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EFFECT OF FLOW MANIPULATION ON THE BIOTA OF A LOWLAND RIVER

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Project duration: 1 July 1996 to 30 June 2001
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Abstract
Intense regulation of the flows in Campaspe River, northern Victoria, have been implicated in the extremely degraded fish fauna. An environmental flow experiment was designed, which involved a ‘before’ period, to assess current status, and an ‘after’ period, which would test the response of components of the biota to the passage of 25% of flow (‘translucent dam’ approach) outside the irrigation season. Comparisons were made with the less regulated Broken River. Response variables included adult fish, fish larvae, macroinvertebrates and shrimp. An extended drought prevented the regulating storage, Lake Eppalock, from reaching the trigger level for environmental flow releases until one month before the project officially ceased. However, our results clearly showed that summer irrigation flows have substantially altered the macroinvertebrate community in the most regulated sections of the Campaspe, from one characteristic of a lowland river to one which resembles that of an upland stream. We do not believe, however, that this has been the primary cause of the virtual elimination of native species of fish from this river. Nor is there any evidence that the lack of high winter and spring flows, caused by storage operation, has resulted in the prevention of spawning of fish. Rather, we conclude it likely that river regulation has created unfavourable conditions for recruitment through an interaction between hydrology and habitat and food availability for the young stages of fish. This, together with barriers to fish movement and the infrequent high winter/spring flows have probably eliminated most species and prevented recolonisation. We suggest that there is an urgent need for the operation of the Campaspe River (and similar rivers) as irrigation conduits be changed to better reflect the requirements of riverine biota.
Project Objectives

The project objectives were:

1) Provide environmental flows outside the irrigation season, to restore a degree of seasonality, variability and duration to the flows in the Campaspe River, downstream of Lake Eppalock, using altered storage operation;

2) Preceding and subsequent to the change in storage operation and the imposition of environmental flows in the lower Campaspe River, investigate:
   a) species composition, movement, maturation and larval abundance of fish;
   b) density and taxonomic richness of the macroinvertebrate fauna associated with a dominant lowland river habitat, coarse woody debris (snags);
   c) density, species composition and life histories of shrimp in backwater habitats;

3) Compare all of the above variables in the Campaspe, a highly regulated river, with those for a mostly unregulated river (the Broken River);

4) Produce a report which integrates the results of the various components of this large-scale experiment, assesses the overall impact of a change in storage operation on downstream biota and which recommends to water managers the efficacy of such a change (assess the environmental impact of a change in storage operation from one providing minimal flows outside the irrigation season to one where a percentage of flows entering the storage are released downstream); and

5) Provide, through consultation and collaboration with relevant community groups and water management agencies, a model for future management of storages in large rivers to enable better management of water for environmental and irrigation water needs.

Introduction

The ‘Effect of flow manipulation on the biota of a lowland river’ project or Campaspe Flow Manipulation Project (CFMP) is an ecosystem-scale long-term environmental flows experiment which aims to assess the effectiveness of a ‘translucent dam’ approach to environmental flow allocation. It is unique in its approach and longevity in Australia and rare in the world. It is the only project of its kind to investigate the issue of environmental flows at appropriate spatial and temporal scales. The project is structured around a BACI (before/after, control/impact) design, and during the past 4 ½ years, data for the ‘before’ component have been collected for adult fish, larval fish and macroinvertebrates.

The original date for the flow change was May 1998, but has been postponed due to the 64% storage trigger level not being reached in two successive years, because of the worst drought in 120 years. This means that the original objectives of the project - to compare aspects of the biota of the highly regulated Campaspe with the less regulated Broken before and after the flow change – have not been met. The experimental flow release began in May 2001 and three years more funding has been secured to measure the ecological response to the flow change.

Despite this setback, this report documents a considerable list of achievements, which contribute substantially to a better understanding of river functioning and which are contributing to better management of our river systems.
Methods

Location of rivers and sections

The study was conducted in the region of the Campaspe River between Lake Eppalock and Echuca, at the confluence with the River Murray (Figure 1). This region can be divided into three sections, delineated by weirs and by their distinct hydrological regimes. The ‘upper’ Campaspe is between Lake Eppalock and Campaspe Weir, the ‘middle’ Campaspe is between Campaspe Weir and Campaspe Siphon and the ‘lower’ Campaspe is between Campaspe Siphon and the Murray River. The hydrologies of the sections of river are described below. The study also included the region of the Broken River between Benalla and Shepparton, where the Broken meets the Goulburn River. Although there are also two weirs in the Broken River region studied, Casey Weir and G wangardie Weir, the section of river between Benalla and Casey Weir has one hydrology, receiving little irrigation flow and the section between Casey Weir and Shepparton has another. However, since weirs act as barriers to fish movement, we refer to the sections as: ‘upper’ Broken between Benalla and Casey Weir, ‘middle’ Broken between Casey Weir and Gwangardie Weir and ‘lower’ Broken between Gwangardie Weir and the Goulburn River.

Macroinvertebrates

Snag macroinvertebrates were sampled bimonthly between February 1997 and June 2001 from 6 sites on the Campaspe River and 3 sites on the Broken River using the snag bag (Growns et al. 1999). Six snags were sampled at each site on each sampling occasion. Samples were preserved in the field in 95% ethanol. Samples were then sorted and macroinvertebrates identified, enumerated and entered in a database.

Shrimp

Shrimp samples were collected monthly, excepting the months of May and July, using a standard sweep net. Five x 1 m sweeps were made through backwater and edge habitats. Samples were preserved in the field in 95% ethanol and later sorted, identified and enumerated. Sex, life history stage and length of each individual was also recorded and all entered in a database.

Larval fish

Fish larvae were sampled monthly between October 1995 and June 2001 from 6 run sites and 2 pool sites in the Campaspe River and 4 run and 2 pool sites in the Broken River, using light traps, seine and drift nets in runs, and light traps and tow nets in pools. Light traps and drift nets were set just before dark and retrieved the next morning, while seine and tow samples were taken after dark. Samples were preserved in 95% ethanol. Samples were sorted using a dissecting microscope and identifications made from published descriptions of larvae, personal observations, and collecting successive larval stages.

Adult fish
Adult fish were sampled bimonthly between October 1995 and June 2001 from 8 run sites and 2 pool sites in the Campaspe River, using 3 small and 7 large fyke nets at each site, backpack electrofishing in runs and boat electrofishing in pools. Electrofishing was sporadic, due to variable flow conditions and accessibility, but fyke nets were used consistently at all sites and on all visits. Fish captured during sampling, were identified to species and, in the case of large native species, such as golden perch or Murray cod, were tagged with individually coded tags.

**Physico-chemical and flow measurements**

Duplicate measurements of temperature, dissolved oxygen, turbidity, conductivity and pH were taken at each reach on each sampling occasion using a Horiba® Water Checker U-10. In addition, temperature data loggers were placed in the Campaspe and Broken Rivers, one in each section. Flow records were obtained from Goulburn-Murray Water for the three sections of the Campaspe River and the two sections of the Broken River.

**Results and Discussion**

**Altered storage operation and the provision of environmental flows**

The Campaspe River rises inland of the Great Dividing Range and flows north, meeting up with the Coliban River and several other tributaries at Lake Eppalock. The river continues north, through the townships of Elmore and Rochester, and finally meets the River Murray at Echuca; in all approximately 245 km in length and draining 3,400 km². Mean annual discharge at Rochester under unregulated conditions is 204,000 ML, with tributaries downstream of Lake Eppalock (Axe, Sheepwash and Mt Pleasant Creeks) contribute 26,000 ML annually. Under unregulated conditions, the majority of the flow in the Campaspe River occurred between May and December, with little or no flow during summer and early autumn.

Lake Eppalock was completed in 1962, has a capacity of 312,000 ML and a total of approximately 100,000 ML is diverted annually from the Campaspe River system for irrigation, stock and town water supply (Rural Water Commission, 1985). Little irrigation water is taken from Lake Eppalock itself, rather water is released downstream during summer and autumn, where it is diverted to irrigation channels at Campaspe Weir and Campaspe Siphon. As a result or irrigation releases and diversions, flows in the Campaspe River below Lake Eppalock have changed dramatically from unregulated conditions. Prolonged periods of irrigation flows now occur through the upper (1 below) and middle (2 below) sections of the river in summer and autumn and the entire river below Lake Eppalock experiences reduced flows during much of winter and early spring, as water is captured and held by this storage. There are now, in effect, three flow regimes:

1) Lake Eppalock to Campaspe Weir (upper section)
   a) releases between November and February, 300-400 ML d⁻¹
   b) releases between March and April, 500-800 ML d⁻¹
   c) releases between May and October, 0-15 ML d⁻¹ as minimum flow for ‘maintenance’ or riverine environment, unless Lake Eppalock spills or inflows from tributaries contribute to river

2) Campaspe Weir to Campaspe Siphon (middle section)
   a) Releases between December and March, 10-50 ML d⁻¹
b) Releases between March and April, 200-500 ML d\(^{-1}\)
c) Releases between May and November, 0-50 ML d\(^{-1}\), unless Lake Eppalock spills or inflows from tributaries contribute to river
3) Campaspe Siphon to the River Murray (lower section)
a) Releases between December and June, 0-50 ML d\(^{-1}\)
b) Releases between July and November, minimal unless Lake Eppalock spills or inflows from tributaries contribute to river

Thus, the two broad hydrological changes to the Campaspe River are: increased magnitude and duration of summer/autumn flows in the upper and middle sections and substantially reduced duration of high flows in winter/early spring period in the river below Lake Eppalock. Lake Eppalock fills and spills in approximately 50% of years. This provided the opportunity to design a new flow regime to ameliorate the effects of the reduced winter/early spring flows; the flows which were considered important in conditioning fish to mature and then spawn in spring and summer. There was, at the time of the inception of the project, no room to negotiate changes to the summer irrigation flow regime.

Negotiations with Goulburn-Murray Water revolved around a change in storage operation from one where minimal flows were released from Lake Eppalock, once the irrigation season had ended to one where a percentage of incoming flows would be allowed to pass down the entire river system: a ‘translucent dam’ approach to environmental flows. This has been documented in several publications (Humphries and Lake, 1996; Smith and Humphries, 1997) and presented at numerous seminars and conferences (see Appendix). Goulburn-Murray Water undertook computer modelling and, after extensive negotiations and iterations, a proposal was developed that struck a compromise between providing a significant flow regime change, whilst not unduly impacting on the supply of water for consumptive use. The key features of the flow regime change that was adopted were:

- Between May and October, 25% of the net daily inflow will be passed downstream of the storage;
- Increases releases will only occur when the storage reached 200,000 ML (64% capacity);
- These releases will be in addition to any releases made to meet downstream consumptive demands, to ensure that flow changes will occur for the full length of the river below Lake Eppalock.

It was estimated from the modelling, that environmental flow releases, as detailed above, would occur in 9 out of 10 years. The original design of the project was for the status of aspects of the biota of the Campaspe River to be assessed under current flow rules between October 1995 and May 1998, for the fish and fish larvae, and between February 1997 and May 1998 for the macroinvertebrates and shrimp. Then the new flow regime was to be implemented and assessment of the biota continued for three years, until June 2001. Due to the driest four-year period on record, Lake Eppalock did not reach the 64% trigger level until May 2001. Thus, the new flow regime was delayed by three years and so allowed almost six and four years of ‘before’ data to be collected for fish and macroinvertebrates, respectively. But it has meant that virtually no ‘after’ data were collected before the LWRRDC (now LAW) funding ceased.
Comparison of biota within the Campaspe and between the Campaspe (treatment) and Broken (reference) rivers

**Novel approaches and methods:**
Since there had been no projects designed to assess the effectiveness of a changed flow regime in Australian lowland rivers before the CFMP, it was necessary to determine the most appropriate response variables or indicators of flow change and to devise methods for sampling the biota in rigorous, standardised and mostly quantitative ways. To this end, we determined that one of the key responses to a flow change for fish would be maturation and spawning. This was based on current knowledge that rises in flow were needed to get species of Murray-Darling Basin fish in a condition suitable for spawning (Lake, 1967; Harris and Gehrke, 1994). We determined early on that it would be extremely difficult, if not impossible, to collect fish in the act of spawning and that even collecting ripe fish might not tell us that the fish would actually spawn, since some species will resorb gonad from an advanced maturational stage should suitable conditions for spawning not eventuate. We decided that the presence of fish larvae - the results of spawning - would be an indication of which fish had spawned, where they had spawned and when. Fish larvae had not been used for the assessment of the efficacy of an environmental flows release before and had rarely been collected from Australian lowland rivers. We developed and justified this approach (Humphries and Lake, 2000) and have established appropriate methods (Humphries, Serafini and King, in press). Macroinvertebrates were chosen as another key indicator of flow change as they had been used for many years as indicators of water quality (Smith et al. 1999, Growns et al. 1995). However, sampling of lowland river macroinvertebrates had often involved rapid assessment techniques and typically avoided the channel-proper, choosing mostly to focus on more accessible and less challenging floodplain habitats (Boon et al., 1990). We undertook an initial comparison of macroinvertebrate sampling methods, which determined that large woody debris or ‘snags’ is the major stable substratum in lowland rivers and one which supports a diverse macroinvertebrate community (Humphries et al., 1998). We then went on to develop a simple and effective method for sampling snag macroinvertebrates, the ‘Snag-Bag’ (Growns et al. 1999). This has allowed us and others (Monash Uni, NRE Victoria, Griffith Uni, Tas Uni, Canberra Uni and others) to sample macroinvertebrates of lowland rivers in a simple, repeatable and quantitative way.

**Adult fish:**
Of the 12 native species that have been recorded historically from the Campaspe River, eight still occur, although only Australian smelt (19% of total electrofished), flathead gudgeon (44% of total electrofished) and golden perch (13.9% of total in fykes) were caught in sufficient numbers to suggest sustainable populations. For the last, it is likely that an annual stocking program maintains numbers of fish at reasonable levels (www.nre.vic.gov.au). Notable for its low abundance was Murray cod, of which only 39 individuals were collected for the entire period using all methods.

Six species of introduced fish were collected from the Campaspe River over the five year sampling period, with dominance by common carp (14% of total in fykes) and European perch (25% of total in fykes). Together, these two species made up approximately 80% and 60% by weight of fish in electrofishing and fyke samples, respectively. Of all species collected, length-frequency plots suggest that only the
two native species, Australian smelt and flathead gudgeon and the introduced carp, European perch, gambusia, brown trout and goldfish are recruiting in most years. The results from one of the most comprehensive and extended sampling programs of fish in Victorian waters indicate that the Campaspe River fish fauna is very highly degraded indeed.

Sampling of adult fish in the Broken River commenced in October 2000. From the limited data available, it is clear that the results for adult fish concur with those for larval fish that this river is in a better condition than the Campaspe. Only 16% of fish captured in small and large fyke nets in the Broken River were introduced. Golden perch alone contributed 62% to the fauna. This contrasts with the Campaspe River during the same period, when 67% of fish captured were introduced and golden perch made up only 6% of the total. Proportionally, Murray cod were 10 times more abundant in the Broken than in the Campaspe River.

Larval fish:
Larvae from a total of 13 species and 9 families were collected from the Campaspe and Broken Rivers between October 1995 and June 2001. Twice as many species were recorded from the Broken River (10) than from the Campaspe River (5) and the two rivers only shared three introduced and two native species. The dominant species in the Campaspe, flathead gudgeon, did not occur in the Broken.

The two most abundant species in the Campaspe, flathead gudgeon and Australian smelt, were classified as ‘opportunists’. They are small, short-lived species, which spawn for up to nine months, encompassing extremes in temperature and flow. The extended spawning period may place a subset of larvae in optimal conditions for recruitment and is hypothesised as being the key to the success of these species. This forms the basis of the ‘window-or-opportunity hypothesis’ (Humphries, 2001).

From results obtained from the Campaspe and Broken Rivers, most species of fish spawned each year, despite large interannual variation in flow and temperature conditions. In the Broken River, native species which are known to be abundant as adults, were recorded as larvae each year and included Murray cod, a species of galaxiid, three types of carp gudgeons (there is some doubt over species due to hybridisation of this group) and crimson-spotted rainbowfish. All were absent from the Campaspe, except for one species of carp gudgeon. This implies strongly that river regulation has not prevented spawning. Poor recruitment over several decades, rather than a failure to spawn, is considered the most likely explanation for differences in the larval fish faunas between the two rivers.

The highly regulated section of the Campaspe River downstream of Lake Eppalock is thought to provide sub-optimal habitat conditions for larvae relative to the less regulated downstream sections. The less regulated lower section of the Campaspe has extended periods of low flows over summer. Low flow times are thought to provide conditions conducive to recruitment of some species of native fishes, especially those which appear to delay spawning until the warmest months associated with the lowest flows. Their ability to recruit during these times forms the basis of the ‘low flow recruitment hypothesis’, which was generated from observations in the Campaspe and Broken Rivers (Humphries, King and Koehn, 1999).

Macroinvertebrates:
A total of 247 taxa from 75 families were recorded from the Campaspe and Broken Rivers. Macroinvertebrate density was not significantly different between the Campaspe and Broken Rivers or among the three Campaspe River sections. The upper Campaspe and the Broken River, however, had greater numbers of species than the middle and lower Campaspe sections, but did not differ from each other. The upper Campaspe experiences higher, more variable and cooler discharges than downstream sections, due to the summer irrigation releases from Lake Eppalock. As a result, several taxa that are characteristic of lower order streams were recorded from samples taken in the upper section of the Campaspe. A moss, typical of regions downstream of dams, was only found in the upper section of the river and is thought to be responsible for providing an additional microhabitat on snags for macroinvertebrates.

Macroinvertebrate communities in the Campaspe River were significantly different from those of the Broken River. In addition, the macroinvertebrate communities from the three Campaspe River sections were significantly different from each other. In each case, it is likely that the distinct hydrology of each section contributes substantially to these differences (Growns et al., in press). Evidence for this is based on the occurrence of macroinvertebrate taxa which are characteristic of specific flow types. Taxa characterising differences among sections, determined using Indicator Species Analysis in PC-ORD statistical package, had lower than average coefficients of variation of mean annual density and therefore can potentially be used as indicators of flow regime.

There was significant change in community structure among years for each section at the Campaspe and Broken Rivers (10 out of 12 comparisons among year within section) and all sections showed a trend of increasing dissimilarity in community structure over time. Major changes in the presence and absence of taxa among years and substantial shifts in the relative abundance of taxa were driving these changes. Individual taxa underwent major shifts in density and relative abundance. The taxa which characterised individual years at each section had above average coefficients of variation of mean annual density, indicating high inter-annual turnover. The identification of sources of spatial and temporal variation in macroinvertebrate community patterns is the subject of a paper shortly to be submitted (Growns, Cook and Richardson, in prep.).

Shrimp:
Two atyid shrimp, Paratya australiensis, Caridina mccullochi, and a palaemonid prawn, Macrobrachium australiense, were collected from the Campaspe and Broken Rivers. Distinct assemblages were found at each section of the Campaspe and the Broken Rivers. The upper and middle sections of the Campaspe were dominated by P. australiensis. No C. mccullochi were collected from either of these two sections. Contributions of the three species were approximately equal in the lower Campaspe and the Broken River.

Patterns of breeding of the three shrimp species, as indicated by the presence of berried females and larvae, varied among section and among years. P. australiensis began breeding earlier and continued for a longer period than the other two taxa. M. australiense was the last of the species to begin breeding and had the shortest breeding season, from November to April. The onset of breeding of M. australiense in the upper section occurred consistently a month later than in the middle and lower sections of the Campaspe. There was a significant temperature depression over the summer period in the upper Campaspe (sometimes 5 °C lower
than downstream) as a result of discharges from Lake Eppalock and this may have been the cause.

The absence of *C. mccullochii* in the upper and middle Campaspe may be attributed to the summer irrigation flows in these 2 sections. Substantial populations persist in the lower Campaspe and the Broken River both which experience reduced flows over the summer/autumn period, a pattern typical under natural flow conditions. *C. mccullochii* is considered a low flow or standing water species and it is likely that the high flows during recruitment are adversely impacting on the recruitment success of the species. The above results are included in a paper shortly to be submitted (Richardson, Grows and Cook, in prep.).

**Integration of components of biota**

Our results indicate a shift in the macroinvertebrate community in the upper Campaspe from one of a lowland river, to one resembling more that of an upland stream. The mechanisms responsible for this are likely to be higher current speeds and cooler water, which:

- alter the biofilm structure and composition
- reduce the build-up of sediment on snags
- enhance the growth of moss.

High current speeds and low biofilm have encouraged the colonisation of filter feeding groups, such as simuliiids and hydropsychid caddisflies and reduced the abundance of groups generally associated with detrital and sediment-rich biofilms, such as many species of chironomids, some mayflies and naidid worms. In addition, the loss of still and slow-flowing habitats in the upper section of the Campaspe are thought to provide sub-optimal conditions for the recruitment of the shrimp *Caridina mccullochii* and thus eliminated them entirely. In the lower Campaspe, development of snag biofilm has been enhanced over summer and winter, so snags are dominated by macroinvertebrates which can utilise this resource. From a comparison with the Broken River, we suspect, also, that the extant community of the lower Campaspe is a subset of the presumed 'intact ecosystem' fauna, consisting predominantly of slow or still water taxa, although it is worth noting that all three shrimp species occur in this section in abundance.

Whilst the changes to the macroinvertebrate community in the Campaspe River, almost certainly due to regulation, are profound, we suggest that these changes are unlikely to have caused the degradation of the fish fauna. The majority of Murray-Darling Basin fishes are generalist carnivores, which essentially consume anything that they can capture and ingest (McDowall, 1996). Fish will respond to an altered macroinvertebrate community structure by switching prey and if the river becomes less productive, it may support fewer fish or fish may experience slower growth (Matthews, 1998). However, it is difficult to imagine how the nature of this change in macroinvertebrate community structure could explain the virtual elimination of native fish species from the river. Also, the relative similarity at times between the macroinvertebrate community of the upper Campaspe and that of the Broken River, yet the enormous disparity in fish composition does not support the conjecture that a change in macroinvertebrates has elicited such a dramatic change in the fish fauna. Whilst the changes to the fish fauna are unlikely to be a result of altered macroinvertebrate community structure, it is far more likely that the availability of microinvertebrates as food for the early stages of fishes may have played a role.
It is clear from our work in the Campaspe and Broken Rivers that the majority of extant species breed every year, irrespective of the antecedent flow conditions. It is axiomatic that the remnant species in the Campaspe will be able to do this, simply because they still occur here. However, several species which occur in the Broken River, but not now in the Campaspe, also spawn every year. Extrapolating from these observations to the situation after river regulation would suggest that most species would continue to spawn, even under considerably altered flow conditions. Of the 15-20 species that would have once occurred in the Campaspe River (Humphries and Lake, 2000), most do not require a spawning migration to complete their life cycle and so would probably have bred in the river. Assuming that river regulation did not prevent spawning, then it must have either (i) reduced or eliminated recruitment, (ii) encouraged fish to emigrate, or (iii) brought about indirect effects, such as disease, an influx of exotic species or prevented necessary movements due to barriers (although this is unlikely, since the Broken River also has significant barriers).

Support for the fact that recruitment may be the focus of the impact of river regulation is provided by an analysis of the life histories of fishes from the Campaspe and Broken Rivers and the observation that the two remnant species in the Campaspe, flathead gudgeon and Australian smelt, both share the trait of an extremely protracted spawning period and substantial variation in recruitment over this time, seemingly unrelated to the abundance of newly hatched larvae. We formulated the ‘window-of-opportunity-hypothesis’, which postulates that river regulation contributes to an alteration to the timing of critical habitat and food availability for the first feeding larvae of some species of fish. This may be especially true for those species which seem to spawn only during low flows (Humphries et al. 1999), but may be important for other species too. Flathead gudgeon and Australian smelt may persist because a proportion of their young will encounter good recruitment conditions at some time during their protracted breeding period, but in many years this will be outside the relatively brief breeding period of other species.

River regulation, especially the release of irrigation flows in summer, is most substantial in the upper Campaspe section, yet the fish fauna in the lower Campaspe, which receives relatively natural summer flows, is almost as depauperate. It is interesting to note, however, that the few individuals of other species collected in the Campaspe were either collected from the lower or middle section (silver perch and flatheaded galaxias) during winter, when presumably they were moving upstream from the Murray River in response to high flows or from the upper section (spotted galaxias) when it is likely that they were washed or moved downstream from above Lake Eppalock for the same reason. Subsequent sampling over several years indicated that they did not remain in the river for very long and this, in itself, may provide a clue to their loss to the system and their continued absence. In other words, the depauperate fish fauna in the Campaspe may be a combination of poor recruitment of those species which are relatively sedentary and emigration and subsequent avoidance by those species which can make larger-scale movements. Why these species continue to avoid the Campaspe River is a mystery and warrants further investigation.

**Suggestions for improved environmental management of a severely regulated river**

Overall, both the reduced winter flows and the enhanced summer irrigation flows have had a major impact on the Campaspe River ecosystem. Whilst we are unable to
assess the impact of the experimental flow releases, we can state unequivocally that the use of the upper (and middle) sections of the Campaspe River as irrigation conduits during summer must be addressed. This practice has shifted the macroinvertebrate community to a different state, one more reminiscent of a lower order stream, resulted in the loss of one of three species of shrimp and contributed to the almost total elimination of native fishes. This situation needs to be addressed most urgently and our recommendations are to:

1. Ensure multiple level off takes from Lake Eppalock to eliminate temperature depression;
2. Determine alternative methods for delivering water to riparian users, perhaps through moderate winter harvesting and development of on-farm storages or piping;
3. Determine alternative methods of delivery or sources of water for out-of-catchment users;
4. Reinstatement of low flow periods throughout river during summer through translucent dam releases;
5. Address water quality issues so that periods of low flow do not encourage algal blooms;
6. Construction of fish passages on weirs or, preferably, decommissioning of existing structures;
7. Encourage catchment management works, such as riparian zone fencing and replanting and limiting stock access to the river.

There is more likely to be a faster recovery toward a 'natural' macroinvertebrate and shrimp community than toward that of a fish community, should the experimental flow regime prove effective. This is because of the requirement for a natural source of recruits or colonists, if conditions improve in the Campaspe. For macroinvertebrates, this source probably still exists either upstream or downstream of the most degraded reaches of the Campaspe River. However, fish colonists would have to be sourced mainly from the Murray River, which is itself degraded, they would have to be enticed to move into the Campaspe and then run the gauntlet of several major barriers, which have not yet had passes built. While stocking of some species would be possible and might expedite recovery of the fish fauna, there are currently too many uncertainties associated with this activity to be sure of the desired outcome.

References


Grown, J.E., Cook, R.A. and Richardson, A. Spatial and temporal variability of snag macroinvertebrate communities of two lowland rivers, south-eastern Australia. (In prep.)


Communications Achievements for the Campaspe Flow Manipulation Project

Technology Transfer Plan

1997

1999

Publications in refereed journals

1998

1999

2000

In press

In preparation

Crook, D.A. and Humphries, P. Problems with translating ecological data into “take home messages” for management with an example of golden perch movement in Australian rivers. To be submitted to *Ecological Restoration and Management*, (approx. August 2002).


**Publications in refereed conference proceedings**

2000


**Publications in non-refereed journals and magazines etc.**

1995


1996


1997


1998

1999

2000

Brochures/leaflets/WWW

Environmental Flows for the Campaspe River. Colour brochure describing the project background, aims and results up to the end of 1997.

Keys
In preparation (May 2002)
Serafini, L.G. and Humphries, P. A preliminary guide to the identification of the larvae of species of freshwater fish from the Murray-Darling Basin.

Conferences / seminars/workshops

1996
Paper presented: Humphries, P. Fish larvae of regulated and unregulated rivers.

1997
Papers presented:
- Growns, J. Introducing the snag bag. (poster)
- Humphries, Whittington, J. and Growns, J. Putting low flows on the agenda.
- In addition Humphries convened a specialist session entitled “River regulation and rehabilitation”, which has been published as Australian Society for Limnology, Special Publication No. 12.

1998
- Presentation: Jane Growns co-presented the 1-day workshop on identification of aquatic mites with Dr. Mark Harvey of the Western Australian Museum.
- Paper presented: Growns, J. Aquatic Mites as Bioindicators, with an Australian Example.
- Paper presented: Growns, J. River regulation has increased macroinvertebrate diversity in a lowland river.
Papers presented:
• Serafini, L.G. & Humphries, P. Life history of the flatheaded gudgeon in relation to the species success in regulated riverine habitats.
• Humphries, P. Relating spawning time and occurrence of larval fish to environmental variables in lowland rivers.

1999
Murray-Darling Association Native Fish Workshop. Mildura, July 1999. Paper presented:
• Humphries, P. Fish and River Condition
• Humphries, P. Fish Research in the CRCFE
• Humphries, P., Serafini, L.G. and King, A.J. Spatial and temporal patterns in riverine fish larvae.
Australian Society for Limnology Annual Congress. Taupo, New Zealand, December 1999. Attended by Jane Growns, Peter Hancock and Anthony Conallin. Papers presented:
• Growns, J.E. Variability in snag macroinvertebrate fauna in relation to flow regime and current speed in a lowland river.
• Hancock, P.J. and Growns, J.E. The influence of flow velocity on site selection by net-spinning caddis larvae.
• Conallin, A. and Growns, J.E. The influence of hydrological regime on the life history and population dynamics of three shrimp species, in lowland rivers of southeastern Australia.

2000
• Growns, J.E. Spatial and seasonal variation in snag macroinvertebrate communities in two regulated lowland rivers.
• Humphries, P. The translucent dam approach to environmental flows and the spawning and recruitment of fish in southeastern Australia.
Murrumbidgee 2000. Recent research on the geomorphology, hydrology and ecology of the river and its floodplain. Attended by R. Cook.

2001
North East Catchment Management Authority. Research Forum. Attended by R. Cook. Paper presented:
• Cook, R., Humphries, P. and Growns J. Fish, macroinvertebrates and flow in the Campaspe and Broken Rivers.
Humphries and Cook. Paper presented:
- Humphries, P. Persistence of fish species following anthropogenic disturbance.
  Australian Society for Limnology Congress, Moama, NSW, October 2001. Attended
  by Humphries, Cook and Richardson. Papers presented:
- Richardson, A. and Cook, R. Patterns in the distribution and life history of shrimp
  in the Campaspe and Broken Rivers.
- Cook, R. and Richardson, A. Variability and persistence of riverine
  macroinvertebrate communities.
- Humphries, P. The Phenomenon of Drifting Fish

Seminars

1998
Cullen, Terry Hillman, and Rod Oliver.
Water, Tatura.
Meeting, Lake Eppalock.
Growns, J. (1998). Rehabilitation of rivers using environmental flows in the Murray-
Darling Basin. MDFRC, Albury.
Growns, J. (1998). Rehabilitation of rivers using environmental flows in the Murray-
Darling Basin. Institute of Freshwater Ecology River Laboratory, Dorset, U.K.
Hobart.

1999
Humphries, P. (1999). Fish larvae in the Campaspe and Broken Rivers. MDFRC,
Albury.

2000
Humphries, P. (2000). The translucent dam approach to environmental flows and the
spawning and recruitment of fish in southeastern Australia. MDFRC, Albury
density and macroinvertebrate community structure in the Murray and Darling Rivers
at Wentworth. MDFRC, Albury

2001
Humphries, P. (2001) Fish and habitat. North East Catchment Management Authority,
Wodonga, Vic.
  Murray-Darling Freshwater Research Centre.
Humphries, P. The Campaspe River, flow and fish habitat. North Central Catchment
  Management Authority, Rochester, Vic.
Talks to community groups/schools etc.

1996
Quality Strategy Committee, Bendigo.

1997
Humphries, P. (1997). The role of fish in riverine ecosystems. Rotary Club of
Bendigo, Bendigo.
Australian Freshwater Fisherman's Assembly, Adaminaby.

1998
Hancock, P. and Conallin, A. Stream Macroinvertebrates. Freshwater
Ecology TAFE students.

2000
Angling Club, Rochester
Landcare group, Rochester.

Activities with community groups/schools etc.

FLAG - Fish Larval Action Group. Mr Mike Copland, MDFRC’s Education Officer,
helped us to set up a joint study with 5 schools near the Campaspe and Broken Rivers.
Students put drift nets in place each week over the summer of 1996/1997 and
collected larval fish.

Technical advice

Humphries was a member of the Campaspe Expert Panel, December 1996 - April
1997 which was set up to advise on future environmental flow needs for the
river.

Humphries was an interviewee on Ecology Flows Study being conducted by CSIRO

Humphries provided advice to Rochester Angling Club on stocking of native fish in

Growns was a member of the Technical Advisory Group for the Assessment of
Environmental Flows for the Murrumbidgee River project run by the NSW
Department of Land and Water Conservation through Charles Sturt

Humphries is a member of the steering committee for "Downstream movement of

Humphries and Growns were members of the Thomson/Macalister environmental flows expert panel. Feb – April 1999.

Humphries attended a forum on allocation of environmental flows to the Macquarie Marshes. NSWN PWS, March 1999.

Humphries and Growns advised DLWC (Paramatta) on translucent dam approach to environmental flow releases. May 1999.

Humphries provided advice on effects of mine blasting on riverine fish to farmer. May 1999.

Humphries was a member of an expert panel assessing the ecological effectiveness of COAG water reforms. CRCFE June 1999.

Humphries and Growns provided advice on translucent dam approaches to Mr Rick Ross, Lethbridge Northern Irrigation District, Canada. October 1999.

Humphries provided advice on importance of fish species downstream of Lake Eppalock in the Campaspe River to Ecology Australia, Pty Ltd., February, 2000.

Humphries provided advice on fish species in the Campaspe River to John McGuiekin, August, 2000.

Humphries provided advice on fish species in the Campaspe River to I, D & A., September, 2000.

Humphries provided advice on aspects of Campaspe River recreational fishery to Melody Jane, DNRE, October and November 2000.

Growns was a member of the Australian Society for Limnology Standing Committee for Policy. 1999 – continuing.

Humphries is convenor of the Habitat Subcommittee for the Australian Society for Fish Biology. 1999 – continuing.

Humphries is a member of the technical advisory group for the AFFA project “Downstream movement of fish”. 2000 - continuing.

Growns is the NSW coastal representative on the Australian Society for Limnology’s Executive. 2000 – continuing.

Humphries was a member of the Broken River Expert Panel recommending flows to improve environmental condition in the Broken River and Broken Creek systems. 2001 – continuing.

Media

1997

1998

1999

2000

2001

Reports

1996


1997

1999

2002

Other activities
We initiated the organisation of a ‘research day’ on the Broken River, to be held in collaboration with the Broken River Catchment Management Authority. Community and conservation groups, natural resource managers and researchers have been invited to participate. The ‘research day’ will be held late 2001, at Dookie.

Humphries is co-convenor of a symposium on “The Role of Drought in Aquatic Systems”, held in Albury in February 2001. He is also editing a Special Issue based on this symposium for the journal *Freshwater Biology.*