Chapter 4 *Research Program*

Photo: John Hawking

Program

Research program

The CRC for Freshwater Ecology undertakes research within six programs under four overarching ecological themes. PhD research projects have made major contributions to research in all program areas. These projects are listed under *Chapter 5, Education*.

During the past year, the CRCFE has continued to develop its research portfolio. The first phase of the Centre's research portfolio has now been largely completed. There has been a subsequent boost in the Centre's technology transfer activities (see *Chapters 6 and 7*) as scientists have set about communicating the results and findings of their projects. A number of new, integrated projects that emphasise a multidisciplinary approach to science have commenced.

Theme

Ecological assessment

Resource management and environmental protection agencies have an increasing need for high quality information relating to the ecological effects of their operations. However, there have been few useful techniques available that can be rapidly employed to assess the effectiveness of management processes. There is renewed interest in the use of more qualitative techniques, mainly because of the high cost of quantitative approaches.

The CRC for Freshwater Ecology is developing innovative methods for assessing river health particularly using macroinvertebrates, fish, benthic diatoms, phytoplankton and habitat. We have been instrumental in developing new risk-based guidelines for nutrients and sediments (ANZECC). Guidelines, developed as a part of the Urban Water Management Program, will enable informed choices for managing urban waterways. Methods for assessing water quality using biological tools have been developed and tested in association with the National River Health Program. The AusRivAS models are now being used by agencies across Australia and their application in Indonesia is being trialed. The Index of Biotic Integrity using fish has been successfully developed to assess river health in New South Wales. Work in these areas is advancing our knowledge of the relationships between assessment measures and related processes. The completion of a major project has advanced our ability to measure bioavailable nutrients. A prototype instrument has been produced for *in situ* measurement of bioavailable phosphorus. Several projects across the CRCFE are devoted to improving the taxonomic methods for aquatic flora and fauna.

Theme

Energy and nutrient dynamics

This theme addresses a range of key processes in aquatic ecosystems. It incorporates questions concerning the major sources of energy and nutrients in different aquatic systems, the flux of these resources through different components of the systems, their impact on trophic structure and food web inter-connections and the resulting changes in population dynamics and community structure.

Algal blooms resulting from excessive nutrients in waterways remain a major concern to the water industry and the Australian community. Research is addressing critical issues such as the fluxes between various forms and pools of carbon, phosphorus and nitrogen, the role of these nutrients in freshwater ecosystems and the impact that floods have on our aquatic resources. Inputs of nutrients during floods (or storms in the case of urban catchments) drive many of the processes that promote algal growth in lakes and streams. Complementary advances in the measurement of bioavailable phosphorus and nutrient limitation are assisting this research.

New risk-based guidelines have been developed with input from CRCFE researchers. These ANZECC guidelines cover a range of ecosystem types-from lowland to upland rivers, lakes and reservoirs, wetlands, estuaries, coastal and marine.
Left: Gibraltor Falls Creek, an upland stream in the ACT. *Photo: Karen Markwort*
Above: The lowland Darling River. *Photo: Rod Oliver*

Research in Chaffey Dam has contributed to our understanding of nutrient processes in major reservoirs. *Photo: John Whittington*

Australia-a land of drought and flooding rains. Low flow in the Murrumbidgee River. *Photo: Karen Markwort*

Recently completed studies of Chaffey Dam and pollution control ponds in three cities, provide new insights to these processes for both major reservoirs and smaller urban ponds. Two new multidisciplinary projects will take this research further: *The ecological functioning of lowland rivers* and *Sediment-nutrient processes* (in Programs A and B, respectively)-they will both be complemented by the nutrient modelling studies in the Goulburn River, Victoria and Lake Burrinjuck, NSW. In a completely different environment, work on the Thredbo River has improved our understanding of the impact of nutrients in Australian alpine streams.

Theme

Water regime and allocation

The extreme variability of Australian rainfall means that occasional floods and long periods of drought dominate our aquatic systems. Many of our management operations limit this variability in order to produce reliable water supplies. CRCFE research seeks to understand how flow variability influences freshwater ecosystems. Through understanding the impact of water regime-volume and variability-on ecological functions and attributes we are then able to predict the impact of regulation on habitats, biota and ecological processes, and hence provide useful advice on better management. A vital part of this research is to measure ecosystem response to 'environmental flow' management.

Application of this knowledge to rivers and floodplains is allowing researchers to understand the impact of water resource development on the connectivity of floodplains and billabongs to the river channel. Completed research has clearly demonstrated the impact of regulation on recruitment and migration of native fish, and successful invasion by alien species. A major study on the Campaspe River will change the way in which water is released from Lake Eppalock. This study will significantly advance our knowledge of the in-stream ecosystem response to a change in management practice. The Menindee Lakes are providing the CRCFE with a whole-system site for observing the impacts of changes in water regime. At a smaller scale, we have been able to demonstrate the impact that flow variability has on the resources and habitat available to in-stream fauna. The Expert Scientific Panel method for deciding on environmental flow allocations, developed within the CRCFE, is being widely used throughout Australia and is a valuable technique for applying new

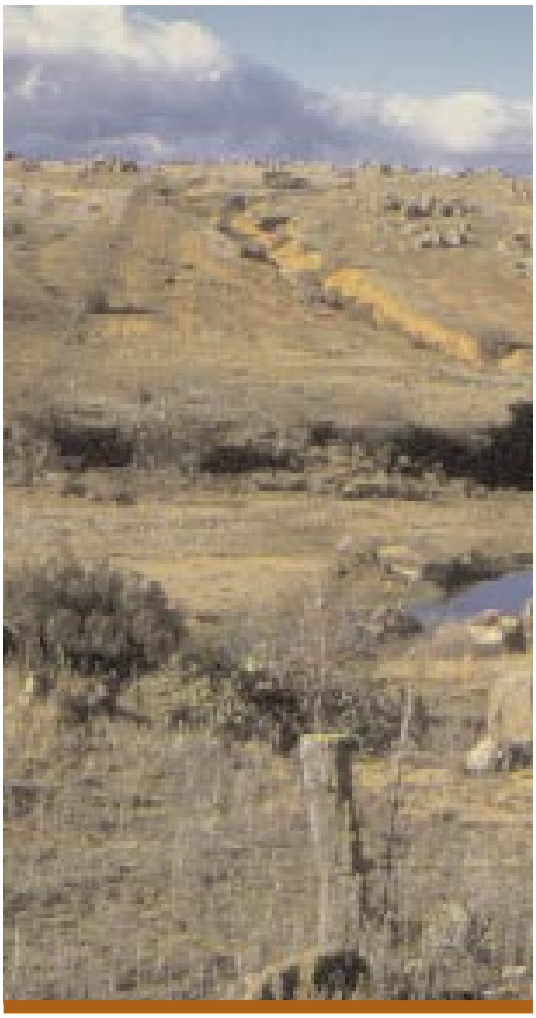
knowledge directly to a management issue. Research in this area is being applied internationally with recent involvement of CRCFE staff in a major World Bank study being conducted in Lesotho, South Africa.

Theme

Restoration and rehabilitation ecology

Most of Australia's freshwater ecosystems have been damaged by human intervention both at the catchment level and within waterbodies. Restoration urgently needs sound ecological guidance. CRCFE research is providing guidance in areas such as the impact of nutrients and nutrient removal on aquatic ecosystems, re-instating natural flow regimes and re-instating more natural urban drainage systems. The impact of alien species, the conservation of endangered aquatic organisms and riparian vegetation are other areas of research. We are also improving our understanding of the importance of floodplain and wetland ecosystems and the mechanisms whereby they interact with the river ecosystem to the benefit of both.

Carp are a major concern to the Australian community and the focus of a body of CRCFE research. The NSW Rivers Survey has provided timely and significant information on the distribution of carp in the Murray-Darling Basin and the apparent links between river regulation and increases in alien fish populations. In addition, the study of an alien aquatic snail is providing valuable information on impacts on native species. The Fish Ecology Program has made a significant contribution to the design and testing of fishways-overcoming barriers to migration for native fish species. The Granite Creeks Landcare project is breaking new ground by studying the ecosystem response to a major restoration program. The project aims to describe the degraded state of three creeks and to implement restorative measures at both the catchment and stream section scales - it provides an exciting opportunity for close interaction between scientists and Landcare groups.



Gully erosion on the Snowy River near Dalgety. Restoration urgently needs sound ecological guidance. *Photo: Karen Markwort*

4.1 Program

Flowing waters

Leader

Prof PS Lake

Flowing waters, rivers and streams, are the lifeblood of this dry continent. They are the interactive channels by which materials and energy are stored and moved from terrestrial to aquatic systems. The levels of movement and retention of materials and energy in the river system affects the dynamics and structure of populations and communities. Of the world's inhabited continents, Australia has the greatest variability in river discharges. CRCFE research seeks to understand how the biota of our rivers has adapted to this variability and how biodiversity has been maintained.

Environmental flow assessment

Project leaders:
Dr Paul Humphries and Prof PS Lake

Project team: Dr Jane Growns, Mr John Hawking, Mr Peter Hancock, Mr Luciano Serafini, Mr Garth Watson and Mr Daryl Nielsen

Sites: Campaspe and Broken rivers, Victoria

Aims:

- Investigate how biota respond to changes in flow regimes by altering the operation of Lake Eppalock to restore seasonality, variability and duration to the flows in the Campaspe River.
- Provide, through consultation and collaboration with relevant community groups and other water management agencies, a model for future management of storages in large rivers.

Progress:

This project involves reinstating part of the natural hydrology of the lower Campaspe River by changing the way releases from Lake Eppalock occur, potentially from May 1999. During the years of the experiment this will allow the downstream release of 25 per cent of

Jane Growns uses the 'snag bag' she developed to sample macroinvertebrates on snags in the Campaspe River. *Photo: MDFRC*

in-flowing water. This is achieved by allowing the storage to fill over a longer period following the irrigation season. The storage will fill following the first rains. This change in operation of Lake Eppalock will substantially increase flows during the winter months and, on average, reduce peak flow but extend duration allowing the responses of flow-related biological variables to be investigated.

Three years of adult and larval fish sampling have been completed. The fish fauna of the Campaspe River is dominated by two small native species, flathead gudgeon and Australian smelt, and two large alien species, European carp and redfin perch. Only these four, and possibly golden perch, are considered to have sufficient numbers to form sustainable populations. By contrast, the larvae of 12 species of fish have been collected from the Broken River-nine species are native.

Despite considerable variation in winter and spring flows and temperatures, there is remarkable consistency in the occurrence of

Campaspe Weir. The weir provides water for irrigation during the summer. *Photo: Jane Growns*

most species. The larvae of some species are present for six months or more and encounter during this time a wide range of environmental conditions, such as flow and temperature. Other species occur for only one or two months and so experience only a narrow range of environmental conditions.

We have completed one and a half years of macroinvertebrate sampling and developed a novel technique for sampling natural communities on snags. From results so far, 149 taxa have been recorded, about one-third of which are chironomids. There are clear differences among sections of the Campaspe, which are characterised by different summer flow regimes, and between the Campaspe and Broken rivers. Immediately downstream of Lake Eppalock, species richness and abundances are similar to those in the Broken, but considerably greater than further down the Campaspe. Community composition immediately downstream of Lake Eppalock is unlike the other sections of the Campaspe and the Broken rivers and resembles that of a more upland stream. The shrimp fauna of the Campaspe is dominated by *Paratya australiensis*, whereas that of the Broken has good numbers of *P australiensis*, *Macrobrachium australiense* and *Caridina mccullochi*. Preliminary data suggest that production of *P australiensis* larvae is delayed immediately downstream of Lake Eppalock and recruitment to the adult population is poor.

This project should provide us with a greater understanding of the ways in which flow regimes influence fish and invertebrates. If the project is successful, we will use similar river systems to test the methods developed for providing environmental flows.

Achievements:

- Shown that the fish fauna of the highly regulated Campaspe River is severely degraded and dominated by small native and large alien species, such as carp and redfin perch.
- Shown that some fish species spawn during a range of conditions, however, others spawn only during the warmer, low-flow times.
- Construction of a key to the larval stages of three species of shrimp common to lowland rivers in south-eastern Australia.
- Presented preliminary results at conferences and conducted an information day for participants in the project.

Planned activities:

- A further year of 'pre' flow-change sampling, presentation and publication of results.
- Initiate a flow change in the Campaspe River in May 1999.

Flow variability, habitat patchiness and diversity of stream communities

Project leaders: Prof PS Lake, Dr Barbara Downes and Dr Richard Marchant

Project team: Ms Alena Glaister, Mr Keith Ferdinands, Ms Genevieve Hehir, Ms Leanne Matheson, Mr Angus Webb and Mr Nick Bond

Sites: Two sites on each of the Acheron, Little and Steavenson rivers, Victoria

Aim:

- Test that flow variability in streams, in particular disturbances by floods, controls habitat and resource patchiness.

Progress:

Experimental work for this project has been completed. We have been able to describe habitat and resource patchiness and relate it back to flow variability. By characterising the disturbances required to move rocks in upland streams, we are able to make predictions about the relative stability of streambeds and the likelihood of rocks moving at the scale of individual rivers.

Analysis of direct measurements of critical tractive forces for stone movement revealed that the reach-scale hydraulic equations commonly used to assess streambed movement provide poor estimates of the actual forces needed to move rocks. By assessing the patchiness of rock movement and relating that back to stream discharge we have discovered high degrees of disturbance patchiness and surprisingly high levels of streambed disturbance during low flow periods.

Measurements of patchiness were extended from rock movement to abrasion. Abrasion was found to be greater at lowland sites compared to upland sites and winter had a greater impact on rocks than summer. Overall, abrasion was very patchy with variation within a stream being more important than variation between sites.

The different levels of disturbance between rivers were reflected in the amounts of production by the trichopteran insect *Agapetus kimminsi*. The larvae had a high growth rate at the site that had the more stable streambed.

Experiments using baffles to generate constant flow conditions combined with disturbance were carried out in the Steavenson, the Little and Acheron rivers. In terms of species richness the results suggest that the effects of disturbance and baffles differ between the rivers. In the Steavenson River both disturbance and baffles decreased species richness whereas in the Acheron there was no significant effect. In the three rivers the baffle treatment induced significant changes in species composition but disturbance did not.

Achievements:

- Disturbance generated by floods is a major feature of upland streams.
- Relatively high levels of stone movement are normal for many upland streams, even in the low flow period of summer.
- Patchiness in terms of stream fauna, and food and space for biota, occur at the scale of individual stones. Availability of resources regulates local species diversity.
- In planning environmental flow regimes and in-stream restoration, direct measurements rather than equation-driven estimates of bed movement need to be made.
- Both disturbance and constant flow conditions may alter the diversity of the macroinvertebrate fauna of upland streams. Constant flow conditions but not disturbance significantly alter the species composition of stream stones. This suggests that in environmental flow management, long periods of unnatural constant flow should not be planned.
- Three papers have been published in international journals and a paper is in press.

Planned activities:

- Prepare further publications.

The Queanbeyan River, NSW.
Photo: Karen Markwort

Impacts of hydrological disturbance on stream communities

Project leaders: Prof PS Lake and Dr Shane Brooks

Project team: Mr Paul Reich and Ms Danielle Warfe

Sites: Avon, Murrindindi and Gibbo rivers and Nariel and Snowy creeks, Victoria, Goobaragandra, Numeralla, Queanbeyan, Shoalhaven and Tuross rivers, NSW

Aims:

- Assess how rapid increases and decreases in river flow influence benthic invertebrate communities that have evolved under different natural disturbance regimes.

Progress:

The experimental work for this project has been completed. This study manipulated stream flow using portable in-stream weirs. The weirs increased the discharge over a section of the streambed by 300%, while concurrently reducing the discharge in another section to just 30%.

Over two days, the response of the fauna did not differ between the 'relatively constant' flowing rivers and those with highly variable discharge. Macroinvertebrate assemblages in all rivers were highly resistant to a decrease in flow. In contrast, high discharge caused significant reductions in species richness, but not in the overall numbers of invertebrates. Declines in the abundance of some taxa were compensated for by increases in densities of other taxa.

Over eight days, the impact of reduced flows was again minimal. The impact of the high flow disturbance differed in each river. High flows caused significant reductions in both species and numbers of invertebrates in Snowy Creek yet led to increases in total abundances and species in the Goobaragandra River.

This project has demonstrated that it is difficult to predict the impacts of short-term hydrological disturbances from hydrological or geomorphological characters. The same flow disturbance can have distinctly different impacts in rivers of similar hydrology and geomorphology. Therefore, hydrological, or geomorphological regionalisations may not be appropriate models for flow management groupings.

Shane Brooks examines the impacts of hydrological disturbances in the Queanbeyan River, NSW. The same flow disturbances can have distinctly different impacts in rivers of similar hydrology and geomorphology. *Photo: Karen Markwort*

Achievements:

- Software developed to calculate hydrological descriptors for flow regimes.
- A hydrological classification of river flow regimes for 145 selected rivers in south-eastern Australia.
- Measures of resistance to elevated and reduced flows for families of aquatic macroinvertebrates in south-eastern Australia.

Planned activities:

- Submit report to LWRRDC and prepare publications.

Ecological functioning of lowland river systems

Project leader: Dr Ben Gawne

Project team: Dr Rod Oliver, Dr Martin Thoms, Dr Keith Walker, Dr David Williams, Dr Ian Webster, Dr Gavin Rees, Dr Darren Baldwin, Dr Chester Merrick, Ms Trish Bowen, Prof PS Lake, Assoc Prof Ian Campbell, Dr Ralph MacNally (Monash University), Mr Simon Treadwell (PhD student), Ms Gillian Beattie (PhD student) and Prof Barry Hart

Sites: The River Murray

Aims:

- Determine the availability and the annual and seasonal inputs of organic carbon to lowland rivers and to determine the effects of changes in the source of carbon on the biotic community.
- Provide recommendations for the management of lowland river systems, with particular reference to riparian communities, snags, algal growth, the impact of floods on carbon and nutrient cycles and the impact of habitat modification on floodplain ecosystems.

Progress:

This large, integrated project commenced in 1998. An essential step toward understanding the functioning of lowland rivers is to determine what carbon sources comprise the base of the food web. We will develop a heuristic model based on existing, published models and our own data from which we can produce testable hypotheses. Our approach has generated two complementary models to deal with 1) the major sources of organic carbon in a single river reach and 2) the food web that relies on the various carbon sources. The models will allow us to make better predictions about how changes in management have affected our rivers.

The project has been divided into a number of manageable components, each of which will contribute data to the model. Some components will determine the amount of organic carbon contributed by the many different types of plants (algae, reeds, floodplain plants) which make up the base of the food web. Other components will look at the way in which the plant material is decomposed or consumed by bacteria, fungi and invertebrates, and examine the relationship between invertebrates and fish. The study will be conducted at three sites along the River Murray, near Albury, Barmah and Mildura. By studying three sites we hope that we will be able to construct a model that can be applied to the entire river, rather than just a small section.

The River Murray, the site of an integrated, multidisciplinary study that will look at the ecological processes that 'drive' lowland rivers. *Photo: Ben Gawne*

Ben Gawne sampling bottom-dwelling invertebrates using an 'Eckman Grab' on the River Murray. *Photo: Lower Basin Laboratory*

Achievements:

- Sites selected, staff recruited, technology transfer strategy written.

Proposed activities:

- Seasonal field trips commenced in June.

Relationships between nutrients, algal growth and macroinvertebrates in rocky and soft bottom streams

Project leader: Assoc Profs Richard Norris and William Maher

Project team: Dr Peter Breen, Dr Ken Thomas, Mr Sean Grimes, Water Ecoscience Pty Ltd (Dr Nick O'Connor and staff)

Sites: Thredbo River, NSW and Yarra Valley Water Ltd wastewater treatment plant, Craigieburn, Vic

Aims:

- Determine the interactions between the development of epilithon, nutrient levels and macroinvertebrate community structure and abundance using artificial channels in an upland stream.
- Measure the response of benthic diatoms to experimentally controlled nutrient concentrations in lowland stream mesocosms to aid the development of Australian guidelines for the discharge of sewage effluent to lowland streams.

Progress:

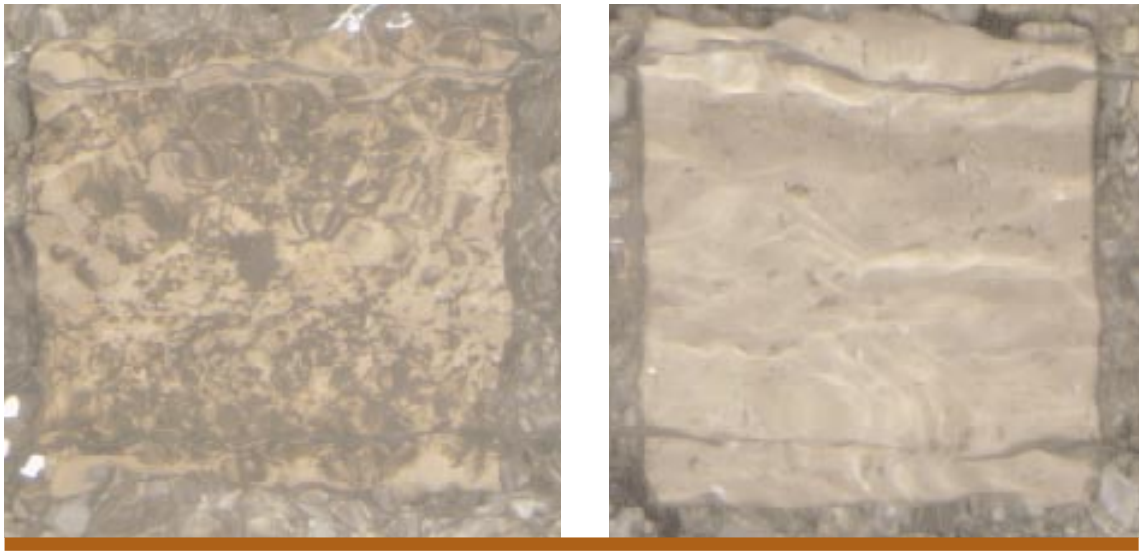
Research in this project was undertaken within two sub-projects:

I. Rocky bottom stream project.

II. Soft bottom stream project.

Experimental work has now been completed for both sub-projects and results are now being analysed. We have shown that inhibiting invertebrate grazing using electricity results in an increase in epilithon biomass in the constructed channels. Removing the electricity resulted in the epilithon being reduced by invertebrate grazing. Within a few days the levels were identical to the channels which had been continuously grazed.

Addition of treated sewage effluent to the channels resulted in a significant increase in epilithon biomass in channels where electricity was applied ie. where grazing was inhibited. Results from stable isotope analysis indicate that in the electrified channels, invertebrates fed on algae, while in the non-electrified channels, they fed on allochthonous material. Mayflies and caddisflies were most common in channels without electricity and small midge larvae were most common in channels with electricity.



Assessing the effects of macroinvertebrate grazing on algae in the Thredbo River. Before and after (right) electricity has been applied to experimental *in situ* channels. *Photos: Richard Norris*

Epilithon metabolism was measured in autumn and winter using an enclosed oxygen chamber technique. Grazing stimulated primary production and limited biomass build-up. Grazing was reduced when predators were excluded using electricity.

Little epilithon growth occurred on substrata in the channels during winter, regardless of the treatment. Growth was generally the same as in the river. There seems to be little epilithon grazing by macroinvertebrates during winter.

Results are being analysed for the lowland stream project. Several experiments were undertaken where nutrients were added to artificial channels in a controlled environment. An initial experiment established the operational procedures, then four subsequent experiments investigated algal community response to high and low concentrations of nutrients delivered either as nutrient media or diluted sewage effluent. A further experiment tested whether algal communities responded differently to chlorinated or un-chlorinated sewage effluent.

Achievements:

- In an alpine stream, removal of invertebrates results in an increase in epilithon. This biomass is much greater where there is an input of treated sewage effluent. However, grazing pressure by invertebrates limits epilithon biomass even with the input of effluent.

Planned activities:

- Prepare further publications and complete final reports.

Monitoring the impacts of resorts in Kosciuszko National Park and the Thredbo sewage treatment plant to adjacent rivers

Project leader: Assoc Prof Richard Norris

Project team: Ms Susan Nichols and Ms Sue Cunningham

Sites: Thredbo River and streams in the Perisher resort area, Kosciuszko National Park

Aims:

- Produce data that may be used to set discharge limits for sewage entering upland streams.
- Assess water quality within the Park's ski resorts so that this information can be integrated with plans to further develop the Perisher and nearby ski resort areas.

Progress:

This work began in 1980 and is likely to continue until 2001. Biological monitoring of the Thredbo River involves sampling quarterly at four sites upstream and downstream of the Thredbo Village and sewage treatment plant. Water quality monitoring is undertaken in streams adjacent to the Perisher ski area. An Honours project is looking at recolonisation pathways of invertebrates in the Thredbo River's gravel bed and associating them with particle composition and organic matter.

Achievements:

- Annual reports published.
- AusRivAS models have been developed for the resort areas of the Kosciuszko National Park and this project demonstrates routine application of the models for management purposes.

Illustrated key to the nymphs of the Australian Ephemeropteran families Baetidae and Caenidae

Project leader: Dr Phil Suter

Project team: Mr Tim Curmi

Sites: Nationwide

Aim:

- To provide a common voucher system and illustrated keys for the mayfly families Baetidae and Caenidae using samples collected by the Monitoring River Health Program.

Progress:

Baetid and caenid mayflies are important constituents of streams yet their taxonomy has been rudimentary. This project has produced

A taxing job—Dr Phil Suter has sifted through more than 20,000 insect specimens to identify and classify Australian mayflies. *Photo: Karen Markwort*

Mayfly. *Photo: Ken Thomas*

keys to the Baetidae (eight genera and 23 species) and Caenidae (five genera and 19 species). A Caenidae key is being evaluated at the Murray-Darling Freshwater Research Centre. This key recognises 19 species of which only six have been described.

A distribution database has been created and provided to LWRRDC. This database is being regularly updated as more material is examined. The first Monitoring River Health Initiative (MRHI) sampling occasion identified at least five new species and the distribution of over 30 species has been extended.

Achievements:

- Description of a new genus of Caenid mayfly and three new species and four new species of Baetidae.
- Report to LWRRDC and publications.

Planned activities:

- Further publications and continuation of species descriptions.
- A final key for the Caenidae will be presented at the CRCFE Taxonomic Workshop in 1999.

Restoration of degraded rural streams: the Granite Creeks Landcare project

Project leader: Prof PS Lake

Project team: Dr Barbara Downes, Dr Brian Finlayson, Dr Richard Marchant, Dr Jennifer Davis, Ms Tracey Johnson and Ms Alena Glaister

Sites: Creeks in the Strathbogie Ranges, north-eastern Victoria

Aims:

- Determine the levels of sediment input and movement within the streams and assess the disturbance to biota by this sediment.
- Develop feasible and rigorous means to monitor stream restoration in this region.
- Determine whether providing increased habitat structure assists restoration and assess whether habitat fragmentation impedes restoration.

Progress:

This project commenced early in 1998. The effectiveness of the restoration works in terms of the physico-chemical conditions and biota of the streams will be evaluated and the techniques developed may have a wide applicability. The project, set at the land- and stream-scape scale, will be multidisciplinary involving geomorphologists, hydrologists and ecologists.

The project will test the following hypotheses:

- that increased inputs of sediment, principally sand, to the target streams has been a major damaging effect of post-settlement catchment land use;

- that within the catchments and the streams there are stores of sediment that are periodically mobilised;
- that the streambeds of granitic sand are unstable and harbour a restricted biota;
- that current stream restoration works carried out by Landcare are effective in restoring water quality and biodiversity;
- that reliable indicators of stream condition can be identified for use in long-term monitoring of stream restoration/ rehabilitation projects;
- that the input of sand to the streams has significantly reduced habitat complexity and heterogeneity and that reinstatement of habitat complexity and heterogeneity will improve streambed stability and increase species diversity;
- that fragmentation of the streams' longitudinal continuity effectively impairs habitat recolonisation and restoration.

Outcomes from this project will include an appraisal of the condition of the catchments and streams of the Strathbogie Ranges, predictions of the outcomes of restoration, the setting of targets for subsequent restoration and the development of restorative techniques to create areas of high diversity and abundance. The project will develop a process for community involvement whereby scientists can work effectively with local landowners, Landcare groups and river management agencies to assess restoration activities.

Achievements:

- A report on the history of the Granite creeks and their catchments.

Planned activities:

- A report on the history and geomorphological condition of the creeks and their catchments. An extensive survey of the macroinvertebrate fauna of the streams will be undertaken to assess damage and set targets for restoration.

Rotenone in streams: A study of impact and recovery in small montane streams

Project leader: Ms Jan Barton

Project team: Dr Ros St Clair

Dave Tiller, EPA Victoria, samples macroinvertebrates in the the Darby River, a small coastal stream in Victoria. Information from this survey has been used in selecting reference sites for the State's monitoring efforts for the National River Health Program. *Photo: Freshwater Sciences, EPA Vic*

Sites: The Goulburn River and streams in the Marysville and Woods Point districts, Victoria

Aims:

- To assess the impact of rotenone, used in trout sampling and eradication, on stream benthic macroinvertebrates and to make recommendations regarding the future use of rotenone.
- To assess spatial and temporal variation in small montane streams.

Progress:

We have found spatial differences between the fauna of the streams. These differences may be explained by altitude as there is a lower diversity in Marysville streams above 1000 metres. Streams in both the Marysville and Woods Point districts have fewer species and lower density of benthic macroinvertebrates than expected. Each stream is distinctly different and the in-stream distribution of fauna patchy. Over time, the fauna varies due to the animals' life histories and again this is influenced by altitude. This study has provided us with valuable taxonomic specimens including a new genus of the tricoptera family Calocidae/Helicophidae.

Rotenone treatment resulted in an increase in filamentous algae suggesting a release from grazing pressure. Our preliminary results indicate changes in fauna density and diversity for at least three months following the treatment.

Achievements:

- The EPA, Victoria now only permit the use of rotenone for the eradication of pest species that threaten native fauna or in properly designed scientific studies necessary for the conservation of native species. Where rotenone is used, the impact on other stream fauna is now being considered. Methods have been modified to minimise the impact on non-target fauna.

Planned activities:

- Complete analysis and prepare publications.

4.2 Program

Standing waters and eutrophication

Leader

Dr Rod Oliver

Nutrient enrichment, or eutrophication, may adversely impact on the water quality of lakes and ponds. Of particular concern to the management of water supplies are algal and cyanobacterial blooms, some of which may be toxic. In Australia, considerable debate continues as to the relative importance of nitrogen and phosphorus in stimulating the production of blooms. However, the conversion of nutrients into algal biomass is also dependent on physical conditions (mixing, temperature and light) and biological conditions (such as the presence of algal grazers and food web interactions). CRCFE research seeks to understand the processes that lead to the production of blooms, and ultimately provide insight as to how they may be managed.

The Chaffey Dam study

I. Destratification and water quality

II. The role of suspended particles/colloids and bottom sediments in modifying the bioavailability of phosphorus

Project leaders: Dr Bradford Sherman and Dr Phillip Ford

Project team: Dr Rod Oliver, Dr John Whittington, Dr Ian Webster, Dr Darren Baldwin, Dr Ron Beckett, Assoc Prof Bill Maher, Mr Zygmunt Lorenz, Mr Pat Hatton; Mr Gary Miller and Mr Leigh Gray, Mr Damian Green and Mr Jason van Berkel (PhD students)

Site: Chaffey Dam on the Peel River near Tamworth, NSW

Aims:

- To understand the capabilities and limitations of bubble plume destratification systems in supplying oxygen to the sediments and in controlling the growth of bloom-forming cyanobacteria in reservoirs.

- Investigate and define the effect of sediment oxidation on sediment-phosphorus interactions and the bioavailability of P; the changing role colloids play as a consequence of changes in the oxygen status of the water column; and the effects that these processes may have on cyanobacterial blooms in subtropical reservoirs.

Progress:

Chaffey Dam is an example of a storage where destratification has failed to live up to expectations. Despite the reduction in density stratification and the increased dissolved oxygen levels at depth produced by artificial destratification, the reservoir still suffered from massive blooms of the toxic cyanobacteria, *Anabaena* and *Microcystis*, which could occur at virtually any time of year.

The final report for this three-year study presents a detailed investigation of the physical, chemical and biological processes within Chaffey Dam that exert the greatest influence on the water column chemistry and the phytoplankton community. The project team used a whole-ecosystem approach to experimental design resulting in a comprehensive data set able to rigorously test complex reservoir water quality models.

Achievements:

The Chaffey Dam study has significantly advanced our understanding of the driving processes in reservoirs.

- Destratification reduced the internal phosphorus load by 85% but had no effect on the surface mixed-layer (SML) depth. Light limitation of algal biomass is only feasible if the SML is sufficiently deep that the phytoplankton cannot return to the surface layer effectively.
- The Peel River supplies at least half of the filterable reactive phosphorus (frP) load to the reservoir. frP accumulation in the hypolimnion was the major determinant of the following year's algal biomass but did not impact on species dominance.
- The majority of the algal biomass was either motile or positively buoyant and therefore unlikely to be light-limited from spring through autumn as they always remain above the seasonal thermocline.
- Desiccation of dam sediments decreases the capacity of sediments to both take up P, and to release P under anoxic conditions.

Planned activities:

- Prepare papers, continue technology transfer activities and complete PhD theses.

Physical and nutrient factors controlling algal succession and biomass in Burrinjuck Reservoir

Project leader: Mr Ian Lawrence

Project team: Prof Peter Cullen, Assoc Prof William Maher, Dr Rod Oliver, Dr Ian Webster, Dr Phillip Ford, Dr Bradford Sherman, Dr Graham Harris and Dr Miriam Borman (CSIRO, Land and Water) and Dr Bob Wasson (ANU)

Sites: Burrinjuck Reservoir, NSW

Aims:

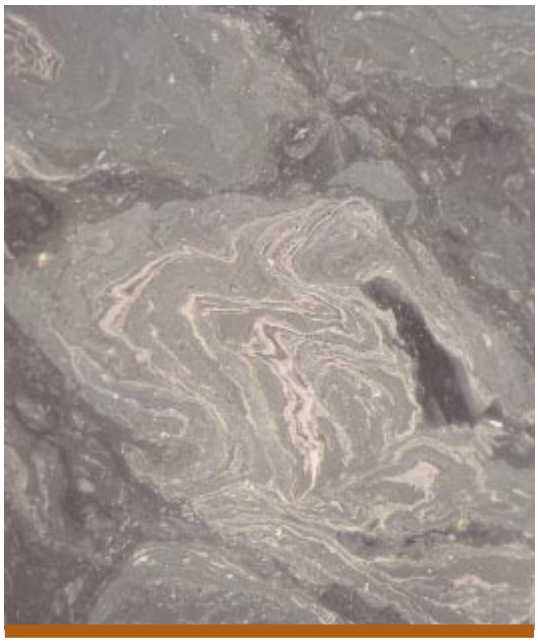
- Identify the major determinants of water quality and algal biomass and their implications for catchment management.
- Determine the role nitrogen plays in influencing algal growth and composition and evaluate a eutrophication reduction scheme for removing nutrients from Canberra's sewage.

Progress:

Main pic: Blue-green algae bloom on Chaffey Dam. *Photo: Bradford Sherman*

Top pic: Chaffey Dam located on the Peel River provides supplies for irrigation and to the city of Tamworth in northern NSW. *Photo: Bradford Sherman*

Bottom pic: Bubble plume rising to the surface of Chaffey Dam during artificial destratification. *Photo: Bradford Sherman*



A blue-green algal bloom. *MDBC, David Eastburn.*

This project utilises existing data sets collected over 20 years for both the upper Murrumbidgee catchment and Burrinjuck Reservoir. These data provide the opportunity to 'manipulate' nutrient budgets for a whole system. So far, the hydrographic, water quality and meteorological data has been checked and consolidated into a single data set, analysis of which is underway.

Planned activities:

- Analyse water quality and heat budgets for the storage.
- Analyse the association between algal growth, nutrient levels and mixing conditions, including assessments of periods pre- and post-tertiary treatment (nutrient removal) of Canberra sewage.

Sediment-nutrient processes

Project leader: Dr Ron Beckett

Project team: Dr Ian Webster, Assoc Prof William Maher, Dr Phillip Ford, Dr Darren Baldwin, Dr Gavin Rees, Mr Ian Lawrence and Dr Jason van Berkel

Sites: Urban and rural rivers and ponds in south-east Australia

Aim:

- Test whether sediments (both bottom and suspended) play an integral and crucial role in determining nutrient concentrations and fluxes in Australian freshwater systems.

Progress:

Commencing during 1998, this project draws together a team representing a range of disciplines from within the CRCFE. The project will investigate various aspects of nutrient dynamics (P, N, C) within the sediment and between the sediment and overlying water column.

The second phase of the project will produce a predictive system model that will provide a useful management tool for simulating the consequence of manipulating environmental conditions on nutrient release and uptake from sediments. This extends to devising better catchment strategies and to improving the design of urban pollution control basins to achieve maximum nutrient retention, given knowledge of the character of the organic inputs.

Planned activities:

- First project meeting following completion of staff recruitment and development of a technology transfer strategy.
- Select sites and commence experimentation.

Algal availability of phosphorus discharged from different catchment sources

Project leader: Dr Rod Oliver

Project team: Mr Shane Perryman and Ms Helen King

Sites: Goulburn River, Victoria

Aims:

- Determine the forms and bioavailability of phosphorus from three representative sources: an upland catchment, a sewage treatment plant and an irrigation return drain.
- Determine how the forms of phosphorus change in the sediments and in response to river processes.
- Develop a sediment transport model that predicts the impact of the form of phosphorus entering the river and the changes occurring within the river, on downstream algal blooms.

Progress:

The study commenced in November, 1997, with the appointment of project staff and selection of the three field sites. At each site transects have been surveyed at 1 km intervals over a 10 km stretch of river to provide a morphometric description of the channel. During the surveys, several sediment samples were collected from each transect, and these are being analysed for elemental composition, particle size distribution, and nitrogen and phosphorus content. This data will provide a description of the sediment types within the river channel at each experimental site, and indicate their potential role in influencing phosphorus concentrations in the overlying water.

Historical data has been sourced from water agencies to provide a description of variations in water quality and flow at each site to help select appropriate sampling periods. Preliminary descriptions of the major processes expected to influence phosphorus concentrations at each site have been developed to help focus the data collection, and to provide a conceptual framework for construction of a model to describe the phosphorus and sediment transport.

Planned activities:

- Complete sediment analysis and identify predominant sediment types.
- Measure the quantity of phosphorus, from each of the sources, that is available to support algal growth. Describe the downstream changes in phosphorus forms and bioavailability.
- Use benthic chambers to measure the exchange of phosphorus between the bottom sediments and the overlying water.

Development of phytoplankton bioassessment protocol for Australian rivers

Project leader: Dr Roger Croome

Project team: Ms Gertraud Hötzel

Sites: 31 sites on streams in north-east Victoria and south-west New South Wales

Aim:

- Develop a phytoplankton bioassessment protocol for Australian rivers and transfer it through consultation with water resource management agencies.

Sampling algae on the River Murray near Tocumwal. A manual has been produced that describes standardised methods for sampling, fixing, preserving and identifying algae in Australian rivers. *Photo: Gertraud Hötzel*

Progress:

The experimental work for this project was completed during 1998 and a report has been submitted to LWRRDC. The research has produced a protocol for algal sampling for Australian rivers. The project went on to determine the influence on phytoplankton concentrations of algal populations advected from upstream. A long-term data set for the River Murray was used for this analysis. The approach is novel because it takes into account water travel times between adjacent sites, thereby allowing the arrival date of cells at a downstream site to be calculated.

The study showed that upstream cell densities were within one cell-doubling of the cell densities at the next downstream site for greater than 50% of the time. Where cell densities between sites are significantly different, there is qualitative evidence that this is due to flow conditions, sources of water and other physico-chemical parameters. Where the water travel times between adjacent sites are long (ie. several weeks or more), algal populations may vary considerably in cell densities and species composition, suggesting that they are independent.

Achievements:

- The book, *Phytoplankton methods manual for Australian rivers*, has been published in the LWRRDC Occasional Paper Series. A workshop was held with industry representatives to discuss the draft of this document.
- New river sampling equipment has been developed and field validation commenced.

Planned activities:

- Prepare publications and extend the manual to other types of waterbodies.
- Develop the prototype of the river sampling equipment TISA (Taylor Integrated Sampler).
- Continue modelling of riverine phytoplankton behaviour including quantitative analysis of the impact of environmental variables.

Site for phytoplankton sampling on Billabong Creek near Culcairn. *Photo: Gertraud Hötzel*

4.3 Program

Floodplain and wetland ecology

Leader

Dr Terry Hillman

Floodplain rivers, such as the Murray and its tributaries, are complex interactive systems. They are made up of the river channel and the floodplain which in turn is composed of a continuum of habitats ranging from permanently inundated wetlands and anabranches to rarely flooded (but still 'flood influenced') terrestrial systems. Fluxes between the river and the floodplain (water, nutrients, carbon, and biota) are vital to the survival of both. Management of a floodplain river should be based on an understanding of both systems and their interaction.

Tension exists between the difficulty of achieving meaningful replication at the large (management) scale and the risk of generalising from small-scale experimental studies. This program addresses these difficulties by carrying out research at a range of scales from laboratory and mesocosm experiments to 'reach-based' studies of whole billabongs and floodplains.

Response of aquatic ecosystems to hydrological change in Barmah-Millewa Forest

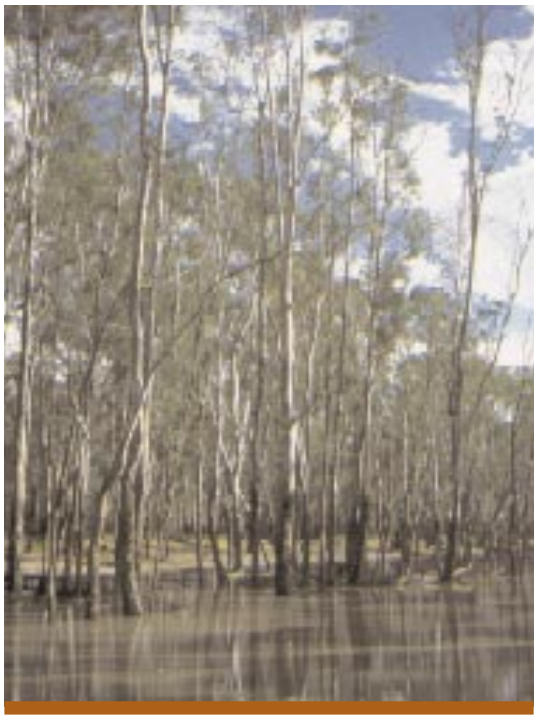
Project leaders: Dr Terry Hillman and Dr Russ Shiel

Project team: Dr Gerry Quinn, Assoc Prof Arthur Georges, Mr Chris Knight, Mr Garth Watson, Mr Alan Chick, Mr Daryl Nielsen and Mr John Hawking

Sites: Barmah-Millewa Forest, River Murray

Aims:

- Characterise the response of natural floodplain wetlands to inundation.
- Assess the significance of timing and duration of inundation to macro and microinvertebrate communities under managed flow conditions.



Barmah Forest. A mix of permanent and temporary billabongs are needed to maintain maximum biodiversity in floodplain systems. *Photo: Karen Markwort*

Progress:

Most of the experimental work for this project has been completed.

Results indicate that macroinvertebrate communities in temporary billabongs follow a predictable successional pattern following inundation and quickly reach levels of biodiversity equivalent to that found in associated permanent billabongs. Even after six months, however, the macroinvertebrate assemblages in temporary billabongs are significantly different from those in permanent billabongs. It follows that maximum biodiversity in floodplain systems can be achieved only with a mix of permanent and temporary billabongs.

Achievements:

- Secondary succession in newly inundated, temporary wetlands does not lead to a community structure identical to that found in associated permanent wetlands (within six months).

- The role of temporary wetlands in the larger-scale landscape, and in maintaining regional biodiversity appears significant and requires further investigation.
- Both temporary and permanent wetlands are required if regional aquatic biodiversity is to be maximised.
- Different reaches of regulated rivers are affected differently by hydrological management (seasonal flow inversion, changes in hydrograph shape, peak depression, levees). Management for wetland heterogeneity needs to take these longitudinal differences into account.
- Papers published and in press.

Planned activities:

- Complete analysis of data, presentation and publication of results.

Water level fluctuations in experimental billabongs-permanent and ephemeral

Project leaders: Dr Terry Hillman and Dr Russel Shiel

Project team: Dr David Williams, Dr Nick Klomp, Mr Daryl Nielsen (PhD student), Ms Felicity Smith, Mr John Hawking, Mr Garth Watson, Mr Alan Chick and Ms Kerri Lee

Site: Michael Ryan Ecological Laboratory, Wodonga, Victoria

Aims:

- Establish a facility in which water levels and biotic composition can be manipulated experimentally.
- Investigate the response to seasonal pattern and duration of inundation in permanent and ephemeral aquatic systems in the following: community structure, biomass, and recruitment response in microinvertebrates; community structure, migration, reproduction and emergence in macroinvertebrates.
- Investigate the effect of predation by a native, planktivorous fish on micro and macroinvertebrate populations.

Progress:

The experimental work for this project has been completed and a report has been presented to LWRRDC.

Achievements:

- Response of zooplankton community to inundation measured under controlled conditions, including seasonal influences.
- Inundation is quickly followed by a 'bloom' of zooplankton in summer or winter/spring, although the species involved vary with the season
- Two forms of short-term response to changes in water volume (evaporation/ inundation) among macroinvertebrates-mobile adults capable of dispersal maintain population densities independently of volume change (densities determined on a larger spatial scale), 'sedentary' organisms (immature and non-dispersive adults) whose densities tend to vary inversely with volume change. The former tend to inhabit the water column; the latter are mainly benthic.
- The presence of planktivorous fish may modify macroinvertebrate community

Constructing the artificial billabongs that were used in an experiment that investigated the effects of different inundation patterns on invertebrates and aquatic plants. *Photo: Daryl Nielsen*

structure through competition with invertebrate predators.

- Constant water level depressed plant diversity but macroinvertebrate species richness was not significantly different with variable water regimes.
- Winter/spring flooded billabongs support more plant species than those flooded in summer. This may be because summer floods, by filling the billabong during the period of maximum evaporation, comparatively reduce the annual range of water levels.
- A mix of flooding times potentially supports maximum zooplankton biodiversity (by favouring different species), but a preponderance of winter/spring floods may maximise plant diversity by maximising water level variability.
- Three papers published and one submitted.

Planned activities:

- Further publication of results.
- Further experiments aimed at understanding the mechanisms that stimulate microinvertebrates to multiply after inundations.

Daryl Nielsen examines a water sample taken from an experiment aimed at identifying factors affecting zooplankton emergence from sediment after it has been dried and then re-wetted. *Photo: Karen Markwort*

Spatial and temporal variation in trophic structure of billabongs-billabong-river interactions during high flow

Project leaders: Dr Terry Hillman and Dr Gerry Quinn

Project team: Dr David Williams, Dr Russ Shiel, Ms Judy Frankenberg, Mr Chris Knight, Mr Rob Cook, Mr John Hawking, Mr Alan Chick, Mr Daryl Nielsen, Mr Garth Watson, Mr Dale McNeil (PhD student), Dr Gerard Closs (University of Otago), Dr Peter Gerhke, Dr Cath Meathrel, Prof Alistar Robertson (CSU-Riverina), Dr Adrienne Burns (CSU-Riverina), Ms Felicity Smith, Dr Rod Oliver, Mr Mike Copland, Dr Martin Thoms, Assoc Prof Brian Button and Mr Trevor Jacobs (MDBC)

Sites: 10 billabongs along the Ovens River and six billabongs along the Murrumbidgee River near Wagga Wagga, NSW

Aims:

Phase 1:

- Determine the changes in billabong biota in response to flooding on an unregulated floodplain and to measure the spatial and temporal variability in these changes.
- Evaluate the spatial variability between billabongs at any time and the effect of general flooding on that variability.

Phase 2:

- Assess the transfer of biota between the main river channel and the billabongs across the floodplain.
- Determine whether the hydraulic connection between river and billabong during high flows, and the consequent flux of water, materials and biota between the two, results in the resetting of the billabong system and the inoculation of the riverine ecosystem with carbon, algae and microorganisms.
- Assess the likely significance of connections between billabongs and river in native fish ecology.

Progress:

The experimental work for the first phase of this project has been completed.

Pre-flood measurements of experimental and control billabongs have been completed for phase two of the project, which involves community and student groups (CSU, Wagga Wagga) who will carry out background observations. Instrumentation has been installed in the study billabongs and sampling protocols have been developed in preparation for high flows in the Murrumbidgee River. Physico-chemical, carbon/microbial, microinvertebrate, macroinvertebrate, and fish surveys have been completed.

Sampling water quality parameters and macroinvertebrates in a billabong on the Ovens River. *Photo: Karen Markwort*

Achievements:

- In small billabongs the presence of large, predacious fish may significantly affect densities of small fish (both planktivores and predators of larger organisms). This in turn can be expected to influence the food web structure of the billabong (see *Water level fluctuations in experimental billabongs* above). In small billabongs, particularly those subject to sheet flooding, distribution of large fish may be patchy and random.
- In larger billabongs large fish communities appear to be similar in composition to those of the parent river. The Phase 2 study indicates that river and billabong sites are distinguished from each other mainly by small specialist species such as gudgeons (billabongs) and smelt (rivers).

Planned activities:

- Complete data analysis, publication and presentation of results for Phase 1.

A billabong on the River Murray near Echuca. *Photo: Karen Markwort*

- Progress on Phase 2 is dependent on flows in the Murrumbidgee reaching sufficient levels to connect the billabongs. Sampling protocols have been developed to cope with the intensive observations that will be required during the 'connection' period.

Environmental flow requirements for inland river systems in the Murray-Darling Basin

Project leader: Dr Martin Thoms

Project team: Dr Fran Sheldon, Dr Ralph Ogden, Mr Neil Sims (PhD student) and Ms Heather McInnes, Mr Pat Levings, Ms Margot Biggin and Mr Oscar Mamalai (Honours students, University of Canberra)

Sites: Barwon-Darling River between Walgett and Wentworth and the Lower Balonne River system downstream of St George (south west Queensland).

I. In-stream processes and environmental flow requirements for the Barwon-Darling River

Aim:

- To determine in-channel flow requirements for dryland rivers by investigating relationships between flow variability, river channel morphological (habitat complexity) and ecological functioning within the Barwon-Darling River.

Progress:

Over 700 channel surveys have been analysed for the Barwon-Darling. These surveys highlight the complex nature of the river channel. The river is composed of a series of inset floodplains or benches. These features trap and store large quantities of organic material and once wet, release dissolved carbon into the water. We have determined the flows required to wet these surfaces and as a consequence have been able to determine the impact of water resource development on the natural wetting and drying processes. This information is important in establishing environmental flow regimes for the Barwon-Darling River system.

Bank erosion on the Gwydir River, Upper Darling system, near Bundarra. Recent work by the CRCFE has revealed that river regulation is a major contributing factor to bank erosion. *Photo: Martin Thoms*

Irrigation near Gunnedah. CRCFE research is exploring flow options that will satisfy the environmental needs of rivers while continuing to meet human demand for our scarce freshwater supplies. *Photo: Martin Thoms*

Achievements:

- We have shown the physical nature of the Barwon-Darling River channel to be complex due to natural flow variability. This complexity is important for ecosystem functioning and the overall health of the river.
- As a result of this work Dr Thoms is now one of the independent scientists who advise the Barwon-Darling River Management Committee on the setting of river flow objectives.

Planned activities:

- Develop a model of the functioning of this river system to aid managers in the setting of river flow objectives.

II. The storage, production and transfer of nutrients and carbon in lowland floodplain river-systems: the Condamine-Balonne River system

Aims:

- Determine the major stores, production areas and fluxes of carbon and nutrients between various morphological compartments on the lower Balonne floodplain at a landscape scale.
- Determine the impact of water resource development on the wetting and drying of these compartments.

Progress:

Field sites have been chosen and a large-scale survey of the geomorphological characteristics of the area undertaken. Sampling and analysis of carbon and nutrients in the surface sediments, collected from the various morphological units, has also commenced.

Data collected from this study will be used to generate criteria for identifying key compartments, in terms of their storage, exchange and production of carbon and nutrients, in semi-arid lowland floodplain systems. The criteria will be used for land management and the setting of flow requirements.

Achievements:

- The Queensland Department of Natural Resources has become a partner in this project.

Planned activities:

- Determine carbon and nutrient storage on the floodplain.
- Determine the impact of water resource development on the inundation character of the floodplain.
- Contribute to the Lower Balonne Floodplain Management Strategy and the Condamine Balonne Water Allocation Management Plan (WAMP).

Measuring the effectiveness of environmental water allocations

Project leader: Dr Gerry Quinn

Project team: Dr Terry Hillman, Dr Michael Reid and Dr Jacqui Brooks

Aims:

- Develop monitoring programs to detect changes in response to environmental water allocations and proposed water management strategies within the Murray-Darling Basin.

Progress:

This project set out to develop generic, basin-wide monitoring programs to detect short (<5 years) and long-term (>5–10 years) change in response to environmental water allocations. The project has been completed and a report submitted to the Victorian Department of Natural Resources and Environment.

Achievements:

- A review of the available literature indicated that aquatic plants (macrophytes) are likely to be the most suitable short to medium term indicators of ecosystem change in wetlands following environmental water allocations.
- A modified before-after-control-impact design, using wetlands in the Barmah Forest, was proposed to test the effectiveness of the recommended indicators

River Murray floodplain. Levees have been constructed to protect infrastructure built on floodplains. Levees are another obstacle that prevents the main river channel from interacting with its floodplain. *Photo: Karen Markwort*

and measure the magnitude of ecosystem change in wetlands following an environmental allocation.

Planned activities:

- Proposal submitted for Stage 2 of this project that will trial the monitoring programs and indicators recommended by Stage 1.

Flow characterisation

Project leader: Dr Jane Growns

Project team: Dr Ben Gawne, Dr Martin Thoms and Dr Nick Marsh, Prof Tom McMahon and Dr Rob Argent (CRCCH)

Aims:

- Develop a comprehensive and ecologically relevant statistics to describe flow regimes.
- Characterise natural flow regimes and determine how flows have been changed in response to water resource development.

Progress:

Flow is a principle structuring force in riverine ecology affecting populations, communities and ecological processes. Few methods for providing 'environmental flows' consider the whole ecosystem of the river and there has not been sufficient evaluation to show that any of them provide the desired results. This project aims to determine (1) whether there are groups of rivers with similar flow regimes and (2) how these groups are related to the type of flow regulation. The first step in this process will be to make a detailed study of the hydrological characteristics of Australian rivers under pre-regulation and regulated conditions. Once this has been completed we will be in a position to relate particular flow regimes and elements of flow regimes to the rivers' ecological characteristics.

Achievements:

- A list of 62 hydrological descriptors have been agreed upon.

Planned activities:

- Data analysis and publication.

The Menindee Lakes have been operating as a storage system since the 1960s. *Photo: Martin Thoms*

The River Murray near Echuca. The Murray is one of Australia's most regulated rivers. Locks and weirs were first built to provide year-round navigation. These were soon co-opted by the irrigation industry and today the river supports the most productive agricultural areas in Australia. *Photo: Karen Markwort*

The Snowy River downstream of Jindabyne Dam-flow in this section of river has been reduced by 99 percent as a result of regulation. *Photo: Karen Markwort*

Riparian vegetation-productivity and ecology

Project leader: Dr David Williams

Project team: Ms Judy Frankenberg, Dr Martin Thoms, Ms Lisa Evans (PhD student) and Mr Dan Mawer

Sites: Murrumbidgee River upstream from Burrinjuck Dam, River Murray upstream from Hume, Goodradigbee and Abercrombie rivers

Aims:

- A better understanding of the ecological and geomorphological factors which determine the composition of riparian vegetation along large rivers.
- Quantify the seasonal contributions this vegetation makes to the total riverine organic matter.

Progress:

Floodplain vegetation is potentially a significant source of carbon for the riverine food web. However, since the makeup of riverine plant communities is affected by inundation patterns, river management may change the yield of carbon derived from floodplain vegetation. In this project, changes in riparian vegetation are being associated with environmental variation following a field survey along the Goodradigbee, Abercrombie and upper Murrumbidgee rivers.

So far, we know that the environmental variables most related to vegetation patterns are floodplain geomorphology, intensity of land use, substrate texture, height above the channel and lithology as it controls valley and channel form. The relationship between vegetation associations and height above, and distance from, the river channel, point to the importance of inundation patterns. Clear floristic and geomorphic/geologic differences were apparent between the Murrumbidgee and Murray rivers. Through experiments, we have also determined the basic regeneration requirements of the main woody riparian species of the Upper Murrumbidgee River.

Achievements:

- The composition of the riparian vegetation along the Upper Murrumbidgee River is closely correlated with variation in geomorphic and flooding attributes of the bank and floodplain, indicating the sensitivity of these communities to alteration in flow regimes.

Planned activities:

- Estimate nutrients and biomass from riparian vegetation litter fall, field experiments on regeneration and survival.
- Prepare publications and thesis.

Tree regeneration strategies and diversity in Amazonian blackwater floodplain forests

Project leader: Dr David Williams

Project team: Dr Rita Mesquita and Mr Leandro Ferreira, National Institute of Fisheries Research, Manaus, Brazil (INPA)

Sites: Rio Negro, Brazil

Aims:

- To determine the role of inundation in controlling the growth and survival of some common tree species occurring in Amazonian blackwater flooded forests.

Progress:

The inundation forests of the Amazon occupy about 5% of the Basin. They are a key resource for riverine peoples who harvest timber, other plants and large quantities of forest-dependent fish stocks. The results will contribute to the limited understanding of tree species diversity and dynamics in these flooded forests. They will have practical significance for predicting the after-affects of disturbances such as clearing and pole harvesting on tree regeneration and subsequent forest composition. Data was collected on growth relationships for five more species at a well-documented floodplain site near Manaus.

Achievements:

- Saplings of a variety of species subject to annual inundation have been shown to respond to flooding by initially limiting their growth in stem diameter, in favour of increasing their height. Differences between species in the size at which they switch to diameter growth help to explain the vegetation pattern across the floodplain gradient and the responses of plants to inundation regimes.

Planned activities:

- Analysis and publication of data.

Conservation of Australian freshwater turtles

Project leader: Assoc Prof Arthur Georges

Project team: Mr Sean Doody (PhD student), Ms Jeanne Young, Mr Rob Taylor (Honours student), Mr Scott Thomson, Ms Jenny Seddon (MSc student) and Mr Peter Baverstock (Southern Cross University), Mr Mark Adams, Ms Jan Birrell and Mr Steve Donnellan (SA Museum), Dr Bradley Shaffer (University of California)

Sites: Northern and south-eastern Australia

Aim:

- Examine the influence of fluctuating temperatures on offspring sex ratios in reptiles.
- Delineate species boundaries in Australian and southern chelid turtles.
- Document patterns of genetic differentiation among populations of freshwater.

The pig-nose turtle, one of the 'blue paintings' at Nourlangie Rock, Kakadu National Park. The pig-nose turtle is a favourite food item of the Aboriginals in the region. It also plays a significant role in the Aborigine's cultural history. *Photo: Arthur Georges*

The heat is on for the rare pig-nose turtle, *Carettochelys insculpta,* which is found on the Daly River in the Northern Territory. The sex of this turtle's offspring is determined by the temperature at which its eggs are incubated. *Photo: R Jenkins*

Progress:

Research in this project covers three main areas and is conducted under three subprojects:

I. Temperature-dependent sex determination in reptiles-the effects of fluctuating temperatures in natural nests.

II. Taxonomy, systematics and evolution of Australian freshwater turtles (family Chelidae) with input to priorities for management and conservation.

III. Genetic differentiation among populations of freshwater turtle in eastern Australia, and its relationship to the history of population contraction and expansion in response to recent glacial events.

The first project is being undertaken in collaboration with the CRC for the Sustainable Development of Tropical Savannas. A season of fieldwork was undertaken during 97/98 and the results are now being analysed. The second project has produced a fully resolved 'family tree' for the side-necked turtles of Australia, South America, Africa and Madagascar using mitochondrial and nuclear gene sequences. The third project commenced this year. Like the second project, it will provide valuable information for the setting of conservation priorities for freshwater turtles in Australia.

Achievements:

- Publication of results.

PhD student Sean Doody digging for turtle eggs on the Daly River. *Photo: Arthur Georges*

Weighing pig-nose turtle eggs. Researchers are investigating whether or not it is possible to determine the sex of the turtle hatchling by looking at the hormonal levels in the fluids of the egg. *Photo: Arthur Georges*

Threatened species-the Corroboree frog and decline in other amphibians

Project leader: Dr William Osborne

Project team: Mr David Hunter, Ms Sara Broomhall (Honours student), Dr Ken Green (NSW National Parks and Wildlife Service), Ms Donna Nunan (PhD student, ANU) and Dr Brendon Mackey (Centre for Resource and Environmental studies, ANU), G. Hollis (Victorian Department of Natural Resources and Environment)

Sites: Kosciuszko National Park including Murrumbidgee, Murray and Snowy River catchments, ACT region, Shoalhaven Catchment, Snowy Mountains, Mt Baw Baw

Aims:

- Determine whether long-term changes in the reproductive success of Corroboree frogs is related to habitat or predation and competition, and population declines to precipitation.
- Determine the extent of use of farm stock dams as breeding sites by frogs and whether water quality or vegetation influence pond choice.
- Examine sensitivity of declining and non-declining amphibians (eggs and larvae) at high elevations to ambient levels of ultraviolet radiation.

A sphagnum bog, typical Corroboree frog habitat in Kosciuszko National Park. *Photo: Dave Hunter*

Progress:

Research is being undertaken in three main areas under three sub-projects:

I. The endangered Corroboree frog (*Pseudophryne corroboree*).

II. Stock dams as artificial breeding sites for frogs: protocols for surveys and monitoring.

III. Ultraviolet radiation and amphibian declines in upland wetlands of south eastern Australia.

In our studies of the Corroboree frog, we have successfully measured *in situ* embryonic and larval mortality and compared this to laboratory controls. We have measured habitat characteristics for a large sample of pools. Toe bone cross-sections, collected from a range of populations, will be used to determine the age structure of the surviving populations and to correlate these with breeding pool condition and catchment characteristics.

Farm stock dams have the potential to contribute significantly to wildlife. We have monitored dams near Canberra through the recent drought and further sampling will determine how frog populations have responded to the prolonged dry conditions. The next phase of this study will relate catchment condition to dam water quality, cover and vegetation with pond use, as well as the extent to which farmers value stock ponds for

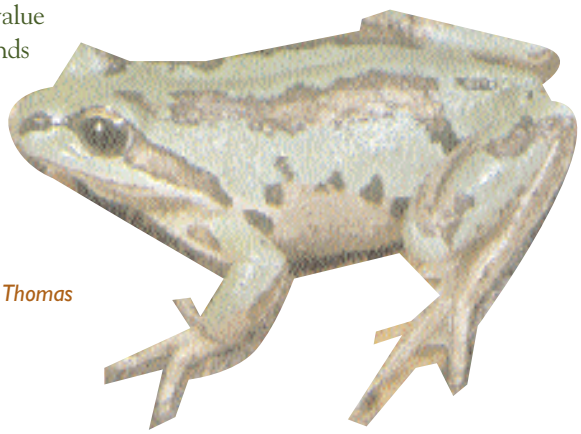


Photo: Ken Thomas

Corroboree frog. *Photo: Dave Hunter*

their broader biodiversity values, including amphibian conservation. This will include estimating whether there is a link between pond ecological condition and on-farm economic value, through, for example, erosion control.

There is international concern that elevated levels of ultraviolet, B, radiation, resulting from ozone depletion, are likely to effect organisms living at high elevations the most. Organisms in the early stages of embryonic development that are confined to clear, shallow pools are most likely to be at risk. In the last decade there have been alarming losses to alpine frog populations, both in Australia and overseas. The third project examines whether these concerns may be related to the sensitivity of declining species to increased UV-B radiation. We have completed a study of UV-B impact on frogs at Thredbo in the Snowy Mountains. The embryos of the declining species: the alpine tree frog suffered greater mortality than the non-declining common froglet, unless the eggs and embryos were screened from ambient UV with a mylar filter.

Achievements:

- Papers, thesis and technical reports published and a national recovery plan prepared for the Corroboree frog.

Planned activities:

- Further publication of results.
- Provide protocols for long-term monitoring of frog populations that can be used in community-based research projects.
- Determine characteristics of declining amphibians and their habitat that may make them more susceptible to UV-B radiation.

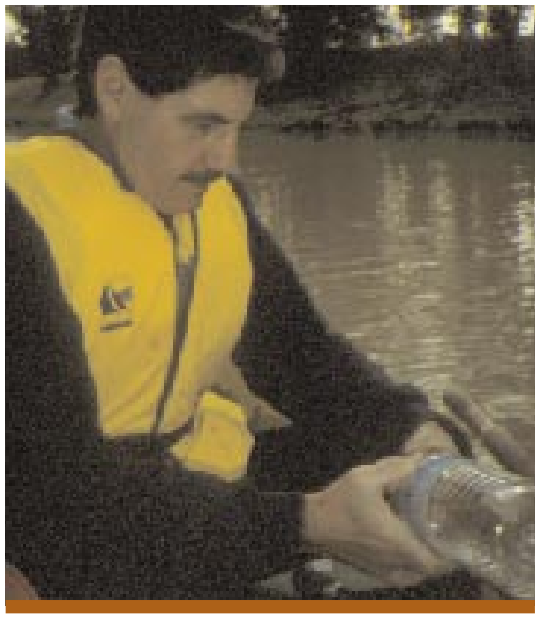
4.4 Program

Water quality and ecological assessment

Leader

Prof Barry T Hart

The need to improve our knowledge about the health of our rivers and lakes has focused attention on the methods we use to monitor and assess water quality and how we might make better use of this information for management purposes. Biological assessment techniques are increasingly being adopted by management agencies throughout Australia because they provide an insight into events that may have occurred in the stream weeks or even months before the sampling. This program has been a driving force in the research and development of biological assessment techniques and improved measurement of nutrients.



Program leader Barry Hart taking samples from the Darling River to determine the different types of phosphorus that occur in the river and how much of this nutrient was available for algal growth. *Photo: Rod Oliver*

Measurement of bioavailable nutrients in natural waters

Project leader: Dr Ian McKelvie

Project team: Prof Barry T Hart, Dr Rod Oliver, Dr Richard Shalders, Mr Tom Harris and Ms Michelle Hindle (summer scholarship student)

Aims:

- Develop and validate methods to measure the bioavailable phosphorus concentration in Australian rivers.
- Develop low cost, portable flow injection analysis systems for determining various nutrient species on site.
- Evaluate the use of UV photo-oxidation for the rapid on-site determination of total phosphorus (TP) by flow injection analysis.

Progress:

This project was completed during 1997. The project has resulted in updated methods for 'bioavailable' phosphorus, rigorous comparisons of the many different 'P' measurements and the development of a portable phosphorus analyser.

A comprehensive study of the iron-strip technique, a possible alternative measure of 'bioavailable' phosphorus in natural waters, was conducted. Our assessment of this procedure shows that it can have unacceptable problems with analytical accuracy and precision, and undesirable demands on labour and time. Traditional and newly developed nutrient parameters for natural and spiked samples of freshwaters were also compared.

We have developed a portable analyser with the capability to determine both TP and FRP in the field. Applications of the analyser to high frequency nutrient measurements and/or multi-site sampling programs can be readily accommodated at a fraction of the cost of traditional sampling and analysis procedures. For FRP in particular, the real-time measurements offer a number of attractive features when compared with traditional laboratory based analysis procedures.

This instrument is being assessed for its commercial application.

The Murrumbidgee River in the ACT. One of the rivers sampled to develop the predictive AUSRIVAS model to assess river health in the ACT. *Photo: Karen Markwort*

Achievements:

- The rapid measurement of FRP and TP can now be performed routinely on-site for a variety of natural waters using the portable flow injection analyser.
- We have developed a modified 'iron-strip' procedure for measuring 'bioavailable P' which provides acceptable results with reduced demands on labour and time.
- We found an absence of alkaline phosphatase hydrolysable phosphorus in all natural freshwaters when measured 24 hours after sampling.
- There was a general paucity of organic phosphorus in the <0.2µm and <0.003µm filtered fractions for the fresh water samples analysed.
- Strong correlations of most phosphorus parameters with bioavailable phosphorus with the exception of total phosphorus measurements of unfiltered samples.
- The identification of <0.003µm alkaline phosphatase hydrolysable phosphorus as the strongest indicator of the <0.2µm bioavailable phosphorus levels, however, filterable reactive phosphorus is also useful.

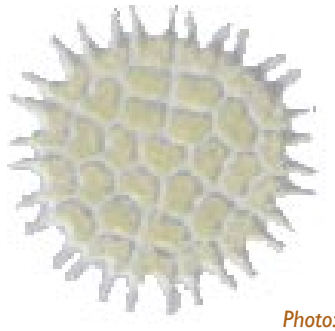


Photo: Jason Sonneman

Biological assessment of water quality

Project leader: Assoc Prof Richard Norris

Research team: Dr Ken Thomas, Dr Richard Marchant, Dr Ian Campbell, Dr Ralph MacNally, Ms Natalie Lloyd (PhD student), Mr Mat Allanson (MSc student), Mr Alistair Hirst, Mr Justen Simpson, Mr Paul Blackman, Ms Karen Markwort, Dr Jenny Davis (Murdoch University), Mr Chris Williams, Mr Phillip Sloane and Mr Dan Mawer

Sites: Australia wide.

Aims:

- Develop cost-effective approaches for assessing the ecological health of freshwater systems using macroinvertebrates.
- Assess the natural long-term variability of populations of stream insects and quantify the scales at which autocorrelation occurs in the benthic riffle fauna of upland streams.

Phil Sloane sampling macroinvertebrates in the Gudgenby River in the ACT as part of the First National Assessment of River Health. *Photo: Dan Mawer*

- Create and evaluate predictive models of water quality for the National River Health Program using benthic macroinvertebrate data from states and territories around Australia.
- Develop, test and apply a predictive model of water quality for ACT rivers.
- Determine the validity of applying predictive models to the assessment of the health of wetlands and to develop a National Wetland Bioassessment Protocol.

Progress:

The experimental work for most of this research has been completed and published. The AusRivAS models are now being used by agencies across Australia. Further development of these models is ongoing.

The CRCFE is involved in the application of AusRivAS in the ACT and surrounding regions. This work forms part of the First National Assessment of River Health. We have completed sampling and data analysis for autumn and spring 1997.

Application of predictive models to wetlands is underway. Models have been completed using data from about 40 West Australian wetlands and are now being tested with new data to determine their effectiveness for assessing water quality. Preliminary results suggest that the models will be an efficient and effective method for assessing water quality of wetlands.

Achievements:

- During 97/98 AusRivAS predictive models completed for the ACT region, the resort areas of the Kosciuszko National Park and the South Coast of NSW.
- Presentations to conferences, four papers published, final reports submitted to LWRRDC and ACT Government, workshops for users of predictive models, and water quality mapping for ACT State of the Environment reporting.
- AusRivAS web site and predictive models up and running and training courses run for the ACT Government, ACTEW, Department of Land and Water Conservation and private consultants.

Planned activities:

- Further publication of results and technical transfer in the use of the predictive models.
- Development of the AusRivAS web site.
- Application of the models for water quality assessment including completion of sampling for the First National Assessment of River Health in the ACT region.

Biological assessment of river health

Project leader: Assoc Prof Richard Norris

Project team: Dr Martin Thoms, Dr Richard Marchant, Mr Leon Metzeling, Mr David Robinson, Dr John Harris, Dr Peter Gehrke, Ms Rossana Silveira

Sites: South-eastern Australian rivers

Aims:

- Develop cost-effective approaches for assessing aquatic ecosystems using a range of ecological information (physical, chemical and biological).
- Understand processes and links between components of an ecosystem and use these to develop appropriate guidelines for ecosystem protection.

Progress:

This project commenced in 1998, after an international conference, *What is River Health?*, was held at the University of Canberra during November. The conference proceedings are being prepared for publication in the international journal, *Freshwater Biology*.

The CRCFE and the National River Health Program (NRHP) have developed predictive models for the biological assessment of river health as described in the preceding project. While these models provide useful information on water quality and the health of Australian rivers, little specific information is available on how the models may be affected by prevailing climatic conditions or how robust they are for assessing different types of impacts. This project seeks to address these knowledge gaps.

The project will answer questions about invertebrate and fish assemblages and their relationship to habitat at a range of scales. It will

investigate the relationship between predictive model outputs and physical habitat quality, the relationship between the index of biotic integrity (IBI) and habitat and water quality, and temporal variation in invertebrate assemblages and the impact this has on predictive modelling.

In particular, the project will address the impact of dams and the ability of the macroinvertebrate communities to cope with reduced discharges, the altered discharge regimes and the reductions in water quality that result. Fish will be investigated as bio-indicators. An IBI based on fish has the potential to assess ecosystem attributes. To make an effective test of the performance of the IBI in Australia, knowledge is needed on the accuracy, sensitivity and precision of the results of the IBI, as related to the AusRivAS and other assessment systems. This project will address that need.

The need to establish and examine long-term data on aquatic ecosystems is a concern of the CRCFE. Long-term environmental variability, ranging from droughts to floods, may affect use of the predictive models and the interpretation of biological monitoring data.

The project team has met to coordinate sample sites and methods across the two states and territories and three centres involved in the study. Sampling of NSW rivers has continued following the NSW Rivers Survey (refer to Program F) and many sites have been identified for coincidental sampling of macroinvertebrates. To avoid confounding effects, sampling was delayed as a result of the drought.

Planned activities:

- Finalise experimental design and commence sampling program, prepare techonology transfer strategy.

Biological assessment using diatoms as water quality indicators in the Kiewa River system

Project leader: Dr Peter Newall

Project team: Ms Nina Bate

Sites: Statewide in Victoria, focusing on the Kiewa River catchment

Aims:

- Develop rapid bioassessment techniques for diatoms and to compare them to invertebrates as indicators of nutrient status and other aspects of water quality or environmental change.
- Develop a sampling and analysis protocol, and south-east Australian database containing diatom and relevant environmental data.

Progress:

About 300 diatom samples have been collected simultaneously with macroinvertebrate and water quality samples (collected for the First National Assessment of River Health program) including two sample sets across the Kiewa catchment. These will form part of a south-eastern Australian regional diatom and water quality database. Data from the first Kiewa catchment sample set have been analysed and compared to data from macroinvertebrate and water quality samples. The diatom data have also been analysed independently, assessing the amount of information that is lost by reducing the size of counts.

Achievements:

- Edited proceedings from the First Australian Diatom Workshop and organised Second Australian Diatom Workshop. Presented a diatom identification course for industry.
- Presented and results and published a national set of standard methods for the sampling of stream diatoms on the web.

Planned activities:

- Publish and analyse second round of sampling.
- Prepare a set of standard laboratory methods for diatom analysis.
- Prepare and mount diatom samples for the south-eastern Australian regional diatom and water quality database.

Above pic: *Euglena*
Photo: Jason Sonneman

The influence of taxonomic resolution on stream classification and predictive modelling

Project leader: Mr Leon Metzeling

Project team: Ms Rebecca Hewlett (MSc student), Dr Richard Marchant, Mr David Tiller, Assoc Prof Richard Norris and Dr Phil Suter

Sites: Statewide, Victoria

Aims:

- Assess the influence of taxonomic resolution on stream classification and predictive modelling.

Progress:

Macroinvertebrate data from 165 sites across Victoria, sampled under the National River Health Program between 1990–1996, have been used to assess the effect of different taxonomic levels on statewide classifications. Physico-chemical and habitat parameters were also collected for each site. These data are being used to examine the influence of different levels of taxonomic resolution on the interpretation of any underlying environmental gradients.

We have completed numerical analyses to group sites across Victoria at various taxomomic levels. Sites were classified using species, genus and family level data. The groups were then characterised by environmental parameters. We compared different taxonomic levels to determine what level of macroinvertebrate identification is necessary to reveal interpretable environmental gradients.

Achievements:

- Validated and consolidated macroinvertebrate and environmental databases from EPA Victoria and Water EcoScience.

Planned Activities:

- Develop predictive AusRivAS models for Victoria, for a range of taxonomic levels and spatial scales.

Impact of nutrients on invertebrate communities of the lower Goulburn River

Project leader: Mr David Tiller

Project team: Ms Nina Bate

Sites: Lower Goulburn River between Nagambie and its confluence with the River Murray

Aims:

- Assess the impact of substantial downstream changes in nutrient levels on invertebrate communities and to help direct nutrient management strategies in the lower Goulburn River.

Progress:

Invertebrate and water quality data have been collected and interpreted. We have observed an increase in nutrient levels as you progress downstream through the city of Shepparton. Levels are very high down towards the river's confluence with the River Murray where irrigation return wastewater is the most likely contributor of nutrients during the summer low flow period. A bloom of cyanobacteria in this part of the river confirmed that a substantial nutrient problem existed. Despite this and evidence that runoff from Shepparton was resulting in a mild impact on the invertebrate community, the invertebrate communities showed little change.

Achievements:

- This project has shown that invertebrates are not a good indicator for nutrient problems in large, turbid lowland rivers of south-eastern Australia.
- These results have assisted in the development of nutrient guidelines.

Planned activities:

- Prepare publications.

Photo: Jason Sonneman

Nutrient guidelines for Victorian inland streams

Project leader: Mr David Tiller

Project team: Mr Peter Newall, Ms Nina Bate and Mr Manfred Lux

Sites: Southern lowlands, urban, north-west and south-west Victorian streams and rivers

Aims:

- Confirm or enhance the preliminary nutrient guideline concentrations for Victoria.
- Assess the accuracy of river region boundaries delineated for Victoria and to assess the value of changing them.

Progress:

This program was initiated to refine the preliminary nutrient guidelines that were published two years ago, particularly where information was limited. Sampling in all river regions has now been completed.

Nutrient, invertebrate and diatom data from all over Victoria has been accumulated, largely from other projects. These data will provide the basis for assessing and refining the preliminary guidelines, potentially incorporating local features and stream type. The new guidelines will be based on improved data and will therefore provide more appropriate management goals.

Planned activities:

- Analyse and interpret data. Prepare publications.

Regionalisation of Victorian streams: an assessment of its potential for the development of ecological objectives

Project leader: Mr Leon Metzeling

Project team: Dr Peter Newall, Ms Fiona Wells, Mr David Tiller, Mr David Robinson, Ms Jan Barton and Dr Richard Marchant

Sites: Statewide, Victoria

Aims:

- Classify Victorian streams into groups based on geographical regions and/or stream types and assess the potential of the classification for the development of ecological objectives.

Progress:

Macroinvertebrate data, collected as part of the National River Health Program, has been used to classify sites based on faunal assemblages. Initially, classifications were conducted for stream edge and riffle habitats separately, then combined, for each of the taxonomic levels (species, genus and family). The classification of data at species level with both habitats combined provides the most information for the purposes of this project. Several different site groupings seemed to offer potential, with 3-8 groups being the most apparent. To further define regional boundaries, we undertook an ordination of the species data, and related this to a few major environmental variables. We used GIS to present the data in map form for a workshop held at the EPA to delineate preliminary ecoregions.

Achievements:

- Data classified to produce a range of possible ecoregions.

Planned activities:

- Progress report, including regionalisation map and assessment of various ecological objectives within the context of the regions already defined, including the outputs from AusRivAS-type modelling.

Photo: Ken Thomas

4.5 Program

Urban water management

Joint Program with CRC for Catchment Hydrology

Leaders

Mr Ian Lawrence

CRC for Freshwater Ecology

Prof Tom McMahon

CRC for Catchment Hydrology

There have been substantial advances in stormwater management across most States and Territories over the last 12 months, as water, regulatory and local government agencies begin to implement recent catchment and stormwater management legislation requirements. At the international level, there have been concerns regarding the poor performance of some 'Best Management Practices', and a recognition of the need for improved selection and design of stormwater pollution control management measures.

There has been continued growth in community requests for information on how to be a more environmentally-responsible citizen, and how to go about restoring local waterways and developing wetlands. These trends place demands on agencies to assess the health of urban waterways, and to set realistic ecosystem targets for urban waterways. The urban water program is able to provide knowledge to support this increasing demand for information.

Water pollution control ponds

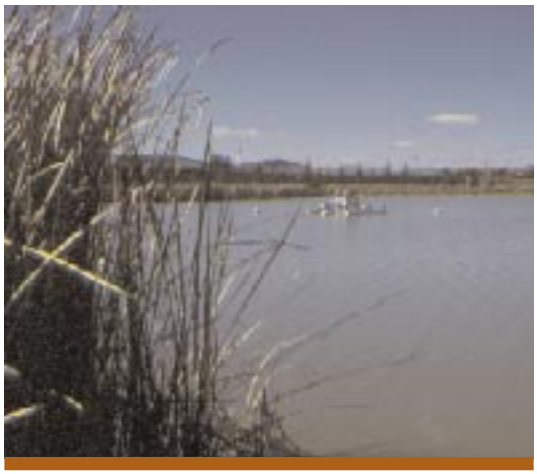
Project leader: Mr Ian Lawrence

Project team: Dr Peter Breen, Dr Chris Gippel, Ms Shelley Baldwin, Assoc Prof William Maher, Dr Phillip Ford and Dr Ian Webster

Sites: Stranger Pond, Canberra; Blackburn Lake, Melbourne; Lake Annan, Sydney

Aims:

- Assess the long-term viability of pond sediments as sinks for stormwater pollutants.



Stranger pond in Tuggeranong, ACT-the site of experimental work conducted to assess the long-term viability of pond sediments as sinks for stormwater pollutants. *Photo: Karen Markwort*

A gross pollutant trap captures an assortment of 'trash' from urban stormwater before it can enter ponds, wetlands and lakes. *Photo: Karen Markwort*

- Assess the validity of the ACT pollutant interception models where applied to different climatic and geochemistry contexts.

Progress:

The experimental work for this project has been completed and reports, guidelines and model drafted. The pond and wetland design guidelines are a valuable output from this project, providing assistance to agencies, government departments and environmental consultants. A computer model for the design

Stormwater in Gungahlin, ACT. Urban areas are typified by impervious areas, such as roads, paving and roofs, which increases runoff volumes and the mass and composition of runoff pollutants. *Photo: Karen Markwort*

A greenfields development in Gungahlin. A golf course and playing fields have been installed that reuse stormwater. *Photo: Karen Markwort*

and performance assessment of ponds and wetlands has been developed, and is undergoing validation and testing.

Achievements:

- Established the long-term viability of pond and wetland sediments as sinks for pollutants, providing that the ponds are sized such that organic loading is limited to non-reducing levels.
- Identified the major physical, chemical and biological processes determining the pollutant pathways, transformation and transfer processes.
- Demonstrated the universal nature of hydraulic retention time (basis of the ACT pollution control curves) as a determinant of pollutant interception, but also highlighted the need to consider ponds and wetlands on the basis of local climatic and geo-chemistry conditions.

Planned activities:

- Publish the pollution control pond and wetland design guidelines, and distribute the pond and wetland water quality model. Workshops and presentations on their implications and application.
- Continued use of consultancies to refine aspects of this research and to expand the scope of systems being studied.
- Further publications.

Biological assessment and management in urban streams

Project leader: Dr Peter Breen

Project team: Mr Ian Lawrence, Prof Tom McMahon (CRC Catchment Hydrology), Dr Chris Walsh, Mr Jason Sonneman, Mr Andrew Sharpe, collaboration with Mr Tim Gippel and Ms Sharyn Ross (CRC for Catchment Hydrology)

Sites: Streams in and around Melbourne.

Aim: To determine the influence of water quality, physical habitat and hydrology on benthic algal and macroinvertebrate communities in urban streams.

Macrophyte plantings in an urban wetland, Gungahlin, ACT. Aquatic plants play an important role in intercepting pollutants in urban wetlands.
Photo: Karen Markwort

Progress:

Experimental work has been completed for this project. Surveys undertaken during this project have pointed to the importance of both natural and anthropogenic variables in explaining the composition of biological communities. Three distinct groups of sites were identified: a rural group on the western plains, a rural group on the eastern foothills and an urban group within the metropolitan area. Macroinvertebrate and diatom communities in the urban grouping were distinctly different to those in the rural groupings. The urban macroinvertebrate communities were less diverse and dominated by pollution tolerant taxa.

The differences in macroinvertebrate communities between the urban and rural groupings was best predicted by anthropogenic patterns of electrical conductivity and nutrient enrichment-biochemical oxygen demand was a good predictor for macroinvertebrates. Total nitrogen and phosphorus were good predictors for difference in the diatom communities, although the urban and rural sites were similarly rich in species for both.

The land use of the rural sites to the east of Melbourne was characterised by a mix of upland urbanisation, agriculture and forest. Macroinvertebrate communities in these sites showed a strong relationship with the percentage of catchment area that was impervious (a direct measure of urbanisation). However, when comparing sites with similar amounts of impervious surface, the rural sites had greater species diversity compared to their urban counterparts. We suspect that lowland urbanisation has more profound effects on the in-stream fauna because stormwater is delivered to streams by highly efficient drainage systems rather than the less efficient open earthen channels found in the rural areas.

We investigated the importance of catchment urbanisation by placing rock riffles in channelled urban streams in the east of the Melbourne metropolitan area. The riffles produced an increase in the heterogeneity of the habitats within each stream. However, eight months after the riffles were installed, the macroinvertebrate communities had remained largely unchanged, both within the riffles, and upstream and downstream. The riffles remained dominated by a small number of pollution-tolerant taxa. This suggests that rehabilitation of such streams cannot be achieved by in-stream habitat changes alone.

Achievements:

- Streams classified into distinct geographic and landuse groups using biota.

Planned activities:

- Complete publications.

RIVPACS for urban streams

Project leader: Dr Peter Breen

Project team: Dr Chris Walsh, Mr John Gooderham, Assoc Prof Richard Norris, Mr Leon Metzeling, Mr David Tiller and Mr Ian Lawrence

Sites: 146 sites around Melbourne.

Aim:

- To develop and test an urban RIVPACS model and protocol.

Progress:

To obtain a dataset large enough for RIVPACS modelling, the macroinvertebrate data from the urban biological assessment project (described above) and datasets supplied by the Melbourne Water Corporation and the Victorian EPA have been consolidated. Two different techniques had been used to collect the data (field or laboratory sorting) so the compatibility of the two types of data was tested using multivariate community-analysis techniques. We found that when we used relative abundance data, and the taxa were identified to the lowest possible level (rather than just to family), and when both dominant and rare taxa were included in the analysis, the datasets were compatible.

Achievements:

- We have shown that data sampling and processing methods can influence the detection of patterns in stream communities and therefore potentially the assessment of stream health.

Planned activities:

- Development of urban based RIVPACS models.

Importance of phosphorus in detergents

Project leader: Assoc Prof Peter Morgan

Project team: Prof Peter Cullen, Ms Gail Ransom and Mr Daryl McGregor (Albury City Council)

Sites: Thurgoona, NSW

Aims:

- Determine the contribution of laundry phosphorus to the total P budget.
- Determine the community response to a campaign to lower P concentrations.

Progress:

The experimental work for this project has been completed. Trials were undertaken where the Thurgoona community was asked to use low-P laundry detergents over set periods. The results have shown that in excess of 25% of total P in the Thurgoona sewage system was due to laundry detergents. The trials resulted in a significant reduction in phosphorus entering the sewage treatment plant.

In addition to the laundry detergent trials, a community education program was undertaken. Since 1989 there has been no increase in water usage in the broader Albury area, despite a 3–4 % increase in population. This 'reduction' in water use, combined with the ability to reduce phosphorus through education about the use of non-phosphorus laundry detergents, has the potential to be a large saving to the Albury community.

Achievements:

- We have demonstrated potential returns to the Albury community through education on the advantages of low-P laundry detergent and a resulting saving in level of sewage treatment required.

Planned activities:

- Complete final report.

4.6 Program

Fish ecology program

Leader

Dr John Harris

Knowledge of fish ecology is essential in understanding freshwater systems. Better understanding enables informed, reliable judgements about sustainable use of freshwater, including pressing issues such as: the degradation of habitats, loss of biodiversity, invasion by carp and declining fisheries. Rivers are a seriously threatened component of Australia's natural resources, yet their ecology remains insufficiently understood, especially in relation to human-induced changes such as river regulation, alien species and catchment alteration. This program concentrates on the ecology of fish communities in river ecosystems.

NSW Rivers Survey

Project leader: Dr John Harris and Dr Peter Gehrke

Project team: Staff from NSW Fisheries Research Institute, Cronulla and Narrandera, Mr Mark Lintermans, Mr Patrick Driver (PhD student), Dr Terry Hillman, Assoc Prof Richard Norris, Dr Gerry Closs (University of Otago)

The short-finned eel is another once-abundant species which now needs careful monitoring. *Photo: Gunther Schmida*

Sites: 80 river sites throughout New South Wales

Aims:

- Study the distribution, diversity, habitat use and abundance of native fish and carp and other alien species in NSW rivers.
- Develop understanding of the ecological effects of river regulation and establish hypotheses for further study of environmental streamflows.
- Establish and test a predictive model for monitoring river health using fish community assessment and a standardised survey structure for use in other studies.

Progress:

The project as planned has been completed. The final report and a plain-English brochure have been published. The surveys conducted during the term of this project are continuing in a streamlined form. The results will provide input to the study of the index of biotic integrity being undertaken in the project *Biological assessment of river health* (Program D) and provide data for the new project, *Measures and benefits of environmental flows*. It is hoped that the survey can be extended to provide a long-term data set for the following:

- assessing the response of rivers to the NSW Water Reforms;
- monitoring the condition of rivers and fish (especially threatened species);
- studying variation in fish communities and populations at large temporal and spatial scales; assessing the impacts of global warming; and
- complementary sampling for other projects.

Achievements:

- Compelling evidence that NSW rivers are degraded and their fish communities are stressed and declining with rapid loss of biodiversity.
- Significant new understanding of the ecology of freshwater fish, especially:

The NSW Rivers Survey sounded an alarm bell for the Murray cod. While anglers and commercial fishermen are still catching cod in parts of the Murray region, its absence from the randomly chosen survey sites shows that its populations have become fragmented and its overall abundance is low. *Photo: Gunther Schmida*

1. The present status of native fish including 11 threatened species, and identifying Murray cod, freshwater catfish and short-finned eels as once-abundant species that now needing careful monitoring
2. There are five characteristic fish communities in NSW rivers, one each in the lower reaches of the Murray, Darling, North Coast and South Coast ecological regions, and one in montane streams.

NSW Fisheries staff launched a new compact, lightweight electrofishing punt, *Polt Volt*, in the Woronora River early this year. The punt is designed to sample fish in small habitats. *Photo: Rossana Silveira*

3. Carp are the dominant fish species of inland rivers, present at all sites below 500 metres altitude and with population densities up to one fish per square metre of river. Carp do better in areas more disturbed by agricultural development.
4. Six alien fish species are common in NSW rivers. Carp, goldfish and gambusia are particularly widespread and abundant.
5. There is substantial seasonal variation in fish distribution, with greater abundance and species richness in warmer months, but little evidence of interannual variation.
6. Diseases and parasites are common, with up to 25% of some fish species showing visible abnormalities.

- The condition of rivers in the River Murray system gives particular cause for alarm, with relatively few native fish present and only 52% of previously known species being recorded.
- River regulation for water supply is a major cause of degradation with significant impacts on fish communities, especially the decline of native fish and the dominance of carp. Regulation has reduced rivers' resilience to invasion by alien species.
- The fish-based Index of Biotic Integrity has been developed and implemented for monitoring environmental quality in NSW rivers.
- The project has been influential in guiding the Government's NSW Water Reforms.

Recruitment ecology of native fish

Project leader: Dr Peter Gehrke

Project team: Dr Craig Schiller, Mr Andrew Bruce and Mr Ian Wooden

Sites: Various habitats in the Murray, Murrumbidgee, Darling and Paroo river systems

Aims:

- To understand the conditions and habitats required for successful recruitment of native fish.
- Develop a rapid method for estimating on-site the nursery potential of habitats.
- Assess the practicality of enhancing fish recruitment by stocking floodplain habitats with hatchery-produced larvae.
- Determine the effects of chemicals on thermal tolerances of native fish in agricultural areas.

The Paroo River-one of the rivers sampled over three years in a study aimed at identifying key processes influencing fish distribution and abundance patterns. *Photo: Craig Schiller*

A large carp captured from Lake Moira during the native fish recruitment study. Juvenile carp were quite numerous in the Murrumbidgee River.
Photo: Craig Schiller

Lignum on Mustang Flat, Paroo catchment. An excellent nursery for native fish when flooded.
Photo: Craig Schiller

Progress:

The experimental work for this project has been completed.

Achievements:

- Negative effects of river flow alteration on native fish populations, and positive effects on carp have been identified, and have been used to develop NSW Water Reforms.
- Floodplains were the most important habitats for juvenile fish. Where floodplains were not available, recruitment declined.
- Recruitment success of native fish species was influenced more by large-scale geographic and climatic factors than by small-scale habitat factors.
- Recruitment of native species was largely confined to catchments with healthy adult populations, emphasising the importance of underlying stock-recruitment relationships as well as environmental variability in determining the success of recruitment.
- Enhancing recruitment of native fish by stocking larvae into floodplain habitats appears to be impractical because of low survival of larvae. Large-scale habitat rehabilitation is likely to be a more successful alternative.
- Chemicals commonly used in agricultural areas lower the thermal tolerance of native fish juveniles, and may contribute to summer fish kills apparently unassociated with chemical use.

Planned activities:

- Publish and transfer results to industry to support water reform.

Analysis of freshwater fisheries

Project leaders: Mr Dennis Reid and Dr John Harris

Project team: Mr Doug Chapman, Dr Karyn Davis, Mr Simon Hartley and Mr Tim Marsden

I. NSW inland commercial fisheries analysis

Aims:

- To analyse historical data from inland commercial finfish and crustacean fisheries, examining trends in catch effort, species composition and geographic distribution.
- To analyse possible relationships between these variables and environmental factors such as droughts, floods, streamflows and changes caused by people.

Progress:

This project has been completed and the final report submitted to Fisheries Research Development Corporation (FRDC). The inland commercial fishery in New South Wales

had a mean annual catch of 344 tonnes over the past three decades, and is currently worth $1.7 million per annum (1995/96 value). The major species currently exploited by the fishery are golden perch, carp, Murray cod and freshwater yabby, while before 1980 redfin perch, silver perch and freshwater catfish were also significant components of the catch.

From the commencement of the commercial fishery there were resource conflicts between commercial fishers, traditional rights of the indigenous fishers, recreational fishers and a continual problem with widespread illegal fishing. The geographical extent of the fishery was gradually reduced to the current boundaries, which allow commercial fishing for finfish in approximately 5% of the linear measure of the inland waters of NSW.

While the information collected from commercial fishers seems to have provided reliable estimates of the total catch and trends by species, the data are not adequate for the application of age-based stock assessment techniques. Even with complete information on the commercial fishery, the geographical extent of the fishery is extremely limited, so the status of a stock in the commercial fishery may not necessarily reflect the whole Murray-Darling system.

Achievements:

- The catches of golden perch have been relatively stable for the past three decades, with peaks in production following good flood years.
- Catches of Murray cod declined sharply from a peak in the mid-1950s but have been relatively stable since the mid-1960s, annual catches generally falling within a range of 10-20 tonnes.
- For silver perch and catfish declines have continued to the present situation of a voluntary ban on their capture.
- Catches of carp stabilised at about 150 tonnes after rising rapidly in the 1970s to a peak of 548 tonnes.
- This study confirms the strong correlation between time series of river levels or flows and catches of Murray cod and golden perch.

II. Issues affecting the sustainability of Australia's freshwater fisheries resources and identification of research strategies

Project leader: Prof Robert Kearney

Project team: Dr Karyn Davis

Aims:

- Identify the key issues facing the sustainability of Australia's freshwater fisheries resources and suggest strategies for addressing those of highest priority.

Progress:

This project has recently commenced. A literature review has provided a list of issues perceived to be the major problems facing the sustainability of Australia's freshwater fisheries resources. Top on the list put together by research and management organisations, were: pollution, environmental flows, water quality, barriers to migration, alien species, habitat degradation. A steering committee met to discuss riparian vegetation, sedimentation, carp, salinity and wetland degradation in addition to the issues listed above. Also discussed were strategies for ameliorating the effects of these issues and the data needed for assessing fisheries resources.

Planned activities:

- Investigate strategies for research and management of key issues.
- Prepare report.

III. Angling catch database

Project leader: Dr John Harris

Project team: Mr Tim Marsden, Mr Simon Hartley, Mr Garry Thorncraft

Sites: Hawkesbury, Hunter, Manning, Murray, Cudgegong, Shoalhaven and Macquarie rivers

Dartmouth Dam spillway. Barriers to migration have been cited among the major problems facing the sustainability of Australia's freshwater fisheries resources. *Photo: John Hawking*

Aim:

- Develop and maintain a standardised angling catch database for monitoring the quality and abundance of freshwater fish populations and the condition of aquatic habitats.

Progress:

Data collection and verification continued on schedule. Preliminary data analysis with feedback to cooperating angling groups was completed for several fisheries. New information has been derived on the status and response to management of recreational target species, including Australian bass and Murray cod.

Achievements:

- A one-day workshop of all participating angling groups was held at Cronulla to assess the project, discuss issues and plan future activities.

Carp control methods

Project leader: Dr Craig Schiller

Project team: Mr Mathew Allanson

Sites: Billabongs in the Murrumbidgee and Murray catchments

Aims:

- Develop and assess various methods for reducing carp abundance in enclosed waterbodies.
- Measure the ecological effects of reduced carp abundance in enclosed waters.

Progress:

This project commenced in 1998 and staff have been recruited. This project deals with the use of direct methods to control populations in enclosed waterbodies. Used by some native fish as nursery areas, and sometimes as drought

A recently commenced project will investigate methods to control carp in enclosed waterbodies. *Photo: John Harris*

refuges, these waterbodies play a vital role in maintaining stocks of native fish in river systems. But these enclosed waterbodies can also provide refuges and breeding areas for carp. Their impact through competition, predation on young native fish and degrading nursery and refuge habitats is likely to be significant. The results of this study will be used to prepare guidelines for agencies and community groups wishing to undertake carp-control in enclosed waterways.

Planned activities:

- Select suitable billabongs and wetlands and assess the ecological responses to carp control.

Hydrologic manipulation as a potential carp control strategy

Project leader: Dr Ben Gawne

Project team: Mr Glenn Wilson, Assoc Prof Keith Walker (University of Adelaide), Mr Ben Smith (University of Adelaide)

Sites: Several locations in both wetlands (eg Menindee Lakes) and sections of major rivers such as the Murray in SA, and Vic and Darling in NSW

Aims:

- Evaluate the role of hydrological factors in determining the success or failure of recruitment of carp in the Murray-Darling Basin.

Glenn Wilson has been appointed to investigate the role of hydrologic factors in the success or failure of carp recruitment. *Photo: Karen Markwort*

Progress:

Information on the age structure of carp populations will be collected to determine the environmental conditions that lead to successful carp recruitment. This approach may then be used to develop management strategies to reduce carp numbers through minimising their reproductive success.

This project has recently commenced. It will explore the potential effectiveness of, as yet untested, control techniques. Pilot studies have been undertaken and staff recruited.

Planned activities:

- Field sampling to monitor carp spawning and recruitment in spring and summer.
- Tetracycline-validation of otolith increment periodicity using captive fish.
- Field sampling to acertain the annual age structure of carp at study sites in summer and autumn.

Fish passage developments

Project leader: Dr John Harris

Project team: Dr Peter Gehrke, Mr Tim Marsden, Mr Garry Thorncraft, Ms Robyn Pethebridge

Sites: Tallowa Dam, Shoalhaven River; Yarrawonga Weir, Murray River; NSW south coast streams; Bell, Macintyre, Tweed, Murrumbidgee, Nepean and Wyong rivers, Macquarie Rivulet, NSW.

Aims:

- Assess fish community responses to restoration of fish passage at Bomaderry Weir.
- Develop low-cost fishways for Australian streams.
- To understand the migrations of freshwater fish.
- Assess the response of a native fish community to the installation of a fishway in the Crawford River.
- Assess the feasibility and effectiveness of high fishways in rehabilitating fish communities affected by large dams

Progress:

The success of recently constructed fishways has generated widespread interest in providing more fishways to conserve and rebuild fisheries resources. One part of this study has concentrated on the Shoalhaven River system where fish communities have changed dramatically since Tallowa Dam was built. Stocking was ineffective in rehabilitating communities. Three high-fishway designs are potentially suitable and a two-year study to establish the reference condition of fish communities has begun.

Achievements:

- Fish passage at Bomaderry Creek has been restored by notching the weir and assessment has begun.
- New fishways have been completed at Cooma (Murrumbidgee River), Theresa Park (Camden, Nepean rivers) and Brays Park (Tweed River).
- Assessments at Yarrawonga Weir have led to recommendations to Goulburn-Murray Water on ways to improve the fishway's performance.

Planned activities:

- Evaluate the effectiveness of an improved rock-ramp fishway design at Theresa Park Weir.
- Complete baseline study of fish communities and migration patterns in the Shoalhaven River system and construct a high fishway on Tallowa Dam in association with Sydney Water. The fish-community study will be repeated following fishway construction.
- Expand the work on Yarrawonga Weir to include the distribution of the downstream fish community.

Conservation of threatened species

Project leaders: Dr Craig Schiller

Project team: Mr Mark Lintermans, Mr Bob Faragher, Mr Ian Wooden, Mr Andrew Bruce, Mr Stuart Curran, Mr Tim Marsden, Mr Garry Thorncraft and Mr Mark Jekabsons

I. The distribution, abundance and management of threatened fish in the Murrumbidgee River catchment with special reference to the endangered trout cod

Sites: Murrumbidgee River

Aims:

- Determine the distribution and relative abundance of trout cod (and Macquarie perch in upper reaches) in relation to habitat and position in the river.
- Monitor recruitment success and identify habitat preferences of trout cod life-history stages.
- Monitor the effectiveness of stocking and threatened species recovery programs.
- Develop trout cod management guidelines for State/Territory/Local government agencies.

Progress:

This study is divided into two parts:
i) Monitoring trout cod in the middle Murrumbidgee River from Narrandera to Burrinjuck Dam (NSW Fisheries), and ii) Monitoring trout cod and Macquarie perch in the Murrumbidgee river upstream of Burrinjuck (Environment ACT).

The first year's field sampling in the upper Murrumbidgee is complete. Young-of-year trout cod were recorded at two sites that had been previously stocked by NSW Fisheries. Strontium analysis of otoliths from a sample of these fish revealed that all were hatchery-bred fish. Although stocked last summer, no trout cod were collected at Angle Crossing, indicating that individuals may have dispersed due to low water levels and drought conditions for the last three years. A 4.25 kg trout cod was collected from Bendora, the first time such a large individual has been sampled.

Sampling in the middle Murrumbidgee is incomplete due to equipment failure. Sites near Narrandera have been sampled and large catches of trout cod in all size-classes were recorded adjacent to the Narrandera Fisheries Centre. Although it is almost certain that these fish are escapees from the breeding program and not a natural population, it does

indicate that conditions in that particular river section are suitable for trout cod. Catches of young-of-year trout cod at or near stocking sites confirms previous observations that stocked individuals exhibit limited dispersion if conditions are adequate.

A steering committee for the project has met twice.

Achievements:

- Site selection, project methodology and first year of sampling completed (sampling in middle Murrumbidgee to be completed by mid-July). A lightweight electrofishing punt constructed for field sampling in small streams.
- Draft Action Plans prepared for ACT populations of trout cod, Macquarie perch and Murray crayfish.

Planned activities:

- Preliminary assessment of habitat preference data for different trout cod life-history stages.
- Second year of sampling.

II. Threatened species: Eastern cod, Australian grayling, Macquarie perch

Sites: Clarence and Richmond rivers; Queanbeyan River above Googong Reservoir, NSW

Aims:

- Assess the population survival and recruitment of restocked eastern cod.
- Assess the distribution and status of Australian grayling in NSW.
- Investigate recruitment, growth rates and dietary ecology of Macquarie perch and potential interactions with trout species.

Progress:

Eastern cod, *Maccullochella ikei*, is an endangered species that was restocked in the Clarence and Richmond rivers in 1989/90. We now wish to determine if stocked fish are recruiting. We have, however, suspended field surveys while developing a new technique for field census.

The Australian grayling, *Prototroctes maraena*, is listed as 'potentially threatened'. We have completed surveys for this fish.

A number of the threatened species *Macquaria australasica*, were translocated into the Queanbeyan River during 1980. Surveys and dietary analysis was undertaken during 1996 and 1997. Successful recruitment was recorded in both years of the study, with a healthy mix of age-classes present in the population. Population data collected during this study will be used in Part I (above).

Achievements:

- Grayling continue to inhabit most of the NSW south coast rivers where they have previously been recorded, plus seven newly identified rivers. Fish ages were estimated at 2–6 years and spawning was estimated to occur from mid-May to mid-July, with site and year variation.
- The overall status of grayling appears to be stable in NSW waters at present.

Planned activities:

- We will test the new direct-census technique for eastern cod in spring, 1998.
- Complete report on Macquarie perch study. Further research will be conducted under Part I. of this project (see above).

Biological effects of cold water pollution below dams

Project leader: Dr John Harris

Project team: Ms Karen Astles, Mr Roy Winstanley

Site: Macquarie River below Burrendong Dam

Aims:

- Study the effects on native and alien fish (golden perch, Murray cod, silver perch and carp) of cold irrigation flows below dams.
- Document the responses of fish to the range of water temperatures experienced in regulated rivers, including avoidance, feeding, growth, interactions and mortality.
- Investigate seasonal distribution patterns of fish in relation to cold irrigation discharges.

Progress:

- Project staff have been recruited, the experimental facility is being built.

Planned activities:

- Complete replicated, controlled-temperature channels at Burrendong Dam to study cold-water effects on biota.
- Measure fish responses to a range of water temperatures.
- Seasonally survey fish in Macquarie River to assess distribution responses.

Measures and benefits of environmental flows

Project leader: Dr Peter Gehrke

Project team: Ms Karen Astles, Mr Roy Winstanley

Sites: 52 river sites throughout western New South Wales

Aims:

- Develop a comprehensive and ecologically relevant measure of river flow alteration.
- Develop a spatial model of responses of fish communities to changes in river flow regime.
- Predict responses in fish communities to changes in river management.

Hume Dam. In addition to preventing native fish from migrating, dams may adversely affect fish populations by 'polluting' downstream rivers with cold, oxygen-depleted bottom waters. *Photo: John Hawking*

Progress:

Field study sites have been selected and sampled once. Hydrological data are being obtained for each site to calculate changes in river flow.

Planned activities:

- Calculate degree of hydrological change at each site.
- Develop and validate a model of fish responses to hydrological change.
- Sampling to improve predictive capacity of the model and provide insights into spatial and temporal variability in fish communities.
- Predict changes in fish communities resulting from NSW Water Reforms.

Downstream transport of larval and juvenile fish

Project leader: Dr Craig Schiller

Project team: Mr Andrew Bruce, Mr Ian Wooden and Mr Michael Rodgers

Sites: Murrumbidgee and Murray rivers

Aims:

- Assess the magnitude, spatial scale, timing and size compositions of downstream transport of fish larvae and juveniles.
- Produce a generic predictive model of downstream transport and predict which weirs will have significant impacts on fish movements.

Progress:

The first round of sampling on the River Murray was completed. Each site was visited seven times and a total of 858 samples were collected. Field samples contained fish eggs and significant numbers of small Murray cod juveniles.

On the Murrumbidgee River we have undertaken intensive sampling to investigate the extent of drift of golden perch larvae and trout cod juveniles. About 20% of these samples have been processed with fish eggs and Murray cod juveniles recorded.

We have shown the sampling methods and apparatus used in the project to be suitable for

detecting the drifting life stages of fish. Light and pressure experiments on silver perch larvae and golden perch juveniles have been completed.

Achievements:

- Silver perch larvae from one to 14 days old were increasingly attracted to light and responded strongly to pressure changes. The direction of the pressure response appears to reverse with age. Rapid pressure decreases resulted in day one larvae swimming up, while larvae older than four days sank.

Planned activities:

- Use a flow chamber to test larval and juvenile swimming.

Drying effects on the ecology of the Menindee Lakes

Project leader: Dr Ben Gawne

Project team: Dr Oliver Schloz, Ms Fiona Betts and Kim Jenkins (PhD student), Dr Andrew Boulton and Dr Margaret Brock (University of New England).

Sites: Menindee Lakes, NSW

Aims:

- Identify hydraulic management options for the Menindee Lakes to maximise environmental value of the lakes as habitat for native flora and fauna and optimise water availability for human use.

Progress:

Six of the Menindee Lakes (Malta, Balaka, Bijiji, Tandure, Menindee and Cawndilla) are being sampled seasonally. Additional sampling will coincide with episodic events, such as at the re-establishment of connection between lakes and river. Comparisons of flow regime impacts on ecological processes between lakes will be possible.

The project has completed three seasonal sampling trips, which will enable us to document the lakes during a drying phase. Lakes Malta and Balaka have now dried. Sediment has been placed in mesocosms for small-scale experiments to help explain the mechanisms underlying field survey patterns.

Members of the Menindee Lakes project team from left: Oliver Scholz, Ben Gawne and Fiona Betts. *Photo: Karen Markwort*

Planned activities:

- Conduct small-scale experiments to investigate the effect of drying on particular elements of the lake ecosystem, such as aquatic plants, invertebrates and fish.
- If water from Lake Cawndilla is pumped into Kangaroo and Packers lakes we will monitor the lakes to observe the faunal response to inundation. A mesocosm experiment will examine the effects of accelerated draw down on subsequent invertebrate emergence.
- One further seasonal field trip-additional trips will only be undertaken if further funding is secured.

Sampling fish larvae in Lake Bijiji. Maximising the environmental value of Menindee Lakes as habitat for native plants and animals, while optimising the water available for human use is the aim of a 12-month project. *Photo: Karen Markwort*

An almost dry Lake Bijiji-one of the Menindee lakes before winter rains. *Photo: Karen Markwort*