current area of river red gum maintained.
- (iii) At least 20% of the original area of Black box vegetation maintained.

These objectives are complemented by the objectives for Condition Monitoring and the Icon site-specific Ecological Objectives. The 2007-08 Condition Monitoring Program will generate high quality, scientifically defensible data that will be used to report on the condition of the Fish and Vegetation Communities present at the site.

Hattah Lakes

The overarching objective is to provide robust, scientifically defensible data on the environmental condition of the Hattah Lakes Icon site. The outcome for the Hattah Lakes Icon site is to “*Restore healthy examples of all original wetland and floodplain communities*”; with the objectives

- (i) Restore the aquatic vegetation zone in and around at least 50% of the lakes to increase fish and bird breeding and survival.
- (ii) Increase successful breeding events of threatened colonial water birds to at least two in ten years.
- (iii) Increase the population size of and breeding events of the endangered Murray Hardyhead, Australian Smelt, Gudgeons and other wetland fish.

These objectives are complemented by the objectives for Condition Monitoring and the Icon site-specific Ecological Objectives. The 2007-08 Condition Monitoring Program will generate high quality, scientifically defensible data that will be used to report on the condition of the Fish and Vegetation Communities present at the Icon site.

► Methodology

Lindsay–Mulcra–Wallpolla Islands

Details of methodology are presented in the document “*The Living Murray: Condition Monitoring Program design for Chowilla Floodplain and the Lindsay-Mulcra-Wallpolla Islands (2008)*”.

Wetland and terrestrial plant assemblages: Standard quadrant techniques will be used to assess changes to distribution, abundance and diversity of understorey vegetation.

Cumbungi and Lignum: Standard techniques will be used to assess changes to distribution and viability of cumbungi and lignum.

Tree condition: The condition of long-lived vegetation will be assessed using standardised visual (on-ground) assessments.

Fish Surveys: Standard active (electrofishing) and active (netting) techniques will be utilised to assess the fish community within the mosaic of flow habitats present at the Icon site.

Photopoints: Photopoints will be utilised to visually document changes at the wetland sites.

Hattah Lakes

Details of methodology are presented in the document “*The Living Murray Initiative: Hattah Lakes Icon Site condition monitoring program design (Scholz et al., 2007)*”. This document is currently being updated to ensure consistency with the Outcomes Evaluation Framework (MDBC, 2008) and the document “*The Living Murray: Condition Monitoring Program design for Chowilla Floodplain and the Lindsay-Mulcra-Wallpolla Islands (2008)*”.

Wetland and terrestrial plant assemblages: Standard quadrant techniques will be used to assess changes to distribution, abundance and diversity of understorey vegetation.

Cumbungi and Lignum: Standard techniques will be used to assess changes to distribution and viability of cumbungi and lignum.

Tree condition: The condition of long-lived vegetation will be assessed using standardised visual (on-ground) assessments.

Fish Surveys: Standard active (electrofishing) and active (netting) techniques will be utilised to assess the fish community within the mosaic of flow habitats present at the Icon site.

Photopoints: Photopoints will be utilised to visually document changes at the wetland sites.

▶ Reports

Wallace T, Henderson M, Sharpe C and Campbell C (2008) 2008-2009 Condition monitoring at Lindsay-Mulcra-Wallpolla Islands. Progress Report to Department of Sustainability and Environment and the Murray-Darling Basin Commission, November, 3pp.

Wallace T, McCarthy B, Tucker M, Sharpe C and Campbell C (2008) 2008-2009 Condition monitoring at Hattah Lakes. Progress Report to Department of Sustainability and Environment and the Murray-Darling Basin Commission, November, 3pp.

Wallace T, Henderson M, Sharpe C and Campbell C (2009) 2008-2009 Condition monitoring at Lindsay-Mulcra-Wallpolla Islands. Progress Report to Department of Sustainability and Environment and the Murray-Darling Basin Commission. Report prepared by The Murray Darling Freshwater Research Centre, February, 5pp.

Wallace T, McCarthy B, Tucker M, Sharpe C and Campbell C (2009) 2008-2009 Condition monitoring at Hattah Lakes. Progress Report to Department of Sustainability and Environment and the Murray-Darling Basin Commission. Report prepared by The Murray Darling Freshwater Research Centre, February, 8pp.

Wallace T (2009) Development Draft. The Living Murray: Condition monitoring program design for Hattah Lakes. Development Draft Report V1.3 prepared for the Murray-Darling Basin Authority, February, 68pp.

Wallace T (2009) Development Draft. The Living Murray: Condition monitoring program design for Chowilla Floodplain and the Lindsay, Mulcra and Wallpolla Islands. Development Draft Report V1.5 prepared for the Murray-Darling Basin Authority, February, 86pp.

Henderson M, Wallace T, Campbell C, Johns C and Kattel G (2009). The Living Murray Condition Monitoring at Lindsay, Mulcra and Wallpolla Islands 2008/2009. Draft Final Report for the Department of Sustainability and Environment by The Murray-Darling Freshwater Research Centre, July, 234pp.

Kattel G, Campbell C, Johns C, Sharpe C, Henderson M and Wallace T (2009). The Living Murray Condition Monitoring at Hattah Lakes 2008/09. Draft Report prepared for the Department of Sustainability and Environment by The Murray-Darling Freshwater Research Centre, July, 237pp.

Client	DEPARTMENT OF SUSTAINABILITY AND ENVIRONMENT (VIC)
Project Title	The Living Murray 2009-2010 Condition Monitoring Lindsay–Mulcra–Wallpolla Islands and Hattah Lakes (M/BUS/323)
Contact Officer	Mr Mark Henderson - m.henderson@latrobe.edu.au
Project Duration	1 st July 2009 to 30 th June 2010
Research Theme	Habitat
Status	Current (continuation from M/BUS/283) Further information to be provided (10 th November 2009)

► Reports

Walters S, Henderson M, Wood D and Wallace T (2009) 2009-10 Condition Monitoring at Lindsay-Mulcra-Wallpolla Islands. A progress report prepared for the Department of Sustainability and Environment by The Murray-Darling Freshwater Research Centre, November, 4pp.

Walters S, Henderson M, Wood D and Wallace T (2009) 2009-10 Condition Monitoring at Hattah Lakes. A progress report prepared for the Department of Sustainability and Environment by The Murray-Darling Freshwater Research Centre, November, 4pp.

Client	DEPARTMENT OF WATER AND ENERGY (NSW)
Project Title	Determining the resilience of fish populations to drought in unregulated rivers (M/BUS/272)
Contact Officer	Dr Rick Stoffels - rick.stoffels@csiro.au
Project Duration	June 2008 to June 2010
Research Theme	Habitat
Status	Current

► Background

Drought has been a prominent feature throughout the recent evolutionary history of Australia. However, the global climate is now changing at a particularly rapid rate and climate models predict that, within Australia, droughts will increase in both magnitude and frequency. These changes in the frequency and duration of drought may have large impacts on flow regimes in unregulated rivers. In particular, the frequency and duration of zero-flow and drying events may increase, during which a river may be reduced to a series of pools.

These pools serve as drought refugia for freshwater fishes. The suitability of a pool as a drought refuge for a particular fish species will be determined not only by the physical, chemical and biological properties of the pool, but by the behavioural and bioenergetic traits of the fish species under consideration. Therefore, robust definition and identification of drought refugia requires knowledge of both the physical characteristics of the river system and of the bioenergetic and behavioural ecology of the species targeted for conservation. Behavioural traits affect a fish species' ability to cope with drought as they determine how well a fish finds adequate refugia and how well they can adapt their behaviour to the potentially stressful conditions (e.g. increased susceptibility to predation) associated with drought refugia. The bioenergetic traits of a fish species affects its productivity during a drought by determining how well a fish species copes with prolonged periods of physiological stress due to higher temperatures, food shortages and a shortage of dissolved oxygen. Such physiological stressors are naturally associated with pools that serve as refugia during drought. Moreover, the bioenergetics of a species also affects how well it recovers from periods of drought. That is, by understanding how fish partition energy under certain temperature and feeding regimes we can improve our understanding of how quickly individuals recover from physiological stress, and how soon they may allocate energy to gonad development for post-drought spawning.

► Aim

An experimental, bioenergetics research project as part DWE's monitoring and modelling of the Unregulated Water Sharing Plan. Due to financial constraints, the project will be focused on a single species, the purple-spotted gudgeon (*Mogurnda adspersa*), a species identified by the DWE as one of high research priority. However, it is worth noting that this project can be adapted to any other species. Indeed, we view this research project as Phase 1 of a larger research program that aims to develop physiologically-structured flow-response models—decision-support tools—for several key species, including river blackfish (*Gadopsis marmoratus*), mountain galaxias (*Galaxias olidus*) and golden perch (*Macquaria ambigua*).

► Objectives

Commence the development of two decision-support tools to aid in the identification of appropriate drought refugia for purple-spotted gudgeon, and to quantitatively define draw-down thresholds on those pools that serve as important drought refuges for purple-spotted gudgeon.

The first decision-support tool will be a bioenergetics model for purple-spotted gudgeon. This model will enable us to predict how the growth of individual purple-spotted gudgeon's is affected by prolonged exposure to the physical, chemical and biological conditions within drought refuges.

Whereas the first decision-support tool helps us understand the response of individuals to drought conditions, the second decision-support tool will improve our understanding of how populations respond to drought conditions in the long-term. The second decision-support tool will be a physiologically-structured population model that relates the physiological condition of individuals to population demographics, like survivorship and fecundity. This physiologically-structured model will require not only the information produced by the experimental bioenergetics project outlined here, but also data from a well coordinated, complimentary field research project, which will be lead by DWE staff.

The project has four components:

- 1) Estimation of the parameters of a bioenergetics model for purple-spotted gudgeon.
- 2) Determining the behavioural and metabolic response of purple-spotted gudgeon to hypoxia.
- 3) Experimental corroboration of bioenergetics model and determination of how energetic condition affects fecundity.
- 4) Modelling the resilience of purple-spotted gudgeon populations to drought scenarios.

▶ Reports

▶ Notes

In July 2009 the NSW government issued Administrative Orders abolishing the Department of Water and Energy (DWE). The water responsibilities formerly in DWE are now managed by the NSW Office of Water, in the Department of Environment, Climate Change and Water.

Client	DEPARTMENT OF WATER AND ENERGY (NSW)
Project Title	Reviewing information on the ecology of the purple-spotted gudgeon, <i>Mogurnda adspersa</i> (Eleotridae), in Australian rivers (M/BUS/297)
Contact Officer	Dr Rick Stoffels - rick.stoffels@csiro.au
Project Duration	December 2008 to March 2009
Research Theme	Habitat
Status	Current, awaiting confirmation from client regarding revised objectives and completion date (Rick Stoffels – 10 th November 2009)

► Objectives

1. Review existing published literature, “grey literature” and unpublished (personal communications with knowledgeable persons) information on the general ecology of purple-spotted gudgeons (*Mogurnda adspersa*), including:
 - The life history; habitat preferences/requirements; water quality tolerances (including dissolved oxygen, and temperature) migration/movement behaviour and cues; velocity and depth limits to passage, for purple-spotted gudgeon (*Mogurnda adspersa*), and where relevant, closely related fish species.
 - Implications of variation in water levels, particularly pool draw down during periods of low or no flow for all stages of its life cycle and habitat usage/requirements.
2. Review existing fish survey data sets for NSW to assess the known distribution, abundance and age classes of purple-spotted gudgeon in NSW, including Tenterfield Creek and priority water sharing plan areas.
3. Prepare a concise draft literature-data review document, prior to January 16 2009. This information is to be presented to fish scientists and DWE staff at a workshop, to be held around late January 2009 or early February. The purpose of the workshop is to discuss and receive comments on the literature and fish survey data reviews. DWE will organise the venue and attendance by internal and external scientists and staff. An electronic copy of the draft literature-data review document is to be provided to DWE 7 days prior to the workshop. Finalise the concise written literature-data review document, by February 28, 2009.

► Background

There is very little known about the purple-spotted gudgeon, *Mogurnda adspersa*, an endangered species in NSW. This paucity of knowledge jeopardises our ability to increase the viability of its populations, which face numerous threats, including habitat loss due to climate change. The purpose of this project is to collate existing information on the ecology of purple-spotted gudgeons and identify key knowledge gaps. This information will be presented in written report to Department of Water and Energy. A major focus of the review will be on how water extraction in unregulated rivers may affect the viability of purple-spotted gudgeon populations. This information review compliments another MDFRC research project, which aims to determine the physiological response of purple-spotted gudgeons to drought scenarios.

► Reports

► Notes

In July 2009 the NSW government issued Administrative Orders abolishing the Department of Water and Energy (DWE). The water responsibilities formerly in DWE are now managed by the NSW Office of Water, in the Department of Environment, Climate Change and Water.

Client	DEPARTMENT OF WATER AND ENERGY (NSW)
Project Title	Integrated Monitoring of Environmental Flows – Freshwater Shrimp in Regulated Rivers (M/BUS/278)
Contact Officer	Dr Amina Price - amina.price@latrobe.edu.au
Project Duration	1 st July 2008 to 30 th December 2009
Research Theme	Biota
Status	Current

► Background

Under the Integrated Monitoring for Environmental Flows (IMEF) Program, the NSW Department of Water and Energy (DWE) has collected samples from the Namoi and Gwydir Rivers over three field seasons. These samples were collected to examine relationships between river flows and fish recruitment. The samples collected have also been found to contain large numbers of freshwater shrimp. DWE is seeking to have these shrimp samples processed, the data entered and analysed and for conceptual models and/or hypotheses on the relationships between river flows and shrimp populations to be developed. In addition, DWE has requested that a project proposal designed to test the conceptual models and hypotheses be developed.

► Objectives

1. Process shrimp samples (identify to species and stage of development, count and measure the carapace length of the shrimp) collected as part of the IMEF monitoring program ensuring appropriate QA/QC checks. If necessary (due to large sample sizes), the minimum number of shrimp required to be processed and measured in order to provide a representation of the total sample will be calculated and a representative sub-sample will be processed.
2. Enter the data into a database ensuring appropriate QA of the data.
3. Analyse the data appropriately to allow for the elucidation of relationships between river flows, temperature and shrimp species composition, abundance and size-structure.
4. Based on the results from the data analysis of shrimp population size structure and abundance and habitat use, develop conceptual models describing the relationships between flow conditions and shrimp populations. These models will examine shrimp community composition and abundance, size and age (or stage) structure for individual species. Specific and testable hypotheses associated with these models will be developed.
5. Develop a proposal to test the hypothesis and/or conceptual models that we have developed.
6. Prepare a draft and a final report for DWE and present the key findings and conceptual models/hypotheses to DWE staff.

► Reports

- Price A (2008) Integrated monitoring of environmental flows - Freshwater shrimp in regulated rivers. Progress Report 1, September, 5pp.
- Price A (2008) Integrated monitoring of environmental flows - Freshwater shrimp in regulated rivers. Progress Report 2, November, 2pp.
- Price A (2009) Integrated monitoring of environmental flows - Freshwater shrimp in regulated rivers. Progress Report 4, May (Excel spreadsheet).
- Price A, Grouns J and Richardson A (2008) Integrated Monitoring of Environmental Flows – Freshwater Shrimp in Regulated Rivers. Project Manual.

► Notes

In July 2009 the NSW government issued Administrative Orders abolishing the Department of Water and Energy (DWE). The water responsibilities formerly in DWE are now managed by the NSW Office of Water, in the Department of Environment, Climate Change and Water.

Client	DEPARTMENT FOR ENVIRONMENT AND HERITAGE (SA)
Project Title	Interim maintenance and breeding of captive Murray hardyhead from Rocky Gully Wetland (Murray Bridge, South Australia) (M/BUS/310)
Contact Officer	Mr Iain Ellis - i.ellis@latrobe.edu.au
Project Duration	30 th April 2009 to 31 st May 2010
Research Theme	Biota
Status	Current

► Background

The Murray hardyhead is a small nationally threatened fish inhabiting mostly discrete saline waters in the mid and lower Murray-Darling Basin. The species is considered extinct in New South Wales and currently survives in a few isolated populations in South Australia and Victoria.

In South Australia, the Murray hardyhead survives in just four known locations: Rocky Gully Wetland, (near Murray Bridge), Dishers Creek and Berri evaporation basin (near Berri) and in the proximity of Hindmarsh Island in the Lower Lakes region of the Murray River system. Ongoing dry conditions and uncertainty over water delivery to the lakes means that the future survival of the species in these lakes is at risk.

Under their “Drought Action Plan”, the South Australian Department for Environment & Heritage (DEH) approached the MDFRC in March 2009 regarding captive maintenance of a sub-population of Murray hardyhead from Rocky Gully Wetland and Dishers Creek (SA) at the Mildura facility; as a backup population given delivery of water and maintenance of habitat *in-situ* at Rocky Gully is precarious.

► Reports

Ellis I and Pyke L (2009) Captive maintenance of Murray hardyhead from three South Australian wetlands (Boggy Creek, Dishers Creek and Berri Evaporation Basin) Quarterly Report #3 prepared for the Mallee CMA, North Central CMA and the Department of Sustainability and Environment by The Murray-Darling Freshwater Research Centre, December, 10pp.

Client	GRIFFITH UNIVERSITY
Project Title	National Climate Change Adaptation Research Facility (M/BUS/302)
Contact Officer	Dr Ben Gawne - b.gawne@latrobe.edu.au
Project Duration	2 nd March 2009
Research Theme	Knowledge Exchange
Status	Current, additional information, duration and background to be advised (Rosie Busuttill, 3 rd June, 2009).

► Overview

In 2007, the Australian Government committed funding to establish the National Climate Change Adaptation Research Facility (NCCARF). Based at Griffith University, NCCARF aims to identify the research and information required to adapt to the physical impacts of climate change (<http://www.nccarf.edu.au/>).

To achieve these aims, eight national research networks have been established to investigate ways to manage, and adapt to, the effects of climate change on areas such as water resources, human health, emergency services, settlements and infrastructure, and biodiversity. Research outputs will be focused on the needs of decision-makers in governments, vulnerable industries and communities as they respond to the likely impacts of climate change. The right to host the ‘Water Resources and Freshwater Biodiversity Adaptation Research Network’ was won by a bid comprising the universities and organisations listed below:

Griffith University (convener)

University of Adelaide	Australian National University	Charles Darwin University
CSIRO	James Cook University	MDFRC (MDBA, CSIRO, La Trobe)
Melbourne University	Monash University	Murdoch University
Museum of Victoria	NRETA	NSW Dept Climate Change
Qld University of Technology	SA Water	SARDI
University of Canberra	University of Newcastle	University of New South Wales
University of Southern Qld	University of Tasmania	University of Technology Sydney
University of Western Australia	Uniwater	

In accordance with the aims of NCCARF, the Water Network will develop research proposals that address adaptation to climate change. Proposals that yield national benefits and foster collaboration by including multiple institutions and disciplines will be encouraged. The primary goals of the network are to:

- Synthesise relevant knowledge to give Australian water and biodiversity managers the best chance of coping with a difficult climate future;
- Facilitate the development of collaborative and cross-disciplinary research at the national scale;
- Build research capacity through support and mentoring of early career scientists.

Victorian Node

The Water Network has been split into regional nodes that will facilitate interaction among researchers in each of the regions, as well as supporting researchers to attend meetings in other regions. The nodes will provide a point of contact for engagement with industry partners (e.g. state and local government agencies), and ensure that issues addressed are locally relevant. Uniwater, a joint initiative of the University of Melbourne and Monash University, is acting as the Victorian Node Coordinator through Monash University.

A priority of the Victorian Node is to facilitate future collaboration among researchers with shared research interests and complementary skills. Funding of projects will initially be sought from NCCARF on a competitive basis. It is envisaged that a maximum of three research proposals will be developed by the Victorian Node, though it is possible to develop proposals across regional nodes and research networks. Recognising that many research topics therefore cannot be included, the Victorian Node aims to develop strong proposals that address key knowledge gaps relating to climate change adaptation from an integrated, multi-disciplinary perspective.

▶ Activities

The coordinators of the overall Water Network have suggested a list of activities that the network will perform:

- Connect existing networks and expertise in water into the Water Network.
- Participate in an inception workshop that will establish strategic priorities for the next few years and decide on lead organisations and individuals for thematic issues.
- A mid-term international workshop/conference aimed at developing stronger links with international developments in the water/climate area.
- Synthesise existing and emerging research into themes.
- Facilitate open exchange of information and sharing of resources among research partners.
- Assist with developing detailed thematic research plans.
- Facilitate the establishment of research teams to work on priority areas with reference to the National Adaptation Research Plan.
- Provide support for early career scientists and postgraduate students to actively participate in regional and national meetings and workshops, and to be included in the development of research proposals.
- Provide access for university students to the water industry, and provide training and job experience in areas of importance to the water industry.
- Encourage and support co-supervision of students across research partners and, where relevant, across disciplines.

The Water Network has recently issued a call to produce synthesis papers aimed at communicating key issues, highlighting knowledge gaps and identifying the role of the network in helping to address these knowledge needs.

▶ Consultation Phase

The Victorian Node is conducting a series of meetings with researchers that have expressed an interest in the Water Network. Addressing the second goal of the Water Network, the aim of the meetings will be to identify common research interests and key knowledge gaps that limit the ability to adapt to climate change. This will be followed by a targeted workshop where research proposals and a Victorian Node plan will be developed.

▶ Reports

Client	GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY
Project Title	Broken River Restoration Project 2008/09 monitoring (M/BUS/285)
Contact Officer	Dr Daryl Nielsen - daryl.nielsen@csiro.au
Project Duration	1 st November 2008 to 30 th March 2009
Research Theme	Assessment
Status	Completed
	This is a continuation of projects M/BUS/105 and M/BUS/105-2 and entails fish and macroinvertebrate sampling for 2007/2008.

► Background

GBCMA has undertaken a long-term rehabilitation program of the Broken River which has included the re-introduction large woody debris (LWD) into selected sites within the Broken River. The re-snagging program commenced in July 2006 and the MDFRC has been monitoring fish populations bi-monthly until June 2008.

Data from the first two years of sampling has not indicated any statistically significant difference in fish communities between reference and re-snagged sites, however, the data does suggest that at one re-snagged site (Burnell's Road) the re-addition of wood is providing habitat for juvenile Murray cod.

The greatest numbers of fish sampled at all sites occurred during the summer months of 2006-07 and 2007-08. It is proposed that for the summer of 2008-09, three surveys will be undertaken (November 08, January 09 and March 09). Data would allow the GBCMA and the MDFRC to continue to track changes in fish populations in response to the re-snagging over the long-term, particularly if the surveys continue for a number of years.

► Objective

To continue monitoring the Broken River to determine the impacts of re-snagging on the fish community within the river. Specifically the long-term objective is to determine whether there are temporal changes in the abundance, species richness, composition and age structure of fish as a result of re-snagging.

► Reports

Nielsen D, Vogel M and Stoffels R (2009). Broken River Rehabilitation Project: Summary Report 2009. Report prepared for Goulburn Broken Catchment Management Authority by The Murray-Darling Freshwater Research Centre, April, 14pp.

Client	GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY
Project Title	Monitoring of Broken Creek: Water Quality and System Understanding - <i>Azolla</i> III (M/BUS/211-2)
Contact Officer	Dr Gavin Rees - gavin.rees@csiro.au
Project Duration	19 th May 2008 to 31 st December 2008
Research Theme	Assessment
Status	Current, on-going discussion with client, with the potential of securing a new phase for continuation. Report to be finalised with outline of new phase (Gavin Rees, 3 rd June 2009) This project is a follow on from the “Ecological Model and Data Assessment Broken Creek” (M/BUS/69-2) and “The lower Broken Creek: aspects of water quality and growth of <i>Azolla</i> species” (M/BUS/211)

► Objectives

- Carry out real-time monitoring of the lower Broken Creek to assess any links between *Azolla* growth and declining water quality.
- To examine possible mechanisms for the *Azolla* boom and bust cycles in the Broken Creek.

► Methodology

- In conjunction with the client and Thiess-services, deploy real-time DO, temperature and weather monitoring systems. Deploy a real-time camera system to determine distribution of *Azolla* within Broken Creek.
- Use standard methods to determine the nutrient status in Broken Creek.
- Deploy thermisters to measure diurnal stratification.
- Deploy additional DO probes to measure longitudinal changes in DO within Broken Creek.

► Reports

Client	GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY
Project Title	Effects of Turbidity on native fish populations: an ecosystems-scale experiment (M/BUS/292)
Contact Officer	Dr Rick Stoffels - rick.stoffels@csiro.au
Project Duration	1 st November 2008 to 30 th October 2009
Research Theme	Habitat
Status	Current

► Background

Many catchment management practices influence the quality of runoff, hence the turbidity of streams and rivers that receive that runoff. However, we have almost no understanding of how turbidity influences native fishes. Turbidity may affect fishes in both direct and indirect ways. For example, turbidity may directly interfere with cues (visual, mechanical) fish utilise to catch prey, whereas it may indirectly affect fishes by reducing levels of primary production, which in turn results in reduced prey productivity. Preliminary data from the Broken River shows that the abundance of certain small fish species may be negatively correlated with turbidity, but an experiment is needed to disentangle the effects of turbidity from the many other factors that covary with turbidity.

The decommissioning of Lake Mokoan presents managers with a rare opportunity to conduct a scientifically rigorous, ecosystem-scale experiment that will improve our understanding of how turbidity influences the productivity of fish populations in lowland rivers. That is, the decommissioning of Lake Mokoan enables a BACI experimental design (before (pre-decommissioning), after (post-decommissioning), control (upstream of Casey’s Weir, hereafter CW), implementation/impact (downstream of CW)), one that is known to be particularly powerful when it comes to elucidating the impact of ecological variables, such as turbidity. Here, we aim to determine the impact that the Lake Mokoan decommissioning - hence turbidity reduction - has on the structure of lowland fish communities.

► Objectives

- 1) Determine structure of fish community above (low turbidity) and below (high turbidity) Casey’s Weir in the Broken River.
- 2) Monitor changes in fish community structure after the decommissioning of Lake Mokoan, hence as turbidity declines in the lower reaches of the Broken River.

► Methodology

The decommissioning of Lake Mokoan presents a unique BACI experimental design on the Broken River, whereby we have a fully factorial ANOVA design with two major factors, each of which has two treatments: “turbidity” (low turbidity, upstream of Mokoan inflows, and high turbidity, downstream of Mokoan inflows) and “time” (before decommissioning and after decommissioning).

We will establish ten sites within the Broken River, five sites in the low turbidity reach and five in the high turbidity reach, each of which will be randomly located. Our aim is to obtain one year of community structure data at all sites before decommissioning, and several years of community structure data after decommissioning as funding becomes available - currently we only have funding for the first year of the project, the “before” data. During the first year we will determine fish community structure at all sites, within each season. The fish community will be sampled using a range of active (electrofishing) and passive (fyke and seine nets) techniques.

In addition, we will individually tag (PITs) all Murray cod and golden perch, in an effort to improve our understanding of the growth and demographic dynamics of these species. Moreover, the habitat structure at each site will be mapped in detail so that we can obtain additional information on the habitat preferences of fishes in lowland rivers.

▶ Reports

Client	LA TROBE UNIVERSITY
Project Title	Australian Tourism in a Water Constrained Economy: Scoping Study (M/BUS/303)
Contact Officer	Dr Ben Gawne - b.gawne@latrobe.edu.au
Project Duration	2 nd March 2009 to 30 th October 2009
Research Theme	Knowledge Exchange
Status	Current

► Background

Description of Project Outcomes

The project will deliver an analytical framework to guide and inform water-related research that is relevant to the tourism industry on two fronts.

- First, the project will set out the process for garnering scientifically-verifiable information that can influence the formulation of Australian water policy. The project will develop a research agenda that will ensure that matters critical to tourism and recreation assume greater prominence in policy forums than has occurred to date. Water resources remain highly contested at the political level and the absence of detailed information on the relationship between water and tourism has limited the capacity of the tourism industry to influence important water-related decisions by state and national governments.
- Second, the project will provide data, information and point towards appropriate solutions for industry practitioners. Importantly, this deliverable will assist the tourism sector to plan effectively at a time when access to water is becoming increasingly constrained.

In broad terms the project has three core aims:

1. to map the process for increasing our understanding of fresh water as an input in the production of tourism outputs;
2. to illustrate the modelling required to establish the trade-offs and complementarities between the use of water for the production of tourism versus other outputs (e.g. agriculture, urban/industrial, environmental);
3. to test and explore the range of policy and institutional responses that would be required to deliver an optimal allocation between competing water demands – including those arising from activities related to tourism.

Research Team

Dr Lin Crase (La Trobe University)
 Professor Ben Gawne (La Trobe University)
 Dr Sue O’Keefe (La Trobe University)
 Professor Fiona Haslam McKenzie (Curtin University)
 Dr Ronlyn Duncan (University of Tasmania)
 Dr Pierre Horwitz (Edith Cowan University)

► Reports

Crase L, Gawne B and Hillman T. Draft. Coase-coloured glasses and rights bundling: Why the initial specification of water rights in volumetric terms matters. October, 13pp.

Client	LACHLAN CATCHMENT MANAGEMENT AUTHORITY
Project Title	Spawning and recruitment of native fish in the Lachlan Catchment (M/BUS/295)
Contact Officer	Dr Amina Price - amina.price@latrobe.edu.au
Project Duration	1 st January 2009 to 31 st December 2009
Research Theme	Habitat
Status	Current

► Background

This research represents the first component of a three year project aimed at investigating the distribution and long-term viability and sustainability of native fish populations in the Lachlan River. The sustainability of fish populations is based on two key processes: 1) the occurrence of regular spawning events and 2) successful recruitment of larvae to the adult population. The project proposes to investigate both of these processes for fish populations in the Lachlan River over three years by examining both the population structure of fish populations and the spatial and temporal spawning and recruitment patterns of fish within the catchment. These patterns will then be related to environmental conditions such as temperature and flow regimes, connectivity and in-stream habitat features to determine which factors are influencing spawning and recruitment success.

As the timing for the commencement of this project precludes a full sampling season for larvae (September to March), the initial component (November 2008 – November 2009) will examine the size structure and recruitment patterns of fish within the river and their relative condition. Measurement of fish condition gives an indication of a fish's physiological condition and growth in response to their environment.

Specifically, the project will:

- Examine the recruitment patterns of fish (which species have successfully recruited and where) in the Lachlan catchment.
- Determine the population structure of fish populations in Lachlan catchment.
- Examine the condition of fish in the Lachlan catchment.
- Relate patterns in fish recruitment and condition to environmental conditions (temperature, water quality, food availability).

This one year project will provide information regarding the condition, distribution and size structure of current populations and of the location of recruitment 'hot-spots' within the river. This information will provide the CMA with baseline data that can be utilised for future assessments of the impacts of management interventions on native fish populations and a report card of the health of native fish populations throughout the system. In addition, knowledge of the recruitment patterns and of the factors that may be impacting on spawning and recruitment, may be used to inform decision-making (e.g. regarding the prioritisation of management actions and/or the identification of high conservation value sites) to yield the best outcomes for native fish communities.

► Reports

Price A (2009) Draft Distribution and recruitment patterns of Fish in the Lower Lachlan River. Draft Report prepared for the Lachlan Catchment Management Authority by The Murray-Darling Freshwater Research Centre, December, 46pp.

Client	LACHLAN CATCHMENT MANAGEMENT AUTHORITY
Project Title	Fish Spawning and Recruitment in the Lachlan River – Stage 2 (M/BUS/295)
Contact Officer	Dr Amina Price - amina.price@latrobe.edu.au
Project Duration	1 st July 2009 to 30 th June 2011
Research Theme	Habitat
Status	Current

▶ Background

This research represents the second component of a three year project aimed at investigating the distribution and long-term viability and sustainability of native fish populations in the Lachlan River. The sustainability of fish populations is based on two key processes: 1) the occurrence of regular spawning events and 2) successful recruitment of larvae to the adult population. The project proposes to investigate both of these processes for fish populations in the Lachlan River over three years by examining both the population structure of fish populations and the spatial and temporal spawning and recruitment patterns of fish within the catchment. These patterns will then be related to environmental conditions such as temperature and flow regimes, connectivity and in-stream habitat features to determine which factors are influencing spawning and recruitment success.

This phase of the project will focus on fish spawning and recruitment patterns within the Lachlan Catchment. Specifically, the project will:

- Examine the spawning patterns of fish (which species have spawned and where).
- Examine the recruitment patterns of fish (which species have recruited and where).
- Relate patterns in fish spawning and recruitment to environmental conditions (temperature, water quality, food availability).

▶ Reports

Client	LOWER MURRAY DARLING CATCHMENT MANAGEMENT AUTHORITY
Project Title	Lower Darling River Fish-Habitat Investigation (M/BUS/301)
Contact Officer	Mr Clayton Sharpe - c.sharpe@latrobe.edu.au
Project Duration	30 th January 2009 to 30 th June 2009
Research Theme	Habitat
Status	Completed

▶ Aims and Objectives

This project aims to:

- (a) characterise the available structural habitat of refuge pools and adjacent runs at those sites investigated by Wallace et al. (2008).
- (b) enable examination of which, if any, habitat characteristics define the species, size and number of fish associated with snags of particular character at those sites investigated by Wallace et al. (2008).

The project objectives will be addressed by:

- 1) Quantifying the density, plan-form area, complexity, orientation and aspect of large-woody debris (snags), and determining the distance between snag complexes, by employing contemporary visual (surface) and acoustic (underwater sonar) mapping techniques.
- 2) Quantifying the species composition and distribution of emergent aquatic macrophytes.
- 3) Examining instantaneous water quality (pH, EC, NTU, DO, Temp) along 3X vertical and 3X longitudinal transects in run and pool habitats.
- 4) Examining the assemblage and population structure of fish in relation to individual habitat(s), (i.e. at the micro-habitat scale; individual snag/vegetation unit).

This information will be useful for the management of refugia for native fish in the lower Darling River, as well as for future habitat rehabilitation works undertaken by the LMDCMA and other agencies in the Murray-Darling Basin. The knowledge gained here may inform the appropriate structure, number and spatial location of snags best suited to achieve a host of fish population/community maintenance or rehabilitation goals.

▶ Reports

Sharpe C, Bindokas J, Rehwinkel R and Fraser P (2009) Fish-Habitat relationships in the Lower Darling River. Final Report prepared for the Lower Murray Darling Catchment Management Authority by The Murray-Darling Freshwater Research Centre, October, 34pp.

Client	MALLEE CATCHMENT MANAGEMENT AUTHORITY
Project Title	Threatened Aquatic Species Management - Murray hardyhead 08/09 (M/BUS/284)
Contact Officer	Mr Iain Ellis - i.ellis@latrobe.edu.au
Project Duration	1 st July 2008 to 30 th June 2009
Research Theme	Biota
Status	Completed Continuing project from Threatened Aquatic Species Management - Age Structure and Food Source Availability of the Murray hardyhead (M/BUS/80-1, 2, 3 and 4)

► Background

This project is an extension of the current study of the population size and structure of the Victorian FFG listed Murray hardyhead (*Craterocephalus fluviatilis*) at Cardross and Hawthorn Lakes in the Mallee region, and captive maintenance of breeding populations from each wetland. The project consists of three components (Population monitoring, summertime water quality and habitat monitoring, and ongoing captive maintenance).

Recent monitoring by the MDFRC has indicated that ongoing drought conditions, water shortages and operational complications have resulted in significant reduction in water level and water quality at both the Cardross Lakes and Lake Hawthorn. In particular, continued reduction in the abundance of Murray hardyhead was identified in Cardross Basin 1 during 2007/08 (Ellis 2008). Monitoring suggests all fish species in the western section of Cardross Basin 1 (Basin 1 West) perished through late 2007 and early 2008, including Murray hardyhead. Environmental watering of the smaller Cardross Basin 1 East in 2007/08 resulted in the preservation of a small population of Murray hardyhead. Murray hardyhead also continue to survive in the eastern area of Lake Hawthorn where small drainage inflows maintain a lower salinity than the northern and western areas in the lake. Successful recruitment in any area of Lake Hawthorn is considered unlikely in 2008/09 at current salinity levels.

The salinity in both Cardross Basin 1 West and Lake Hawthorn is escalating as a result of evaporative concentration of salts and possible groundwater intrusion. Although the species is regarded as relatively salt tolerant, the impact of increasing salinity on developing egg and larval stages is unknown. Furthermore, increases in salinity may indirectly threaten Murray hardyhead by causing a progressive reduction in the diversity of each wetlands zooplankton community (Nielsen et al. in prep), which constitute a major component of Murray hardyhead diet (Ellis 2006).

The last four years of monitoring by the MDFRC has highlighted the fact that salinity is not the only threat to the ongoing viability of Murray hardyhead populations in Lake Hawthorn and Cardross Basin 1. Reductions in water level in both systems pose immediate threats to each population through:

- Reduction in both the quantity and quality of available habitat as the water level in each lake decreases.
- Associated with this is a loss of connectivity between the water body itself and fringing vegetation, which may provide important habitat to various life stages of Murray hardyhead (Ellis 2005, 2006).
- As water levels fall beds of the submerged aquatic plant *Ruppia sp.* in both lakes (which are usually suspended throughout the water column) collapse into thick physical barriers, reducing available habitat for foraging, refuge and as a substrate for spawning.

- Reduced water levels also impact on habitat quality through higher water temperatures. Elevated water temperatures may also decrease concentrations of dissolved oxygen (DO) in the water column, indirectly stressing fish and other organisms and resulting in mortality in extreme cases. This was highlighted by the deaths of thousands of carp in Lake Hawthorn in late 2006 (Ellis personal observation).

The project will improve our understanding of the population structure and status, environmental requirements, and threats to this threatened species through targeted assessment of spawning activity and recruitment success over consecutive breeding seasons. Ongoing monitoring of the size structure of each population throughout consecutive breeding cycles will provide a clearer picture of the seasonal dynamics and inter-annual variability of population size and structure for the species.

► Reports

Ellis I (2009) Conservation of the EPBC Act listed Murray Hardyhead. Captive Murray Hardyhead from Lake Hawthorn and Cardross Basin 1 (near Mildura, VIC). Progress Report for the Mallee CMA, North Central CMA and Department of Sustainability and Environment, January, 16pp.

Ellis I and Pyke L (2009) Captive maintenance of Murray hardyhead from two Victorian wetlands (Lake Hawthorn and Cardross Basin 1) and three South Australian wetlands (Boggy Creek, Disher's Creek and Berri Evaporation Basin). Report prepared for the Mallee Catchment Management Authority, Victorian Department of Sustainability and Environment and the South Australian Department for Environment and Heritage by The Murray-Darling Freshwater Research Centre, June, 12pp.

Ellis I and Pyke L (2009) Population monitoring of Murray hardyhead *Craterocephalus fluviatilis* in wetlands near Mildura (Victoria), preliminary assessment of translocation site, and status of the captive breeding program. Report prepared for Mallee Catchment Management Authority, June, 53pp.

Client	MALLEE CATCHMENT MANAGEMENT AUTHORITY
Project Title	Conservation of Murray hardyhead (<i>Craterocephalus fluviatilis</i>) 2008-2009 preliminary monitoring of translocation sites and expansion of the maintenance program (M/BUS/284) Part 2
Contact Officer	Mr Iain Ellis - i.ellis@latrobe.edu.au
Project Duration	1 May 2008 to 31 December 2009
Research Theme	Biota
Status	Current
	Continuing project from Threatened Aquatic Species Management - Age Structure and Food Source Availability of the Murray hardyhead (M/BUS/80-1, 2, 3 and 4)

► Background

Recent monitoring by the MDFRC has indicated that ongoing drought conditions, water shortages and operational complications have resulted in significant reduction in water level and water quality at both the Cardross Lakes and Lake Hawthorn monitoring suggests all fish species in the western section of Cardross Basin 1 (Basin 1 West) and Lake Hawthorn perished through 2008, including Murray hardyhead. Environmental watering of the smaller Cardross Basin 1 East in 2007/08 has resulted in the preservation of a small population of Murray hardyhead, with evidence of small scale breeding occurring in late 2008.

The proposed project will indicate the success of environmental watering programs in conserving Murray hardyhead and creating suitable translocation habitat through targeted assessment of spawning activity and recruitment success over consecutive breeding seasons. Ongoing monitoring of the size structure of each population throughout consecutive breeding cycles will provide a clearer picture of the seasonal dynamics and inter-annual variability of population size and structure for the species. Cardross Basin D and Koorlong Lake are currently being explored as a translocation site for Murray hardyhead from either Cardross Basin 1 East, or from the captive population at MDFRC should breeding events this year provide sufficient numbers from which to harvest.

► Objectives

The proposal consists essentially of three components.

1. Quarterly fish and water monitoring in Koorlong Lake and Cardross Basins 1 East and D.
2. Ongoing Captive to house captive fish (until December 31, 2009).
3. Consulting with Victorian and interstate managers and community groups and workshops regarding conservation of the Murray hardyhead.

► Reports

Client	MALLEE CATCHMENT MANAGEMENT AUTHORITY
Project Title	Aquatic Vertebrate Surveys at Kings Billabong (M/BUS/308)
Contact Officer	Mr Iain Ellis - i.ellis@latrobe.edu.au
Project Duration	11 th March 2009 to 30 th June 2009
Research Theme	Assessment
Status	Completed

▶ Background

The Mallee Catchment Management Authority (MCMA) are investigating options for managing hydrological regimes of three Mallee wetland systems, at which the hydrology has been altered from ephemeral (alternating between dry and wet phases) to almost permanent inundation and connection to the Murray River above its regulatory weirs.

▶ Aims

Assess the diversity and abundance of aquatic fauna in Margooya Lagoon, Sandilong Creek and backwaters, and Kings Billabong Wildlife Reserve (including Ducks Foot Lagoon, Butlers Creek, and Kings Billabong). The information collected will complement that of existing monitoring programs (water quality, macroinvertebrates and vegetation), and provide recommendations for future management and monitoring of the wetlands to conserve and potentially increase the biodiversity of the wetlands.

An understanding of the presence/absence of aquatic vertebrates in each system and identifying threatened species or communities of importance is essential in the interpretation of potential impacts of the proposed management of these wetland systems.

▶ Reports

Chapman D, Ellis I and Pyke L (2009) Mallee aquatic vertebrate surveys at three wetland systems in the Mallee. Preliminary Report to the Mallee Catchment Management Authority, June, 4pp.

Chapman D, Ellis I and Pyke L (2009) Aquatic Vertebrate Surveys in three wetland systems in the Mallee. Final Report to the Mallee Catchment Management Authority, June 30pp.

Client	MALLEE CATCHMENT MANAGEMENT AUTHORITY
Project Title	Aquatic Vertebrate Surveys at Kings Billabong Part 2 (M/BUS/322)
Contact Officer	Mr Iain Ellis - i.ellis@latrobe.edu.au
Project Duration	3 rd August to 30 th November 2009
Research Theme	Assessment
Status	On-going – continuation of M/BUS/308

► Background

The Mallee Catchment Management Authority (MCMA) are investigating options for managing hydrological regimes of three Mallee wetland systems, at which the hydrology has been altered from ephemeral (alternating between dry and wet phases) to almost permanent inundation and connection to the Murray River above its regulatory weirs. This project aims to thoroughly assess the diversity and abundance of aquatic fauna in Margooya Lagoon, Sandilong Creek and backwaters, and Kings Billabong Wildlife Reserve (including Ducks Foot Lagoon, Butlers Creek, and Kings Billabong). The information collected will complement that of existing monitoring programs (water quality, macro-invertebrates and vegetation), and provide recommendations for future management and monitoring of the wetlands to conserve and potentially increase the biodiversity of the wetlands.

An understanding of the presence/absence of aquatic vertebrates in each system and identifying threatened species or communities of importance is essential in the interpretation of potential impacts of the proposed management of these wetland systems.

► Objectives

1. Carry out surveys in Spring 2009 to obtain information about the diversity, relative abundance and population size structure of fish assemblages within Margooya Lagoon, Sandilong Creek and backwaters, and King's Billabong Wildlife Reserve (including Ducks Foot Lagoon, Butlers Creek, Psyche Creek and Kings Billabong), and record the presence / absence of turtle and frog species in each wetland system (above).
2. Conduct these surveys using standard methods to allow comparison with past and future surveys.
3. Describes the aquatic habitat of each site surveyed using AUSRIVAS physical and chemical assessment protocols.
4. Provide recommendations for management of each wetland system and suggestions for further work.

► Reports

Client	MURRAY CATCHMENT MANAGEMENT AUTHORITY
Project Title	Assessing the Impacts of Recreational Boating Activities on River Bank Stability (M/BUS/226)
Contact Officer	Dr Darren Baldwin - darren.baldwin@csiro.au
Project Duration	1 st April 2007 to 30 th April 2009
Research Theme	Assessment
Status	Completed

► Objectives

- A) Review the national and international literature.
- B) Develop a methodology and conduct field research on the frequency of use from different types of recreational boats within the Murray River, to assess their effects on bank stability caused by:
- the size of wave from various recreational boats
 - the various wave action affects
 - any correlation between the boats and wave action.

Stage 1 - Literature Review - completed

► Outcomes

National and international scientific studies summarised.

An outline of the relative importance of various erosive mechanisms on sediment delivery at the catchment scale.

An assessment of whether or not geochemical indicators can be used to differentiate between sediment derived from gully erosion in, the upper catchment and sediment derived from channel erosion.

Stage 2 - Draft Review and Methodology for Field Study

Stage 3 - Field Study

To address an assessment of techniques for determining the relative impacts of river bank erosion and whether or not they can be used to differentiate erosion impacts from various forms of recreational boating. Conduct field studies on at least three discrete locations.

Stage 4 - Submission of Final Report recommendations.

► Reports

Huzzey L and Baldwin D (2007) Impacts of Recreational Boating on River Bank Stability: a literature review (Stage 1). Report prepared for the Murray Catchment Management Authority, May, 26pp.

Baldwin DS and Boulding A (2007) Progress Report – Impact of recreational boating on bank erosion in the Murray River. Progress Report prepared for the Murray Catchment Management Authority, August, 6pp.

Baldwin DS (2008) Impacts of Recreational Boating on River Bank Stability: Wake Characteristics of Powered Vessels. Report prepared for the Murray Catchment Management Authority, March, 31pp.

Baldwin DS, Boulding A and Huzzey L (2009) Impacts of Recreational Boating on Bank Stability in the River Murray. Final Report prepared for the Murray Catchment Management Authority by The Murray-Darling Freshwater Research Centre, May, 89pp.

Client	MURRAY CATCHMENT MANAGEMENT AUTHORITY
Project Title	Interpretation of analysis data from perennial and ephemeral streams in the Murray Catchment (M/BUS/264)
Contact Officer	Dr Daryl Nielsen - daryl.nielsen@csiro.au
Project Duration	31 st March 2008 to 31 st December 2008
Research Theme	Review
Status	Current, this project is on hold until the present drought conditions cease (Daryl Nielsen 4 th June 2009)

▶ **Background**

The Murray CMA is collecting catchment run-off data from several streams within their region. The MDFRC is providing technical expertise in the analysis of data and interpretation of salinity data quarterly for the remainder of the 2008 calendar year.

▶ **Aims**

- Compare and interpret cation and anion data for each stream.
- Provide a brief overall description of the stream (i.e. if there will be any downstream impacts, where the salt is coming from (e.g. base flow, run off), what parameters exceed the ANZECC guidelines, general health of the stream etc).

▶ **Reports**

Client	MURRAY CATCHMENT MANAGEMENT AUTHORITY
Project Title	Climate Change Monitoring in the Murray River Catchment using Macroinvertebrates (M/BUS/318)
Contact Officer	Mr Rob Cook - r.a.cook@latrobe.edu.au
Project Duration	June 2009 to June 2010
Research Theme	Biota
Status	Current

► Background

A comprehensive review of the scientific literature on the known and potential impacts of climate change on stream communities will be conducted. This review will inform the development of the predictions and hypothesis that will be investigated and will inform the design of targeted sampling regimes. In conjunction with this review an evaluation of a range of methods for assessing biological change with particular reference to macroinvertebrates and climate change impacts will be conducted. This will enable the most appropriate sampling and analytical techniques to be employed to test the hypotheses generated.

Subsequent to this review, a field based pilot study will be conducted based on the recommendations to assess the applicability of the recommendations. A final report will then be prepared which will present the results, analysis and findings from the pilot study and final recommendations for a monitoring strategy for the Murray Catchment Management Authority (Murray CMA).

► Objectives

- Provide a review of the known and predicted impacts of climate change on stream biota with an emphasis on aquatic macroinvertebrates.
- Provide an evaluation of the potential techniques for assessing climate change impacts and there application to the Murray Catchment with particular emphasis on aquatic macroinvertebrates.
- Provide recommendations on the most appropriate techniques for a hypothesis based biological monitoring program within the Murray CMA management area.
- To establish a hypothesis based biological monitoring program for the Murray CMA which will investigate the impacts of climate change on river health and the resilience of the biotic communities.

► Reports

Client	MURRAY CATCHMENT MANAGEMENT AUTHORITY
Project Title	Understanding Blackwater Events and Managed Flows in the Wakool System – A Scoping Study (M/BUS/319)
Contact Officer	Dr Darren Baldwin - darren.baldwin@csiro.au
Project Duration	May 2009 to June 2010
Research Theme	Connectivity
Status	Current

▶ Background

Recent Murray cod mortalities in the Wakool River region have highlighted the paucity of information of blackwater events, in particular in relation to managed flows. Blackwater events are caused by the inundation of high loads of carbon during high water temperatures, following drying events. This in turn decreases oxygen levels in the water column to limits lethal to aquatic organisms. These events have occurred historically, however, recent management practices have seen an increase in fish mortalities.

Many permanent and ephemeral creeks in the Wakool region and other parts of NSW have recently dried as a result of water abstraction and drought conditions. Blackwater events are likely to become more common due to current management practises of releasing flows for irrigation purposes under drought conditions without consideration of timing and carbon loads. We wish to broaden our understanding of blackwater events through an investigation of carbon dynamics in order to better inform managers in this region.

▶ Objectives

1. Develop a statement of current understanding of blackwater events.
2. Undertake a baseline assessment of carbon dynamics of creeks within the Wakool region.
3. Communication of project findings.

▶ Reports

Hladyz S, Watkins SC and Baldwin DS (2009). Current understanding of blackwater events relating to the Edward-Wakool River System. Draft Report prepared for the Murray Catchment Management Authority by The Murray-Darling Freshwater Research Centre, October, 43pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Macroinvertebrate Monitoring Program 2007/08 to 2009/10 (M/BUS/244)
Contact Officer	Mr John Hawking - j.hawking@latrobe.edu.au
Project Duration	1 st July 2007 to 30 th June 2010
Research Theme	Assessment
Status	Current

► Background

This project was formed by merging two monitoring projects undertaken for the MDBC into one project:

- Upper Murray – (Biggara, Jingellic and Yarrawonga – M/BUS43), and
- Lower Murray – (Euston, Lock 9 and Burtundy – M/BUS/101).

The MDFRC has conducted Macroinvertebrate Monitoring for the MDBC at two sites, Jingellic (Site 801) and Yarrawonga (Site 804), as part of the MDBC Water Monitoring Quality Program, since 1980. In November 2005, the MDFRC was contracted by Goulburn-Murray Water, on the MDBC's behalf, to undertake the macroinvertebrate monitoring at Yarrawonga (Site 804), Euston (Site 808), Lock 9 (Site 811) and Burtundy (Site 810) for two years (spring 2005 to autumn 2007).

► Objectives

The macroinvertebrate component of the MDBC's River Murray Water Quality Monitoring Program (WQMP), primary aim is to systematically sample and record the aquatic macroinvertebrate populations of the rivers in such a way as to provide a substantial long-term biological record to complement chemical and physical data being collected, and so provide an additional aid to detecting and interpreting changes in water quality and environmental conditions in the River Murray and its tributaries. To conduct biological monitoring, which includes the placement and retrieval of macroinvertebrate traps and collection of water quality data, identification of the invertebrates to species/taxa level, reporting via database and hard copy, for six sites.

► Reports

McInerney P and Hawking J (2009) Murray River Macroinvertebrate Monitoring Program. Report prepared for the Murray-Darling Basin Authority by The Murray-Darling Freshwater Research Centre, May, 5pp.

Ratnarajah L, McInerney P and Hawking JH (2009) Murray River Macroinvertebrate Monitoring Program Milestone Report. Final Report prepared for Murray-Darling Basin Authority, September, 18pp.

Ratnarajah L and Hawking J (2009) Murray River Macroinvertebrate Monitoring Program. Progress Report prepared for the Murray-Darling Basin Authority by The Murray-Darling Freshwater Research Centre, December, 5pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Mitta Mitta River Catchment Long-Term Monitoring Project: Continuation of the existing ecological monitoring of the river health below Dartmouth Dam and the additional monitoring sites in the Upper Mitta Mitta Catchment (M/BUS/291)
Contact Officer	Mr John Hawking - j.hawking@latrobe.edu.au
Project Duration	30 th June 2009 to 30 th December 2011
Research Theme	Assessment
Status	Current, this project is a continuation of M/BUS/266

► Background

The current project investigates the Mitta Mitta River and several tributaries below Dartmouth Dam and it is suggested that this valuable monitoring continue. However, this study ignores the river health of the Mitta River catchment above Dartmouth Dam. This revised project will study the macroinvertebrate communities at strategic sites to detect degradation in the upper Mitta River, above the lake to its alpine source. Nine monitoring sites are proposed. Five sites on the Mitta River proper: (1) Alpine site, on Whiterock Creek, the source of the Big River; (2) Subalpine site, The Big River, Mt Nelse Track, with dense Mountain Ash stands; (3) Big River, in the Glen Valley, subjected to farming and mining; (4) Mitta Mitta River, in the the Omeo Valley, subjected to intense farming and land clearing, especially the riparian vegetation; (5) Mitta Mitta River, in the Alpine National Park, above Dartmouth Dam. Four tributaries of the Mitta Mitta River, with two impacted: (6) Livingstone Creek, Omeo Valley, (7) Bingo Munjie Creek, Bingo Munjie. Which are subjected to intense farming; Two streams forested and least impacted: (8) Cobungra River, Cobungra Valley; (9) Gibbo River, in the Alpine National Park.

The study will use AusRivAs methods and SEPP guidelines to assess river health values, which has the ability to detect the presence of environmental impairment or degradation, from the past and present catchment management practices. The study will be conducted over three years, with sampling in spring and autumn each year. This expanded project will value add to the existing monitoring program by providing a more detailed evaluation of the total Mitta Catchment from the headwaters of the Big River to the junction with the Hume Dam and fulfil the Commissions duty to identify catchment impairment that degrades the health of the river.

► Methodology

The project follows the Vic EPA AUSRIVAS methods for biological assessment (EPA Vic 2003).

- Sample edge and riffle habitats, live pick for macroinvertebrates, and identify to species level (a variation on the Vic EPA methods is that all invertebrates are identified to the lowest taxonomic level to provide a biodiversity listing for each site, as well as a family level result).
- Undertake habitat assessments at each site.
- Measure standard physical and chemical parameters and perform additional nutrient analysis to provide greater information on water quality parameters.
- Determine indexes for the following metrics; taxa richness, O/E ratio, EPT, key taxa, SIGNAL
- Use the Victorian AUSRIVAS model to determine the river health score and determine band placement.

► Reports

Davey C and Hawking J (2009). Mitta Mitta Monitoring Program: Progress Report. Report prepared for the Murray-Darling Basin Authority by The Murray-Darling Freshwater Research Centre, May, 4pp.

Davey C (2009) Mitta Mitta Monitoring Program: Progress Report, Spring 2009. Report prepared for the Murray-Darling Basin Authority by The Murray-Darling Freshwater Research Centre, December, 40pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Drought Contingency Monitoring of NSW Wetlands–Euston Lakes system (M/BUS/247)
Contact Officer	Dr Bernard McCarthy - b.mccarthy@latrobe.edu.au
Project Duration	17 th August 2007 to 15 th December 2009
Research Theme	Assessment
Status	Current

► Objectives

To monitor selected wetlands to detect potential change in their ecological value due to drought contingency measures. Wetlands to survey are:

- Euston Lakes system (Murray River near Euston/Robinvale) – M/BUS/247
- Back Creek and Tumudgery Creek (Edwards River) – M/BUS/250
- Salt Creek/Tareena Billabong (Murray River near SA Border) – M/BUS/251

► Methodology

Methods will follow the recommended monitoring protocol outlined in Wallace et al. (2007) – Reference to M/BUS/232. The components and their frequency of sampling include:

- Water quality and levels (sampling frequency = 1 month)
- Blue-green algae (sampling frequency = 3 months)
- Groundwater (sampling frequency = 3 months)
- Tree vegetation (sampling frequency = 6 months)
- Fish (sampling frequency = 3 months)
- Photo-points (sampling frequency = 3 months)

► Overview

Four permanent wetlands in NSW have been identified for disconnection from the main river channel as part of the drought contingency measures. This project will monitor the ecology of these wetlands over a two year period to evaluate ecological values before, during and after their disconnection. The project will adopt the methods of Wallace et al. (2007).

As part of the program, water quality and levels, acidification potential, blue-green algae, groundwater, river red gum and fish will be monitored. Photo-points will also be established to assess visual changes in wetland condition over time. Results from each field trip will be evaluated against pre-determined trigger thresholds to ensure management is informed of the condition of the wetlands throughout the project.

► Reports

Baldwin DS, Fraser MA and McCarthy B (2008) Assessment of sulfidic sediments at Washpen Creek, NSW. Report prepared for the Murray-Darling Basin Commission, April, 10pp.

McCarthy B, McGuffie P and Rehwinkel R (2008) Drought Contingency Wetland Monitoring Euston Lakes – 3 month report. Report prepared for the Murray-Darling Basin Commission, January, 20pp.

McCarthy B, McGuffie P and Rehwinkel R (2008) Drought Contingency Wetland Monitoring Euston Lakes – 6 month report. Report prepared for the Murray-Darling Basin Commission, April, 21pp.

McCarthy B, McGuffie P and Rehwinkel R and Stoffels R (2008) Drought Contingency Wetland Monitoring Euston Lakes – 9 month report. Report prepared for the Murray-Darling Basin Commission, June, 26pp.

McGuffie P, McCarthy B, Rehwinkel R and Stoffels R (2008) Drought Contingency Wetland Monitoring Euston Lakes – 12 month report. Report prepared for the Murray-Darling Basin Commission, October, 25pp.

- McGuffie P, McCarthy B, Rehwinkel R, Stoffels R, Allen-Ankins S and Walters S (2009) Drought contingency wetland monitoring Euston Lakes - 15 month report. Report prepared for the Murray-Darling Basin Authority, January, 33pp.
- McCarthy B, Rehwinkel R, Chapman D, Stoffels R, Walters S and McGuffie P (2009) Drought Contingency Wetland Monitoring Euston Lakes – 18 month report. Report prepared for the Murray-Darling Basin Authority, April, 38pp.
- McCarthy B, Chapman D, Walters S, Rehwinkel R, and McGuffie P (2009) Drought Contingency Wetland Monitoring Euston Lakes – 21 month report. Report prepared for the Murray-Darling Basin Authority, July, 32pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Drought Contingency Monitoring of NSW Wetlands – Back Creek and Tumudgery Creek (M/BUS/250)
Contact Officer	Dr Bernard McCarthy - b.mccarthy@latrobe.edu.au
Project Duration	17 th August 2007 to 15 th December 2009
Research Theme	Assessment
Status	Current

► Objective

To monitor selected wetlands to detect potential change in their ecological value due to drought contingency measures. Wetlands to survey are:

- Euston Lakes system (Murray River near Euston/Robinvale) – M/BUS/247
- Back Creek and Tumudgery Creek (Edwards River) – M/BUS/250
- Salt Creek/Tareena Billabong (Murray River near SA Border) – M/BUS/251

► Methodology

Methods will follow the recommended monitoring protocol outlined in Wallace et al. (2007) – Reference to M/BUS/232. The components and their frequency of sampling include:

- Water quality and levels (sampling frequency = 1 month)
- Blue-green algae (sampling frequency = 3 months)
- Groundwater (sampling frequency = 3 months)
- Tree vegetation (sampling frequency = 6 months)
- Fish (sampling frequency = 3 months)
- Photo-points (sampling frequency = 3 months)

► Overview

Four permanent wetlands in NSW have been identified for disconnection from the main river channel as part of the drought contingency measures. This project will monitor the ecology of these wetlands over a two year period to evaluate ecological values before, during and after their disconnection. The project will adopt the methods of Wallace et al. (2007).

As part of the program, water quality and levels, acidification potential, blue-green algae, groundwater, river red gum and fish will be monitored. Photo-points will also be established to assess visual changes in wetland condition over time. Results from each field trip will be evaluated against pre-determined trigger thresholds to ensure management is informed of the condition of the wetlands throughout the project.

► Reports

Baldwin DS, Fraser MA and McCarthy B (2008) Assessment of sulfidic sediments at Back Creek, NSW. Report prepared for the Murray-Darling Basin Commission, May, 9pp.

Baldwin DS, Fraser MA and McCarthy B (2008) Assessment of sulfidic sediments at Tumudgery Creek, NSW. Report prepared for the Murray-Darling Basin Commission, May, 10pp.

Durant R, McCarthy B and Vogel M (2008) Drought Contingency Wetland Monitoring Back Creek – 3 month report. Report prepared for the Murray-Darling Basin Commission, March, 14pp.

Durant R, McCarthy B and Vogel M (2008). Drought Contingency Wetland Monitoring Tumudgery Creek – 3 month report. Report prepared for the Murray-Darling Basin Commission, March, 14pp.

Durant R, McCarthy B and Vogel M (2008) Drought Contingency Wetland Monitoring Back Creek – 6 month report. Report prepared for the Murray-Darling Basin Commission, April, 16pp.

- Durant R, McCarthy B and Vogel M (2008) Drought Contingency Wetland Monitoring Tumudgery Creek – 6 month report. Report prepared for the Murray-Darling Basin Commission, April, 17pp.
- Durant R, McCarthy B and Vogel M (2008) Drought Contingency Wetland Monitoring Back Creek – 9 month report. Report prepared for the Murray-Darling Basin Commission, June, 17pp.
- Durant R, McCarthy B and Vogel M (2008) Drought Contingency Wetland Monitoring Tumudgery Creek – 9 month report. Report prepared for the Murray-Darling Basin Commission, June, 18pp.
- McCarthy B and Durant R and Vogel M (2008) Drought contingency wetland monitoring –Back Creek - 12 month report. Report prepared for the Murray-Darling Basin Commission, October 16pp.
- Durant R, McCarthy B and Vogel M (2008) Drought Contingency Wetland Monitoring Tumudgery Creek - 12 month report. Report prepared for the Murray-Darling Basin Commission, October, 18pp.
- Durant R, McCarthy B and Vogel M (2009) Drought contingency wetland monitoring Back Creek - 15 month report. Report prepared for the Murray-Darling Basin Authority, January, 18pp.
- Durant R, McCarthy B and Vogel M (2009) Drought contingency wetland monitoring Tumudgery Creek - 15 month report. Report prepared for the Murray-Darling Basin Authority, January, 21pp.
- Durant R, McCarthy B and Vogel M and Reid C (2009) Drought Contingency Wetland Monitoring Back Creek 18 month report. Report prepared for Murray-Darling Basin Authority, April, 20pp.
- Durant R, McCarthy B and Vogel M and Reid C (2009) Drought Contingency Wetland Monitoring Tumudgery Creek 18 month report. Report prepared for Murray-Darling Basin Authority, April, 23pp.
- Reid C, Durant R, McCarthy B and Vogel M (2009) Drought Contingency Wetland Monitoring Back Creek 21 month report. Report prepared for Murray-Darling Basin Authority, July, 20pp.
- Reid C, Durant R, McCarthy B and Vogel M (2009) Drought Contingency Wetland Monitoring Tumudgery Creek 21 month report. Report prepared for Murray-Darling Basin Authority, July, 24pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Drought Contingency Monitoring of NSW Wetlands – Salt Creek/Tareena Billabong (M/BUS/251)
Contact Officer	Dr Bernard McCarthy - b.mccarthy@latrobe.edu.au
Project Duration	17 th August 2007 to 15 th December 2009
Research Theme	Assessment
Status	Current

► Objectives

To monitor selected wetlands to detect potential change in their ecological value due to drought contingency measures. Wetlands to survey are:

- Euston Lakes system (Murray River near Euston/Robinvale) – M/BUS/247
- Back Creek and Tumudgery Creek (Edwards River) – M/BUS/250
- Salt Creek/Tareena Billabong (Murray River near SA Border) – M/BUS/251

► Methodology

Methods will follow the recommended monitoring protocol outlined in Wallace et al. (2007) – Reference to M/BUS/232. The components and their frequency of sampling include:

- Water quality and levels (sampling frequency = 1 month)
- Blue-green algae (sampling frequency = 3 months)
- Groundwater (sampling frequency = 3 months)
- Tree vegetation (sampling frequency = 6 months)
- Fish (sampling frequency = 3 months)
- Photo-points (sampling frequency = 3 months)

► Overview

Four permanent wetlands in NSW have been identified for disconnection from the main river channel as part of the drought contingency measures. This project will monitor the ecology of these wetlands over a two year period to evaluate ecological values before, during and after their disconnection. The project will adopt the methods of Wallace et al. (2007).

As part of the program, water quality and levels, acidification potential, blue-green algae, groundwater, river red gum and fish will be monitored. Photo-points will also be established to assess visual changes in wetland condition over time. Results from each field trip will be evaluated against pre-determined trigger thresholds to ensure management is informed of the condition of the wetlands throughout the project.

► Reports

Baldwin DS, McCarthy B and Henderson M (2007) Assessment of sulfidic sediments at Tareena Billabong, NSW. Report prepared for the Department of Environment and Climate Change, September, 12pp.

McCarthy B, McGuffie P and Rehwinkel R (2008) Drought Contingency Wetland Monitoring Tareena Billabong – 3 month report. Report prepared for the Murray-Darling Basin Commission, May, 17pp.

McCarthy B, McGuffie P and Rehwinkel R (2008) Drought Contingency Wetland Monitoring Tareena Billabong – 6 month report. Report prepared for the Murray-Darling Basin Commission, June, 15pp.

McCarthy B, McGuffie P and Rehwinkel R (2008) Drought Contingency Wetland Monitoring Tareena Billabong – 9 month report. Report prepared for the Murray-Darling Basin Commission, October, 21pp.

McGuffie P, McCarthy B, Rehwinkel R and Walters S (2009) Drought contingency wetland monitoring Tareena Billabong - 12 month report. Report prepared for the Murray-Darling Basin Authority, February, 21pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Implementing a systems approach to support adaptive management of river wetland health in the Murray-Darling Basin (M/BUS/248)
Contact Officer	Dr Ben Gawne - b.gawne@latrobe.edu.au
Project Duration	1 st April 2008 to 30 th June 2011
Research Theme	Knowledge Exchange
Status	Current

► Background

Current investment in MDFRC is on a project by project basis. This leads to data and knowledge fragmentation and limits the opportunity to improve our understanding of how the ‘whole ecological system’ functions and our ability to adaptively manage the rivers and wetlands in the Murray-Darling Basin.

► Aims

This project aims to support MDFRC redevelop its strategic research focus. The process involves more closely aligning MDFRC research with core activities being undertaken by the MDBA Office. Through this process, an improved systems understanding of the ecological response of river and wetland systems to management interventions will be developed. This will enable the MDBA to more effectively implement adaptive management and also identify opportunities to increase the ecological benefit generated by the available environmental water and river operation management strategies.

The key activities in the project relate to reviewing, collating, analysing and synthesising ecological data collected across the different MDBA programs. A process will be implemented to ensure that the learning gained through this project will feed back into the operations and decisions being made by the MDBA.

► Objectives

- Support the effective implementation of adaptive management in the Murray-Darling Basin (MDB) by developing a ‘systems understanding’ of the ecological response of rivers and wetlands to management interventions.
- Identify and provide advice on ecological risks, opportunities and knowledge gaps that are likely to impact on the health of rivers and wetlands in the MDB.

► Methodology

Key approaches/methodology are listed under the following broad categories:

Data collection/generation activities

- Develop/implement a database for recording observations of ecological response measured by MDFRC in the MDB. This database would most likely build on SRA protocols/processes. The first step would be to implement a system to record metadata associated with monitoring programs.
- Protocols outlining the procedure for short-term response to monitoring interventions (Event ready capacity). This would include:
 - Identifying events that will require a rapid response.
 - Document monitoring protocols required for the identified events.
 - Document process for implementing a rapid response to an event (this would include who would fund, who needs to approve funding prior to implementing a rapid response, likely supplier of monitoring, key contacts).

- Development of experimental protocols and funding proposals to address key knowledge gaps in our system understanding. As our systems understanding develops, critical knowledge gaps will be identified. Experimental protocols will need to be developed to address key knowledge gaps as they emerge.

Synthesis activities

- Review, refine, develop and document conceptual models (causal linkages) of species/community response to key variables (habitat, connection, biota, and metabolism). The IBR process will prioritise key species and communities and review/refine the conceptual models. These conceptual models will be used in the Integrated Basin Reporting Program to assess the significance of gaps and strategic issues. The first two synthesis products would focus on:
 - a. ecological impacts of salinity,
 - b. ecological impacts of the drought
- Report on conceptual models of ecological response to environmental watering. This would be include:
 - A review of the appropriateness of current ecological indicators at Icon sites, this would include the conceptual model linking management intervention and ecological response.
 - Review of improvements in understanding developed since MFAT, specifically improved ecological indicators and updated conceptual models linking management intervention and ecological response.
 - Recommended conceptual models of ecological response to management interventions to be incorporated into eWater Ecological Response Model.

► Outcomes

This project will contribute towards the broad outcome of improving the ecological management of rivers and wetlands in the Murray-Darling Basin.

Specific outcomes that will result from this project include:

- Consistency in methods for monitoring and reporting the ecological response from management interventions.
- Improved knowledge base on the ecological response of river and wetland systems to management interventions.
- More effective adaptive management by incorporating latest ecological data into the policy and management decisions being made by the MDBC and jurisdictions.
- MDFRC having a longer-term strategic research focus.

► Reports

Gawne B and Gigney H (2008) The Effects of Drought on Aquatic Ecosystems of the Murray-Darling Basin. Draft Report prepared for the Murray-Darling Basin Commission by The Murray-Darling Freshwater Research Centre, August, 48pp.

Watson G, Nielsen D and Gawne B (2008) The Effects of Salinity on Aquatic Ecosystems of the Murray-Darling Basin. Report prepared for the Murray-Darling Basin Commission by The Murray-Darling Freshwater Research Centre, September, 40pp.

Vilizzi L and McCarthy B (2009) Synthesis report on conceptual models of ecological response to management interventions: Hattah Lakes. Report prepared for Murray-Darling Basin Authority, June, 34pp.

Gigney H, Gawne B, Hladyz S, Kattel G, Kavanagh M, Meredith S and Petrie R (2009). Clarification of definitions in the *Water Act 2007*. Draft Report prepared for Murray-Darling Basin Authority, June, 39pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Ecological Advisory Services related to the Northern Basin (M/BUS/265)
Contact Officer	Dr Amina Price - amina.price@latrobe.edu.au
Project Duration	2 nd January 2008 to 30 th December 2011
Research Theme	Knowledge Exchange
Status	Current

▶ Background

This project provides an opportunity for the Northern Basin Program and the MDFRC to work more closely on ecological projects that will emerge from the Northern Basin Program's work plan and address the Program's role to assess and report on the health of the Darling Basin.

The MDBC will provide funding for half the salary of a research assistant who will work closely with the Senior Manager of the Commission's Northern Basin Program and the Director of MDFRC to deliver on the services below. This project recognises the need for the Program to establish a working relationship with a research body capable of supporting its science needs.

▶ Objective

To provide ecological advisory services related to the Northern Basin.

▶ Services Provided

- Support the Northern Basin program in an advisory role in the scoping of science projects and input into the initial contract briefs.
- Provide information to the Northern Basin Program on relevant scientific issues.
- Continue to make input into the development of long-term ecological monitoring of wetlands and rivers in the Northern Basin.
- Once a year, in conjunction with the requirements of the Northern Basin Program, convene a science forum/agency workshop on issues relevant to the Northern Basin.
- Consult with key agencies involved in aquatic ecosystem monitoring and management.

▶ Reports

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	An ecological evaluation of the Environmental Watering of the Gunbower Wetlands ICON site in relation to the aquatic animal community (M/BUS/271)
Contact Officer	Mr John Hawking - j.hawking@latrobe.edu.au
Project Duration	1 st June 2008 to 30 th June 2010
Research Theme	Knowledge Exchange
Status	Current
Funding	<i>The Living Murray</i>

► Background

Environmental water allocation to Icon sites is an important component of The Living Murray's plan to improve ecological condition. Monitoring the benefit or success of environmental flows into wetlands is critical in our understanding of timing and volume of flow to maximise ecological benefit.

Currently the MDBC's TLM program monitors birds and fish at Icon sites to establish population dynamics on these larger animals. However, success of environmental flows into ephemeral wetlands can be calculated by determining the increase in the abundance and availability of food resources created by the addition of water to the floodplain Quinn et al. 2000. Aquatic invertebrates comprise the vast majority of food resources found in wetlands (Hillman and Shiel 1991) and are an important driver of ecological process (Wilson et al. 2008). Determination of the invertebrate community structure, development time and succession trends will portray a snapshot of food resource availability.

The project consists of two components. An initial response survey (conducted in June) to provide basic background information on two freshly flooded wetlands in the Gunbower Forest, a wetland in the Barmah Forest and two river sites adjacent to these wetlands. This information allowed the development of a robust sampling routine to survey six wetlands, three freshly flooded by environmental water and three maintained at a consistent level for stock and domestic consumption. The second part of the project investigates the ecological effects of environmental watering in ephemeral wetlands.

► Objectives

This pilot study investigates in detail the effects of flooding in ephemeral wetlands at one Icon wetland site (Gunbower— Koondrook-Perricoota Forest);

- To provide valuable information about the effectiveness of artificial flooding to macroinvertebrate communities and its subsequent benefits to the larger vertebrate communities.
- To provide an assessment of the macroinvertebrate communities of the Gunbower—Koondrook—Perricoota Forest Icon site ephemeral wetlands, and in particular, compare them to associated wetlands that are kept permanently full to assess the value of environmental flows to the forest.
- Investigation of food web dynamics, and in particular, the relationship between invertebrate and vertebrate communities during flood events (provide support to existing condition reporting on fish, birds and vegetation).
- To provide information on macroinvertebrate community succession in ephemeral wetlands through a wetting drying phase.
- To provide an ecological measure of the benefit of recovered water to the environment.

- To provide valuable knowledge on the available food resources which form the major components of the diet of fish and water fowl, (presently not being undertaken in *The Living Murray* program).
- The knowledge gained from assessing the invertebrate community at one Icon sites will allow *The Living Murray's* water recovery program will provide important information for future management of Icon sites and for water management across the basin.

Null hypothesis

- Artificial flooding of ephemeral wetlands within Icon sites will not provide increased diversity, abundance and community structure of macroinvertebrates compared to adjacent permanent wetlands.
- Timing, frequency, duration and extent of artificial flooding will not alter diversity, abundance and community structure of macroinvertebrates compared to adjacent permanent wetlands.

▶ Reports

McInerney P and Hawking J (2009) ICON Sites Pilot Study: Macroinvertebrates in Ephemeral Floodplain Wetlands on Gunbower Island. Report prepared for the Murray-Darling Basin Authority by The Murray-Darling Freshwater Research Centre, May, 4pp.

McInerney P, Hawking J and Cook R (2009) ICON sites pilot study: macroinvertebrates in ephemeral floodplain wetlands on Gunbower Island. Draft Milestone Report prepared for the Murray-Darling Basin Authority by The Murray-Darling Freshwater Research Centre, July, 75pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Development of semi arid wetland conceptual models (M/BUS/275)
Contact Officer	Dr Amina Price - amina.price@latrobe.edu.au
Project Duration	1 st May 2008 to 30 th June 2009
Research Theme	Knowledge Exchange
Status	Completed

► Background

Conceptual modelling has been identified as a foundation component of environmental monitoring programs, providing an integration of system understanding and identification of complex interactions and relationships between indicators and ecological states or processes (Gross, 2003). A well-constructed conceptual model provides a scientific framework for a monitoring program and justification for the choice of indicators (Gross 2003) (Figure 1). In the case of a multi-stakeholder monitoring program, a conceptual model can also provide a forum for stakeholders to come to a common understanding of the system that is being investigated (Hierl et al. 2007).

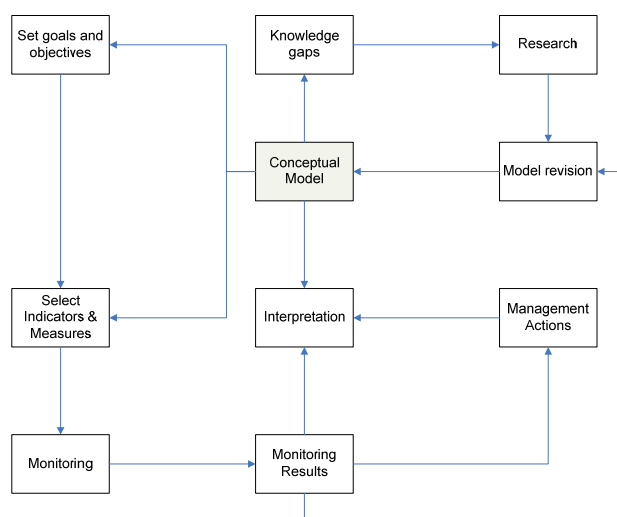


Figure 1: Linkages between Conceptual Models and the wider monitoring program (adapted from Fischenich 2008)

To successfully implement a monitoring and evaluation project, it is critical that the program is based on a conceptual model of how the system works and how it will respond to a given management intervention. Having a conceptual model of how the system works not only helps identify which elements of the ecosystem will respond in the anticipated way – but also helps identify changes that might be detrimental (and therefore also require monitoring). Conceptual models can also illustrate linkages between activities, processes and pressure-response relationships.

The importance of conceptual modelling has been recognised through the national wetland monitoring framework, which recommends that managers should develop conceptual models of wetlands and these models should underpin the selection of appropriate indicators for wetland condition assessment.

► Investment Needs

Given that in the Northern Murray-Darling Basin, semi-arid wetlands predominate, NSW DECC and the Qld EPA are hoping that, using the draft guidelines used by the other jurisdictions, the MDBA will take on the conceptual modelling for the semi-arid wetland types. Given that one of the MDBA's roles is to provide integration across jurisdictions and that once completed, the conceptual models will form the basis for national and state monitoring programs and are likely to provide an important tool for directing future investment in wetlands across the whole of the MDB, it would seem appropriate for the MDBA to take a leadership role in conceptual model development for semi-arid wetlands. This leadership role is seen as being vital given that to-date, cross-jurisdictional coordination and integration has been facilitated by the NLWRA, and funding for the NLWRA beyond June 2008 is uncertain.

If the MDBC agrees to undertake the conceptual modelling for semi-arid wetlands, they will need to make a decision as to whether they are prepared to use the conceptual models developed for wetland types in other climatic zones, given that they would have had no direct involvement in their development.

The MDFRC has undertaken some preliminary work to determine the level of investment that would be required by the MDBA. Based on the attributes that have been agreed to by NSW and Qld, and in conjunction with both of these jurisdictions, the MDFRC has identified ten proposed semi-arid wetland types for which conceptual models need to be developed. These are:

- Periodically inundated non-floodplain freshwater lakes
- Periodically inundated non-floodplain lakes with a variable salinity regime
- Periodically inundated non-floodplain saline lakes
- Commonly wet non-floodplain freshwater lakes
- Commonly wet non-floodplain saline lakes
- Periodically inundated floodplain freshwater lakes
- Periodically inundated floodplain lakes with a variable salinity regime
- Commonly wet floodplain freshwater lakes
- Periodically inundated non-floodplain freshwater swamps
- Periodically inundated floodplain freshwater swamps

In addition to the conceptual modelling for semi-arid lacustrine and palustrine wetlands, there was some discussion at the meeting in March around the need/utility of developing conceptual models for riverine wetlands (i.e. all wetlands and deepwater habitats within the channel). As there has been some conceptualisation done for rivers as part of the SRA, it was agreed that it may be possible for the MDBA to undertake this in addition to models for lacustrine and palustrine wetlands. This would need to involve the MDBA SRA team. To determine whether this would be feasible, the SRA team would need to be consulted about what work they have done for riverine wetlands to determine whether any of their work could be easily adapted to riverine wetland conceptual models that would be consistent with the NSW and Qld approach.

► Recommendations

The former MDBC (now MDBA) undertake a literature review for semi-arid wetlands, organise and facilitate a conceptual modelling workshop for semi-arid wetlands and collate the outputs from this workshop into conceptual models for the 10 semi-arid wetland types.

Should the MDBA decide that a similar conceptual modelling exercise be undertaken for the riverine wetlands, it is recommended that a meeting between the MDBC SRA team and the Qld EPA and NSW DECC be organised to discuss the feasibility of using existing SRA data to develop riverine wetland conceptual models that would be consistent with the NSW and Qld approach.

▶ Activities

- Development of draft conceptual models
- Expert panel conceptual modelling workshop
- Finalisation of conceptual models

▶ Reports

Price A and Gawne B (2009) The Development of wetland conceptual models for Semi-Arid zone. Final Report prepared for the Murray-Darling Basin Authority, January, 47pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Ecological outcomes of managed flooding and control structures at Webster's lagoon (M/BUS/293)
Contact Officer	Dr Todd Wallace - t.wallace@latrobe.edu.au
Project Duration	1 st May 2008 to 30 th June 2009
Research Theme	Assessment
Status	Current, Draft Report submitted to client, comments pending (Helen Missen 6/10/2009) continuation of "Ecological outcomes of managed flooding and control structures at Webster's Lagoon" Client: Dept. Sustainability and Environment (M/BUS/268)

► Background

The construction of a regulator and carp screen at Webster's Lagoon during July-October 2006 was funded by TLM W&MP. This structure has been used during the intervening period to re-introduce a drying phase to Webster's Lagoon. Water available in late 2007-08 is to be used by DSE to re-inundate the wetland for the first time since construction of the regulator structure. A detailed, BACI design monitoring program funded by TLM was developed and undertaken by the MDFRC to collect baseline (pre-intervention data) at both Webster's Lagoon (intervention site) and a control site (to remain permanently inundated). Reports were prepared by the MDFRC and submitted to the MCMA in 2005, 2006 and 2007. Monitoring of the response to inundation will allow an assessment of the effectiveness of the capital investment in the regulatory structure and carp screen at Webster's Lagoon.

► Objective

The overarching objective is to determine if the re-introduction of a wet-dry cycle in Webster's Lagoon (previously permanently inundated by pool levels of Lock 6) via construction of a regulator and carp screen has improved the ecological values of the wetland and consequently the Icon site.

► Reports

- Wallace T, Campbell C and Sharpe C (2008) Ecological outcomes of managed flooding and control structures at Webster's Lagoon 2007-2008. Progress Report to the Murray-Darling Basin Commission, October, 4pp.
- Wallace T, Walters S and Ellis I (2009) Ecological outcomes of managed flooding and control structures at Webster's Lagoon 2007-2009. Progress Report #5 to Murray-Darling Basin Authority, May, 4pp.
- Wallace T, Walters S, Ellis I and Tucker M (2009) Ecological outcomes of managed flooding and control structures at Webster's Lagoon. Draft report prepared for the Murray Darling Basin Authority, June, 126pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Literature review and experimental design to address retaining floodwater on floodplains and flow enhancement hypotheses relevant to native tree species (M/BUS/313)
Contact Officer	Ms Christine Reid - christine.reid@latrobe.edu.au and Ms Caitlin Johns - c.johns@latrobe.edu.au
Project Duration	1 st April 2009 to 30 th June 2009
Research Theme	Biota
Status	Completed

► Objectives

- Identify flow characteristics that best create or maintain habitat suitable for the germination of native tree species.
- Identify flow characteristics that best create or maintain habitat suitable for the health and growth of native tree species.
- Identify flow characteristics that best create or maintain habitat suitable for the recruitment of native tree species.
- Identify the risks of weed germination, growth and dispersal with the flow characteristics identified as suitable for native tree species.

► Background

The Murray-Darling Basin is dominated by three species of trees: River Red Gum (*Eucalyptus camaldulensis*) is the most wide-spread within the Basin, Black Box (*Eucalyptus largiflorens*) is found predominantly in the south and west along the Murray River, and the Coolibah (*Eucalyptus microtheca*) in the north and west, and particularly in the Darling system.

The River Cooba (*Acacia stenophylla*) is also a notable, but physically smaller, species occurring throughout the western part of the Basin, and is found within *The Living Murray* (TLM) sites. These species, along with others, such as Silver Wattle (*Acacia dealbata*), River Oak (*Casuarina cunninghamii*) and Melaleuca species are keystone species that perform a range of critical roles in floodplain ecosystems including primary production, micro-climate regulation, soil formation and the provision of habitat for fauna, such as birds.

The majority of studies investigating riparian and floodplain tree species in the MDB have been undertaken on *E. camaldulensis* and *E. largiflorens*. CSIRO have undertaken extensive basin-wide modelling of *E. camaldulensis* communities and hydrology along the Murray channel and floodplain, which includes TLM sites.

The Living Murray (TLM) processes, particularly, the Intervention Monitoring Assessment Framework, has identified that there are knowledge limitations regarding the response of native tree species to floodwater retention on floodplains. This limits the MDBA's capacity to optimise outcomes from environmental flow management. This is required for improved decision-making, investment and monitoring of TLM sites, and for Basin-wide management. It is understood that outputs from this project will directly be used by the TLM Environmental Watering Group (EWG) and its associated taskforces.

► Reports

Johns C, Reid CJ, Roberts J, Sims N, Overton I, Doody T, McGinness H, Rogers K, Campbell C and Gawne B (2009) Native trees of the River Murray floodplain: Literature review and experimental designs to examine effects of flow enhancement and floodwater retention. Final Report prepared for the Murray-Darling Basin Authority, June, 88pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Northern Basin Program Review (M/BUS/314)
Contact Officer	Dr Ben Gawne - b.gawne@latrobe.edu.au
Project Duration	30 th March to 30 th June 2009
Research Theme	Review
Status	Current – Draft Final report submitted to client – comments pending (Helen Missen 6/10/2009)

▶ Background

The MDBC Northern Basin Program was established to promote the strategic objectives of the Murray-Darling Basin Commission in the northern regions of the MDB. The MDBC Strategic Objectives included;

- Protection and enhancement of the basin’s shared environmental assets and water resources.
- Efficient and equitable delivery of water for productive and sustainable domestic consumption, environmental benefit and economic use.

Progressing these strategic objectives in the Northern Basin represented a significant challenge for the MDBC given the complex institutional arrangements for managing water and water-dependent natural resources in the region. In order to meet these challenges the Northern Basin Program undertook a variety of activities that produced a variety of direct and indirect benefits for both the MDBC and jurisdictions.

With the passing of the *Water Act* and the formation of the Murray-Darling Basin Authority, the Northern Basin Program activities have been incorporated into Basin wide planning and management. With the transition it is important to capture the major outputs, outcomes and lessons from the Northern Basin Program.

▶ Reports

Gawne B, Cummins T, Wilson GG, Southwell M and Watson G (2009) Northern Basin Program Review. Draft Final Report prepared for Murray Darling Basin Authority by The Murray-Darling Freshwater Research Centre, June, 66pp.

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Comprehensive Review of the 1980–2008 Murray River Monitoring Data (M/BUS/330)
Contact Officer	Mr John Hawking – j.hawking@latrobe.edu.au
Project Duration	1 st July 2009 to 31 st December 2010
Research Theme	Review
Status	Current

► Background

The Biological Monitoring Program commenced in 1980 and the results from the first five years of the study were published in the MDBC Water Quality Report No. 3 (Benison, Hillman & Suter 1989). The program continued with a reduction in the number of sites sampled from 14 to 8 sites and the frequency of sampling was reduced from four times per year (seasonal) to twice per year (autumn/winter and spring/summer). Over time, several reports have reviewed sections of the program; i.e. 1980 to 1997 data was reported in “Water Quality Monitoring Program Review (AWT 1999) and 1998 to 2001 monitoring (AWT 1999b, 2000; Water ECOscience 2001, 2005) and the 1980 to 2000 in Hoenderdos (2006). It is now possible to provide a comprehensive evaluation of the total data set from 1980 to 2008.

Long term biological data sets are rare both within Australia and indeed world wide, with most ecological research limited to one to three years at best. This is an inadequate time frame to elucidate the underlying patterns and processes that occur in riverine systems and is unable to identify long term ecological change as opposed to natural short term fluctuations which occur in biological communities. The 28 year data set generated by the Murray River Monitoring program is of exception value. This period has incorporated cycles of wet and extreme dry years and provides an opportunity to assess how these altered climatic conditions, discharge and management of the Murray River impacts on river health and the biological communities of the Murray River. The geographic extent of the Murray River Monitoring Program from Biggara in the headwaters to Woods Point in the Lower Murray, will enable an examination of how the biological communities of different sections of the Murray River respond to these climatic and human induced changes. The combination of the temporal scale and geographic extent of this data set is therefore rare and potentially unique on a world scale and is of immense value to both river managers and the scientific community.

► Objectives

To undertake an analysis and investigation of possibly the longest continuous macroinvertebrate data set in Australia, from 1980 to 2008 Through this process identify and assess the long, medium and short term changes in the river health, biodiversity, community structure and water quality of the River Murray. Investigate links in macroinvertebrate communities to climatic, hydrological, water quality changes and flow management over this period to help elucidate drivers of river health and changes in biotic communities.

Provide an analysis, interpretation and comprehensive report of this unified long term data set. This analysis and report will incorporate a diversity of operational and climatic conditions and as such will enable a more powerful and informative analysis and interpretation. Such a report will provide robust ecological information on the biological response to changed operational, discharge and climatic conditions and thus provide an improved understanding of the drivers of river health in the Murray River.

► Reports

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Comprehensive Review of the 1998–2008 Mitta Mitta River Monitoring Data (M/BUS/331)
Contact Officer	Mr John Hawking – j.hawking@latrobe.edu.au
Project Duration	1 st July 2009 to 31 st December 2010
Research Theme	Review
Status	Current

▶ **Background**

The Mitta Mitta Monitoring program has been conducted in its current format since 1998/1999 giving a continuous record of river health in the Mitta Mitta River for the past 11 years. Biological data sets of this duration are rare and of immense value to both river managers and the scientific community and provides insight into long term and short term fluctuation in water quality, river health and biological communities and the associated drivers of these changes. The resulting report would then provide an insight into the temporal and spatial shifts in river health, biological communities and water quality in the Mitta Mitta River below Dartmouth Dam under a range of irrigation release regimes and climatic conditions, including the worst drought on record. The study design incorporates a number of unregulated streams which will enable a comparison of water quality and river health under both regulated and unregulated conditions over this period. An evaluation on the total data set will provide insight into long term trends, account for inter-annual effects and provide greater understanding of water quality and river health under different management and climatic conditions.

▶ **Objectives**

To provide the MDBA with a unified data analysis of the last 11 years of the Mitta Mitta Monitoring data, currently reported as a series of individual reports. Provide an analysis, interpretation and comprehensive report of this unified long term data set. This analysis and report will incorporate a diversity of operational and climatic conditions and as such will enable a more powerful and informative analysis of the impacts of Dartmouth Dam on river health in the Mitta Mitta River. Such a report will provide robust ecological information on the biological response to changed operational and climatic conditions and thus provide an improved basis for future management decisions.

▶ **Reports**

Client	MURRAY-DARLING BASIN AUTHORITY
Project Title	Evaluation of Local Biological Effects (Water Quality) (M/BUS/327)
Contact Officer	Dr Darren Baldwin – darren.baldwin@csiro.au
Project Duration	12 th October 2009 to 12 th November 2009
Research Theme	Review
Status	Current

▶ Background

A core requirement in the development of the Water Quality and Salinity Management Plan (WQSMP) for the Murray-Darling Basin is the articulation of water quality objectives and targets.

For the purpose of the WQSMP, the following definitions apply:

Water quality objective – A qualitative narrative statement, to be achieved, to maintain or restore the value or use of a water resource. This is similar to the ‘Management Goals’, as defined by the National Water Quality Management Strategy (NWQMS).

Water quality target – Numerical values (or ranges) which if exceeded indicate an unacceptable risk in meeting the objective.

▶ Objective

To collate and analyse existing information on water quality sensitivity of aquatic ecosystems relevant for the Murray-Darling Basin.

▶ Reports

Watson GO, Bullock EK, Sharpe C and Baldwin DS (2009) Water Quality Tolerances of Aquatic Biota of the Murray-Darling Basin. Draft Report prepared for the Murray-Darling Basin Authority by The Murray-Darling Freshwater Research Centre, December, 32pp plus Biotic Tolerance and References xls sheets.

Client	THE MURRAY-DARLING FRESHWATER RESEARCH CENTRE
Project Title	Drought Monitoring (M/BUS/214)
Contact Officer	Dr Daryl Nielsen - daryl.nielsen@csiro.au and Dr Todd Wallace - t.wallace@latrobe.edu.au
Project Duration	1 st November 2006
Research Theme	Knowledge Exchange
Status	Current

► Background

During spring 2006, staff at MDFRC began to discuss a MDFRC Drought Strategy Plan, which was approved by the Board of Management in late November 2006.

The drought poses a number of significant risks for the natural environment including poor water quality (e.g. high temperatures, low dissolved oxygen and high salinity); fish kills; blue-green algal blooms; wetland acidification; loss of vegetation; and increased erosion when drought breaks. The drought also provides a number of opportunities to examine the response of the system to a rare but significant disturbance. There may be opportunities to observe both the effects of the drought but also the systems recovery which may help inform restoration planning.

After reviewing its current externally funded sampling activities (Water quality in Broken Creek; Fish and water quality in the Broken River; Water quality and blue-green algae in Lake Hume; Fish and water quality sampling at Lindsay Wallpolla; and Wetland monitoring at Hattah Lakes, it became apparent that the parameters common to many of these sampling programs were Fish; Zooplankton; and Water Quality.

In terms of management interest and opportunities to gain significant insights, it was decided to add three sites to our sampling regime. These sites are: the Ovens River (unregulated and likely to cease flowing); the Lower Darling (already very low with potential for significant deteriorations in water quality and fish kills); and the Murray River at Barmah (a Significant Ecological Asset in *The Living Murray* for which we have existing data).

It is proposed MDFRC will conduct monthly sampling trips to these sites with the potential to increase sampling frequency if there are marked changes in flow or water quality at the sites. To undertake this additional sampling we have appointed two additional summer scholarship students (one at Wodonga and one at Mildura) who will provide field assistance for MDFRC core staff.

The data gathered will provide an insight into the response of six rivers with very different flow regimes. This will help explore the effects of one of the more widespread effects of flow regulation which is anti-drought. The research is therefore consistent with the strategic objectives of developing an understanding of cause and effect and improving our understanding of Australia's highly variable rivers and wetlands.

The data gathered may also be relevant to *The Living Murray*, eWater CRC and Water for a Healthy Country. The data will also enable us to alert managers to risks around native fish communities and water quality issues.

► Reports

Client	MURRAY IRRIGATION LIMITED
Project Title	Murray Irrigation Area Aquatic Ecosystem Monitoring (M/BUS/86)
Contact Officer	Mrs Lyn Smith – lyn.smith@latrobe.edu.au
Project Duration	April 2005 to 30 June 2010
Research Theme	Assessment
Status	Current

► Background

The Murray Irrigation Region Aquatic Ecosystems monitoring program aims to establish baseline conditions in the rivers and creeks of the Region, and then provide the capacity to measure trends in key components of river health (vegetation, fish, macroinvertebrates and water quality) over the longer-term.

The objective is to detect and track changes in the condition of the aquatic environment over an extended timeframe and is expected to be an important part of Murray Irrigation's commitment to ensuring decisions about river management are based on current scientific knowledge.

Ten sites have been selected from five water courses throughout the Region; two sites each on the Murray, Edward and Wakool Rivers, Billabong Creek, and one site each on Niemur River and Tuppal Creek.

A pilot study was conducted in April 2005, with the biannual monitoring (Autumn and Spring) initiated in April 2006. The project was anticipated to continue for 10 years, however, the duration of the project will be terminated after four years of sampling.

An Annual Report has been produced for the client each year that provides an assessment of stream condition. Negotiations are taking place for the production of a 4-year trend analysis report.

► Reports

Gigney H (2006) Murray Irrigation Region Aquatic Ecosystem Monitoring Program. Autumn Sampling 2006 - Preliminary Data & Observations, November, 3pp.

Gigney H (2006) Murray Irrigation Region Aquatic Ecosystem Monitoring Program. Spring Sampling 2006 - Preliminary Data & Observations, November, 3pp.

Gigney H (2007) Murray Irrigation Region Aquatic Ecosystem Monitoring Program. Autumn Sampling 2007 - Preliminary Data & Observations, May, 5pp.

Gigney H (2007) Murray Irrigation Region Aquatic Ecosystem Monitoring Program. Spring Sampling 2007 - Preliminary Data & Observations, October, 7pp.

Gigney H and Smith L (2007) Murray Irrigation Region Aquatic Ecosystem Monitoring Program: Annual Report for 2006. Report prepared for Murray Irrigation Limited, August, 107pp.

Gigney H, Hawking J, Smith L and Gawne B (2007) Murray Irrigation Region Aquatic Ecosystem Monitoring Program: Protocols Handbook. Report prepared for Murray Irrigation Limited, April, 71pp.

Gigney H, Hawking J, Smith L and Gawne B (2007) Murray Irrigation Region Aquatic Ecosystem Monitoring Program Development 2005: Pilot Study Report. Report prepared for Murray Irrigation Limited, April, 60pp.

Gigney H and Smith L (2008) Murray Irrigation Region Aquatic Ecosystem Monitoring Program: Autumn Sampling 2008 [31 March to 4 April]. Preliminary Data & Observations Report prepared for Murray Irrigation Limited, May, 6pp.

Gigney H and Smith L (2008) Murray Irrigation Region Aquatic Ecosystem Monitoring Program: Annual Report for 2007. Final report prepared for Murray Irrigation Limited, August, 86pp.

Gigney H and Smith L (2008) Murray Irrigation Region Aquatic Ecosystem Monitoring Program - Spring Sampling 2008 Preliminary data and observations. Report prepared for Murray Irrigation Limited, November, 7pp.

Smith L (2009) Murray Irrigation Region Aquatic Ecosystem Monitoring Program: Autumn Sampling 2009-Preliminary Data and Observations. Report prepared for Murray Irrigation Limited by The Murray-Darling Freshwater Centre, April, 9pp.

Smith L (2009) Murray Irrigation region Aquatic Ecosystem Monitoring Program : Spring Sampling 2009 – Preliminary Data and Observations. Report prepared for the Murray Irrigation Limited by The Murray-Darling Freshwater Research Centre, November, 8pp.

Gigney H and Smith L (2009) Murray Irrigation Region Aquatic Ecosystem Monitoring Program: 2008 Annual Report. Final report prepared for Murray Irrigation Limited, July, 85pp.

Client	NATIONAL WATER COMMISSION
Project Title	Minimising Environmental Damage from Water Recovery from Inland Wetlands: Determining water regimes to minimise the impact of sulfidic sediments (potential acid sulfate soils) (M/BUS/228)
Contact Officer	Dr Gavin Rees - gavin.rees@csiro.au and Dr Darren Baldwin - darren.baldwin@csiro.au
Project Duration	1 st June 2007 to 30 th December 2010
Research Theme	Metabolic Function
Status	Current
Collaborators	NSW Murray Wetlands Working Group

► Background

This project will be administered by the NSW Murray Wetlands Working Group, with staff from MDFRC undertaking the work [A sub-contract has been signed between LTU and NSW MWWG (27 July 2007) and a sub-sub contract has been signed between LTU and MDFRC Pty Ltd (17 August 2007)].

The Australian Government through the Raising National Water Standards program will contribute \$517,520 of a total project value of \$739k to determine appropriate wetting and drying strategies in inland wetlands to minimise the formation of sulfidic sediments. It will provide environmental water managers with tools and guidelines on how to best manage inland wetlands to prevent the build-up of acid sulphate soils, and how to remediate affected systems. The tool will be tested across different inland wetland regions of Australia affected and potentially affected by this problem to see if it can be applied as a national model.

Sulfidic sediments (potential acid sulfate soils) in wetlands across Australia are an emerging and significant threat to the long-term ecological sustainability of inland wetland systems. This threat has come from significant changes to the hydrologic regime of wetlands thereby creating conditions that are (1) favourable for the development of sulfidic sediments and (2) facilitate the detrimental environmental impact of sulfidic sediments. This project will deliver clear recommendations for the delivery of appropriate watering regimes to both minimise the onset of the development of sulfidic sediments in non-impacted wetlands and, minimise ecological harm in those wetlands already affected.

► National Technical Team

Leigh Sullivan (Southern Cross University), Neil Saintilan (NSW DECCW); Peter Waanders (SA MDB NRM Board); Peter Davies (Consultant); Jenny Davis (Monash University); Julia Reed (Vic DSE) and Bernie Powell (QLD DNR and Water).

► Steering Committee

Darren Baldwin, Gavin Rees and Michael Halsey (MDFRC), Deb Nias (Murray Darling Wetlands), James Maguire (NSW DECCW) and Judy Frankenberg (Consultant).

► Reports

NWC, MDFRC and NSW MWWG (2008) Sulfidic Sediments: Threatening Australia's Inland Wetlands Brochure, 2pp.

Client	NATIONAL WATER COMMISSION
Project Title	Optimising Environmental Watering Protocols to Maximise Benefits to Native Fish Populations (M/BUS/229)
Contact Officer	Dr Daryl Nielsen - daryl.nielsen@csiro.au and Dr Ben Gawne - b.gawne@latrobe.edu.au
Project Duration	1 st June 2007 to 30 th December 2010
Research Theme	Connectivity
Status	Current
Collaborators	Freshwater Ecology Section, Arthur Rylah Institute for Environmental Research (Department of Sustainability and Environment), NSW Murray Wetlands Working Group (now part of the NSW Department of Environment, Climate Change and Water), Goulburn Broken CMA, North East CMA, Murray CMA and MDBA

► Background

This project is administered by La Trobe University who will sub-contract all work to MDFRC. MDFRC to sub-sub-contract with Arthur Rylah Institute (part of the DSE).

The Australian Government through the Raising National Water Standards program will contribute \$1.84m for this project with a total project cost of \$2.56m in which wetland managers and research providers are collaborating to evaluate how the fish respond to significantly increased water flows in a series of actively managed wetlands on the Murray River. This project will develop appropriate monitoring protocols to demonstrate the ecological benefits of wetland watering and underpin the implementation of effective adaptive management options for native fish.

► Aim

The project is a collaboration between wetland managers and research providers, and will evaluate the fish community response to inundation in a series of actively managed wetlands on the Murray River, between Hume Dam and Echuca. The wetlands will have a variety of connection types to the River (disrupted flood way, open floodway, constructed regulators, open channel etc.) and management interventions. Wetlands will be monitored to relate changes in the fish community to characteristics of the habitat such as water quality, food abundance, food quality and habitat complexity. Experimental manipulations using both large mesocosms and field experimentation will also allow field patterns to be explored.

Specifically, the project will:

- Trial established and newly conceptualised wetting protocols in actively managed wetlands and designated reaches, by:
 - monitoring the productivity and condition of wetland and riverine fish and invertebrate assemblages;
 - monitoring the exchange of fish into and out of wetlands in response to managed and natural watering events;
 - monitoring the exchange of organic material and nutrients between wetlands and the river in response to managed and natural watering events; and
 - monitor changes in productivity within the river channel as floodwaters recede.
- Conduct targeted experimental manipulations of key habitat variables to determine their impact on fish recruitment and production.
- Undertake extensive briefing of consortium partners on the early results with the aim of experimentally modifying and then evaluating newly developed wetting protocols.
- Produce predictive tools linking the extent, timing and duration of floodplain and wetland inundation to native fish recruitment.

- Produce refined wetting protocols and monitoring recommendations for implementation across a broad range of wetland types. A demonstration wetland will be used as the focus of a wetland management workshop that will encourage wetland managers to present their data on wetting protocols and their effectiveness. The information presented will be synthesised and compiled into a final report.

▶ Reports

National Water Commission (2009) Environmental Watering Protocols to Benefit Native Fish. Information Sheet on *Optimising Environmental Watering Protocols to Benefit Native Fish Populations* project, funded under the Raising National Water Standards Program administered by the National Water Commission, November, 2pp.

Client	NATIONAL WATER COMMISSION
Project Title	The Farms, Rivers and Markets Project: Catchment Scale Demonstration of Integrated Water Management (M/BUS/296)
Contact Officer	Dr Daryl Nielsen - daryl.nielsen@csiro.au and Dr Ben Gawne - b.gawne@latrobe.edu.au
Project Duration	
Research Theme	
Status	Current, additional information, duration and background to be advised (Rosie Busuttill, 3 rd June 2009).
Collaborators	In conjunction with The University of Melbourne (Melbourne Water Research Centre), Department of Sustainability and Environment, Monash University, Goulburn-Murray Water, National ICT Australia, Victorian Water Trust and the Tallis Trust.

► Background

The original proposal was submitted under the Raising National Water Standards Program in September 2006 and was signed off by The Hon Malcolm Turnbull, MP, however, the contract was not signed before the 2007 election was called. The project was re-evaluated and awarded by Senator the Hon Penny Wong (Minister for Climate Change and Water) on 22 June 2008. Total value of \$8.6 million, with MDFRC to receive \$100K for three years, into how changed farming practices can simultaneously improve water use and productivity, while delivering better environmental outcomes.

The project will run out of the University of Melbourne's Dookie research farm and the surrounding Goulburn-Broken River catchment. The project, to run over three years, will be managed by Uniwater (a joint initiative of the University of Melbourne and Monash University).

“The Farms, Rivers and Markets Project will develop a ‘how to’ guide for farmers to integrate their farm water needs with broader environmental needs,” Minister for Climate Change and Water, Senator Penny Wong, said. “This project will involve farm-scale demonstrations exploring how the latest technology in water measurement and management, combined with better use of water markets, can boost farm profits and productivity, improve delivery of water to the farm gate, reduce leakage, and improve water use efficiency.”

Under the project, researchers in engineering, agriculture and economics will work in close partnership with farmers and water managers to help them choose the best mix of production opportunities according to their individual circumstances.

The project will provide farmers with practical ways to make the most of available irrigation water supplies – including rainfall and recycled water – through better planning, technology and predictive tools. The project will also provide spin-off environmental benefits including improved salinity and water quality management. It will consider how water markets can be used to provide ‘win-win’ outcomes for both farmers and the environment.

“The aim is to find ways to make much better use of the water we have, creating benefits for both farmers and the environment,” Senator Wong said. “The project is in line with the Rudd Government’s long-term plan *Water for the Future*, which has as key priorities using water wisely and supporting healthy rivers and wetlands.”

► Reports

Client	NORTH CENTRAL CATCHMENT MANAGEMENT AUTHORITY
Project Title	Gunbower Forest Fish Surveys (M/BUS/294)
Contact Officer	Dr Todd Wallace - t.wallace@latrobe.edu.au and Mr Clayton Sharpe - c.sharpe@latrobe.edu.au
Project Duration	20 th November 2008 to 30 th June 2009
Research Theme	Assessment
Status	Current – Draft report submitted, waiting for comments from client to finalise (Clayton Sharpe – 2 nd November 2009)

► Background

The purpose of this project is to investigate the fish populations within Gunbower Creek, lagoons and Gunbower Forest wetlands through comprehensive surveys and use the results from current and previous surveys to make comparisons on fish populations in the Gunbower System.

In consultation with the NCCMA Project Manager, the project will be delivered in two parts: Part A (Spring fish surveys) and Part B (Autumn fish surveys). The contract will initially be awarded as Part A, Part B will be delivered as a variation to contract.

Part A deliverables include; background review, project inception meeting and site inspection, spring fish survey, and delivery of a brief preliminary report including tabulated results of catch by site, and digital photographs and GPS references of sites.

Part B deliverables include; autumn fish survey, electrofishing demonstration, detailed data analysis, presentation of draft report to PSC, delivery of detailed final report including comparison of data from Part A, Part B and pre-existing data).

► Methodology

Following MDFRC (2005) (Richardson et al. 2005), the fish community at each of 23 sites across wetland, lagoon and creek environments will be assessed by fyke-netting, and where accessible, by boat- electrofishing and bait-traps.

Netting: At each site, four replicates of one small fyke net and one large fyke net, identical to those used by Richardson et al. (2005) will be set to best represent the diversity of aquatic habitats available at each site thus increasing the encounter rates with resident fish. Nets will be set late in the afternoon and collected the following morning, with soak time recorded for calculation and standardisation of catch per unit effort, which will enable spatial comparison among sites and temporal comparisons to previous and future survey events.

Electrofishing: Consistent with Richardson et al. (2005), boat electrofishing will be utilised following SRA protocols for wetlands and riverine (creek) sites (MDBC 2004). Twelve x 90 second electrofishing shots as well as 10 x bait traps deployed for approximately 2 hours will be applied at each site accessible to the electro-fisher.

Additional Techniques/divergence from methodology recommended in MDFRC (2005):

Richardson et al. (2005) recommended targeted sampling for larval and early juvenile life stages. We recommend that this component be removed from the project at this time as there are difficulties associated with interpreting data on larval and early juvenile fish that is obtained from a "snap-shot" or single data point. Long-term time series of larval data from the Lindsay Island Anabran system (Vilizzi et al. 2007) demonstrates that different species spawn at different times of the year.

Consequently, failure to observe larvae of a specific species (or group of species) in a snap-shot data point cannot be interpreted as a failure for that species to recruit in any given year. In addition, the cost of processing larval samples is quite substantial. For example, a standard approach would involve 9-light traps (3 sets of 3) at each site. For two sampling periods at 21 sites, this would involve around 76 days of staff time to process the samples collected. We would suggest that evidence of young-of-year fish recorded from fyke net catches is a more reliable and cost effective indicator that successful spawning and subsequent survival to early juvenile life stages has occurred.

We also propose the use of 3 x 5m seine hauls at each site in conjunction with the above techniques. Seine netting greatly enhances capture rates with open-water (pelagic) and cryptic fish species which may be under-represented by the use of fyke nets alone (MDFRC 2008). The benefits of seine netting in enhancing the proposed project sampling program outweigh the negligible increase in project costs. Contemporary MDFRC data analysis techniques enable seine netting to be decoupled from standard methods (i.e. MDFRC 2005) in reporting, thus the sampling regime is enhanced while remaining comparable with previous surveys.

► Reports

Rehwinkel R and Sharpe C (2009) Gunbower Forest Fish Monitoring Surveys. Progress Report prepared for North Central Catchment Management Authority, January, 14pp.

Client	NORTH CENTRAL CATCHMENT MANAGEMENT AUTHORITY
Project Title	Angler Diaries for Gunbower Island: Community contribution to knowledge generation of fish distribution across Gunbower Island (M/BUS/320)
Contact Officer	Mr Clayton Sharpe – c.sharpe@latrobe.edu.au
Project Duration	1 st June 2009 to 30 th June 2010
Research Theme	Knowledge Exchange
Status	Current

▶ Objectives

- (a) Engage the local community in the collection of meaningful information regarding the distribution of native and exotic fishes across the Gunbower Island region
 - (b) Disseminate data collected from Angler Diaries to inform the NC CMA about:
 - * Representative Angler effort in the Gunbower Island region
 - * Some elements of the recreational use of the Island
 - * The distribution of particular fish species across Gunbower Island
- * Potential management requirements with regard to fish communities across Gunbower Island.

▶ Methodology

- 1) Design and print a Diary specific to Gunbower (up to approx 500 copies)..
- 2) Attend NC CMA community forum to launch and distribute diaries, and place diaries at tackle outlets/fuel outlets etc
- 3) Receive completed diaries from anglers: April 2010.
- 4) Use data from diaries for
 - estimating angler effort across Gunbower
 - Quantifying the species composition and spatial distribution of fish encountered by Anglers across Gunbower
 - Estimating the potential effect upon native fishes as a result of Angler effort across Gunbower
 - Comparing data collated from diary returns with data generated by Gunbower Island fish surveys to enhance understanding of any impact of angling on fish community structure.

▶ Reports

Client	NORTH CENTRAL CATCHMENT MANAGEMENT AUTHORITY
Project Title	Status of freshwater catfish (<i>Tandanus tandanus</i>) populations in Gunbower Creek (M/BUS/321)
Contact Officer	Mr Clayton Sharpe - c.sharpe@latrobe.edu.au
Project Duration	14 th July 2009 to 14 th December 2009
Research Theme	Assessment
Status	Current

► Background

To aid the NC CMA's overall objective of understanding the status of freshwater catfish on Gunbower Island, a community engagement event organised by the NC CMA was attended by MDFRC staff who gathered anecdotal evidence regarding the spatial distribution of catfish across Gunbower Island. This event identified two extra lagoon sites known by the local community to be occupied by catfish, which were subsequently agreed (by the NC CMA and MDFRC) to be included into the survey program.

The survey program applies techniques suitable to encounter the full range of life-history stages of freshwater catfish expected to occur at these study sites at the time of sampling, whilst maintaining standardised effort appropriate to evaluate the presence/absence, spatial distribution, relative abundance, and population structure of freshwater catfish populations, thus determining the current status of this species at those study sites in the Gunbower Creek. Furthermore, comparison of the population structure of freshwater catfish between wetlands (sites) may then be correlated to particular habitat features and prevailing water management regimes in order to elucidate potential benefits or negative impacts result of both current and planned water management regimes. As such, robust surveys of physical aquatic habitat characteristics at each site in conjunction with a thorough understanding of present and planned water management on Gunbower Island is required.

► Objective

Apply a scientifically robust environmental assessment program that will be able to evaluate the current status of freshwater catfish (*Tandanus tandanus*) populations in Lagoons associated with the Gunbower Creek; including Turner, Phyland, Longmore and Gunbower Lagoons, as well as within the Gunbower Creek immediately adjacent to those Lagoons.

► Reports

Rehwinkel R and Sharpe C (2009) Status of Freshwater catfish (*Tandanus tandanus*) populations in Gunbower Creek 2009. A report prepared for North Central Catchment Management Authority by The Murray-Darling Freshwater Research Centre, December, 36pp.

Client	NORTH CENTRAL CATCHMENT MANAGEMENT AUTHORITY
Project Title	Wetland and Waterway Condition Assessments (M/BUS/329)
Contact Officer	Ms Cherie Campbell – c.campbell@latrobe.edu.au
Project Duration	15 th October 2009 to 11 th January 2010
Research Theme	Assessment
Status	Current

▶ Background

This project involves vegetation condition assessments and Ecological Vegetation Class mapping being undertaken at seven wetland sites and three waterway sites within the North Central CMA. Significant environmental values will be identified at each site and the hydrological requirements of these significant values will be assessed or the knowledge gaps identified. Key threats to the ecological health of the sites will also be identified. A Technical Paper will be produced and the results of this will be presented at two Stakeholder Workshops. The NCCMA will develop Environmental Watering Plans (EWP) for the 10 sites based on the information in the Technical Paper, and these EWPs will be reviewed.

▶ Objectives

- Undertake vegetation condition mapping at seven wetland sites and three waterway sites
- Identify and record the hydrological requirements of the significant environmental values at each site. This will be based on significant vegetation values observed in the field and historical data provided by the NC CMA.
- Confirm the identification of vegetation species where required (e.g. *Ruppia* spp.)
- Report on ecological status and provide recommendations to stakeholders.

▶ Reports

Client	NSW DEPARTMENT OF PRIMARY INDUSTRIES
Project Title	Resnagging the Pomona Priority Habitat Reach, Lower Darling River (M/BUS/262)
Contact Officer	Dr Todd Wallace - t.wallace@latrobe.edu.au
Project Duration	11 th February 2008 to 30 th June 2010
Research Theme	Habitat
Status	Current

► Background

The Lower Murray Darling CMA in conjunction with NSW DPI are planning a strategic and targeted investment in aquatic habitat restoration within the LMD Catchment in the Pomona Priority Habitat Reach of the Lower Darling River. The Pomona Priority Habitat Reach is accessed by the public and is a known recreational fishing area. The development and progression of fish habitat restoration activities in this area will directly engage both fishing club affiliated stakeholders and broader catchment community members.

One of the key activities is to undertake a re-snagging project in the Darling River at Pomona. The project is the second of its type that addresses the Catchment Action Plan target to improve riverine health. This current project aims to demonstrate the effect of the re-snagging works on rehabilitating native fish populations within targeted areas.

The monitoring program will:

- (i) Establish the pre-intervention status of fish communities within targeted reaches at Pomona.
- (ii) Establish and monitor control, treatment and reference sites.

The data generated will allow for a rigorous assessment of the benefit to native fish populations resulting from the re-snagging works undertaken at Pomona on the Lower Darling River

► Objectives

1. Establish a control, treatment and two reference sites.
2. Determine the pre-works (current) status of the fish community (composition, population structure and abundance) within the control, treatment and two reference sites.
3. Monitor the control, treatment and reference sites through time to determine the effect of the proposed works on rehabilitating native fish communities.
4. Provide scientifically defensible information to enhance future re-snagging works in the Lower Murray-Darling region.

► Reports

Sharpe C and Ellis I (2008) Assessment of snag-habitat and fish community relationships in the Pomona Priority Habitat Reach, Lower Darling River. Progress Report to Lower Murray Darling CMA and NSW DPI, May, 7pp.

Ellis I and Sharpe C (2009) Draft Assessment of snag-habitat and fish community relationships in the Pomona Priority Habitat Reach, Lower-Darling River. A draft technical report prepared for the Lower Murray Darling Catchment Management Authority by The Murray-Darling Freshwater Research Centre, December, 38pp

Client	NORTH EAST CATCHMENT MANAGEMENT AUTHORITY
Project Title	Willows Monitoring (M/BUS/274)
Contact Officer	Dr Ben Gawne - b.gawne@latrobe.edu.au and Mr Paul McInerney – p.mcinerney@latrobe.edu.au
Project Duration	27 th February to 30 th November 2009
Research Theme	Assessment
Status	Current

► Background

In March 2006, MDFRC was commissioned by NECMA to develop a literature review and a long-term monitoring program detailing the effects of willow removal on freshwater aquatic systems and to monitor these effects. The literature review was completed in June 2006. This review demonstrated that although anecdotal evidence suggests an overall increase in ‘stream health’ in the long term following willow removal, there is a consistent lack of data describing the effects of willows and willow removal on Australian aquatic environments. This made accurate predictions about short and long term effects of willow removal difficult and led to the next phase of the project that identified key issues and recommended a monitoring program.

The monitoring and key issues report developed a protocol for identifying key issues and a monitoring program associated with potential long term effects of willow removal on aquatic systems. These key issues were based on the knowledge available and their importance to stream ecology.

The next phase of the project was the implementation of the monitoring program at willow removal and control sites to ascertain the key long term effects of willow removal on aquatic systems. Willow removal was undertaken in sites along a 600m reach of Little Snowy Creek, Eskdale, Victoria, during April 2007. Monitoring was undertaken before (March 07) and after (May 07-Nov 08) willow removal in control and willow removal sites along Little Snowy Creek.

A report which summarised the literature review, key issue assessments and monitoring outcomes for the 2007 spring and autumn season following willow removal was produced.

The next phase of the project is to identify and establish two native vegetation sites and an additional willow removal and control site to use in the willow monitoring study. The two existing sites will continue to be monitored. Monitoring of the six sites will be undertaken in autumn and spring 2009. A report will be produced in December 2009 detailing the results of the monitoring.

► Objectives

This project will continue to monitor a willow removal and control site in Little Snowy Creek to assess the ecological impacts associated with willow removal. Four additional sites will be added, two native sites, one willow removal and one control site to the monitoring program.

► Aims

Monitor long-term stream health with a focus on water quality, nutrients, light and temperature changes, macroinvertebrate and fish communities, bank erosion, and riparian vegetation in order to detect and assess potential changes in river health resulting from willow removal.

▶ Reports

McInerney P and Gawne B (2009) Effects of Willow (*Salix* spp.) Removal on Freshwater Ecosystem Dynamics: New Monitoring Sites. Draft Report for the North East Catchment Management Authority prepared by The Murray-Darling Freshwater Research Centre, October, 9pp.

Zukowski S, Gawne B, Smith L and Whiterod N (2009) Effects of Willow (*Salix* spp.) Removal on Freshwater Ecosystem Dynamics. Autumn/Spring monitoring 2007 and 2008. Report prepared for the North East Catchment Management Authority by The Murray-Darling Freshwater Research Centre, October, 92pp.

McInerney P, Zukowski S and Gawne B (2009) Effects of Willow (*Salix* spp.) Removal on Freshwater Ecosystem Dynamics: New Monitoring Sites. Final Report prepared for North East Catchment Management Authority by The Murray-Darling Freshwater Research Centre, November, 9pp.

Client	SINCLAIR KNIGHT MERZ
Project Title	Salinity Target Reviews (M/BUS/326)
Contact Officer	Mr Garth Watson – g.watson@latrobe.edu.au
Project Duration	8 th September 2009 to 31 st March 2010
Research Theme	Biota
Status	Current

► Background

There are currently two significant initiatives within the Murray-Darling Basin Authority (MDBA) requiring a substantive review of the existing salinity targets in the Murray-Darling Basin:

- **Water Quality and Salinity Management Plan:** The MDBA must include salinity objectives and targets in the Basin Plan (*Water Act 2007*, Part 2, Division 1, Section 25 (1) (b)). These targets, together with other water quality targets, are part of the mandatory content of the Plan and will be used to monitor the condition of key environmental assets and the health of the Basin system overall. In undertaking this function, the MDBA must have regard to the National Water Quality Management Strategy.
- **Basin Salinity Management Strategy (BSMS):** The MDBA has established a series of End-of-Valley salinity targets, including a Basin Salinity Target at Morgan, South Australia. The MDBA must, at intervals of not more than 5 years, review the adequacy and appropriateness of each End-of-Valley Target (*Water Act 2007*, Schedule 1, Schedule B, Part III, Clause 9).

This project is to both review the suite of BSMS End-of-Valley Targets and to recommend salinity objectives and targets for adoption in the WQSMP. In addition, the 2007 Mid-Term Review of the BSMS recommended investigation of options for targets that are more closely integrated with the accountability framework and allow for adaptive real-time salinity outcomes. The *Water Act 2007* allows for targets to be specified in terms of a particular level of salinity being met for a particular percentage of time. The recommended suite of objectives and targets will need to consider both these matters.

Salinity targets need to be robust and meaningful from the Federal, State, regional and local communities' perspectives, to enable timely monitoring, reporting and evaluation into the future, and should include a transparent process for the revision of targets by ensuring that the Targets are SMART (Specific Measurable Attainable Realistic Timely).

► Reports

Client	SOUTH AUSTRALIAN MURRAY-DARLING BASIN NATURAL RESOURCES MANAGEMENT BOARD (SA MDB NRM Board)
Project Title	Tree Health Monitoring for the Pike River Floodplain (M/BUS/299)
Contact Officer	Dr Todd Wallace - t.wallace@latrobe.edu.au
Project Duration	2 nd February to 29 th May 2009
Research Theme	Assessment
Status	Completed

► Background

This project will provide for an assessment of the influence of current and future hydrology on the condition of long-lived vegetation at the Pike River Floodplain complex.

► Tasks

1. Develop a scientifically defensible tree condition assessment program that will provide for an annual assessment of prevailing tree condition and predicted trajectory. This will include adoption of the standardised tree condition methodology that has recently (November 2008) been developed for use at all of the *The Living Murray* Icon sites to ensure consistency of data.
2. Establish a total of 21 Tree Condition assessment sites at the Pike River floodplain complex. At each site a 0.25ha transect will be established. It is proposed that the sites will be stratified across (i) the spatial components outlined in the project brief; and (ii) the elevation gradient and the associated hydrological regime on the floodplain.
3. Undertake Tree Condition surveys to establish the baseline condition. These surveys will be undertaken in autumn 2009.
4. Produce a report that contains a description of:
 - the Tree Condition monitoring program
 - the methodology to be used for Tree Condition assessment
 - site description including site access notes,
 - analysis of current tree condition and predicted trajectory for each transect; and
 - an assessment of the change in Tree Condition between 2003 and current using the existing data from the 2003 DEH Baseline Survey. The extent of this analysis will be dependent on back compatibility between the 2003 DEH data and the data that will be collected in 2009.

We propose to establish a total of 21 sites in a stratified design across the Pike River floodplain complex. The design outlined below will be reviewed during the Inception Meeting and Initial Site Visit to ensure it is appropriate for the task. Where possible sites will incorporate sites previously assessed in the 2003 DEH Baseline survey.

Distribution of sites across the three spatial components:

Due to the large variation in size between the three spatial components, the stratified design will be “unbalanced” to ensure representative spatial coverage of each spatial component. We propose to establish 9 sites (3x3) in Area 1, and 6 sites (3x2) in each of Area 2 and 3.

Distribution of sites within the three spatial components:

The sites will be stratified within each of the three spatial components according to elevation and the associated hydrological regime (3 water regime classes). It is anticipated that the flood inundation frequency will reflect the dominant vegetation type (outlined below) and is likely to be a major determining factor in tree condition:

1. Regularly inundated; *Eucalyptus camaldulensis* var *camaldulensis* (river red gum) forest and *Acacia stenophylla* (river cooba) forest.
2. Moderate inundation frequency; *Eucalyptus camaldulensis* var *camaldulensis* woodland.
3. Infrequently inundated; *Eucalyptus largiflorens* (black box) woodland.

*NOTE: dominant vegetation classes indicated above are based on vegetation layers provided in the tender documents.

▶ Reports

Wallace TA (2009) An assessment of Tree Condition at the Pike Floodplain (South Australia). Final Report prepared for the South Australian Murray-Darling Basin Natural Resources Management Board by The Murray-Darling Freshwater Research Centre, May, 78pp.

Client	SOUTH AUSTRALIAN MURRAY-DARLING BASIN NATURAL RESOURCES MANAGEMENT BOARD (SA MDB NRM Board)
Project Title	Fish and Fish Habitats of the Pike River Anabranh and Floodplain Complex (M/BUS/309)
Contact Officer	Mr Clayton Sharpe - c.sharpe@latrobe.edu.au
Project Duration	1 st January 2009 to 30 th November 2009
Research Theme	Habitat
Status	Current

► Background

The Pike Anabranh system is a series of creeks, backwaters and lagoons that extends over 4,000 ha of lower River Murray floodplain between Paringa and Lyrup in South Australia (Jensen et al. 1996). The system is one of three systems (along with the Chowilla and Katarapko systems) in the South Australian River Murray that bypasses a main channel weir. The subsequent head loss through these systems has created a mosaic of different wetland types in a relatively small area, including flowing habitats that were present in the main channel before river regulation (Mallen-Cooper et al. 2008). These artificial systems probably play a similar role to the flowing habitats lost from the main channel due to regulation and provide an important refuge for riverine species adapted to flowing habitats (Mallen-Cooper et al. 2008).

Whilst the system has experienced a significant decline in ecological condition in recent years due to rising saline groundwater, lack of flooding, pest plants and animals, altered flow regimes, grazing and barriers to fish passage, the SA MDB NRM Board has recognised the environmental values of the Pike Anabranh system and categorised it as a high priority system with a high potential for restoration.

There is little information regarding the fish communities of the Pike Anabranh system; however, similar anabranh systems in the region such as Lindsay Island (Sharpe et al. 2009) Katarapko (Leigh et al. 2008) and Chowilla (Zampatti et al. 2008) support significant populations of large and small bodied native fish. Similarly, there is little information about the physical habitats present in the Pike Anabranh system.

Data from Lindsay, Chowilla and Katarapko have shown that the combination of flow and physical and habitat type can influence the distribution and abundance of fish species. For example, golden perch are present in significantly higher numbers in fast flowing reaches with *Phragmites australis* and medium sized woody debris, Murray cod in fast flowing reaches with large woody debris and carp in slow flowing reaches or backwaters dominated by *Vallisneria americana*.

Information of this nature is needed to be collected before the Pike Implementation Plan proceeds to determine the most appropriate restoration techniques are applied, to ensure efforts are focussed in the areas where they will have the most benefit, to protect areas with high conservation values and ensure maximum benefit from on ground works. In addition, this information will serve as a quantitative for ongoing monitoring activities to measure the success of restoration activities and because this project will use the same methods as used in Chowilla and Katarapko, direct comparisons can be made across the three sites.

► Reports

Beyer K, Marsland KB, Sharpe C, Wallace T, Zampatti BP and Nicol JM (2010) Fish and Fish Habitats of the Pike River Anabranh and Floodplain Complex. A Draft Final Report prepared for the South Australian Murray-Darling Basin Natural Resources Management Board by The South Australian Research and Development Institute (Aquatic Sciences) and The Murray-Darling Freshwater Research Centre, January, 53pp.

Client	SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE (SARDI)
Project Title	Integrated Pest Management (M/BUS/219)
Contact Officer	Dr Lorenzo Vilizzi - l.vilizzi@latrobe.edu.au
Project Duration	1 st March 2007 to 1 st June 2011
Research Theme	Biota
Status	Current
Collaborators	Environmental Protection Agency; PIRSA Rural Solutions; Adelaide University; Commercial Fishers (Damien Wilksch, Barmera; K & C Fisheries); South Australian Murray-Darling Basin Natural Resources Management Board; Loxton to Bookpurnong Local Action Planning Group and Banrock Station.

► Background

Researchers from SARDI Aquatic Sciences (Drs Ben Smith and Jason Nicol), the Environmental Protection Agency (Peter Goonan) and The Murray-Darling Freshwater Research Centre (Dr Lorenzo Vilizzi) will undertake this project.

Site access to Banrock Station wetland has been pre-arranged, as has the necessary fishing permits (Section 59 permit, issued through PIRSA Fisheries) and hydrological regime (Banrock Station water license 110143).

► Aims

- Initially remove carp from exclusion areas by drying the wetland, and ensure their exclusion upon refilling using fencing and a range of integrated control activities over the project's duration. The carp control techniques that will be demonstrated during the life of this project include:
 - water level manipulations to expose spawned eggs to desiccation and trap adult carp on the floodplain,
 - wetland carp separation cages (used in lieu of carp screens) to monitor carp movement to and from the wetland,
 - remote tracking of 'judas' fish to evaluate carp habitat use and identify carp spawning and overwintering aggregations,
 - netting gear (seine nets, gill nets, fyke nets),
 - commercial fishing, and
 - testing of attractant flows at the wetland outlet.
- Measure and compare the response of environmental parameters (i.e. water quality and the diversity and abundance of fish, vegetation and macro-invertebrate communities) in 'exclusion' versus 'control' plots.
- Continuous promotion of the project rationale, methods and results and the benefits of carp removal to riverine stakeholders and the wider public.

Fish sampling will be bi-annual from September 2007.

After the wetland is refilled, one quadrat will be randomly established within each of the control and exclusion plots. To sample aquatic macroinvertebrates, we will pilot the use of dip nets using a modified version of the AUSRIVAS sampling protocol.

► Executive Summary

The SA River Murray Wetlands Baseline Surveys (RMWBS) are the most comprehensive wetland surveys ever undertaken in the Murray-Darling Basin. They have occurred each year since 2004, at 87 wetlands distributed from the SA/NSW/VIC border to the Murray Mouth. These major biological and physical surveys have been undertaken in a bid to learn about the River Murray and its wetlands. Thus, at each wetland, baseline data on the site characteristics, fish, water quality, groundwater, vegetation, birds, frogs and/or macroinvertebrates has been collected. This information has been used to identify conservation values and derive wetland management plans for a number of wetlands. Wetland management plans include concise statements about local conservation values and planned management objectives. Importantly, the data provides a basis for evaluating the success of future management plans.

Annual reports are available for each survey year but until now, there has been no attempt to integrate and analyse the total dataset for any ecological parameter. This report documents the analyses of the combined 'fish' dataset from 74 wetlands (some wetlands were dry at the times of sampling), including nine from the Lower Lakes (Murray Mouth to Wellington), six from the Lower Swamps (Wellington to Mannum), 35 from the Murray Gorge (Mannum to Overland Corner) and 24 from the Riverland (Overland Corner to the SA/NSW/VIC border) regions, and forms a milestone report for two projects funded under the MDBA's Native Fish Strategy (Evaluation of carp exclusion screens at wetland inlets and this project).

Analyses highlight four key regional patterns in the relative density and diversity of wetland fishes in SA, which are discussed in light of possible interactions with river flow and habitat availability. Carp specific information is also discussed in relation to the species' broad habitat, dietary and ecological requirements and the apparent effectiveness of existing carp exclusion screens in controlling the density and biomass of carp within wetlands:

1. The Lower Lakes region contains the most diverse wetland fish assemblage of any region in the SA MDB. Species that are exclusively or predominantly (in which case, also in Lower Swamps wetlands) found in the Lower Lakes region include those that are tolerant of a wide range of salinities (i.e. blue-spot goby, lagoon goby, congollis and small-mouthed hardyhead), migratory between fresh and salt waters (i.e. common jollytail, Tamar river goby, bridled goby, salmon trout and yellow-eye mullet) and/or listed under state (SA Fisheries Act 1982 i.e. southern pygmy perch) or national (EPBC Act 1999 i.e. Yarra pygmy perch and Murray hardyhead) legislation. Each of these species was also relatively more abundant in small-shallow wetlands in 2007-7, and southern pygmy perch alone were more abundant in ephemeral wetlands in 2004.
2. Wetlands in the Lower Swamps region, on average, have the most diverse fish assemblages and the least variation in species counts across wetlands.
3. The Riverland and Murray Gorge regions always recorded the highest relative densities of wetland fishes—particularly 'generalist' species with broad habitat and eco-physiological requirements such as bony herring, carp gudgeon, Murray rainbowfish, unspecked hardyheads, eastern gambusia and goldfish. These species, in addition to Australian smelt, dwarf flathead gudgeon, flathead gudgeon, golden perch, redfin perch and common carp all tend to be more abundant in permanent wetlands and in large-shallow, large-deep and small-deep relative to small-shallow wetlands.
4. Species counts are typically lower and more variable in small-shallow ephemeral wetlands than in permanent wetlands.
5. Patterns in the relative density and habitat use of carp were consistent across the four RMWBS regions.

6. Patterns in the relative density and habitat use of carp were not related to the presence/absence of flow control structures (regulators) or carp exclusion screens, even after splitting the density data into age 0+ and 1+ components (2005-7 dataset only) based on a 100 mm (total) length criterion.

▶ Reports

Smith B, Vilizzi L and Conallin A (2007) Analyses of the combined 'fish' dataset from the 2004-2007 annual South Australian River Murray wetlands baseline surveys. Report for the Primary Industries and Resources South Australia, SARDI Publication Number F2007/000526-1, SARDI Research Report Series Number 288, August, 47pp.

Smith B, Vilizzi L, Nicol J, Madden C and Thwaites L (2009) Project MD756 'Integrated carp maintenance at Brenda Park wetland'. Milestone Report #1 for the Murray-Darling Basin Authority, December, 39pp.

Client	SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE (SARDI)
Project Title	The protection of drought refugia for native fish in the Murray-Darling Basin (M/BUS/286)
Contact Officer	Mr Clayton Sharpe - c.sharpe@latrobe.edu.au
Project Duration	
Research Theme	
Status	Additional information, duration and background to be advised (Rosie Busuttill, 10 th November 2009).
Sub Contract	This project is subcontracted to MDFRC by SARDI. Original contract is with the Murray-Darling Basin Commission MD1087

▶ Background

▶ Reports

McNeil D, Gehrig S and Sharpe C (2009). Resistance and resilience of Murray-Darling Basin fishes to drought disturbance. Draft report to the Murray-Darling Basin Authority, June, 107pp.

Client	SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE (SARDI)
Project Title	Ecosystem resilience and importance of refugia for native fish communities/populations (M/BUS/287)
Contact Officer	Mr Clayton Sharpe - c.sharpe@latrobe.edu.au
Project Duration	
Research Theme	
Status	Additional information, duration and background to be advised (Rosie Busuttill, 10 th November 2009).
Sub Contract	This project is subcontracted to MDFRC by SARDI. Original contract is with the Murray-Darling Basin Commission MD1086

▶ Background

▶ Reports

MDFRC –PhD Students

PhD Student	Paul McInerney
Title	Effects of Willow removal on freshwater ecosystem dynamics
University	La Trobe University (Albury-Wodonga campus)
Supervisors	Ben Gawne (MDFRC) and Phil Suter (La Trobe University)
Project Duration	July 2008 to July 2017
Status	Current

► Summary

The effects of willows and willow removal on river function and the rehabilitation process required to return willow removal sites to an ecologically and socially acceptable state need to be investigated if future willow removal works are to be conducted to their highest potential.

This PhD project will investigate how willows and willow removal have altered stream function, requirements for stream rehabilitation, rehabilitation classification, ecological niche function and changes in food web dynamics between areas with willows and areas without willows. It will also isolate and investigate social aspects associated with willow removal and best practice management.

Some key knowledge gaps to be investigated are:

1. Extent of impact on fish community composition and abundance (habitat, shade, temperature, feeding and predator avoidance).
2. Extent of impact on macroinvertebrate community composition and abundance (feeding and habitat).
3. Extent of impact on food web (timing, quantity and quality of allochthonous input, shade, temperature and algal production).
4. Extent of impact on water quality (nutrient input and runoff, pH, salinity and dissolved oxygen levels).
5. Extent of impact on riparian habitats (bank soils and erosion, use of riparian corridors by animals, impact of riparian zone fragmentation following de-willowing and riparian vegetation).
6. Extent and timing of impacts and recovery periods.

The ongoing extent of willow invasion and the large scale movement of asexual propagules downstream from existing stands means catchment and regional planning strategies need to consider willow management in Australia. Priority setting requires quantitative knowledge of impacts, costs and benefits from willow invasion and willow removal at both reach and catchment scales (Wilson 2001). In addition, catchment managers require access to knowledge that will enable willow removal to be undertaken in a manner that minimizes detrimental short term impacts and accelerates recovery of the system. This project aims to provide answers for many of the questions surrounding the benefits and impacts of willow removal from streams in the Murray-Darling Basin.

► Thesis Report

PhD Student	Nick Whiterod
Title	Construction of a bioenergetics model for Murray cod
University	Charles Sturt University (Thurgoona campus)
Supervisors	Paul Humphries and Robyn Watts (Charles Sturt University), Shaun Meredith (MDFRC) John Koehn (Arthur Rylah Institute, DSE) and Brad Sherman (CSIRO Land and Water)
Project Duration	April 2006 to October 2009
Status	Current

▶ Summary

Fish bioenergetics allows us to determine the optimum habitat and feeding requirements of fish at an individual species level. Bioenergetics models have been used to manage fisheries throughout the northern hemisphere for 20 years, however currently there exists only one parameterised model for an Australian species – the carp gudgeon (*Hypseleotris* sp.). The application of this gudgeon model showed that it could accurately predict changes in the habitat used by different life stages of fish in a Queensland reservoir.

Similar outcomes would be possible through the application of such a model for Murray cod. Further, the model could be used to critically examine why Mullaroo Creek represents such an apparently ideal system for cod spawning and recruitment, and would allow us to optimise habitat conditions for cod in other sites within the Murray Darling Basin. The model is species specific, and would be applicable across the whole range of Murray cod distribution, allowing for management at the population scale.

▶ Thesis Report

PhD Student	Janice Williams
Title	The role of fungi in the carbon cycle of floodplain wetlands
University	La Trobe University (Albury-Wodonga campus)
Supervisors	Roger Croome (La Trobe University) and Darren Baldwin and Gavin Rees (MDFRC)
Project Duration	Part-time, over five years Commenced July 2006 to July 2011
Status	Current

► Summary

The carbon cycle of aquatic systems incorporates biological, chemical and geological sinks and fluxes that provide profound insights into the characteristics of these ecosystems. Recent research has illuminated many aspects of carbon movement through streams and wetlands but the contribution of fungi to these systems has not yet been investigated.

Given the intrinsic economic, environmental and social values of the wetlands of the Murray River (particularly the Barmah-Millewa Forest), a complete understanding of the carbon cycle of these ecosystems is important. This is because knowledge of carbon dynamics in floodplain wetlands allows more reliable prediction of:

- (1) the impacts of various flooding regimes on ecosystem function,
- (2) the onset of "blackwater" events, and
- (3) the impact of slugs of nutrients of pollutants.

The activities of fungi may attenuate or exaggerate these effects, and are also of significance to invertebrate food chains and nutrient cycling.

► Aims

1. To investigate the role of fungi in the decomposition of floodplain leaf litter and woody debris in wetlands associated with the Murray River (including the Barmah-Millewa Forest).
2. To compare fungal communities in terrestrial, aquatic/aerobic and aquatic/anaerobic environments.
3. To determine how wetland wet/dry regimes affect rates of fungal degradation of floodplain litter.
4. To determine which chemical substrates (carbon sources) are being degraded by different fungal groups under the three above conditions and what the products of the degradation process are.
5. To determine the impacts of fungal activity on carbon availability to other aquatic organisms.

This will be achieved through an experimental program that will:

- Provide an indication of genetic diversity.
- Determine the major fungal taxonomic groups present.
- Determine fungal biomass and production.
- Quantify rates fungal activity.
- Calculate the decomposition rate of floodplain litter, under various conditions.
- Determine the rate of loss of major groups carbon compounds (cellulose, hemicellulose, phenolic compounds, water soluble compounds, ether and alcohol soluble compounds and proteins) from decomposing litter.

► Thesis Report

PhD Student	Clayton Sharpe
Title	Spawning and recruitment ecology of golden perch
University Supervisors	Griffith University Victorian Fisheries Revenue Allocation Committee Angela Arthington and Brad Pusey (Griffith University) and Shaun Meredith (MDFRC)
Project Duration	February 2004 to August 2007
Status	Writing up

► Summary

Due to range and abundance reductions and certainly due to their recreational popularity, hundreds of thousands of hatchery reared golden perch (*Macquaria ambigua* Richardson 1845) are annually liberated into rivers of the Murray-Darling Basin to augment natural recruitment and sustain recreational fisheries (Rowland 1996). The principal objective of this research program is to present a conceptual model of natural golden perch recruitment ecology based upon empirical field observations and experiments, aimed at balancing conjecture and quantifying existing assumptions relating to this species life-history strategies and recruitment ecology. Greater understanding of the ecological processes contributing to survival and recruitment of golden perch is required to discover how aquatic ecosystems might be managed differently to allow rebuilding of golden perch populations and fish communities through improved natural recruitment.

► Objectives

- To decouple the role of flow, temperature and seasonality as stimuli for golden perch reproduction.
- To compare patterns of reproductive effort for populations between spawning events during flood and non-flood years.
- To examine the timing, habitat and duration of spawning between populations (catchments) affected by different flow regimes.
- To examine ontogenetic patterns of dispersal and habitat use for larval and juvenile golden perch.
- To examine/compare growth rates, diet and other recruitment factors for golden perch larvae/juveniles inhabiting floodplain and river channel habitats.

► Methods

- Measure indices of golden perch reproduction in wild populations at three different locations (catchments) affected by varying flow regimes and river regulation scenarios.
- Determine developmental patterns, growth rate, prey availability and diet of larval and juvenile golden perch between floodplain and riverine habitats.
- Correlate sexual development, growth rate and age with environmental parameters such as habitat, flow, prey availability and temperature.

► Main Findings

Golden perch spawned in the main channel of the Darling River (at Menindee) in response to a flood event during 2004 (after a long period of no flow). Downstream of Menindee, golden perch spawning was delayed, and pronounced in response to a within channel flow event. Golden perch in the upper-Murray (upstream of Yarrawonga) population failed to spawn during 2004. Larvae and juvenile golden perch from the floodplain Menindee Lakes and Darling River have been sampled monthly for 12 months, with age, growth, diet, and habitat data obtained.

► Thesis report

PhD Student	Nicole McCasker
Title	Native fish recruitment and flood pulse water quality monitoring on Lindsay Island
University	Charles Stuart University(Thurgoona campus)
Supervisors	Paul Humphries (Charles Sturt University) and Shaun Meredith (MFDRC)
Project Duration	February 2005 to February 2008
Status	Writing up

▶ **Summary**

Objectives

What are the main sources of mortality of the egg, larval and early juvenile stages of freshwater fish?

What role do life history traits play in determining the vulnerability of species to particular sources of mortality?

What are the typical patterns of mortality loss during the major ontogenetic/developmental stages of young fish?

Does a 'critical period' or a survivorship 'bottleneck' exist during the egg to early juvenile transition? What is the ecological significance of this time? i.e. is this period of potential high mortality responsible for determining year class strength?

What traits, characteristics turn an individual into a survivor? Understanding the role of natural selection in mortality processes (e.g. body size, developmental stage, growth rate, size at hatching, yolk sac size).

▶ **Thesis report**

PhD Student	John Hawking
Title	Systematics, Biogeography and Ecology of Australian Nymphulinae Moths
University	La Trobe University (Albury-Wodonga campus)
	Funding Body - Commonwealth Environment Research Facilities (CERF): National Taxonomy Hub
Supervisors	Phil Suter and Roger Croome (La Trobe University) and Marianne Horak (CSIRO/Australian National Insect Collection)
Project Duration	March 2007 to March 2010 (part time)
Status	Current

► Summary

The Pyralidae is one of largest family in the Lepidoptera (Butterflies and Moths) and in Australia contains nearly 300 genera and about 1100 species. One of its subfamilies, the Nymphulinae has become important to organizations conducting biological monitoring program, because larval and pupal stages are aquatic. Presently the larvae of all species are unknown and identification is by a key to voucher species (Hawking 2001).

The subfamily Nymphulinae is represented by 81 presently described species, however, of these only 48 are considered genuine species and the other 33 species are considered synonyms (Shaffer, Nielsen & Horak 1996). A revision of the systematics of the subfamily needs to be undertaken using morphological characters and genetic analysis, to produce dichotomous keys to the adults. The adults also need to be associated with their respective larvae, which will allow the positive recognition of the larval voucher species in the taxonomic key (Hawking 2001) presently used by ecologists. None of the larvae have been formally described, figured or published and this will be possible after the larvae have been associated with their corresponding adult stage. It will be possible to collect material for associating, because the MDFRC presently have 26 voucher specimens of larvae, with associated collection locations and dates.

The Nymphulinae are considered to have a tropical origin and the distribution of many genera show radiation in Australia. From an examination of the collection sites of specimens in the Australian National Insect Collection (ANIC) housed in Canberra, species of genus *Parapoynx* are probably more cosmopolitan in their Australian distribution and worldwide, between 40 degrees north and south, whereas, the species of *Margarosticha* and *Eoophyla* are restricted to tropical north. The biogeography of the Australian species needs to be investigated and related to studies in Asia and Japan.

Presently the ecology of this subfamily is almost non-existent. Common (1990) reported the known information on this group in half a page. He suggested that the larval stage in many species is associated with vegetation and construct cases, mainly in standing water, however, others inhabit stones in streams and construct silk retreats. Presently the MDFC can match the voucher larvae with water-body type and many taxa with their specific vegetation type. This needs to be verified and the life histories of each species documented.

► Thesis Report

PhD Student	Tegan Evans
Title	Identification of fungal communities in activated sludge using culture independent methods
University	La Trobe University
Supervisors	Robert Seviour and Ian Swift (La Trobe University) and Gavin Rees (MDFRC)
Project Duration	January 2006 to January 2010
Status	Current

▶ **Summary**

▶ **Thesis Report**

PhD Student	Nirmala Wijieratne
Title	Organic carbon speciation in the water and sediment of lowland rivers
University	La Trobe University (Albury-Wodonga campus)
Supervisors	Ewen Silvester (La Trobe University) and Darren Baldwin (MDFRC)
Project Duration	February 2009 to March 2012
Status	Current

► Summary

The flooding frequency and intensity of wetlands in the lower Murray-Darling Basin has decreased in the recent past due to river regulation and climate change effects. Flooding events serve to re-supply the floodplain soils with carbon, nutrients and minerals, as part of the aquatic-terrestrial exchange processes. The effect of the change in frequency and intensity of flooding events on floodplain health is unknown.

This project will examine the soil-floodplain interaction, soil carbon speciation on flooding regimes, soil micro aggregates and historical record of a floodplain sediment profile to determine the past frequency of flooding events, and the characteristics of the deposited carbon, with the ultimate aim of determining the catchment origins of the organic carbon. Carbon analysis will focus on molecules that are highly stable, and likely to be characteristic of different types of vegetation (e.g. sterols, lipids, etc.).

The work will form part of a larger CERF funded project dealing with carbon dynamics more generally in Yanga Nature Reserve (Murrumbidgee River) in the lower Murray-Darling Basin.

The project work will entail:

- (i) Development of extraction, concentration and analysis techniques for identifying and quantifying organic carbon species such as carbohydrates (neutral sugars and amino sugars), proteins (amino acids), phenols, lignins and lipids), Organic N and P species and Potential Plant Biomarkers.
- (ii) The identification of biomarker molecules from a range of upper catchment aquatic and terrestrial plants, allowing the development of a library of biomarker compounds.
- (iii) Analysis of organic carbon deposits in preserved soil cores from the study area, and cross referencing with biomarker library.
- (iv) Dating of sediment cores (^{210}Pb), and development of a natural history model for floodplain soils in the Yanga Nature Reserve.

Techniques to be used will include:

- Carbon extraction techniques
- Colorimetric methods
- Chromatographic methods - HPLC, GC-MS, LC-MS
- Spectroscopic methods - Solid state ^{13}C NMR, NEXAFS, IR and ^{13}C -NMR
- Dating of sediment cores (^{210}Pb)

The work will be conducted at MDFRC. This laboratory is well equipped for the proposed project, with suitable field and laboratory equipment. Additional analytical instrumentation will be accessed through other agencies (e.g. LC-MS - State Chemistry laboratory, ^{210}Pb - AINSE).

► Thesis Report
