What happens when you re-start a dry river – the Northern Fish Flow

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Key Points

- Environmental flows were used to re-start the Barwon-Darling River in 2019 to improve water quality and prevent fish kills
- River pools showed signs of thermal stratification and low dissolved oxygen (<2 mg/l) at depths below 3m
- The flow release was effective in replenishing weir pools and improving their water quality
- Pool stratification was also influenced by atmospheric conditions with cold snaps appearing to reduce stratification. This could have implications for the timing of environmental water delivery

Abstract

In 2019, the northern Murray-Darling Basin was in severe drought, rivers had stopped flowing and weir pool water levels along the Barwon-Darling River were low. To improve water quality and prevent fish kills, an environmental flow (the Northern Fish Flow – NFF) was delivered down the Barwon-Darling River. We monitored conditions before, during and after the NFF to inform a risk assessment and then monitor temporal changes to water quality. Initially, some of the deeper pools showed signs of thermal stratification and low DO (<2 mg/l) at depths below 3m. Detailed sampling at several pools suggested the volume of low DO water was relatively small (~10% pool volume). Water quality was more consistent through the water profile within shallower pools (2-3m deep). Ongoing monitoring suggests that the NFF was successful in replenishing weir pools and improving their water quality. Pool thermal stratification was also influenced by atmospheric conditions, with cold snaps appearing to reduce the presence or depth of stratification. While this was not always reflected in improved DO at depth, it does suggest that if environmental flow deliveries are timed to coincide with cold fronts, then smaller volumes may be needed to break the already weakened thermal stratification and promote full water column mixing.

Keywords

Environmental flows, water quality, dissolved oxygen, water temperature

Introduction

In February/March 2019, the northern Murray Darling Basin in southern QLD and northern NSW was in the grip of an extended and severe drought. The Barwon-Darling River had ceased to flow along much of its length, with some weir pools, such as Bourke, being at their lowest levels in recorded history (nearly 50 years). Many of the natural water holes in between weir pools had dried to very low levels or dried completely. In addition, significant fish kills had recently occurred in some waterholes near Menindee at the end of the Darling River, and there were concerns that this may also happen in waterholes throughout the system. In response, the Commonwealth Environmental Water Office, in consultation with the Gwydir River Environmental Contingency Allowance Operations and Advisory Committee (ECAOAC), started planning for

the delivery of a northern Basin replenishment flow (named the Northern Fish Flow) – NFF from the Macintyre and Gwydir River catchments targeting in-channel refuge waterholes.

This report outlines the findings of water quality monitoring undertaken within various weir pools from Mungindi on the NSW-QLD border, downstream to Bourke in NW NSW. The study had two main aims: to assess the pre-NFF delivery quality of water within a selection of waterholes and the risks to native fish populations of the prevailing conditions; and to monitor the response of water quality to the delivery of the NFF during and after the flow event moved through the system.

The Northern Fish Flow

As part of the Northern Fish Flow 7,400 ML of held environmental water was released from Glenlyon Dam into the Dumeresq/Macintyre River (and in turn the Barwon River system) on the 24 April 2019 (Figure 1). Following this, 28,600 ML of both state and federally managed environmental water was released from Copeton Dam in the Gwydir catchment of which 25,883 ML entered the Mehi River channel in May 2019. This flow reconnected the lower Mehi River with the Barwon River upstream of Collarenebri. This flow continued downstream as far as the Culgoa River junction with the Darling River upstream of Bourke. While the flow released from Glenlyon Dam provided a flush in the Macintyre and Barwon Rivers above Collarenebri, due to high transmission losses the flow did not quite reach the Collarenebri weir pool and did not contribute to flows downstream of this point.

The Northern Fish flow peaked on 12 June 2019, with 489 ML/d passing gauge 422003 at Collarenebri. The flow continued above 300 ML/d for 30 days at Collarenebri, with stations downstream still peaking until 10 July 2019 when gauge 422002 at Brewarrina recorded a peak of 172 ML/d (Figure 2).

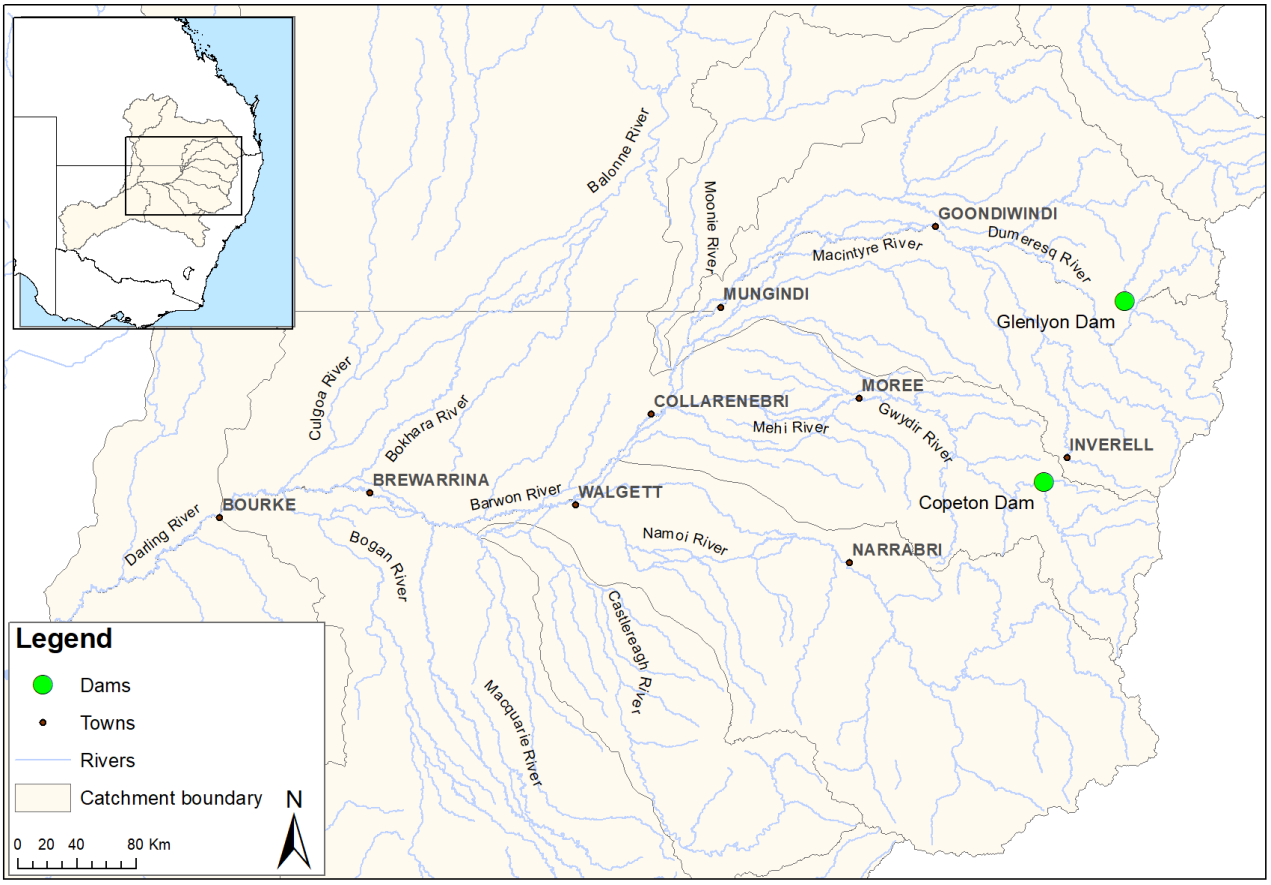

Figure 1. Location Map of the study area in the northern Murray-Darling Basin.

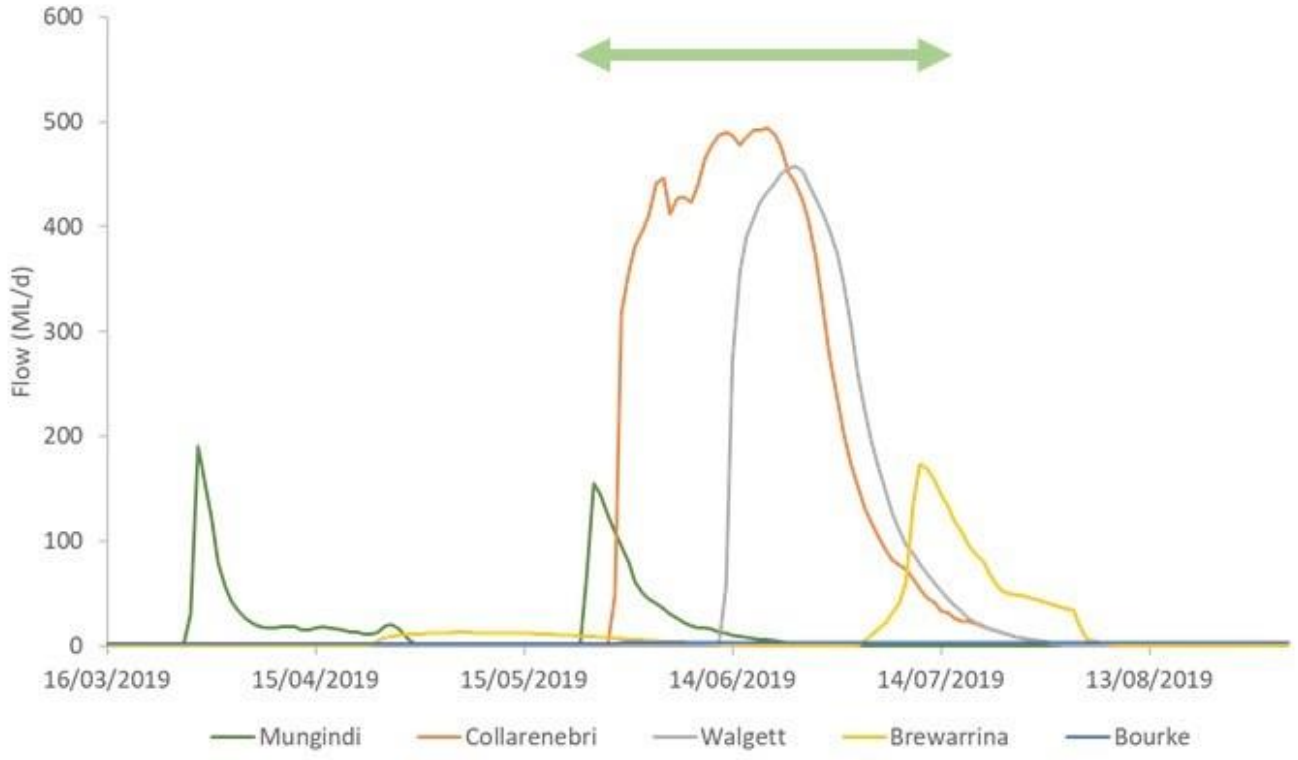

Figure 2: Flow rates (ML/d) of the Barwon and Darling Rivers at various stations during the Northern Fish Flow identified by the green arrow.

Study area and methods

Water quality parameters were measured within the Bourke, Brewarrina, Walgett, Collarenebri and Mungindi weir pools on the Barwon-Darling River during 25-28 February 2019 to assess the in-situ water quality in each weir pool (Figure 1). Parameters including temperature (°C) and dissolved oxygen (DO) (mg/l), conductivity (mS/cm), and pH were directly measured at the surface and 1m depth intervals down to 4m at each site using an YSI 556 MPS multi-probe.

Within each weir pool, temperature and DO loggers were placed at multiple depths from the surface to within 1m of the bed. These recorded measurements every 30 minutes, to allow tracking of diurnal and long-term changes. A mixture of D-Opto and Mini-Dot DO and temperature loggers were deployed at each site. Between these, two hobo temperature loggers were deployed at even depth intervals throughout the water column at each site. Loggers were suspended from a buoy using wire and tethered to a besser block to keep them in place. Enough slack was left in the wire during initial deployment to allow for variation in water levels over time.

Following the initial sampling round in March, water quality measurements were subsequently collected in May, July and August to assess temporal changes in the weir pools during and following the delivery of the NFF. Dissolved oxygen and temperature loggers were downloaded and cleaned before being re-deployed during the May and July fieldtrips.

Results and Discussion

Most weir pools monitored over the duration of the study showed some degree of thermal stratification driven by prolonged periods of no-flow throughout the system (Figure 3). As a result, DO concentrations also showed marked variation through the water column of these pools, with concentrations near the bed of most pools being hypoxic and at dangerously low levels for aquatic biota (<2 mg/l, Saari *et al,* 2018; Figure 3).

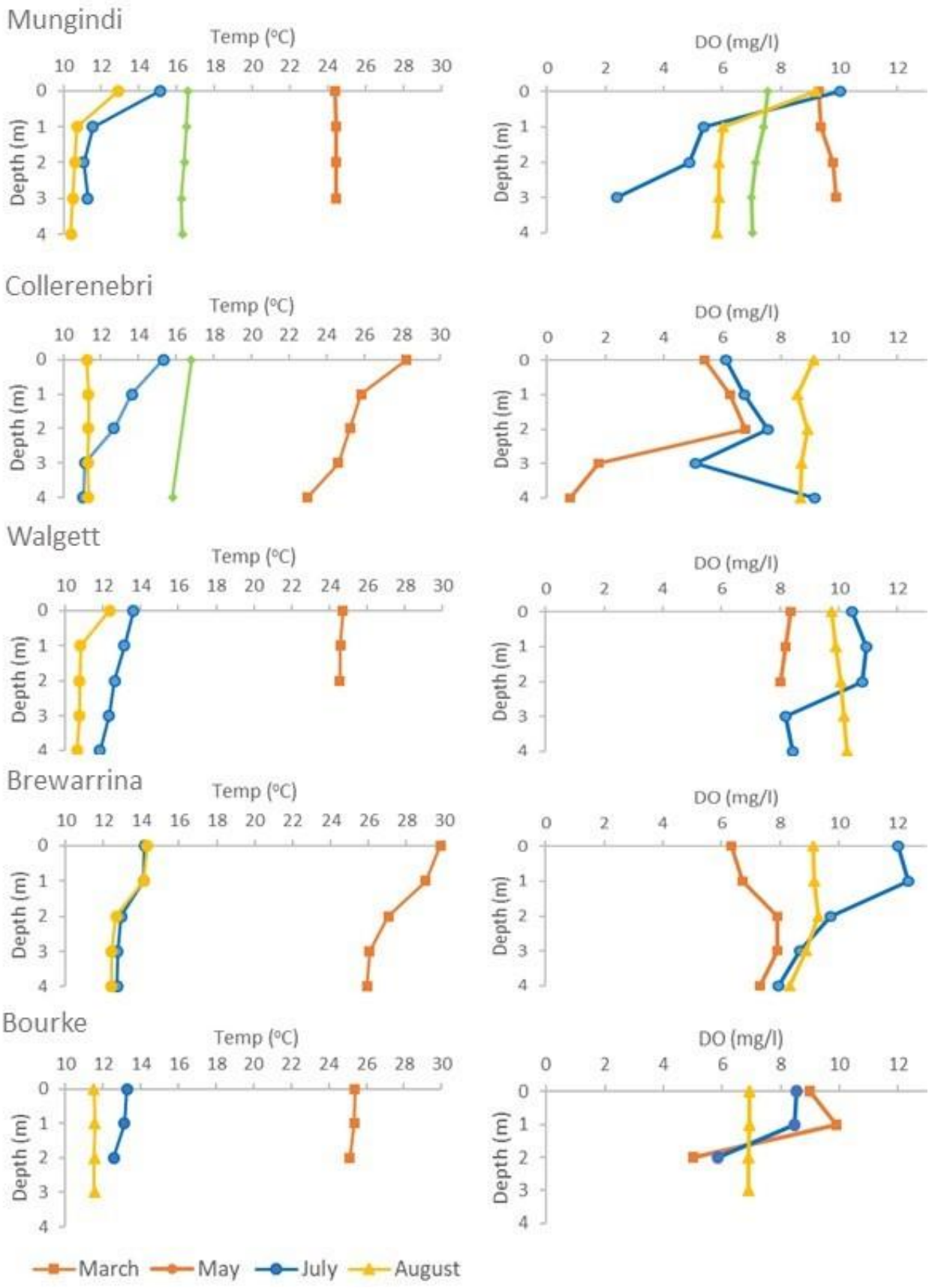

Figure 3: Spot temperature and dissolved oxygen (DO) readings measured within weir pools along the Barwon-Darling River during the study.

Spot sampling showed that the hypoxic water was primarily confined to the bottom of the pools and was more severe in deeper pools over 3m depth. The logger data suggested that near bed water also turned anoxic in some of the shallower pools (like Walgett and Bourke) at times during the study (Figure 4). Other parameters measured like pH and electrical conductivity were generally within guideline values.

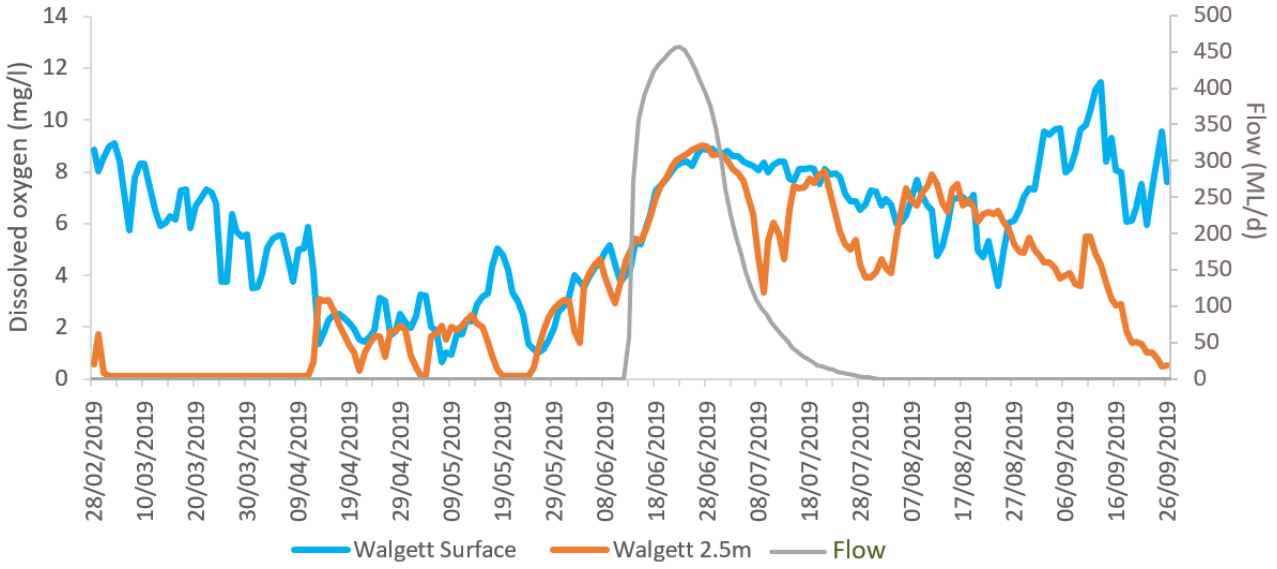

Figure 4. Daily average dissolved oxygen (DO) at the surface and 2.5m depth measured at the Walgett site during the study period. River flow data for the Barwon River @ Dangar Bridge gauge also presented.

The logger data was effective at showing temporal variations in both temperature and DO concentrations within the weir pools (Figure 5). This clearly showed the benefit of the NFF delivery to water quality in riverine pools, especially for improving the DO concentrations of near bed water. However, this work also suggests that this benefit was relatively short-lived in many pools, with near bed DO levels returning to dangerous levels on or shortly after flows ceased. A targeted survey of Collarenebri weir pool, undertaken as a separate component to the current study (Eco Logical Australia 2020), suggests that the volume of hypoxic water in this pool, and most likely other weir pools, was relatively low compared to the overlying volume of better quality water. Hence, the consequences of thermal stratification for aquatic animals in the river was probably low. It is likely that this is how the water quality in these pools naturally responds during extended cease to flow periods. There are several explanations for near bed hypoxia, and they are linked to the relative ease of these pools to thermally stratify, even in mild temperature conditions. First, insufficient light may penetrate to a depth that allows photosynthetic processes and replenishment of oxygen near the bed. This is not a surprise given the highly turbid nature of the Barwon-Darling River. Second, it appears that the flow was not of sufficient magnitude to entrain and transport in-channel stores of benthic organic matter and leaf litter that are likely driving the high oxygen demand and de-oxygenation of the near bed water. Hence, once the NFF provided reaeration of the water column, the oxygen in the near bed waters was stripped once again as bacteria began to break down the benthic organic material.

More positively, the delivery of the NFF did not cause any major declines in water quality, with surface waters remaining in good condition and no algal blooms noted following the flow delivery. In mixing the oxygen poor/nutrient rich water at the bottom of the pools with the surface waters where light penetration can stimulate algal growth, there was a risk that the flow event could have stimulated algal blooms in the weir pools. This did not occur in any of the pools assessed (Eco Logical Australia 2020, WaterNSW 2019a & b) suggesting that algal concentrations decreased, and the presence of potentially harmful algal species reduced post flow.

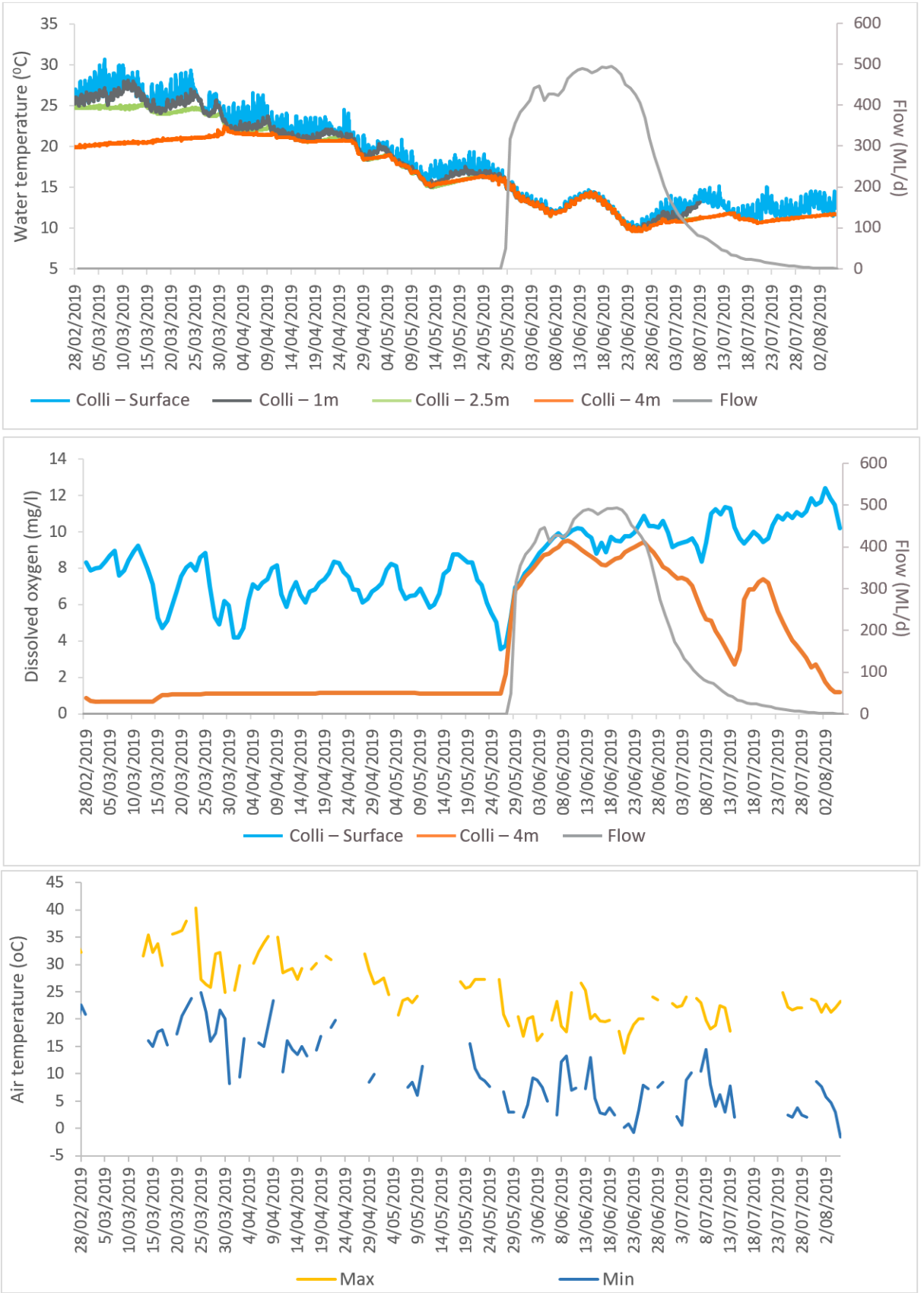

Figure 5. Hourly water temperature (top), daily average dissolved oxygen (DO, middle) and daily air temperature (bottom) measured within the Collarenebri (Colli) weir pool during the study period. River flow data for the Barwon River @ Collarenebri gauge also presented.

This monitoring also highlighted the influence of atmospheric temperature fluctuations on the strength of thermal stratification in riverine pools, with sudden drops in atmospheric temperature causing stratification to break and mixing of the water column. However, this mixing did not always correspond to a breaking of the thermoclines that control DO concentration, with layers of low DO remaining in some pools (Collarenebri most notably; Figure 5) even with relatively large changes in water temperature. Thus, it appears as if the physical mixing of the water through the flow delivery was more effective at improving DO conditions that atmospheric variations alone. It does suggest that if flow deliveries can be timed to coincide with colder periods when thermal stratification is weaker, there would be an increased chance of achieving complete water column mixing. In this way, the delivery of smaller volumes of water may be able to achieve similar ecological and water quality outcomes.

Conclusions

This study was effective at determining the prior water quality conditions in the weir pools of the Barwon-Darling, and monitoring their changes following the delivery of the NFF. Initial sampling identified that some of the deeper weir pools (and sections within weir pools) were showing signs of thermal stratification and low DO (<2 mg/l) at depths below around 3m. These included Mungindi, Collarenebri, and likely Brewarrina weir pools. Water quality parameters were more consistent through the water profile within Bourke and Walgett weir pools, which were between 2-3m deep.

Ongoing monitoring suggested that the NFF was successful in replenishing the weir pools and improving their water quality. No negative water quality effects were noted, and algal concentrations were reduced during the NFF delivery. Interestingly, hypoxic layers of water near the bed of the weir pools were relatively quick to re-establish, suggesting that these pools thermally stratify even under mild temperature conditions and that the flows delivered were of insufficient magnitude to transport the stored benthic organic material driving bacterial deoxygenation processes.

The degree of stratification in these pools was also influenced by atmospheric conditions, with the occurrence of cold snaps appearing to reduce stratification. While this was not always reflected in an improvement of DO at depth, it does suggest that if flows are timed to coincide with cold fronts, then potentially less water might be needed to break the already weakened stratification and promote full water column mixing. In situations where the relative volume of hypoxic water in the waterholes is relatively small (~10%), as was found in the current study, such mixing would improve conditions for fish and other aquatic animals in the weir pools. However, when the relative amount of anoxic water is much higher, as in the waterholes of the Lower Darling around Menindee during summer 2018-19 (Australian Academy of Science 2019), then this mixing may be detrimental to aquatic life when pools are completely mixed. Therefore, river flows should be managed where possible to minimise the development of hypoxic water in water holes by regularly breaking the thermal stratification. The delivery of the NFF is an example of this, where environmental water from multiple valleys was delivered to improve water quality and ecological condition of waterholes through an extended length of river channel.

Acknowledgments

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