ECOLOGICAL CONNECTIVITY OF THE RIVER MURRAY

This research helps river operators understand what impact different river management options (using weirs and regulators) has on riverine resources, biological activity, ecology and water quality

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Project partners:

The lower River Murray channel and floodplain is an important complex ecosystem and vital economic zone in South Australia, and we need to understand how current and planned interventions in floodplain inundations will affect the ecosystem.

The management of riverine and floodplain structures such as weirs and regulators has the potential to both threaten and enhance in-channel processes. This project developed knowledge and tools to support river operators to examine how different water delivery operations will influence ecological outcomes and water quality.

KEY FINDINGS

Fieldwork provided empirical evidence of how hydrological and hydraulic variables affect riverine processes and the transfer of resources between the floodplain and the river that support the ecosystem. This was used to investigate improved management options for both terrestrial and aquatic life, like suitable habitat and the food resources to support Murray cod and prevent conditions that encourage hypoxic blackwater events and algal blooms.

The project synthesised the findings to improve current understanding of the connected riverine-floodplain system, taking into account local records dating back to 1946 and used newer methods like machine learning and stable isotope analysis. The results were used to update the eWater Source hydrological model for the South Australian River Murray. This allowed possible river operation strategies to be tested to see how operational decisions could affect key ecological processes and water quality, allowing for improved decisions to maximise ecological and water quality outcomes.

IMPACT

The project developed tools that are being used by river operators in the Murray Darling Basin to mitigate water quality risks and improve ecosystem health associated with integrated floodplain infrastructure operations. Management decisions can now be made faster and more reliably, using operational scenarios that predict benefits and trade-offs for entire ecosystems.

Ongoing training of hydrologists in the Department for Environment and Water (DEW) is also enabling maximum uptake and impact of the methods developed, and this uptake leads directly to advice being provided to inform environmental water planning and river management.

UNDERSTANDING THE RIVERINE ENVIRONMENT

Weirs and regulators are commonly used to augment the natural frequency and duration of floodplain inundation events to restore wetland and floodplain habitats. These hydraulic interventions can either enhance or threaten river ecology but there are still many gaps in our understanding of how these inundation events specifically influence riverine resources, biological activity and water quality.

To fill some of these gaps, the riverine environment along the lower River Murray was sampled and historical hydrological and weather records were used to investigate how:

- *dissolved oxygen and organic carbon moves from the floodplain during inundation events.* This included how river operations alter the source, quantity, and quality of organic matter entering the floodplain and ultimately, the riverine foodweb.
- *river operations influence phytoplankton abundance and algal community composition flowing through South Australia*. This focused on what drives cyanobacterial growth and the testing of forecasting methods to support avoiding adverse conditions.
- *natural events and human intervention influence the transport of plant propagules, microinverterbrates, Murray cod larvae and energy sources for the riverine food web*.

INUNDATION AND WATER QUALITY

Organic material becomes mobile during floodplain inundation and this can have an impact on dissolved oxygen (DO), dissolved organic carbon (DOC) levels, and water quality on the floodplain and in receiving waters. The project quantified the amount of organic material for the main vegetation types in the lower River Murray floodplains to help determine the impact of riverine vegetation on water quality. While black box and red gum dominated litter loads, six vegetation community types were sampled in total, including cooba woodland, mixed tree species, shrubs and grasslands. The project found that vegetation amount, type, and age as well as inundation history, water temperature and natural aeration rates all influenced the amount and rate of DOC released into the water, with subsequent changes to DO in the water column.

The research, building on previous research methodologies used on the Chowilla and Katarapko floodplain, improved the predictive capability of numerical models that provide the likely range of water quality outcomes from infrastructure operations. Modelling suggests that:

- current infrastructure operations for the lower River Murray being considered maintain DO levels above 6 mg L^{-1}
- impacts from extreme operations beyond current operational rules were largely contained to the site scale.
- because water temperature has a large impact on DO conditions, negative impacts can be lessened by timing operations earlier in the season.

Conceptual representation of in-channel changes when creating inundation using structures. The left image represents normal conditions, with a given water depth (D) and velocity (v). The right image represents increased floodplain inundation due to a downstream structure, for the same flow. The possible changes in-channel include release of dissolved organic carbon (DOC) - resulting in consumption of dissolved oxygen (DO) and lower DO concentrations, reduced velocity, and increased depth - which in combination with the reduced velocity may lead to stratification, a pre-condition to cyanobacterial blooms

PHYTOPLANKTON ABUNDANCE AND CYANOBACTERIAL GROWTH CONDITIONS

Some phytoplankton, particularly the highly digestible food sources for many animals, need turbulence and higher water velocities to remain in suspension. In contrast, cyanobacteria (blue green algae), which can be a serious problem in the River Murray, thrives in stiller water. Changes in water velocity associated with inundation can have a big impact on phytoplankton abundance and cyanobacterial growth. Underwater light conditions, salinity, nutrient availability, increased growing seasons and global warming can also affect cyanobacterial growth.

The project used current and historical data to develop a model that could assess the likelihood of cyanobacterial blooms under different river management scenarios. Collating all known data, and using a dataset of phytoplankton cell counts, the team aggregated and applied the information at five locations expected to respond differently to varying flow and temperature conditions.

A machine learning algorithm, the Random Forest model, was applied to the data to produce forecasts for cyanobacterial growth, driven by predictors describing the physical environment. Testing of combinations of various predictors found week of the year (and thus seasonal dependence) together with temperature, velocity and salinity, were the main physical drivers for cyanobacterial growth.

Upstream conditions were also found to play a major role in forecasting water conditions downstream. While keeping the water flowing at a certain speed to prevent stratification is a well-known management technique, updates to the eWater Source Model through this project now allows easier forecasting of slow-flowing water that can lead to undesirable stratification.

TRANSPORT OF BIOLOGICAL PROPAGULES

Dams and weirs disrupt connectivity and modify hydrodynamics in regulated rivers, particularly upstream of regulators where moving water systems are converted to slower water or still lakes. The project investigated the relationships between hydrodynamics and the transport and deposition/retention of biological propagules. Connectivity between the floodplain and rivers is critical for aquatic ecosystems to support the transport of plant propagules (seeds), microinvertebrates and fish larvae (Murray cod, *Maccullochella peelii*).

The project identified the water velocity thresholds and seasonal timing that affected transport. It found that:

- sediment deposition was significantly greater with regulated in-channel inundation than during an in-channel flow pulse
- there was no difference in seed density between regulated in-channel inundation and an in-channel flow pulse, despite the large differences in sediment deposited
- flow delivery or regulator operation should be timed to coincide with seed fall of eucalypts to maximise recruitment
- Murray cod larvae thrive in slackwater habitats within broader fast-flowing reaches
- velocities >0.2 $m.s^{-1}$ are optimal to mobilise and transport rotifers and other zooplankton, which are critical links in the riverine food chain.

FOOD WEB DYNAMICS

There are several key differences in potential outcomes for food webs between natural and managed inundation of floodplains and wetlands. For example, flooding benefits carbon release, but does not provide the water speed needed by zooplankton and Murray cod larvae to drift and grow successfully. If water flow is too low following a flood, hypoxic conditions can build and algal blooms may be encouraged.

The project investigated the response of the lower River Murray foodweb to regulated low flows and a managed inundation. It was found that not only were there different responses to these events, but there was an influence of historical conditions, ie. previous high flows and managed flooding during drying conditions.

The updated eWater Source model for the lower Murray River now takes into account water quality, ecological responses, and river hydrodynamics over hundreds of kilometres.

DELIVERING RAPID, RELIABLE MODELLING TOOLS

The team brought all of this work together to quantify how hydraulic changes influence in-channel processes and water quality, then fed the criteria into the eWater Source model. They defined velocity thresholds to promote important ecological processes like the entrainment and drift of nutritious zooplankton and creation of suitable retention habitat for Murray cod larvae. The team used a mixing criterion to assess changes in velocity and depth that can disrupt thermal stratification, and in turn, discourage hypoxic black water formation and cyanobacteria blooms. Water quality risk assessment was improved by the DODOC model developed for integration into the eWater Source model. The DODOC model predicts:

- organic matter on the floodplain
- how organic matter will release carbon to the water when inundated
- how carbon might be broken down in the water by micro-organisms
- the overall influence on dissolved oxygen levels.

This is the first time a model has been developed for the River Murray that incorporates water quality characteristics, ecological responses, and river hydraulics at the scale of hundreds of kilometres of river reach to inform infrastructure operations.

FOR MORE INFORMATION

The following technical report associated with the research program is available at www.goyderinstitute.org/publications/technical-reports/:

- Gibbs, M.S., Bice, C., Brookes, J., Furst, D., Gao, L., Joehnk, K. Marklund, M. Nicol, J., Pethybridge, H., Szarvas, S., Wallace, T., Welti, N., and Zampatti, B. (2020) Ecological connectivity of the River Murray: Managing ecological outcomes and water quality risks through integrated river management. Goyder Institute for Water Research Technical Report Series No. 20/03, Adelaide, South Australia. ISSN: 1839-2725

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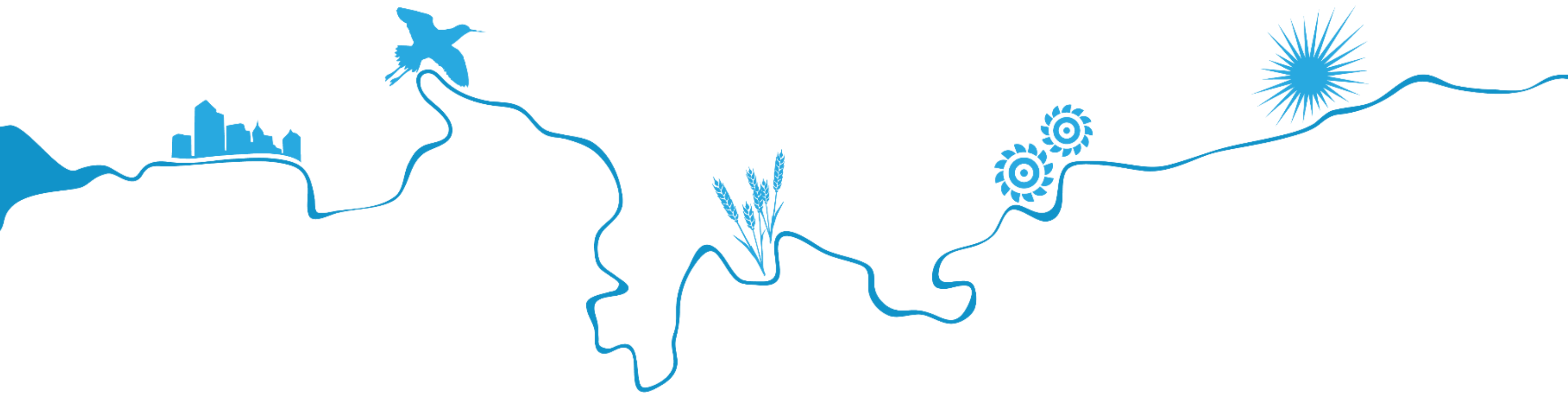

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