Dissolved organic carbon in the lower Namoi River, New South Wales:

Determining responses to flow, loads and food web linkages

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Abstract

Like many lowland rivers around the world, the Namoi River in north-west New South Wales (NSW) has greatly reduced rates of flow due to effects of regulation and abstraction. This has likely led to reduced amounts of allochthonous dissolved organic carbon (DOC) entering main channels through less frequent wetting of benches, flood runners and floodplains. However, these changes in DOC have not been quantified. In addition, the benefits that increased delivery of DOC may have to aquatic food webs are not well understood for lowland rivers.

The NSW Government has focussed on the sustainable use of natural resources with a strong environmental protection component. Part of the legislative requirements was to supply environmental flows to rivers and to quantify ecological benefits. A scientific approach was developed, and monitoring of these releases began in 1999 under the Integrated Monitoring of Environmental Flows (IMEF) program.

In this study DOC concentrations were quantified over different flow regimes across three sites at a variety of temporal scales with export loads and diel variation determined. DOC concentrations over low flow periods were fairly similar between sites and ranged between 5 and 10 mg L^{-1}. DOC concentrations during a major flood increased substantially with a mean of 20.4 mg L^{-1} and a maximum of 44 mg L^{-1}. A significant (P<0.05) positive linear relationship was found between median DOC concentration and flow. The relationship between DOC and flow was used to estimate DOC loads to the river under different modelled flow scenarios including without environmental flow, with environmental flow, and simulated natural flow. Environmental flows were found to increase DOC delivery relative to current flows and approximated that delivered under natural conditions.

To determine diel variability, DOC was sampled at 4 hr intervals from two sites across two distinct flow regimes. This included a large flood (mean flow 224 m^3 sec^{-1} and a peak flow of 376 m^3 sec^{-1}) sampled four hourly for ten consecutive days. DOC concentrations were significantly greater at night than during the day (P<0.05) and the mean DOC concentration was 23.4 mg L^{-1} at night compared to 18.9 mg L^{-1} during daylight hours. The magnitude and duration of flow within this lowland river system and the mobilisation of large quantities of

allochthonous carbon appeared to play a role in increasing DOC concentration and the diel difference.

Experimental investigations were also carried out to determine the responses of the planktonic food web (i.e., bacterioplankton, phytoplankton and zooplankton) to various additions of DOC. *In-situ* microcosm results indicated that ambient DOC availability limited the bacterioplankton for the three seasons over which we conducted the experiments. When DOC was added alone, dissolved oxygen concentrations decreased primarily because of increased bacterial respiration and bacterioplankton growth generally increased relative to controls. Additions of DOC alone led to a pattern of decreased chlorophyll a concentration relative to that of the controls, except for willow leachate. Additions of inorganic nutrients alone increased chlorophyll *a* concentrations above that of the controls, indicating limitation of phytoplankton productivity.

Results from 70 L mesocosm experiments to determine zooplankton responses revealed that DOC addition with and without nutrients increased heterotrophic respiration and led to significant increases in bacterial biomass. In treatments with the natural leachate, zooplankton concentration and diversity increased relative to that of the controls. Amendment with glucose alone also resulted in their increased growth and diversity, but not to the same extent. Glucose with inorganic nutrients led to similar growth and diversity to that of the control.

This study has shown that environmental flows increase the delivery of allochthonous DOC to the river and should create conditions that more resemble natural conditions. Furthermore it supports the hypothesis that allochthonous sources of DOC delivered to a river with inflows will stimulate heterotrophic bacterioplankton and alter the food web leading to increased zooplankton concentration and diversity.

Structure of thesis

Please be advised that Chapters 3 to 6 have been written as papers for publication and therefore some repetition of sections (e.g., Materials and Methods) is necessary.

Chapter 5 has been published in the journal Hydrobiologia as follows:

Westhorpe, D.P., Mitrovic, S.M., Ryan, D. & Kobayashi, T. 2010, 'Limitation of lowland riverine bacterioplankton by dissolved organic carbon and inorganic nutrients', *Hydrobiologia,* vol. 652, pp. 101-117.

Chapter 4 has been published in the journal Limnologica as follows:

Westhorpe, D.P., Mitrovic, S.M. & K. Benjamin Woodward. (2012). 'Diel variation of dissolved organic carbon during large flow events in a lowland river', *Limnologica,* vol. 42, pp. 220-226.

Chapters 3 and 6 are currently in preparation for submission to appropriate journals.