Research Portfolio

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Murray-Darling Freshwater Research Centre,

Lower Basin Laboratory.

The Murray-Darling Freshwater Research Centre

COOPERATIVE RESEARCH CENTRE FOR FRESHWATER ECOLOGY

The Murray-Darling Freshwater Research Centre
Lower Basin Laboratory

This research portfolio provides summaries and updates of the various projects undertaken by the Lower Basin Laboratory, Mildura.

The research portfolio is intended to be a "living document" and will therefore be regularly updated and expanded as new projects are acquired and current projects develop.

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The MDFRC is part of the Cooperative Research Centre for Freshwater Ecology and is a CSIRO Land & Water site.

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Research Portfolio

Weir Pool Management:

Environmental Flows:

Wet/Dry Cycles in Lakes and Wetlands:

Primary Productivity:

Knowledge Exchange:

Blue-Green Algal Dynamics in the Weir Pools of Sunraysia

Issues:

In Australia's rivers, blue-green algae have come to be recognized as a symptom of an unhealthy environment and represent a significant threat to both public health and the economic viability of industries such as tourism and horticulture. Blue-green algal blooms are not the result of any single variable, but rather the simultaneous occurrence of particular nutrient, light, temperature, flow and weather conditions.

Objectives:

- To examine the environmental conditions in Murray River weir pools near Mildura and to determine relationships between these and the formation of blue-green algal blooms.
- To identify management options aimed at preventing the occurrence of environmental conditions likely to result in the development of blue-green algal blooms.

Method:

- Annual weekly water quality and algal monitoring in Euston, Mildura and Wentworth weir pools conducted during the summer period.

Main Findings:

Conditions that lead to an increased risk of algal bloom development include:

- *Thermal stratification* – occurs when flows are less than 4000 ML d^{-1}, surface water temperatures are above 25 ^{o}C and wind speeds are low.
- *High nutrients* – particularly available forms of phosphorus.

Completed Tasks and Outputs:

- Annual monitoring reports describing blue-green algal abundances and the conditions that have likely contributed to algal bloom formation.
- Identification of potential management options available for reducing the likelihood of bloom development.
- This monitoring has resulted in the formulation of soon to be commenced project examining the possibility of destratifying the Mildura weir pool (see 'Mitigating the effects of blue-green algal blooms in the Mildura weir pool').

Weir Pool Impacts and a Proposed Weir Pool Drawdown

Issues:

It is believed that the regulation of rivers through the construction of weirs and dams has had a major impact on the ecology of rivers, floodplains and wetlands. Physical changes arising from weirs and the weir pools they create include stable water levels and lower current velocity. As a result, species typical of wetlands appear to have displaced riverine species within the weir pools. In addition, Australia's flora and fauna may be less able to compete with exotic species under the artificially-created stable water condition. Natural breeding cycles and other important physical processes such as nutrient cycling may also be interrupted.

Objectives:

- Compare the ecology of weir pools and free flowing sections of the Murray River.
- Monitor the drawdowns (lowering) of the Mildura weir pool in 2001 and 2002.
- Propose and conduct a trial drawdown at Euston to determine if there are ecological benefits in reinstating water level variability to the weir pool.
- Develop a conceptual model of the ecological response to reinstating variability to weir pools.

Method:

- Seasonal examination of a variety of ecological characters including water quality, biofilm community, macroinvertebrates and macrophytes in weir pools versus free flowing sections of river.
- Monitor water quality changes in the Mildura weir pool when lowered for brief periods of maintenance.
- Monitor any changes to the biota in response to the trial drawdown at the Euston weir pool.

Main Findings:

- Groundwater movements contributed to a significant increase in river salinity levels during the 2001 and 2002 drawdowns of the Mildura weir pool.
- Biofilms in weirpools contain a higher proportion of algae compared to biofilms in free flowing sections of river.
- Particles settle out on the bottom of weir pools (estimated at up to 16 tonnes/day in the Euston weir pool), which may disadvantage bottom-dwelling biota.
- Vegetation along the edge of the river appears to differ between weir pools and free flowing sections.

Completed Tasks and Outputs:

- Issues Paper as part of the first phase of the project (internal MDBC document).
- Brochure outlining a proposed drawdown of the Euston weir pool (2001 MDBC document).

Pre-drawdown monitoring has been ongoing since 2001 and results are being reported

Mitigating the Effects of Blue-Green Algal Blooms in the Mildura Weir Pool

Issues:

Blue-green algal blooms pose a significant environmental and economic threat to the Sunraysia district. Previous monitoring undertaken by the Lower Basin Laboratory in the Mildura weir pool has indicated that blue green algal cell counts increase to dangerous levels only when thermal stratification occurs (see Blue-Green Algal Dynamics in the Weir Pools of Sunraysia). Mechanical methods such as paddle wheels, speece cones and bubble plumes have been used to prevent and break up thermal stratification in large water storages such as dams and reservoirs. Such tools have not been trialled in weir pools. Their application may be successful in significantly reducing the occurrence and magnitude of algal blooms.

Funding has been obtained through the Mallee Catchment Management Authority as part of the National Action Plan for salinity and water quality to produce a scoping study to examine the potential use of existing destratification mechanisms and to explore possible novel options more applicable to weir pools.

Objectives:

- Examine the potential effectiveness of different mechanical stirrers in both preventing stratification, and reducing the occurrence and magnitude of algal blooms in the Mildura weir pool.
- Recommend strategies for the management of blue-green algal blooms in the Mildura and other weir pools.

Method:

- A scoping study will be undertaken to collate previous research in this area and determine the most likely effective stirring device and the most appropriate placement of this device within the weirpool.

Completed Tasks and Outputs:

- Project commenced in December 2002.

Murray River Data Audit and Trend Analysis

Issues:

Water quality data have been collected by numerous agencies and individuals within the Sunraysia district. This information has been collected using many different methods and is presented in a variety of units. By collating and standardising salinity, nutrient, algal and other more sporadic data, it may be possible to determine long-term trends. Such information will provide an important baseline from which we can both assess the effectiveness of current management practices, and set targets for future management.

Objectives:

- To find and standardise all current and historical water quality data (including salinity and blue-green algae data) collected by a diversity of agencies on the Murray River between lock 15 (Euston) and the South Australian Border
- To use the collated data to analyse long term trends in river water quality and provide the baseline information for future decision making

Method:

- Identify all data sources/agencies/individuals along the Murray.
- Standardising data quality and units of measurement.
- Transfer all data to an easy to use database.
- Make rigorous analysis of water quality and other parameter trends on a variety of time scales (seasonal, yearly etc).
- Prepare a final report and CD-ROM containing raw data and analyses

Completed Tasks and Outputs:

- This project commenced in December 2002

Flow Related Variation in Diets of Fish

Issues:

Native fish populations have suffered significant decline under the current regulation and management of our river systems. One of the causes of this decline is the breakdown in trophic linkages within aquatic food webs. That is, native fish may not have their preferred food source available to them. Understanding the diet requirements of our native fish and how food source responds to river flow will contribute to the sustainable management of native fish stocks.

This project forms part of the larger CRC FE funded Lowland Rivers Project. It provides a more detailed analysis of the dietary variation in native fish and how diet changes in response to flow.

Objectives:

- Determine the link between river flow and diet for several native fish species.
- Suggest environmental flow regimes that will maintain healthy fish populations.
- Develop a conceptual model of the relationship between river flows and fish diets.

Method:

- Collect of native fish under different flow events - normal river flows, rising waters and flood flows.
- Determine diet of native fish through direct inspection of gut contents.
- Stable isotope analysis of fish tissue to determine more long-term dietary trends.

Main Findings:

- River flow significantly influenced the diets of native fish – suggesting the flow influenced the abundance and availability of food resources.
- Fluctuating flow conditions provide the adequate food supply for native fish.
- Diets did not differ significantly between rivers.

Completed Tasks and Outputs:

- Final report and conceptual model completed Nov 2002.

Fish Larvae on Lindsay Island

Issues:

Our understanding of the spawning cues and habitat requirements for both native and exotic species is poor, but improving. The common simplistic paradigm suggests that the overbank flows stimulates spawning and produces more native fish such as Murray cod and golden perch. However, recent work by Humphries *et al.* (1999, 2002) suggests that overbank flooding is not a spawning trigger for the majority of native fish.

Lindsay Island is a floodplain wetland ecosystem comprising a diversity of interconnected aquatic habitats (including a fast creek system, a shallow ponded system and a weir pool). We examined the use of these different habitats for fish breeding and determined the timing of spawning for the 12 fish species present on the Island. Fish breeding models developed from this type of study can be used to manage environmental flows and potentially improve native fish stocks.

Objectives:

- To monitor the production of fish larvae in three different habitats on Lindsay Island.
- To construct a conceptual model to facilitate the application of environmental water to improve native fish stocks.

Method:

- Collection of fish larvae from a fast creek system, a shallow ponded system and a weir pool on fortnightly-to-monthly basis.
- Incorporation of results into a broader spatial context to produce a model for use by water managers.

Main Findings:

- Spawning in many native fish occurs at similar times of the year independent of flow – refuting the commonly held notion that a flood pulse is required to initiate spawning.
- Fish species collected can be divided into groups based on spawning time:
    - Early breeders: Australian Smelt, Common Carp.
    - Mid-season breeders: Flathead gudgeon, Murray Rainbowfish, Gudgeon, Murray Cod.
    - Late-season breeders: Gudgeon, Hardyhead, Bony Herring.
    - Flood dependant breeders: Golden Perch, Silver Perch.

Completed Tasks and Outputs:

- Field collection of larvae is ongoing, and has recently been coupled to monitoring of microinvertebrates.
- Final Report and conceptual model completed Nov 2002.

Measuring the Effect of Environmental Flows on Lindsay and Wallpolla Islands

Issues:
With recent moves to reclaim water for environmental purposes, we need to better understand how we derive the maximum environmental benefit from the water made available. This project ties in with the current Mallee CMA and NRE Vic environmental flows project on Lindsay and Wallpolla Island. This new project aims to provide the 'before' (baseline) ecological data prior to the installation of structures and the application of environmental water on the Islands that will occur in the next 1-3 years. Without this data it will be difficult to quantify effects of environmental flows.

Objectives:
- To collect baseline chemical and biological data on Lindsay and Wallpolla Island necessary for the determination of the health of the system prior to the installation of an environmental flows regime.
- Answer specific questions regarding the health of these important floodplain wetland systems.

Method:
- Seasonal collection and analysis of nutrient, algal, zooplankton, macro-invertebrate, and fish data from targeted sites within the islands prior to the introduction of an environmental flows project.

Completed Tasks and Outputs:
- Project commenced in December 2002

Aquatic Micro-Invertebrate Ecology

Issues:

Aquatic micro-invertebrates provide the major links in aquatic food webs between bacteria/algae and higher order consumers. For example micro-invertebrates are a key component of the diets of many inland native fish species, particularly at the larval stage.

Compared to the Northern Hemisphere, little is known of the ecological role these aquatic micro-invertebrates play in Australian systems or the factors that cause their proliferation. Despite environmental flows now being implemented, there is little knowledge available to say how these flows may affect the aquatic micro-invertebrate community in rivers and riverine wetlands. Without such basic information we cannot provide meaningful information to managers, nor can we understand the true complexity of aquatic ecosystems.

Objectives:

- To identify aquatic micro-invertebrates from various projects.
- To collect baseline chemical and aquatic micro-invertebrate biological data necessary for determining the health of riverine/wetland systems prior to the installation of environmental flows regimes.
- To provide baseline ecological data for long-term environmental flows projects, and address specific questions regarding the health of these important floodplain wetland systems.
- Provision of a seasonal record of the pre-environmental flow aquatic invertebrate community necessary for future analysis of the effects of environmental flows.
- The creation of a taxonomic reference collection of invertebrate specimens, held by the laboratory, to which future specimens may be compared.

Method:

- A literature study will be undertaken to collate previous research in this area and determine possible outcomes.
- Monthly/seasonal collection and analysis of micro-invertebrates, from targeted sites, prior to the introduction of environmental flows projects.
- Monthly/seasonal collection and analysis of micro-invertebrates, from targeted sites, post introduction of environmental flows projects to gain information of responses.

Completed Tasks and Outputs:

- This project commenced October 2002.

Darling Anabranch Monitoring Program

Issues:

Water resource development above and within the Darling Anabranch has greatly modified the flow regime of this important watercourse. The increased permanence of water has contributed to a number of environmental problems, including channel siltation, increased salt and nutrient loads, increased incidence of blue-green algal blooms, the proliferation of some aquatic plants (Cumbungi) and exotic fish (European Carp). Reductions in native Fish and yabbies have also been reported. The Anabranch currently consists of a series of 17 weir pools of varying salinities. Such a system provides a unique opportunity to study the sub-lethal effects of salinity on a diversity of aquatic organisms.

The recently completed Darling Anabranch Management Plan (DAMP) proposed that a pipeline be constructed along the Anabranch to supply stock and domestic water. This would allow the Anabranch to be returned to a more ephemeral system, potentially improving water quality and water use efficiency as well as addressing many of the other environmental problems. This provides an important opportunity to monitor the physical, ecological and water quality changes that would occur directly as a result of these proposed management changes. Further, the flexibility of water supply to the Anabranch implied in the DAMP would provide a sound basis for the adaptive management of the system to achieve targeted environmental outcomes (eg. improved native:exotic fish ratios).

Objectives:

- To examine the sub-lethal effects of varying salinity levels on aquatic biota.
- To develop a monitoring program capable of measuring the impact of potential changes in flow management on key ecosystem attributes.

Method:

- Design a monitoring program that allows us to both examine the sub-lethal effects of salinity on a diversity of biota, and to assess the ecological response to the restoration of the Darling Anabranch to a more ephemeral system.
- Application of monitoring program on a frequent routine basis.

Completed Tasks and Outputs:

- Pilot study and routine monitoring commenced mid-2002.
- Because the processes that drive each of the recognised environmental issues operate over different spatial and temporal scales, four separate monitoring programs have been proposed: i) siltation, nutrient and salt loading, ii) blue-green algae, iii) macrophytes, and iv) fish.

Ecology and Management of Ephemeral Deflation Basin Lakes

Issues:
Wetlands, including Ephemeral Deflation Basin Lakes (EDBL), represent a critical component of lowland river floodplain ecosystems. Water resource development, and the installation of weirs and levies, has resulted in the modification of hydrological cycles of many EDBL. This has restricted connectivity between the different floodplain environments, and led to declines in wetland water quality, diversity and productivity. Understanding the ecology of these systems will aid managers and may help to minimize the impacts of regulation, achieve significant water savings and potentially enhance the overall environmental value of the EDBL system.

Objectives:
- To develop an understanding of the ecological responses of EDBL biota to cycles of wetting and drying.
- To produce management guidelines for water regime management of these systems.

Method:
- Review of existing water quality and algal databases.
- Bimonthly collection and analysis of nutrient, algal, zooplankton and fish data from seven lakes within the Menindee Lakes System.
- Monitoring of other EDBL at key times during their wetting and drying cycles.
- Perform small-scale experiments that address the impact of specific hydrological variables (i.e. duration of lake dryness) on ecosystem function.

Main Findings:
- Dry phases are crucial to the nutrient cycling within the Menindee Lakes system.
- The wet/dry cycle drives the trophic cascading within the Menindee system.

Completed Tasks and Outputs:
- Review of literature pertaining to the impact of wetting and drying on EDBL on aquatic biogeochemistry, flora and fauna.
- Reports derived from field monitoring and small-scale experiments relating the impacts of regulation and drying on aquatic ecosystem function.
- A conceptual model of the ecology of the Menindee Lakes System.

Vegetation Dynamics of the Menindee Lakes System

Issues:

River regulation, to provide a reliable water supply, has dramatically changed the flow regimes of most rivers in the Murray-Darling Basin. The Menindee Lakes on the Lower Darling River is the fourth largest storage in the Murray Darling Basin and provides a reliable water supply for Broken Hill, Menindee and Lower Darling irrigators. Since the completion of the scheme in the 1960's the lakes have changed from shallow ephemeral lakes to deeper semi-permanent lakes. The longer periods of inundation and deeper water depths could reduce the area, number and diversity of plants recruiting on the lakebeds and significantly change the vegetation composition of the lakes.

Objectives:

- To determine the composition of the seed bank and standing vegetation of the system.
- Determine the change in the seed bank and standing vegetation during a drying cycle and correlate the changes with environmental variables.
- Examine the effect of hydrology on recruitment form the seed bank.
- Investigate the flooding tolerances of *Xanthium occidentale* (noogoora burr), *Cyperus gymnocaulis* (spiny sedge) and *Ludwigia peploides* (water primrose).

Method:

- Glasshouse emergence trials to determine the composition of the seed bank.
- Vegetation surveys to determine the composition of the standing vegetation.
- Controlled pond experiments to investigate the effect of hydrology on recruitment from the seed bank and flooding tolerance.

Main Findings:

- The seed bank is generally depauperate around the edges of the lakes except in the strandlines (especially in the large lakes).
- Hydrology is a major factor in determining the species recruited from the seed bank.
- All other experiments are yet to be completed.

Completed Tasks and Outputs:

- Developed a conceptual model describing the vegetation dynamics of the Menindee Lakes System.
- Literature review.
- Thesis and papers (in progress).

Lowland River Productivity Trophic Link

Issues:

Production and processing of carbon is fundamental to aquatic food webs and therefore to the health of aquatic systems. Changes in flow regime and river management can influence the production of carbon in aquatic systems as well as the location of carbon production (ie wetlands/floodplain versus the river channel) and the form of that carbon (filamentous algae, blue-green algae versus large vascular plants).

Objectives:

- Examine the effects of flow on carbon production of in lowland river systems.
- Develop an understanding of the linkages between the various trophic levels within lowland river systems.
- Develop conceptual models of lowland river ecology.
- Ensure these models are available to aid in the design of rehabilitation projects and monitoring programs.

Method:

- Collection and analysis of primary producers (algae and plants) under different flow events - normal river flows, rising waters and flood flows.
- Measure zooplankton, benthic invertebrates and fish in response to flow events.

Main Findings:

- The Murray has probably experienced a shift from a system in which benthic and floodplain sources of carbon dominated to a system where these sources are dwarfed by Phytoplankton production.
- Linkages between carbon production and carbon consumption have probably also been weakened.
- A link exists between algal production and bacterial production, confirming the importance of algae as a source of organic carbon for bacteria.
- While not necessarily providing large carbon inputs, plant aquatic plants (such as Cumbungi and common reeds) play an important role in creating habitat for other organisms.

Completed Tasks and Outputs:

- Project reports
- Refinement of Riverine productivity models.

Knowledge Exchange Program

Issues:

Managers are often frustrated by the difficulty in accessing up-to-date, high quality and relevant knowledge when designing management plans. Similarly, scientists need to be kept informed of the relevant and important gaps in our understanding of how to manage aquatic systems. The knowledge exchange program aims to provide a link between scientists and management for mutual benefit.

In addition, the program aims to inform, educate and involve the local community of the issues surrounding sustainable ecosystem management and their role in this process.

Objectives:

- Ensure managers are using the best available scientific knowledge in the management of water resources and aquatic habitats.
- Increase the awareness within local community of the research effort of the laboratory and how this relates to issues of ecosystem health and sustainable management of water resources.
- Provide quality educational experience to science students interested in aquatic science.

Method:

- Develop and enhance linkages with local management agencies.
- Develop and conduct a work experience program for students at a variety of levels.
- Interact with the community through a variety of means, including presentations to management agencies and community groups, the running of aquatic ecology based camps and open days.

Completed Tasks and Outputs:

- Participated in the development of various management plans within the local region.
- Conducted the "Health of the River Forum" at Lake Cullulleraine in conjunction with Rotary.
- Provided work experience and educational programs for students at a variety of levels.
- Presented to community groups such as bird observers and Rotary as well as participated in water week activities and public open days.