Department of Planning and Environment

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Ecosystem processes – monitoring river refuges, productivity and basal resources

Environmental Outcomes Monitoring and Research Program Annual Report 2021-2022

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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More information

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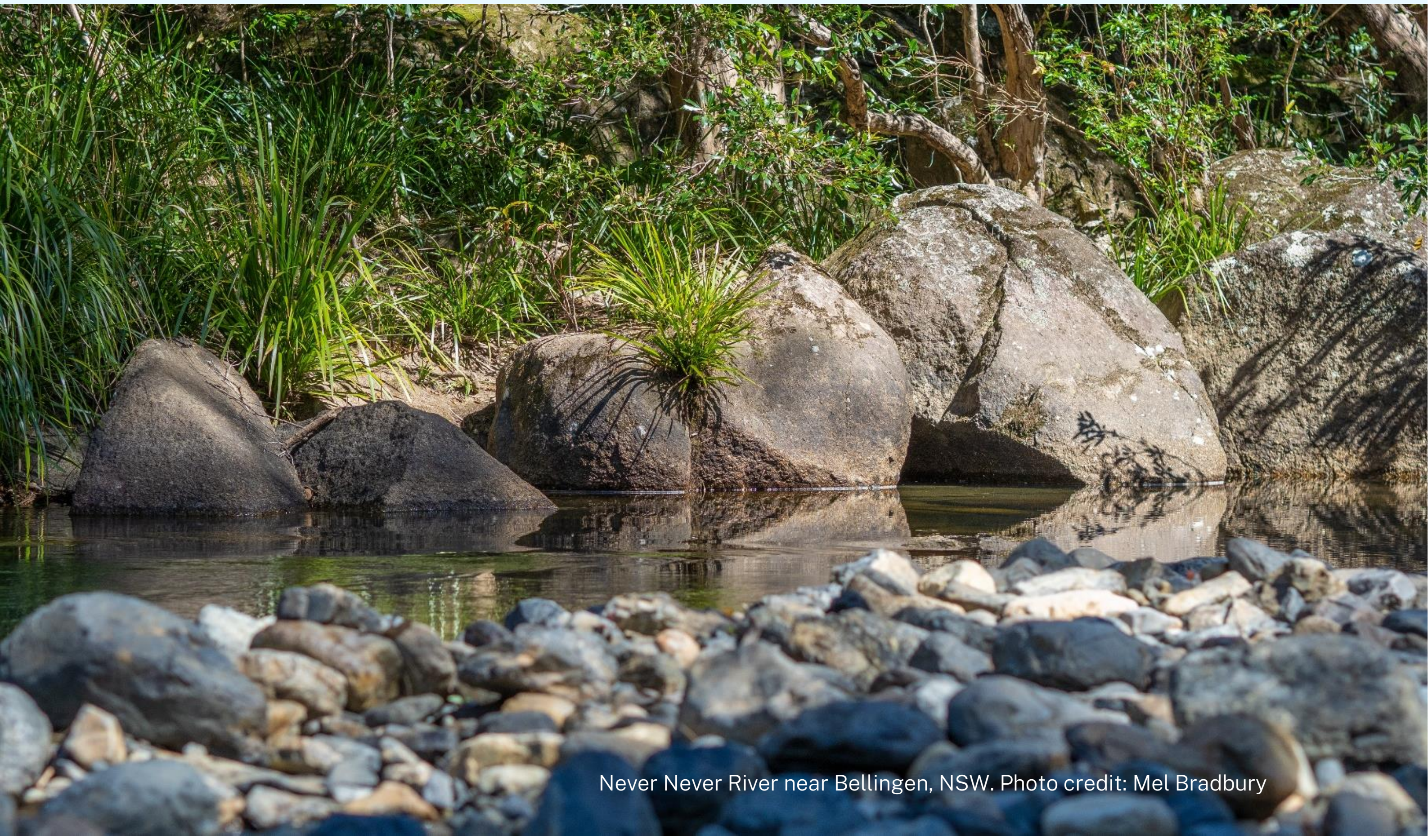
Abbreviations and Acronyms

	Description
Basin Plan	Murray-Darling Basin Plan 2012
BWS	Basin-wide Environmental Watering Strategy
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
DPE- EHG	New South Wales Department of Planning and Environment – Environment and Heritage Group
DPE-Water	New South Wales Department of Planning and Environment – Water Group
DPI Fisheries	NSW Department of Primary Industries Fisheries
EOMRP	Environmental Outcomes Monitoring and Research Program
EWRs	Environmental Watering Requirements
Flow MER	CEWO Environmental Water MER program
FMP	Floodplain Management Plan
FPH	Floodplain harvesting
GDE	Groundwater Dependent Ecosystems
HEVAE	High Ecological Value Aquatic Ecosystems
LTWPs	Long Term Water Plans
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MER	Monitoring, evaluation and reporting
NMDB	Northern Murray-Darling Basin
NRAR	Natural Resources Access Regulator
NRC	Natural Resources Commission
NSW	New South Wales
TEC	Threatened Ecological Community under the *NSW Biodiversity Conservation Act 2016*
SDL	Sustainable Diversion Limit
WMA	Water Management Act 2000 (NSW)
WRP	Water resource plan
WSP	Water sharing plan

Monitoring ecosystem processes



Never Never River near Bellingen, NSW. Photo credit: Mel Bradbury

Why are we monitoring ecosystem processes?

Ecosystem processes are the physical, chemical and biological processes that link water dependent plants and animals with their environment. River ecosystems are influenced by a range of factors that affect their health. Water quality characteristics such as temperature and dissolved oxygen impact the availability of refuges for fauna during drought, or the growth rate of cyanobacteria (blue green algae) leading to algal blooms. Changes to basal resources like nutrients, and productivity are crucial to aquatic wildlife such as fish, frogs and birds as they influence food availability, breeding, recruitment, dispersal and survival.

It is important to know how and why ecosystem processes respond to changes in the amount of water in our rivers. This information allows the Department of Planning and Environment – Water (the department) to consider and protect the needs of animals living in our rivers when making resource management decisions and developing plans to share water between people and the environment.

Report purpose

The 2021-22 Annual Report for the ecosystem processes theme (this document) outlines completed activities and their findings under the Environmental Outcomes Monitoring and Research Program (EOMRP) between July 2021 and June 2022. This annual report is one of a set of 5 different themes for the EOMRP. The other themes are:

1. Floodplain connectivity and inundation
2. Ecological processes (this report)
3. Water dependent native vegetation
4. Water dependent fauna
5. Groundwater dependent ecosystems.

The program delivers information annually to meet several requirements. These include: NSW reporting obligations under the Basin Plan Schedule 12; performance indicator research; data collection and analysis to inform and evaluate water sharing plans (WSP); floodplain management plans (FMPs), and the NSW State of the Environment Reports . Tools that represent the information and feed into these reports include the NSW River Condition Index (RCI) tool and the High Ecological Value Aquatic Ecosystems (HEVAE) spatial layer.

The projects are staged over several years, building knowledge about water dependent ecosystems and their responses to water management plans, made up of actions and decisions. For further information about the EOMRP see the EOMRP website. Technical reports for each research project will be published separately and made available on the department's website.

The EOMRP was designed to implement the NSW Water Management Monitoring, Evaluation and Reporting (MER) framework (DPIE Water, 2020) which addressed Basin Plan requirements. The EOMRP was extended, in 2022, to cover coastal and non-Basin areas. A new framework designed specifically for the evaluation of all NSW water sharing plans is in development. The department is undertaking this work in response to the Natural Resources Commission (NRC) findings and recommendations about the way we monitor, evaluate, and report information about water sharing plans outcomes.

Report structure

The Ecosystem Processes theme is broken into sub-themes for reporting purposes. These sub-themes are:

- water quality, connectivity, and refuges
- basal resources and ecosystem productivity
- habitat and flows.

For some ecosystem processes, reporting may be of one catchment only, while other forms of ecosystem monitoring may have reporting across large spatial regions. All reporting is bounded by the NSW State border (Figure 1).

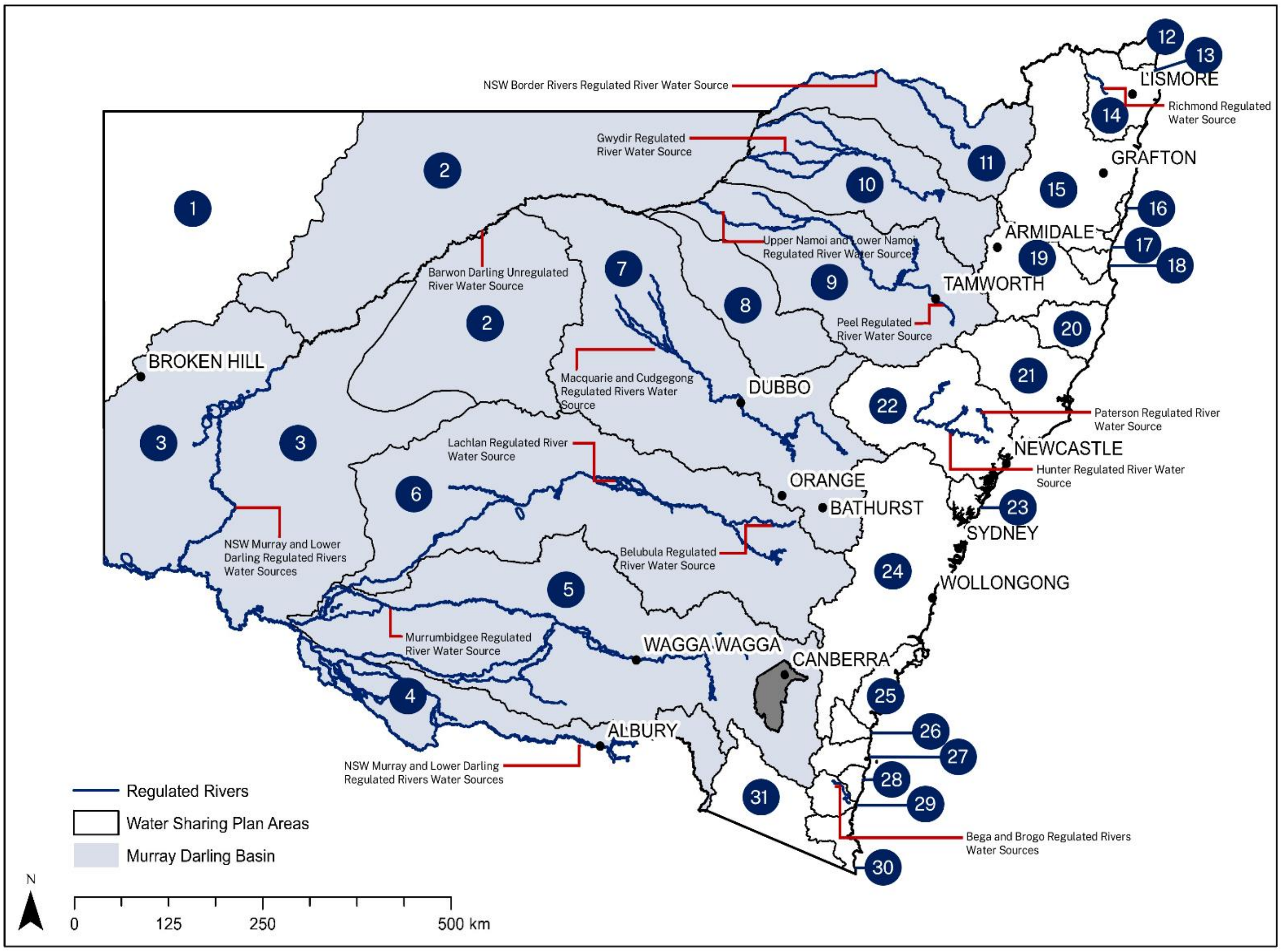


Figure 1. Map of NSW showing the Murray-Darling Basin boundaries, regulated rivers, and the NSW water sharing plans boundaries.

Water sharing plan Legend:

1. North Western Unregulated and Fractured Rock Water Sources
2. Intersecting Streams Unregulated River Water Sources
3. Lower Murray-Darling Unregulated River Water Source
4. Murray Unregulated River Water Sources
5. Murrumbidgee Unregulated River Water Sources
6. Lachlan Unregulated River Water Sources
7. Macquarie Bogan Unregulated Water Sources
8. Castlereagh Unregulated Water Sources
9. Namoi and Peel Unregulated Water Sources
10. Gwydir Unregulated Water Sources
11. NSW Border Rivers Unregulated River Water Sources
12. Tweed River Area Unregulated and Alluvial Water Sources
13. Brunswick Unregulated and Alluvial Water Sources
14. Richmond River Area Unregulated, Regulated and Alluvial Water Sources
15. Clarence River Unregulated and Alluvial Water Sources
16. Coast Harbour Area Unregulated and Alluvial Water Sources
17. Bellinger River Area Unregulated and Alluvial Water Sources
18. Nambucca Unregulated and Alluvial Water Sources
19. Macleay Unregulated and Alluvial Water Sources
20. Hastings Unregulated and Alluvial Water Sources
21. Lower North Coast Unregulated Water and Alluvial Water Sources
22. Hunter Unregulated Water and Alluvial Water Sources
23. Central Coast Unregulated Water and Alluvial Water Sources
24. Greater Metropolitan Unregulated River and Alluvial Water Sources
25. Clyde River Unregulated and Alluvial Water Sources
26. Deua River Unregulated and Alluvial Water Sources
27. Tuross River Unregulated and Alluvial Water Sources
28. Murrah-Wallaga Area Unregulated and Alluvial Water Sources
29. Bega and Brogo Rivers Area Regulated, Unregulated and Alluvial Water Sources
30. Towamba River Unregulated and Alluvial Water Sources
31. Snowy Genoa Unregulated and Alluvial Water Sources

Each project has key project questions that relate to water management activities. The key project questions are targeted research questions the project is trying to answer, whilst the link to water management activities highlights the specific strategy or WSP rule that a project aims to inform.

Below is an example of how the project aims are broken up for each project within this report.

Key project question(s)

- Specific question(s) that the project aims to answer.

Link to water management activities

- The link to a water management activity the project aims to inform. Water management within NSW aims to ensure adequate flows of each type are provided to meet environmental water needs of water dependent biota and processes.

Drivers of environmental outcomes

Water management within NSW aims to ensure adequate flows of each type are provided to meet environmental water needs of water dependent biota and processes Protecting and maintaining water quality, refuges, basal resources, and productivity, supports healthy and productive aquatic habitats. Water dependent plants and animals rely on these processes to support breeding, recruitment (addition of new individuals to a population), survival, and dispersal. The monitoring outcomes in this reporting theme are dependent on a wide range of factors, many of which are beyond the control of water resource managers. These include climate events (droughts and flows), invasive pests (carp for example), fire, disease, pollution, habitat loss and climate change.

However, one of the key drivers of environmental outcomes in surface water environments is river flow. Particularly the location, magnitude, timing, frequency, and duration, all of which are impacted by water management activities. River flows can be broken into broad flow categories, which include cease to flow, low flows (and baseflows), fresh flows or ‘freshes’, bankfull, and overbank flows (Figure 2). Each flow category can influence a range of aquatic processes, habitats, and organisms.

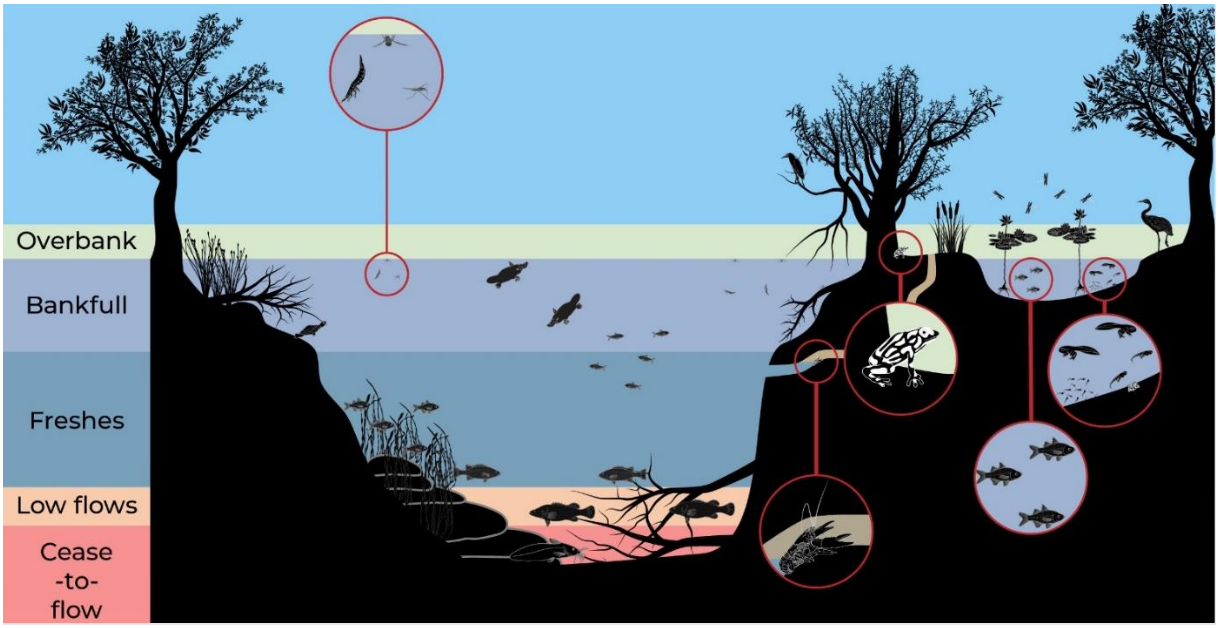


Figure 2. Conceptual model of the main flow categories and what areas of a river they influence.

The effect of flows on connectivity and the water quality of refuges

Barwon-Darling/Baaka stratification: minimising persistent thermal stratification and algal blooms in weir pools

Project Team

Doug Westhorpe and Andrew Brooks.

Project collaborators

This project is led by the department in collaboration with the University of Technology, Sydney.

Introduction

Thermal stratification is the development of temperature layers in weirs, reservoirs, and lakes. This often occurs during summer. In storages the surface layers become warmer than natural river temperatures and bottom waters can be up to 15°C cooler than natural river temperatures (Figure 3). Low flows and persistent thermal stratification are key drivers of algal bloom events. They may also lead to fish kills when destratification, or mixing of these layers, creates anoxic conditions (water depleted of oxygen) throughout the water column.

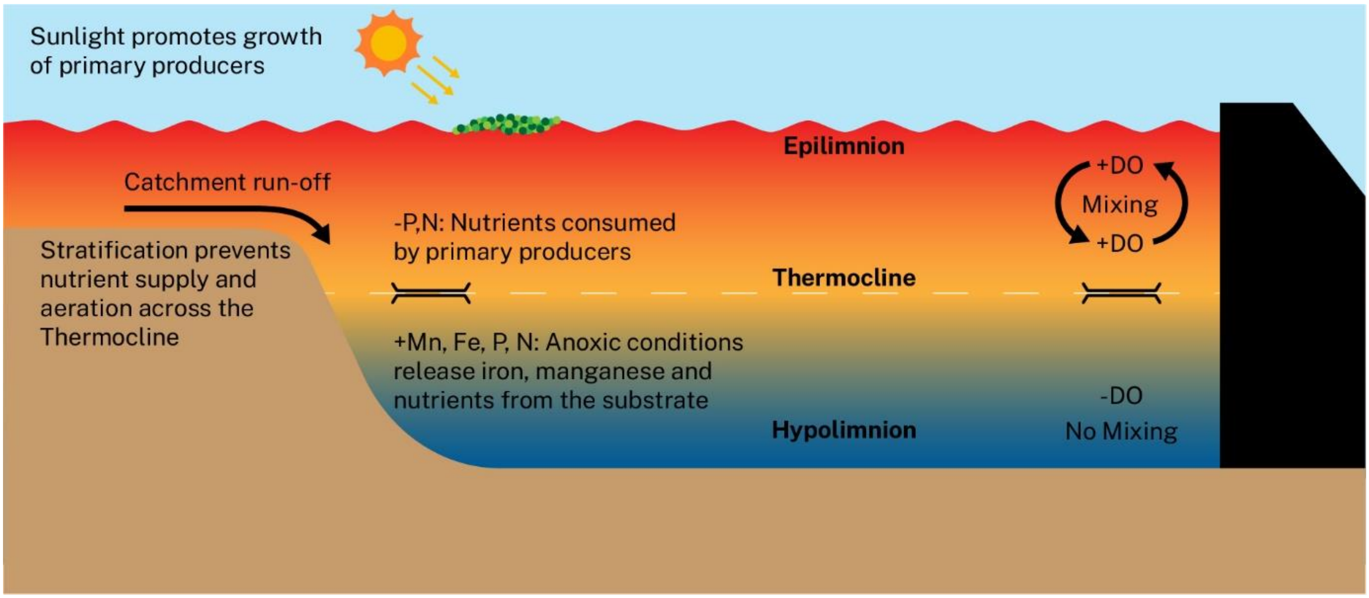


Figure 3. Conceptual diagram showing thermal stratification in a weir pool.

Project Aims

The aim of this project is to obtain a greater understanding of flow velocity and discharge targets that will assist water managers to improve river ecosystem health, water quality and instream connectivity. This study continues an earlier study by Facey et al. (2021). However, this project will incorporate a detailed understanding of how hydrology, and in particular flow velocity and discharge, influences stratification. The study is taking into consideration local weather conditions such as air temperature, windspeed and river bathymetry to identify prevention and management of pool stratification.

This project is a research collaboration with the University of Technology, Sydney (UTS). The project focuses on major weirs within the Barwon-Darling/Baaka River, that represent key sections of the system from Collarenebri to Pooncarie (downstream of Menindee Lakes).

The specific aims relate to the following questions.

Key project questions

- What is the critical flow velocity required to supress persistent thermal stratification in weir pool sites along the Barwon-Darling?
- How does the strength and persistence of thermal stratification vary within a weir pool?
- To what extent do cyanobacteria (blue-green algae) blooms coincide with periods of low flow in the Barwon-Darling?

Link to water management activities

- These results will provide data which will help inform the development of water management decisions and evaluation of WSP rules aimed at improving water quality and environmental outcomes by providing advice on the best flows for connectivity between refuge pools that minimise stratification.
- This data can help inform the management of pumping restrictions (A, B and C Class* cease to pump events), resumption of flows (protection of the first flow after an extended period of no flow), and water shepherding of environmental water.

**Class licences represent the available entitlement able to extract from the lowest flows (A class), slightly higher flows (B class) and highest Cease to Pump flow class (C class).*

- Provide data for the ongoing monitoring and evaluation of the Basin Plan/ Water Management Act 2000 -section 324 temporary water restrictions during extreme drought periods.

Methods

Eleven weir sites were studied along the Barwon-Darling/Baaka (Figure 4). All sites were within weir pools because these are the sites with the greatest depth and lowest flow velocity, making them the most likely parts of the river to experience persistent thermal stratification.

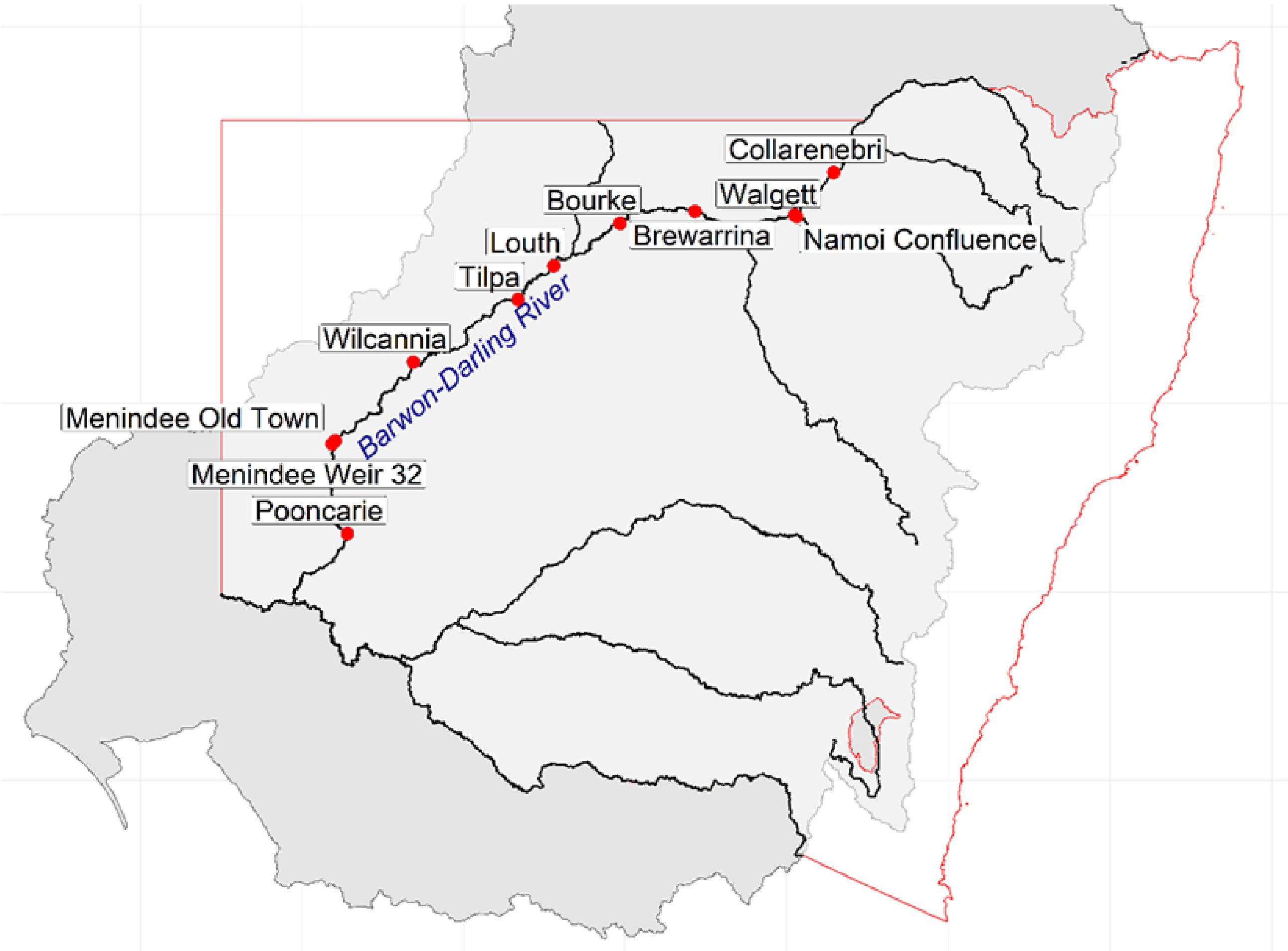


Figure 4. Map displaying locations of study sites within the Barwon-Darling Basin.

Thermistor chains (a series of temperature sensors) were deployed at these sites, where they will log temperature at 1m depth increments until at least May 2024. An Acoustic Doppler Current Profiler (ADCP) was used to determine velocity (discharge) rates and weir pool bathymetry (shape and depth) and geomorphology (structure) at multiple locations within each weir pool, particularly in low flow periods and warmer months (Figure 5).

Figure 5. Acoustic Doppler Current Profiler being towed behind a kayak collecting data in a weir pool. Photo credit: Doug Westhorpe.

Results

Ongoing flooding in 2022 within the Murray-Darling Basin has meant that the fieldwork component of this project has been delayed, and the project is in its infancy. Therefore, we cannot categorically link outputs to theme specific questions. We have obtained 10 years of historical algal data (2012 – 22) from WaterNSW from 7 major weir pools within the study area.

Initial findings of historical algal data show the relationship between *Dolichospermum* (a blue green algae species formerly known as *Anabaena*) and river flows. *Dolichospermum* is a cyanobacteria commonly found in freshwater phytoplankton assemblages. This species often blooms in calm warm water bodies (low flows) with high nutrient concentrations. Blooms of *Dolichospermum* in the Murray River have been linked to a combination of low flows and warm conditions (NSW DPE 2022).

Figure 6 below shows potential patterns of low flow and *Dolichospermum* growth with significantly higher abundance (cell counts) related to lower river discharge at Bourke weir (Figure 7). This was particularly evident in December and January.

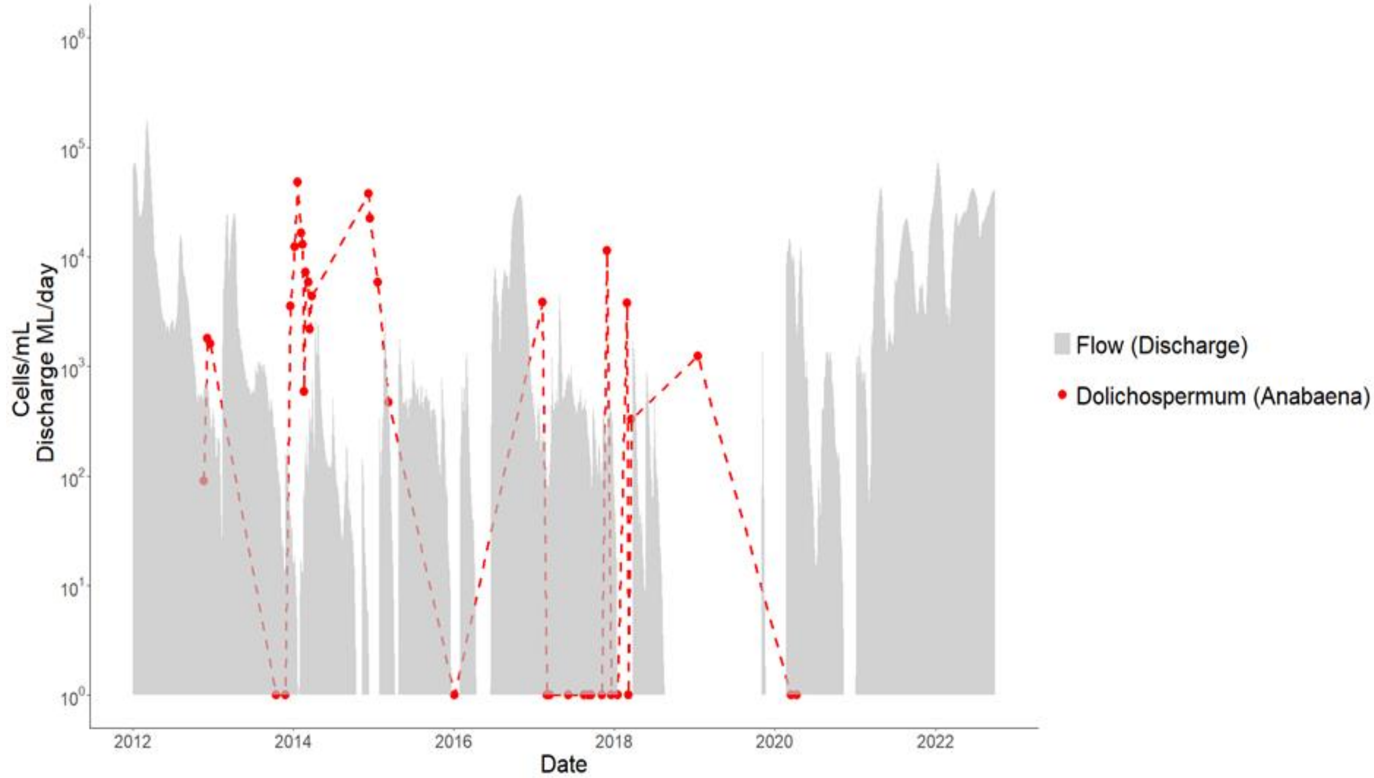


Figure 6. *Dolichospermum* (formerly *Anabaena*) cell counts and daily discharge from Darling River at Bourke Weir (gauge station 425030) from 01/01/2012 to 01/10/2022.

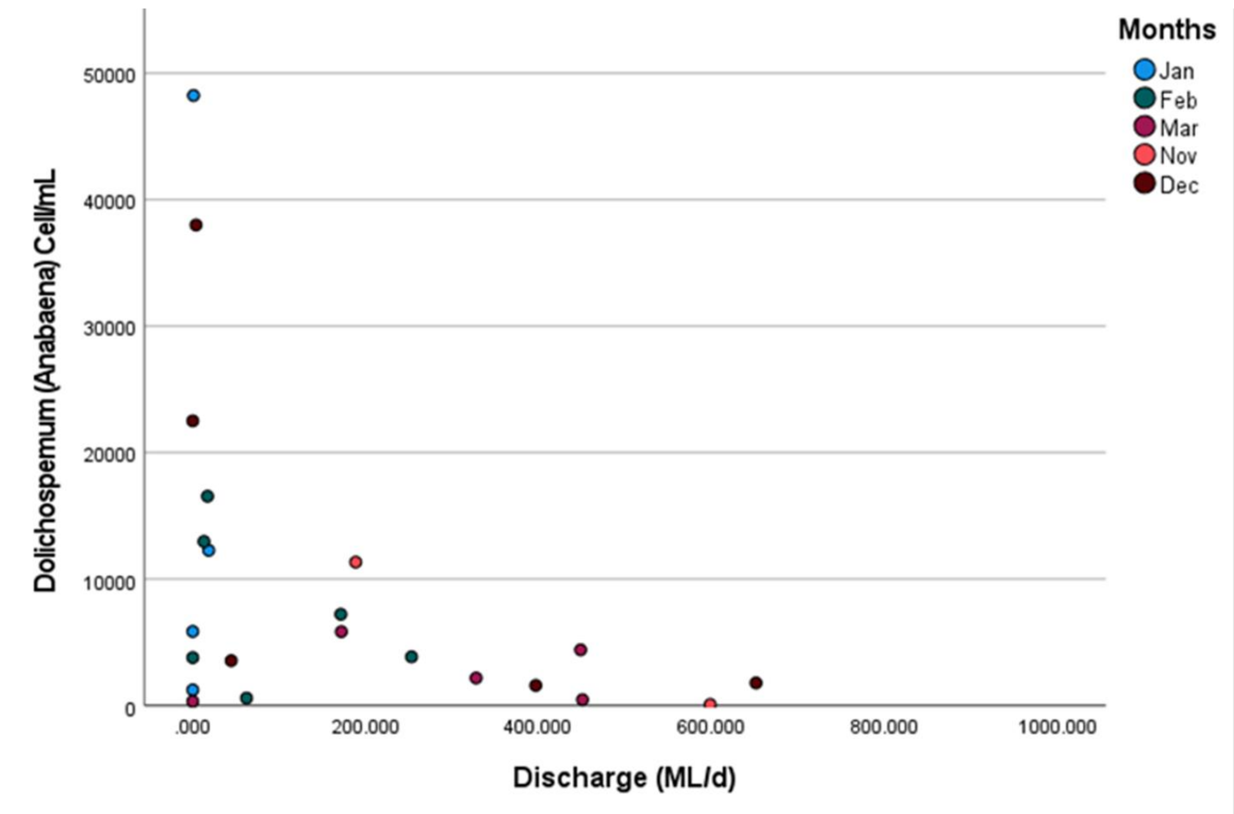


Figure 7. Scatter plot of *Dolichospermum* (*Anabaena*) by discharge (ML/d) by months (November to March 2012-2022).

Figure 8. Bourke weir spilling, 15 February 2021. Photo credit: Doug Westhorpe.

Conclusions

The historical data indicates a relationship between blue-green algal species and river discharge. However, recent floods (2022) have delayed field work to explore the relationship further. The results of the next stage of this study will provide evidence of the flow velocity thresholds required to prevent the formation of persistent thermal stratification in major weir pools. This information may be used to inform the operation of the regulated river to avoid the formation of toxic algal blooms, anoxic conditions and fish kills.

This evidence-based approach will strengthen previous research that estimated flow velocity targets (<0.05 m/s) required to prevent or breakdown instream stratification (e.g., Mitrovic et al. 2003). Findings will help improve the way water management decisions in NSW are made for ecological and water quality outcomes in the Barwon-Darling/Baaka River.

Next steps

The project has obtained and analysed 10 years of historical data. Further results are expected in December 2023. Preliminary analysis of historical data is insightful showing patterns of algal biomass linked to hydrology and seasonality. Therefore, the project has the potential to inform the refinement of water management decisions and evaluation of WSP rules aimed at improving water quality and environmental outcomes.

Results from this study will quantify and predict how protecting flows in the river and after inflows following dry periods will influence stratification. This will help define the appropriate flows (based on suppressing stratification) that will maximise environmental outcomes and minimise adverse issues such as algal blooms and fish kills. This is important data for the ongoing monitoring and evaluation of the Barwon-Darling WSP (2012). In particular, this data should help inform the management of pumping restrictions across a range of flow class licences. These licences represent the available entitlement of water able to be extracted, from the lowest flows (A class), slightly higher flows (B class) and highest Cease to Pump flow class (C class). This information will also support outcomes from the resumption of flows rule (protection of the first flow after an extended period of no flow), and water shepherding of environmental water.

A spatial analysis of the influence of tributary inflows below large storages in the NSW Murray-Darling Basin

Project Team

Andrew Brooks, Doug Westhorpe and Matt Balzer.

Project collaborators

This project is led by the department in collaboration with La Trobe University.

Introduction

Rivers often experience major changes in ecological function downstream of dams. The timing and volume of river flow, plus the influence on water chemistry, can be significantly altered from upstream to downstream of the dam, impacting ecosystem productivity and aquatic food webs. Tributary inflows from unregulated (without dams) catchments can play an important role in mitigating changes in water chemistry below large dams.

Tributary inflows can be rich in nutrients and dissolved carbon, boosting biogeochemical processes and ecosystem productivity downstream from where tributaries join more heavily regulated rivers. Yet, there have been few attempts to identify potential priority tributaries that may play a larger role in driving biochemistry and ecosystem function below dams. These tributaries may have a significant influence on improving ecosystem health below major water storage areas.

This report summarises the results of a spatial analysis to identify significant unregulated tributaries to regulated rivers, across the NSW Murray-Darling Basin.

Key project question(s)

- What are the key tributaries in NSW that play the largest role in boosting biochemistry and ecosystem function in regulated rivers?

Link to water management activities

- Identify priority tributaries in NSW that could provide hydrological benefits to regulated rivers if in-flows from the unregulated tributary to the regulated river were protected.
- Guide development of end of system and supplementary rules in key tributaries within the Murray-Darling Basin.

Methods

NSW rivers within the Murray Darling Basin had a measure known as the degree of regulation calculated at each tributary junction. The degree of regulation is a ratio between the storage capacity of all upstream reservoirs relative to the mean annual runoff. This provides a measure of how controlled the river flows are compared to natural conditions. A degree of regulation less than 1 indicates that the cumulative upstream storage volume is less than the mean annual flow (Figure 9).

The differences in the degree of regulation were then categorised as either low storage impact (degree of regulation less than 0.5, medium storage impact (0.5 – 2) or high storage impact (greater than 2)). The degree of regulation was then mapped across NSW (Figure 10). For each Water Sharing Plan area, the differences between the degree of regulation ratio at the tributary junction with the main river was identified. From this list, the 10 most significant (largest difference in degree of regulation) tributary junctions were identified. This identifies the 10 most important tributaries for improving ecosystem function in each water sharing plan area in the NSW Murray Darling Basin.

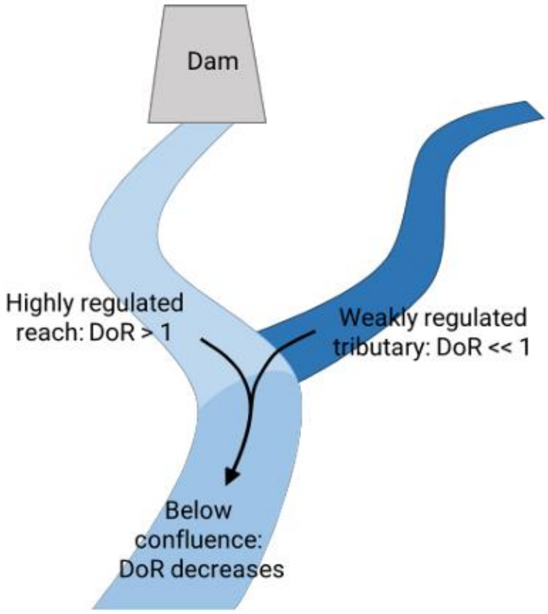


Figure 9. The effect of the low degree of regulation (DoR) tributary inflow on a regulated mainstream, showing change of degree of regulation above and below the tributary junction (Bond et al. 2022).

Results

The results identified that the degree of river regulation varies significantly across the NSW portion of the Murray Darling Basin. The Gwydir had the highest degree of regulation while the Border Rivers had the lowest (Bond et al., 2022).

For the majority of tributary junctions across NSW, the differences in the degree of regulation difference metric successfully identified patterns in the impact of tributaries on mainstem flows (Figure). Generally, large changes in the degree of regulation occurred with either single tributary inputs and/or smaller, cumulative effects of multiple tributaries. The reduction in degree of regulation on the main channel flow as it moved downstream, potentially results in improving ecosystem function. This trend was apparent across most catchments.

This approach shows high potential as a valid indicator and assessment method for the potential importance of different tributaries and protection of tributary inflows to regulated rivers in NSW.

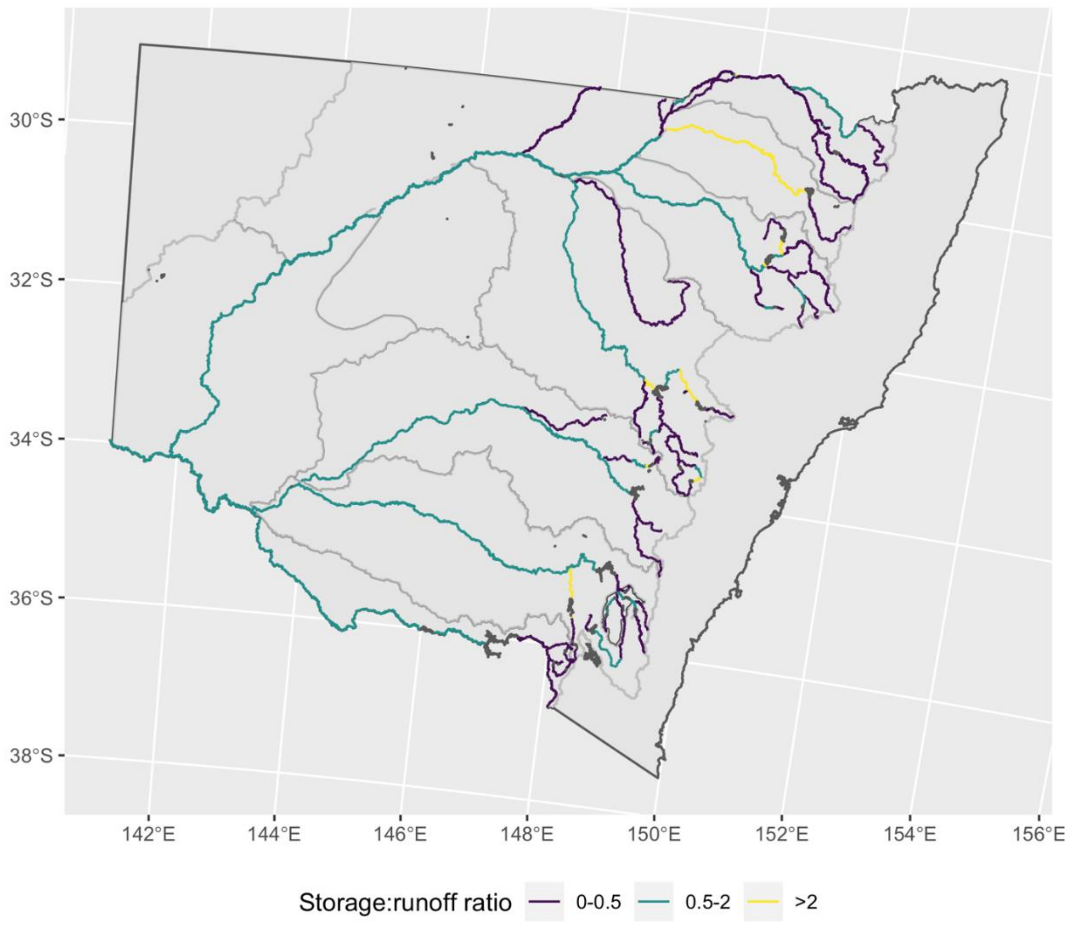


Figure 10. The relative impact of dams on large rivers throughout the NSW Murray Darling Basin as described by the relative Degree of Regulation (a.k.a. Storage: runoff ratio in the figure legend). The continuous index Degree of Regulation has been broken into three classes: 0-0.5 (Low storage impact), 0.5-2 (Medium storage impact), >2 (Large storage impact). Note the map has been limited only to large rivers with a mean annual discharge of >10GL.

Recommendations

The potential management applications of the degree of regulation approach include the:

- identification of key tributaries for management of flows from unregulated rivers into regulated rivers to improve ecosystem function and improve river health
- identification of potential tributary refuge habitats for sensitive species requiring natural flows for survival and breeding success
- comparisons of the scale of potential new dam impacts through examination of cumulative effects from natural conditions
- assessment of the relative benefits of ecosystem functions on mainstem rivers from input of unregulated tributaries.

The full report can be found here (Bond et al., 2022).

Aquatic food webs and stream productivity

The importance of variable river flows to wet in-channel benches. Linking flow and food web productivity in the Barwon-Darling/Baaka River

Project Team

Andrew Brooks, Dane Parsons and Tim Haeusler.

Project collaborators

This project is led by the department in collaboration with the University of Canberra.

Introduction

River regulation and water extraction have changed the hydrology of lowland rivers in the Murray Darling Basin. These changes have impacted ecosystem functions and processes including how frequently different bank heights and the floodplain receive water. The inundation of these areas is important for triggering the release of zooplankton resting eggs from dry sediment. Zooplankton are the base of the food web and when there is a boom in the population, other organisms such as fish will be able to access greater food sources and similarly breed successfully. Hence, inundation of different bank heights is important to trigger zooplankton populations and subsequently sustain healthy and productive food webs within the river ecosystem. Whilst the potential ecological response to over-bank flooding and cease-to-flow periods have been well conceptualised, less is known about the role of different volume in-channel flows to trigger stream productivity. This is important as it is often these medium sized flow events most impacted by river regulation.

This project will quantify the inputs of organic matter and zooplankton emergence to inundation of river banks at different heights. We will also model responses under different flow scenarios to provide information in assessing new flow rules in the Barwon-Darling and northern basin

Project aims

This project aims to determine how the inundation of river benches and banks during in-channel flow events provides the base resources (organic matter) to trigger zooplankton populations and improve riverine food webs.

Key project question(s)

- Are there quantifiable differences in organic matter loads of different bench heights?
- What is the influence of bench height on carbon and nutrient release, zooplankton emergence?
- What are the ecological outcomes of different flow resumption thresholds and protection of in-channel flow events?

Link to water management activities

- These results will provide data which will help inform the development of water management decisions and evaluation of water sharing plan rules.

Methods

Two locations were chosen as study sites: the Mehi River at Ballin Boo (Site A) and the Mehi River at Bronte (Site B) (Figure , Figure). Both sites were chosen as they have gauging stations, river height marked, and were accessible for the purposes of transporting large amounts of sediments. Both sites had similar inundation histories and flow at each site remained at or below the surface water height during sampling for the previous four weeks (Figure). Prior to this flow had been highly variable with overbank flooding occurring in late December 2021.

Figure 11. Top: Site A Mehi River at Ballin Boo, showing a section of the bank sampled in the bottom part of the photo. Bottom: Site B Mehi River at Bronte showing section of the bank sampled in the top half of the photo. Photo credit: Tim Haeusler.

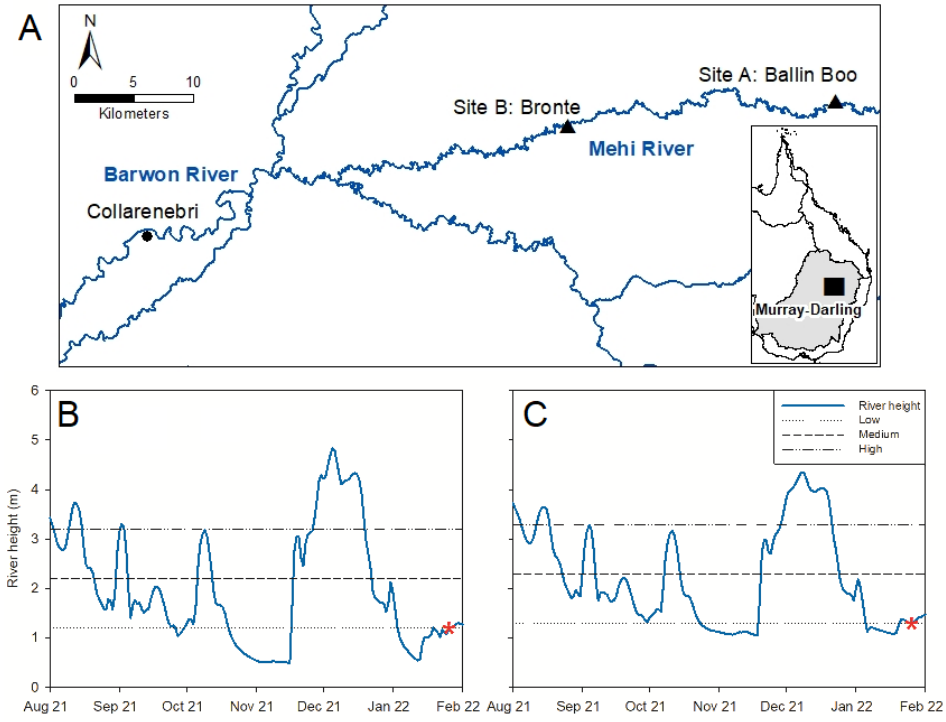


Figure 12. Sampling locations and flow conditions of the Mehi River. A) Map of the Mehi River and surrounding catchment with sampling sites highlighted. Flow conditions on the Mehi River for six months prior to sampling for B) Mehi River at Ballin Boo (Site A), and C) Mehi River at Bronte (Site B). Data shows mean daily river height recorded at gauging stations at each site. Dashed lines indicate the Low, Medium, and High treatments where transects were established and soil sampled. The asterisk denotes the date sediment samples were collected.

At both sites 50 m transects were established at low (immediately above water level), mid (1 m above water level), and high (2 m above water level) bank heights. A hypsometer (measures altitude) was used determine the heights of transects relative to river gauging station height and current river height. Nine 1 m x 0.6 m quadrats were used collect sediment at randomly selected intervals along each transect. Sediment was collected by scrapping and removing, with hand troughs, all leaf litter, live plants, and the first 3 cm of sediment within each quadrat. Sediment was collected in bags and the weight of each bag measured prior to transporting back to the mesocosm facility.

Additional organic matter content was measured for collected material grouped into fine particulate organic matter, coarse particulate organic matter, leaves, bark, twigs, nuts and seeds.

The experiment was performed by adding the sediment and surface litter to twenty-eight 1000 L round plastic enclosures (1.5 m diameter, 0.57 m deep), each filled with dechlorinated water, between 31 January to 8 March 2022 at the University of Canberra's mesocosm facility (Figure). This period allowed sufficient time for basal resources to enter the water column and to be assimilated into the food web by microbes, algae and zooplankton.

Figure 13. Mesocosm facility at the University of Canberra. 1000 L mesocosms are each fitted with a pump, providing constant flow and connected to dechlorinated water system to ensure water levels are maintained throughout the experiment. Photo credit: Andrew Brooks

Three treatments were used for the experiment which consisted of added sediment from different bank heights: Low (L), Low+Mid (LM), and Low+Mid+High (LMH). These treatments were selected to determine the potential differences between bank heights, as well as the any potential interactions from mixing sediment across different bank heights which will happen during flow events. Each mesocosm within the L treatment received three randomly selected bags of sediment. The LMH treatment mesocosms were allocated one bag from each of the appropriate bank height. Mesocosms within the LM treatment received 1.5 bags each from the low and mid bank heights, for a total of three bags. Sediment was added to mesocosms on day zero and spread by hand evenly across the base of each enclosure. Sediment volume collected and added was determined to create coverage across the entire base of the mesocosm equivalent to 3 cm in depth, with the total weight of sediment added to each being 10-12 kg.

Measures of food web within the mesocosms occurred at days 4, 8, 16, 23, and 29 of the experiment:

1. Water quality – turbidity, temperature, conductivity, dissolved oxygen and pH.
2. Basal resources: nutrients and dissolved organic carbon (DOC).
3. Biological - algae, microbial biomass, micro- and meso-zooplankton, invertebrates.

Data will be used to model basal resource input and food web outcomes under different river height/discharges and flow scenarios to assess the ecological impact of Barwon-Darling Water Sharing Plan rules.

Results

This project is in progress. Key project questions will be addressed in the 2022-23 theme report. Our initial findings show that soils from the high bank heights had significantly higher organic matter content, leaf litter and live plant coverage than those on the lower bank heights. This translated into high concentrations of organic carbon and phosphorus in treatments receiving sediment from the higher section of the bank. Chlorophyll-a concentrations were low throughout the experiment and were higher in the Low bank treatment.

Zooplankton community was dominated by rotifers, copepods, and Cladocera. Zooplankton abundance was initially low. During days 16 – 29 zooplankton abundance increased, peaking at day 23, and was greater in the High and Mid-bank treatments than the Low treatment (Figure 14).

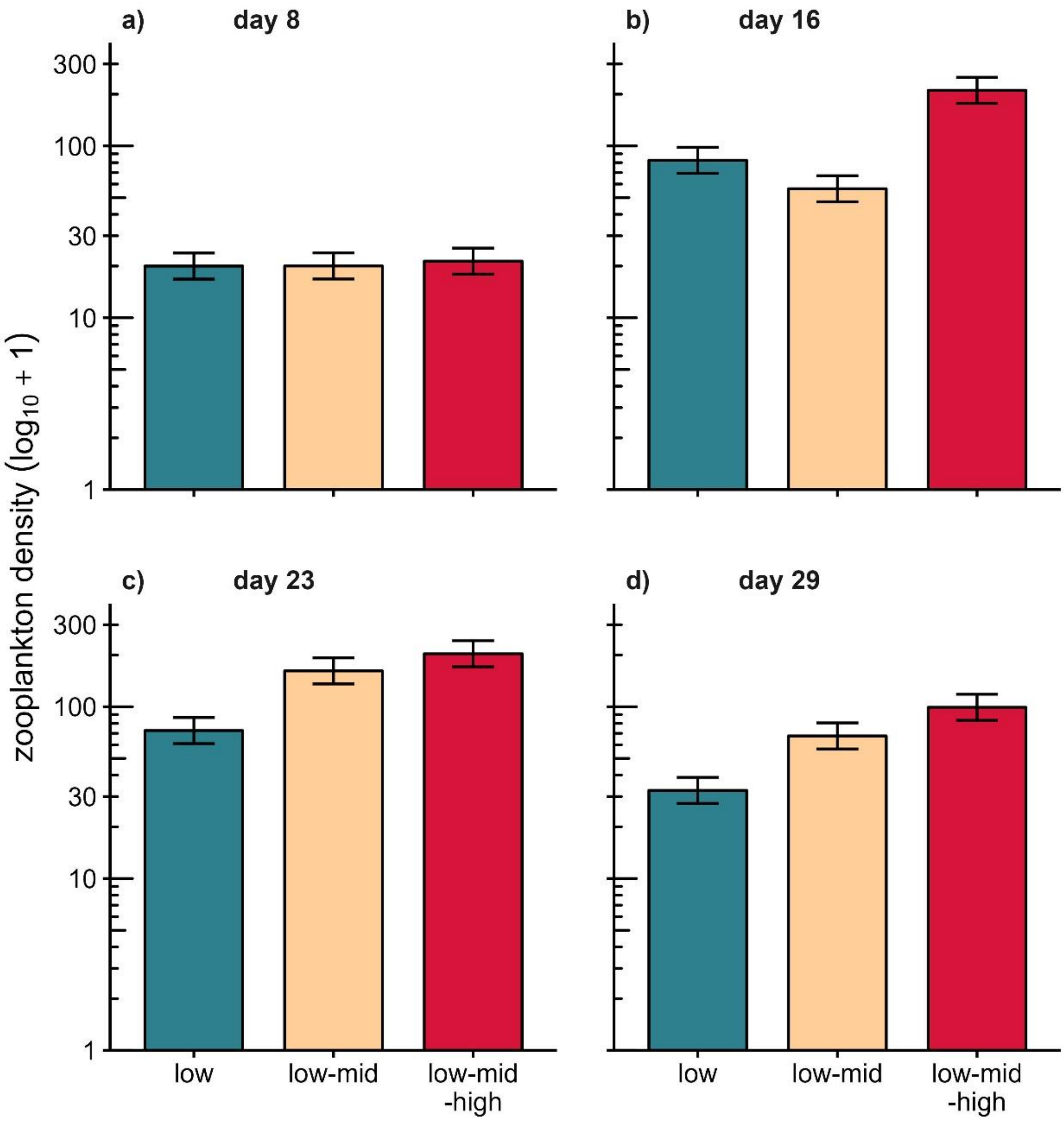


Figure 14. Mean total zooplankton density at (a) 8 days, (b) 16 days, (c) 23 days and (d) 29 days from sediments collected at low, low-mid and low-mid-high bank heights at two sites in the Mehi River.

Conclusions

These preliminary results indicate that inundation of the higher bank within river channels can trigger increased food web productivity. Consequently, protection of medium flows that remain in-channel but wet the upper banks are important for and restoring the productivity of river ecosystems.

Next steps

A food web model of the Mehi River will be constructed to understand how different flow management scenarios may impact the river ecosystems. This model will be informed by the outcomes of the mesocosm experiments. Specifically, the model will be used to assess food web productivity and biomass under different modelled flow scenarios.

Habitat and flows

Fragmentation of drought refugia in the Barwon-Darling/Baaka River

Project Team

Adrian Matheson and David Ryan.

Project collaborators

This project is led by the department.

Introduction

Extended periods of no-flow can result in a series of disconnected pools that act as drought refuge in a river. As the period of no-flow gradually increases, water quality may deteriorate with rising water temperatures and reduced dissolved oxygen levels (Lake, 2011). Fish and other aquatic biota may become stressed and die if conditions persist and become worse (Boulton, 2003). Overall this trend causes a deterioration of river health (Vertessy et al., 2019).

Spatial tools (satellite imagery and aerial photography) can be used to identify locations of drought refugia and determine whether they dry and disconnect (fragment) in a similar way each dry period. This information can then be compared with past fish kill events, or poor water quality events, to identify if the same pools act as refugia in each dry event. Mapping and measuring past dry period refugia can assist in identifying critical locations and points of time where the likelihood of a poor ecological outcome may occur in order to actively intervene with adaptive management options.

Project aims

This project aims to use remote sensing data to map how surface water contracts and disconnects during dry periods. From this the key pools acting as refugia in dry periods will be identified.

This project will:

- identify drying patterns of drought refugia and determine whether similar patterns exist during different dry periods
- determine whether these drying patterns can be used to predict trajectories (through a range of metrics) and identify when temporary water restrictions may be required, based on previous associated fish kills and poor water quality events
- develop a tool/dashboard to display drying trajectories to transparently show how the system responds and the potential need for protecting flow events to support hydrological connectivity.

Key project question(s)

- Can refugia drying trajectories determined from satellite imagery be used to set triggers for protecting flow events prior to critical dry times for the environment?

Link to water management activities

- Draft critical environmental triggers that inform the introduction of temporary water restrictions have been proposed as part of the Western Regional Water Strategies. These are based on hydrological analysis in MDBA (2018). As part of the Western regional water strategy, it was identified that further research was needed in the area on how refugia dry and disconnect. This study will assess the feasibility of using satellite imagery analysis to develop dry condition triggers (points where temporary water restrictions may be implemented) ahead of critical drying thresholds in the Barwon-Darling River.
- Improved management of dry period refugia pools will assist maintenance of habitat for native fish in the Barwon-Darling River, improving population survival and health in drought.

Methods

Satellite imagery and aerial photographs will be used to map drought refugia in the Barwon-Darling River. The mapped drought refugia will be compared in across different years to determine whether similar patterns of drying and the same pools acted as refugia in different events.

The mapped refugia will then be compared with the location and timing of known fish kills, poor water quality to understand if there are links or similarities between these ecological events.

Any identified links will then be used to develop a framework to forecast the drying trajectories of drought refugia and to set triggers ahead of critical points where poor ecological outcomes are more likely to occur.

Results

The pool fragmentation mapping is underway with 2 trial reaches near Wilcannia being analysed. Satellite images are being analysed as the system dries out during 2019 to establish how the system dries and disconnects and whether there are trends between dry events (Figure).

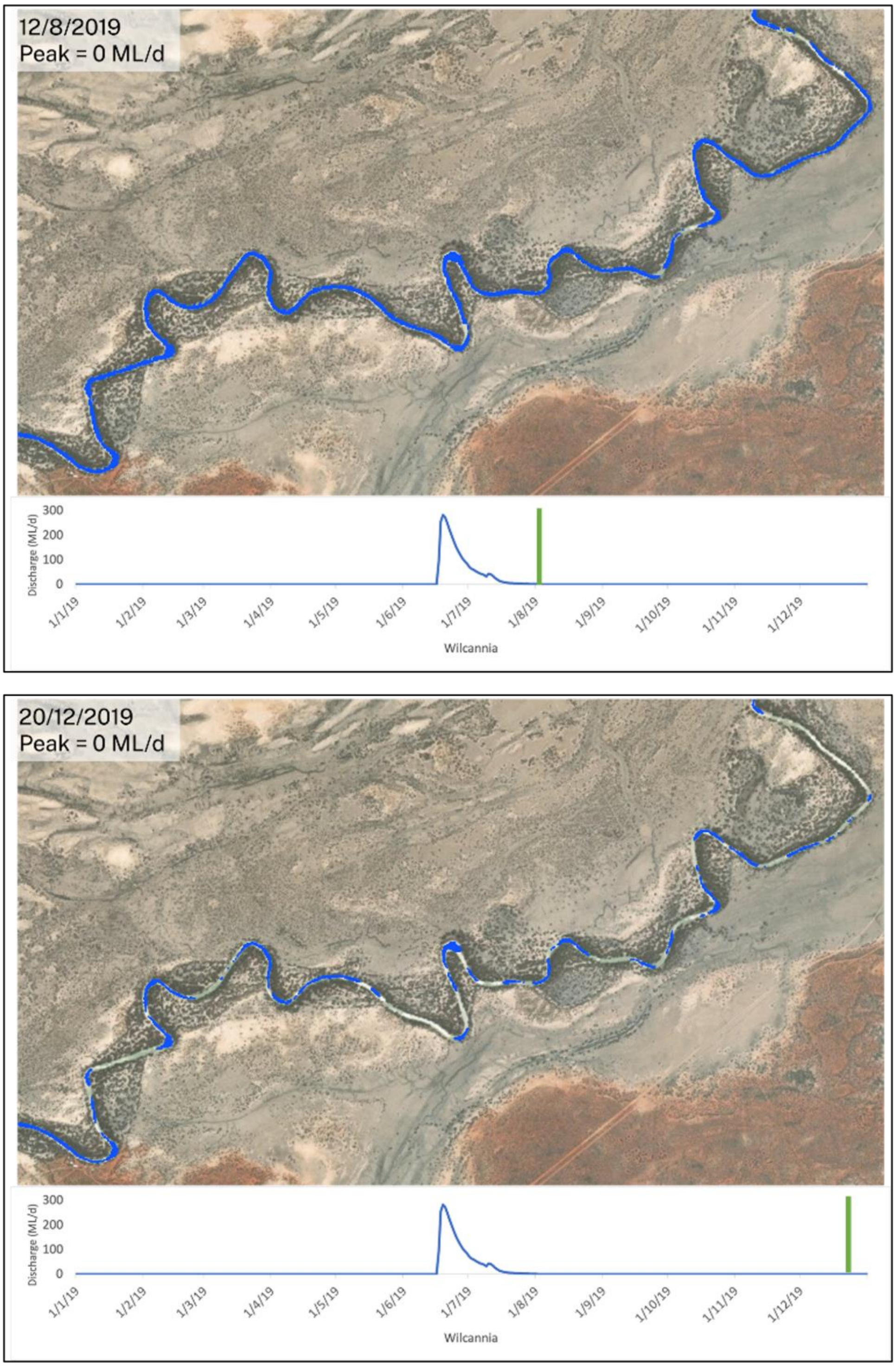


Figure 15. Two satellite images for the river reach near Wilcannia showing a comparison of the drying of the river channel during the 2019 drought. The first image on the top taken in August 2019 shows a predominantly connected river reach and the second taken in December 2019 image on the bottom shows a small number of pools remaining in the river channel (scattered blue sections along the river is the water drying in the channel). The green vertical line at the bottom of the images shows when the image was taken along the hydrograph, the peak in the hydrograph is a small flow connecting event prior to images being taken (Source: Southwell et al., In Press).

Next steps

The project is still in its early stages of analysis and there is limited information on current trends between satellite images and ecological datasets. The next steps are to apply a refined method along all of the reaches of the Barwon-Darling River and assess available ecological data to determine any trends in the data. In doing so, the project will establish the feasibility of using remote sensing to help develop triggers ahead of critical drying points, to improve hydrological connectivity, particularly during dry period and to protect flows for environmental purposes.

Potential available fish habitat in the Barwon-Darling/Baaka – analysis of current and future flow management rules

Project Team

Adrian Matheson and Jay Van Den Broek.

Project collaborators

This project is led by the department in collaboration with the NSW Department of Planning and Industry (DPI) Fisheries.

Introduction

A healthy river will contain a diversity of habitats to provide refuge and food sources for a diverse and robust fish population. Large woody debris such as fallen trees, in addition to benches in the banks, are important physical features to provide habitat diversity. These features also provide a substrate for invertebrates and algae to attach to, providing base food web sources. Fish will use these features as physical structures to hide, lay eggs and seek food.

Large woody debris and benches are the primary physical features in the Barwon-Darling River. Understanding at what heights these features are inundated and the frequency and duration of inundation is important for water management. It will enable an understanding of how current flow management provides important physical habitats for biota. It will also enable relative comparisons of what habitat may be available under different flow scenarios created by different flow management rules. This project will contribute to the Basin resources and productivity project (described above) to explore the potential food web productivity rates with different bench inundation frequency and duration.

Project aims

The project aims to develop a spatial tool to identify the location of large woody debris and river bank benches in the Barwon-Darling River. Once the presence of these features are mapped we will be able to:

1. analyse the current physical features and link them to appropriate gauges to understand inundation patterns and potential available habitats in the Barwon-Darling River under different flow conditions
2. develop an evidence-based method to enable current and future water management options to be assessed against potential habitat provision within the river channel.

Key project question(s)

- Have changes to specific water sharing rules# over the plan term protected and contributed to the enhancement of significant physical habitat for native fish?

  #These specific rules include A-class* access, individual daily extraction components and flow protection measures such as, temporary water restrictions.

*Class licences represent the available entitlement able to extract from the lowest flows (A class), slightly higher flows (B class) and highest Cease to Pump flow class (C class).

- Have changes to specific water sharing rules# over the plan term protected and contributed to the enhancement of longitudinal connectivity to support target ecological processes?
  #These specific rules include A-class* access, individual daily extraction components and flow protection measures such as, temporary water restrictions.
  *Class licences represent the available entitlement able to extract from the lowest flows (A class), slightly higher flows (B class) and highest Cease to Pump flow class (C class).

Link to water management activities

- Hydrological analysis and habitat assessments demonstrates that significant habitat for native fish in the Barwon-Darling River is maintained and where possible enhanced over the plan term.
- Hydrological analysis and habitat assessments demonstrates that hydrological connectivity in the Barwon-Darling River is maintained or enhanced to support targeted ecological process, including the provision of significant habitat for native fish.

Methods

Habitat features of in channel large woody debris and benches was collected by DPI Fisheries. The location of these will then be associated with the nearest hydrological gauge to determine the river heights and flow needed to inundate individual features. Flow timeseries will then be analysed to compare with the habitat features location and elevation within the channel. Identified changes in the duration and frequency of inundated features with different flow rates will then be used to better understand how different water sharing plan rules may influence the availability of potential habitats that support the ecology of the river.

Results

Currently no results are available as the project is in development. This project is due for completion in June 2023.

Next steps

The next steps are to link the available datasets with hydrological gauge information to understand the river heights and flows that individual habitat features require for inundation.

Flow timeseries will then be used to compare how often these physical features are inundated under different scenarios. This will provide information on potential changes in the frequency and duration of inundated features as a result of changes in water sharing plan rules.

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