Institute for Land, Water and Society
Charles Sturt University

Answers to some questions about the 2016 hypoxic blackwater event in the southern Murray-Darling Basin

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Institute for Land, Water and Society, Charles Sturt University, 20 December 2016

Over the past few months there has been widespread flooding in the southern-Murray-Darling Basin associated with record-breaking rainfall in parts of the catchment. Some areas of the floodplain that have been inundated this year have not been flooded for more than 20 years. In the Murray catchment, inputs from the Kiewa and Ovens Rivers were the highest since 2010 and the Murray River flows at Yarrawonga in October were the highest since 1993 (River Murray Weekly Report 7th Dec).

In association with the floods there has been a hypoxic (low oxygen) blackwater event that has extended throughout the Murray River system, including the Edward-Wakool system and Billabong Creek. Blackwater also occurred in parts of the Murrumbidgee and Lachlan Rivers. Fish kills have been reported in many areas with very low dissolved oxygen levels. Understandably, this has caused much concern within communities in the southern Murray-Darling Basin. For more information about the fish kills, listen to an interview by Ian Ellis from NSW Department of Primary Industries (Fisheries).

What has caused the blackwater?

Blackwater occurs when large quantities of organic compounds (carbon based substances) dissolve into flood water resulting in a dark tea colour in the water (see factsheet on blackwater). How much carbon dissolves into the water will be affected by the type of vegetation (live and dead) on the floodplain, the area that is inundated and how warm the water is. Like pouring hot water on tea leaves, carbon leaches into warm water more quickly than in cold water. This dissolved organic material in the water is then consumed by microbes which can rapidly multiply and consume a lot of oxygen, leading to a sudden depletion of dissolved oxygen in the water.

The impact the blackwater will have on the river is also affected by temperature. When the weather is hot there is naturally less oxygen in the water and the consumption of carbon occurs more quickly, so hypoxia is more likely to occur and is more likely to result in fish kills. In cooler weather organic carbon can stimulate productivity in the food chain but the dissolved oxygen is not consumed so quickly that the water becomes hypoxic.

What is happening with the blackwater now?

The blackwater is slowly making its way downstream. The oxygen concentrations in the Murray River from Hume Weir to Euston are currently good but hypoxic blackwater continues to be recorded in the lower Murray around Mildura and in South Australia (see River Murray Weekly Report 14th Dec). Dissolved oxygen in these areas will improve as river levels return to within the channel and the volume of water returning from the floodplain reduces. The impact of blackwater on the river ecosystem can change as the water moves away from the carbon sources, so downstream impacts may be different to those upstream, depending on whether or not the flood waters have come in contact with new sources of carbon. As the mixture of compounds in the blackwater changes over time the biological processes using oxygen from the water will slow down. This means that further downstream the effects of the blackwater may be less severe, even if the water still has some dark colouration. As the amount of dissolved carbon in the water decreases, people will notice a decrease in the black colour of the water and this will generally indicate improved oxygen concentrations.

Why has the blackwater been so extensive and severe this year?

What we have seen in the southern Murray-Darling Basin system this year is blackwater associated with a series of large floods that have inundated parts of the floodplain that have not been flooded for many years. Those parts of the floodplain will have built up a substantial amount of leaf litter and soil carbon (see example in Photo 1), with leaf fall possibly exacerbated by the record heat in autumn 2016. As river regulation has reduced the number of small to medium overbank flows in winter and early spring, there have been fewer opportunities for carbon to be exported from the floodplain during the cooler months. A YouTube video posted on the Fish Habitat Network provides more information on the extent of flooding and includes some satellite images of the inundation.

Photo 1: Banks of Barber's Creek (Koondrook Forest) showing accumulated leaf litter and bark prior to flooding (Photo: James Abell).

Why was the hypoxic blackwater particularly bad in the Edward-Wakool River system?

The Edward-Wakool system is an anabranch of the Murray River and is downstream of both the Barmah-Millewa Forest and Koondrook-Perricoota Forest. During the flood event this year the Wakool River received water with high dissolved carbon that had returned from both of these floodplain forests in addition to carbon entering the river from localised overbank flooding within the Edward-Wakool system.

In late October and early November 2016 there were very low dissolved oxygen levels throughout a large part of the Edward-Wakool system and fish deaths associated with the hypoxic blackwater were recorded at a number of locations. Figure 1 shows the dissolved oxygen concentrations in the Edward River at Deniliquin and the Wakool River at Gee Gee Bridge from 1 June to 19 December 2016. There was an extended period of time when dissolved oxygen concentrations were less than 4 mg/L, when fish are known to become stressed, and also many weeks when the dissolved oxygen was less than 2 mg/L, when fish deaths are expected to occur. The low oxygen conditions persisted longer in the mid-section of the Wakool River at Gee Gee Bridge than in the Edward River at Deniliquin. Dissolved oxygen concentrations between 6.5-8.5 mg/L would commonly be seen in these rivers at this time of year and the readings are now entering this range.

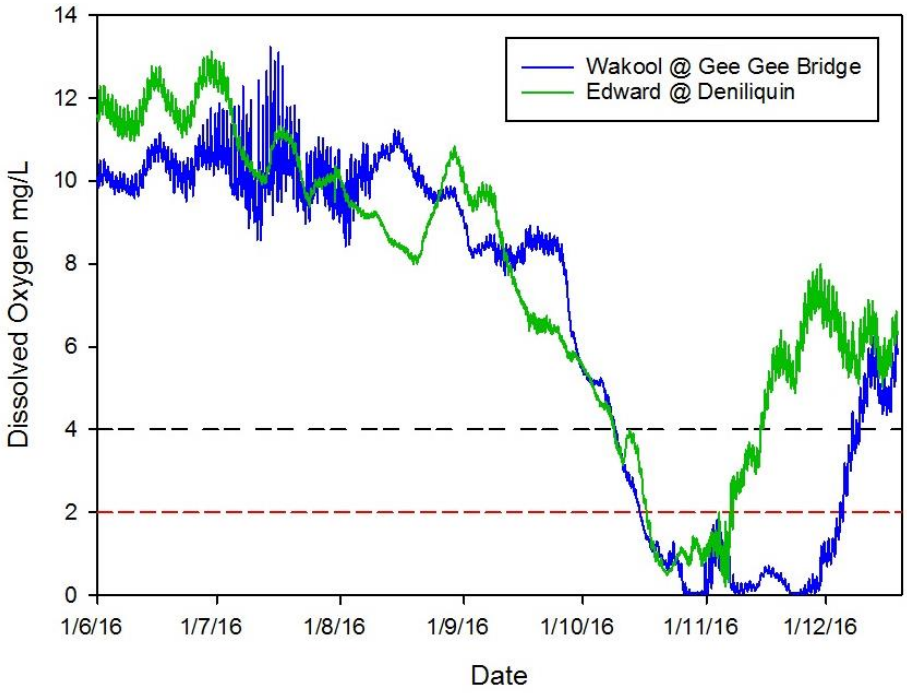

Figure 1: Dissolved oxygen concentrations in the Edward and Wakool Rivers from June to December 2016. (Data source). The dotted lines represent concentrations at which fish are known to become stressed (4 mg/L) and when fish deaths can occur (2 mg/L).

Researchers from the Institute for Land, Water and Society at Charles Sturt University and our research partners have been studying ecosystem responses to flows in the Edward Wakool system. We collected and analysed water samples every week during the flooding and blackwater event this year (Photo 2). Our results show that carbon export from the Barmah-Millewa Forest has been decreasing for a number of weeks, and in late December 2016 we were starting to see an improvement in water quality leaving the Koondrook-Perricoota Forest, although this water may continue to be dark coloured for some time.

Photo 2: Collecting water quality samples from Thule Creek which runs through the Koondrook Forest. The dark water colour indicates high dissolved organic carbon (around 25 mg/L on this date) and the dissolved oxygen was low (1.9 mg/L). (Photo: Nicole McCasker 14/11/2016)

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What is being done to minimise fish deaths during this hypoxic blackwater event?

It was not possible to fully mitigate the impacts of this hypoxic blackwater event because it extended over such a large area. However, considerable effort has been undertaken by communities, individuals and water management agencies over the past few months to provide local refuges for native fish and other freshwater animals. In the Edward-Wakool system this has been done through the release of environmental water from irrigation canal escapes (see Photo 3). In November and December 2016 the water in the Mulwala canal had lower dissolved carbon and more dissolved oxygen than the blackwater in the Wakool River. The environmental water released from the canal to the river created local areas of refuge habitat for animals such as Murray cod and Murray crayfish. Other small refuges have been created through community members deploying a range of creative, improvised devices that introduce turbulence to the water surface or bubble air into the water column (See photo 4). There have been reports of fish congregating within these small refuges of higher water quality. NSW Department of Primary Industry (Fisheries) researchers are monitoring the movement of tagged golden perch, silver perch and Murray cod through a radiotelemetry network and when the data are analysed early in 2017 we will be able to evaluate how native fish responded to the floods and the creation of local refuges.

Photo 3: Water from an irrigation escape (cloudy, containing high dissolved oxygen and low dissolved carbon) mixing with water from the Wakool River (dark brown, containing low dissolved oxygen and high dissolved carbon) to create a local fish refuge (Photo: Robyn Watts 9/11/2016)

Photo 4: Small aeration system deployed in the Edward River upstream of Moulamein to create a local fish refuge (Photo: Roger Knight 1/11/2016)

Are there any good outcomes from the floods and blackwater?

Photo 5: Invertebrates collected during the flood in the Wakool River. (Photo: Nicole McCasker)

While floods can cause damage and economic loss in areas that are prone to flooding, floods play a vital role in river and floodplain ecosystems and also benefit our society. Some blackwater events have good outcomes for river ecosystems. Blackwater that is not low in dissolved oxygen is usually associated with higher river productivity. The recent flood triggered a huge increase in biomass of aquatic invertebrates (photo 5) on the peak of the flood that was many times higher than we have previously observed during regulated flows. These invertebrates are an important source of food for native fish and other animals. CSU researchers will be undertaking fish surveys in early 2017 to evaluate the impact of the floods on native fish growth and recruitment, comparing growth rates of fish this year with growth rates of fish from the previous two years.

Can we prevent hypoxic blackwater events happening in the future?

Blackwater is a natural phenomenon, so blackwater events will continue to occur in the future. It isn't possible or desirable to prevent all blackwater events. However, it may be possible to reduce the duration and severity of hypoxic blackwater events by facilitating more frequent flushing of forests and floodplains in winter and early spring. This will help remove some of the carbon load, so the carbon inputs during subsequent floods will be lower and more likely to result in good outcomes for river ecosystems.

CSU scientists and our research partners have been monitoring the rivers of the Edward-Wakool system since 2010. We provide regular updates to managers and stakeholder groups to assist the adaptive management of environmental water in this system. Reports on our research, including descriptions of how the findings have contributed to water management decisions, are on the CSU website. The data collected during the 2016 flood will help us learn more about these systems and will assist planning and management decisions in the future.

About the authors

Professor Watts and Dr Howitt are members of a team of researchers from Charles Sturt University, NSW Department of Primary Industries (Fisheries), NSW Office of Environment and Heritage, Murray Local Land Services and La Trobe University who have been studying the Edward-Wakool River system since 2010. Our work takes an ecosystem approach and integrates studies of hydrology, hydraulics, water quality, stream metabolism, vegetation, and fish (populations, movement, reproduction and recruitment). The team's research on environmental flows and blackwater is funded by the Commonwealth Environmental Water Office, Forestry Corporation of NSW and Murray Local Land Services with in-kind contributions from Charles Sturt University, NSW DPI (Fisheries), NSW Office of Environment and Heritage and Monash University.
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