

Assessment of thermal pollution in the Snowy River below Jindabyne Dam

Summary

This study assessed water temperature in the highly regulated Snowy River below Jindabyne Dam.

What did we study?

- The thermal regime of rivers plays a critical role in the health of aquatic ecosystems. We monitored water temperature below Jindabyne Dam to assess the thermal regime of the regulated Snowy River. Monitoring began in 2011, following the installation of a multi-level offtake and the delivery of environmental flows. It continued until 2013. During this time we compared the regulated thermal regime with a natural thermal regime model. The model was developed using pre-dam (1962-1967) water temperature data.

What did we find?

- Cold water pollution in the Snowy River below Jindabyne Dam is not a significant issue.
- Warm water pollution remains an issue in the regulated Snowy River, particularly between March and July. Yet water temperatures are rarely more than 2 - 4°C warmer than natural. Temperatures never exceed the expected natural temperature range of the Snowy River before Jindabyne Dam.
- Water temperatures match the expected natural water temperatures at the town of Dalgety. This is approximately 20km downstream of Jindabyne Dam.

What does this mean for water management?

- The multi-level offtake has improved the thermal regime in this regulated river. Additional management strategies to improve the thermal regime are limited. An alternate release point in the Mowamba River may further improve water temperatures. The extent of improvements would depend on the dilution of flow volumes from the Mowamba River into the Snowy River.
- Future releases from the Mowamba weir should consider the impact of autumn and winter flows on temperatures in the Snowy River.

A large environmental flow release from Jindabyne Dam in October 2011



Background

How do dams influence water temperature and how can we manage it?

The thermal regime of rivers (e.g. diel, daily and seasonal water temperature variability) plays a critical role in the overall health of aquatic ecosystems. Large dams can affect the thermal regime of rivers by releasing unseasonal cold or warm water, reducing daily variability and changing the maximum and minimum temperatures in the river. Natural, unregulated river thermal regimes are primarily driven by air temperatures. The buffering effect caused by the large volume of water stored in reservoirs is the key cause of changes to regulated river water temperatures. One of the best methods to manage this issue is to adjust the depth that water is sourced from in the dam using infrastructure so that it matches a more natural water temperature in the downstream river.

Why did we investigate the impacts on water temperatures?

The Snowy Water Initiative (SWI) was formally established in 2002 to achieve significant improvements in river health by releasing environmental water into the Snowy, upper Murrumbidgee, and upper Murray river systems. Embodied in the Snowy Water Inquiry Outcomes Implementation Deed 2002 (SWIOID 2002). The SWIOID 2002 sets out five key environmental objectives. Objective one of relates to water temperature in the Snowy River:

1. improving the temperature regime of river water

The NSW Government is required to monitor and evaluate the objectives of the increased flows provided under the SWI. Early work by Preece (2004) suggested that Jindabyne dam released water colder than the natural water temperature experienced in the Snowy River due to the deep release point in the dam. Bevitt and Jones (2008) found that cold water pollution was not an issue in the Snowy River. Instead it was found that warm water in winter months (5-7 °C warmer) was caused by the deep dam release point. Both these information sources assessed water temperature before the multi-level offtake was installed in Jindabyne Dam.

We present the first comprehensive assessment of thermal pollution (non-natural water temperatures) in the Snowy River below Jindabyne Dam (Figure 1) since the new release strategies were implemented post 2006.

Location of water temperature and flow gauge sites used in this study

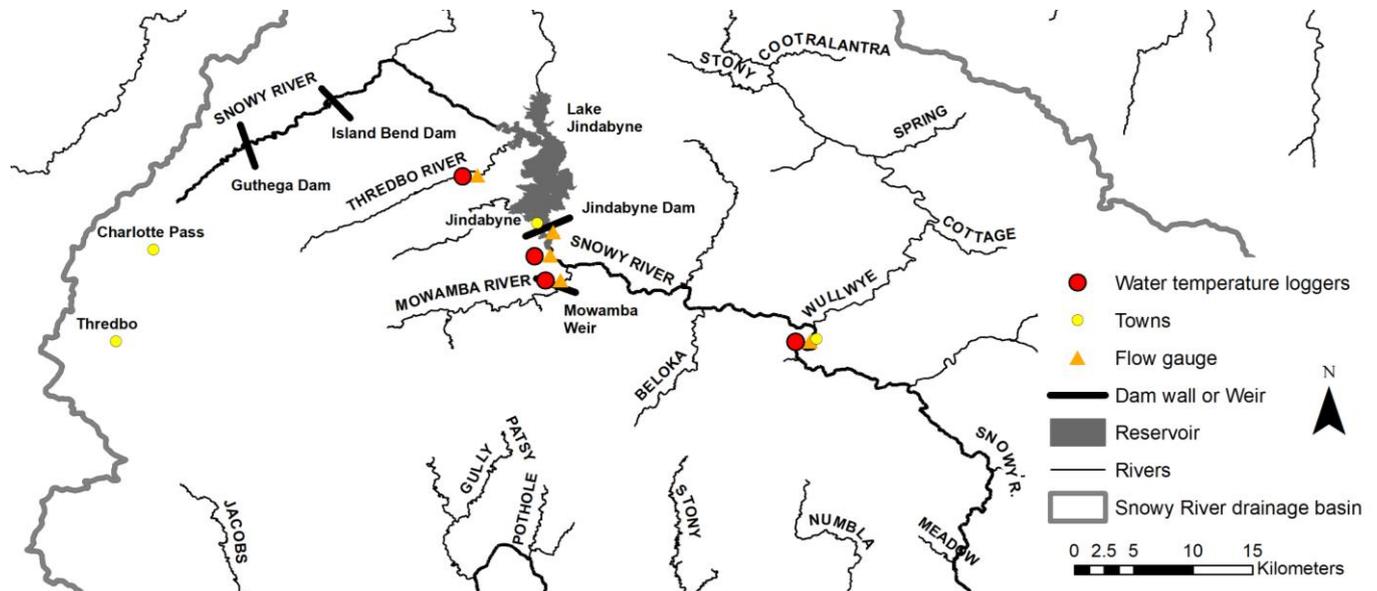


Figure 1. Map of water temperature and flow gauge sampling sites in the Snowy River catchment.

Study sites and sampling

Observed water temperature data were collected at two sites in the Snowy River below Jindabyne dam and one in each of the unregulated tributaries: Thredbo River and the Mowamba River (Figure 1). Hourly water temperature measurements were collected from August 2011 – November 2013 at each site. Water temperature data were sourced for the Snowy River site immediately downstream of Jindabyne for the period July 1962 - July 1967. The data represents the period immediately before the completion of Jindabyne Dam in 1967 and is considered a measurement of the natural thermal regime before regulation. This data, along with key meteorological and hydrological data were used to create a natural water temperature model for the Snowy River. The natural water temperature model and observed data from the unregulated tributary sites were used to assess the impact of Jindabyne Dam on water temperatures in the Snowy River below Jindabyne.

Results

Water temperatures are more similar to natural due to the multi-level offtake.

This study shows that the thermal regime of the regulated Snowy River is still influenced by Jindabyne Dam, but is now closer to natural after implementation of the new multi-level offtake. Prior to the multi-level offtake, water temperatures were estimated to be 5-7 °C warmer during winter months (Bevitt and Jones 2008). Our results show that warm water pollution was still evident in autumn and winter (mean daily water temperature in the Snowy River below Jindabyne was ≥ 2 °C warmer for 82%, 100% and 87% of days for May, June and July respectively but rarely exceeded 4 °C in any of the autumn or winter months (Figure 2a).

Comparison of regulated Snowy River water temperatures to modelled natural and reference rivers

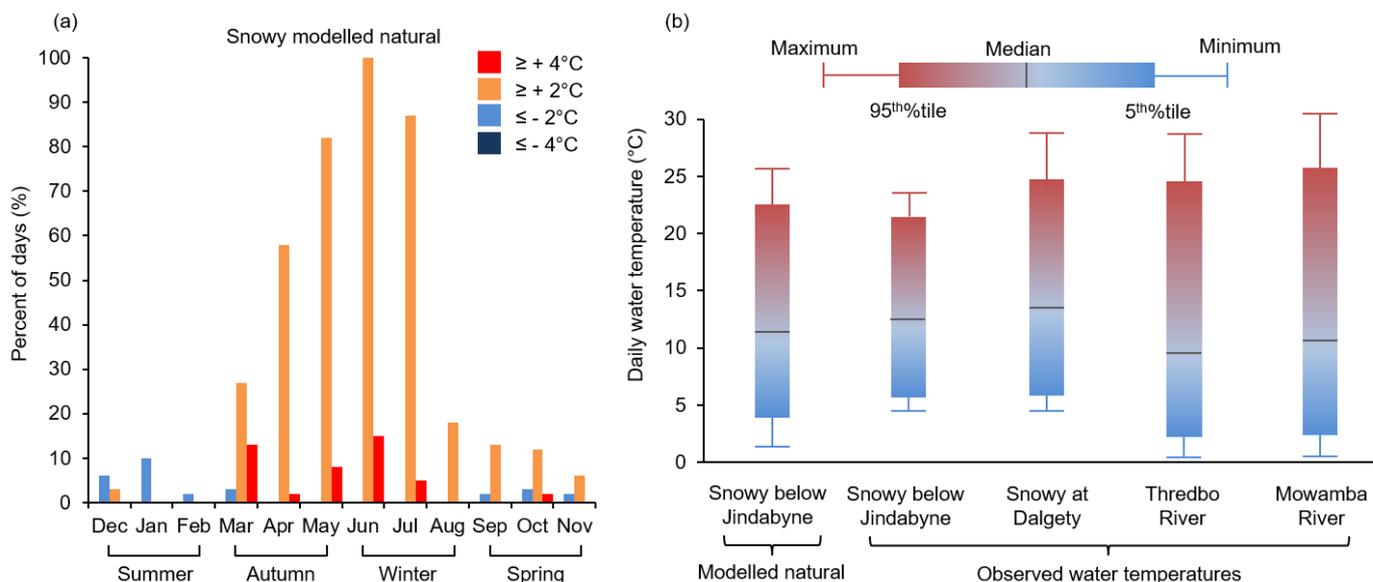


Figure 2. (a) Percent (%) of days (2011-2013) that observed post-regulated mean daily water temperatures in the Snowy River below Jindabyne differed by more than -4 °C, -2 °C, +2 °C and +4 °C from modelled natural Snowy River below Jindabyne. (b) Daily water temperatures (2011-2013) in the Snowy River below Jindabyne (GAM modelled and observed) and observed daily water temperatures of the Snowy River at Dalgety, Thredbo River and Mowamba River. The box represents the 95th, 50th (median) and 5th percentiles whilst the whiskers are the maximum and minimum daily temperatures observed or modelled.

Whilst thermal pollution (cold or warm) appears to be minimal in the Snowy River, the buffering capacity of Jindabyne Dam has reduced the range and variability of water temperatures downstream of the dam. The maximum and minimum water temperatures were restricted (i.e. did not get as cold or as hot) compared to the range of the modelled natural Snowy River and the two reference streams (Figure 2b).

Based on the modelled natural minimum temperatures, 5% (42 days) of the study period would have experienced temperatures below 3.9 °C (coldest predicted temperature was 1.5 °C) but in reality temperatures never dropped below 4.7 °C. Nearby unregulated reference streams reached minimum temperatures below 1 °C. In addition, maximum temperatures during summer are slightly lower (~1 °C cooler) than the predicted natural water temperatures.

Comparison of regulated Snowy River water temperatures to modelled natural and reference rivers

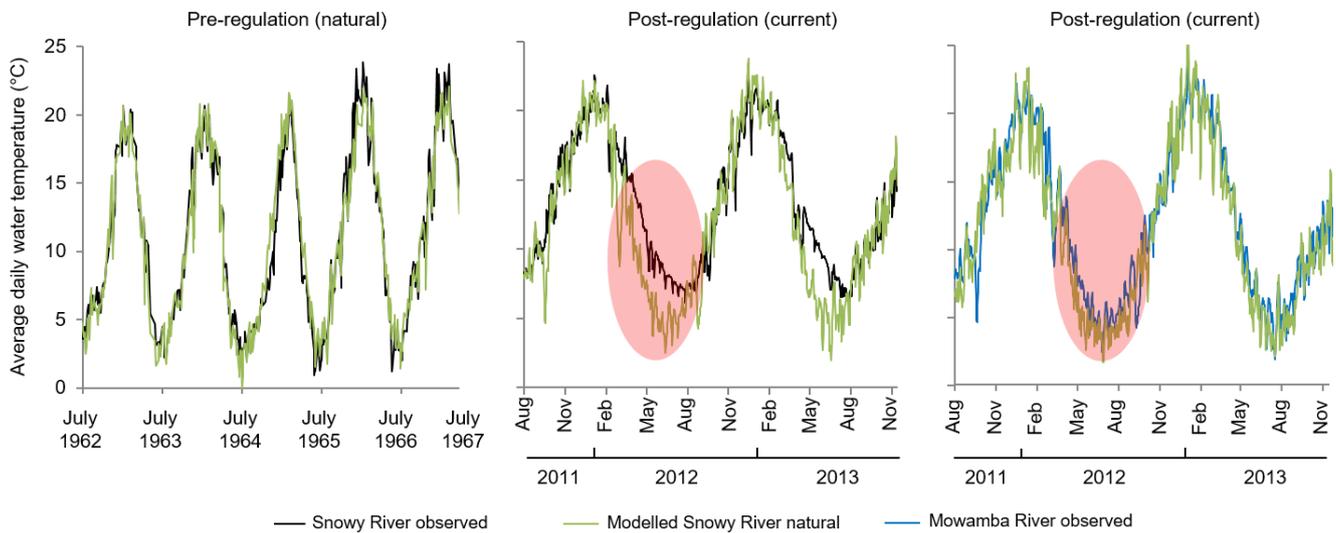


Figure 3. Mean modelled natural and observed daily water temperature (°C) for the Snowy River (pre and post regulation) and the Mowamba River. The red circles highlight key months of interest.

Future management options

Matching the water temperature at the multi-level offtake intake to more natural water temperatures is the most obvious option to improve the thermal regime in the Snowy River below Jindabyne. However, water temperature monitoring at the multi-level offtake intake tower in Lake Jindabyne shows that the temperature during this study period was constant at all possible intake depths between May-August with some degree of cooling at greater depths in March and April (Snowy Hydro 2012, 2013). This suggests that manipulating the level water is drawn from for environmental releases in the Snowy River would have very little influence on downstream water temperatures.

The Mowamba River provides an alternate release point for flows into the Snowy River with water temperatures closely matching the modelled natural temperatures. However, the proportion of Mowamba River flows would be well below 50% (Table 1) during the months of Mar-July. The dilution of Mowamba River flows entering the large Snowy River pools will likely have a limited effect on Snowy River water temperatures below Mowamba River.

Table 1 Discharge comparisons between Mowamba River and the Snowy River for months with differences in water temperature of 2 °C or more. Period: Jan 2007 – December 2018.

Month	Mowamba River aqueduct diversions (ML/day)	Snowy River below Jindabyne dam (ML/day)	Mowamba River as a proportion (%) of Snowy River
March	Average: 39 Median: 24	Average: 348 Median: 98	Average: 11 Median: 25
April	Average: 50 Median: 29	Average: 185 Median: 104	Average: 27 Median: 28
May	Average: 24 Median: 15	Average: 98 Median: 88	Average: 25 Median: 17
June	Average: 76 Median: 50	Average: 275 Median: 162	Average: 28 Median: 31
July	Average: 95 Median: 65	Average: 338 Median: 264	Average: 28 Median: 25

Conclusions

Overall, the thermal regime of the Snowy River is different to the modelled natural and nearby unregulated reference streams. Warm water pollution remains the main issue, however the water temperatures were primarily only 2 - 4 °C warmer during autumn and winter. This is an improvement compared to the pre-multi-level offtake assessment of 5 - 7 °C warmer water temperatures during winter. Whilst the thermal regime has improved, knowledge on the ecological consequences of small degrees of warm water pollution in snowmelt streams like the Snowy River is limited. Any future work should:

- target additional flow delivery options to more closely match the natural thermal regime, and
- assess the impacts of 2 - 4 °C warmer temperatures during autumn and winter on the Snowy River aquatic ecosystem.

More information

Daniel Coleman

Senior Ecohydrologist

daniel.coleman@dpi.nsw.gov.au

Water | Department of Planning, Industry and Environment

84 Crown St. | PO Box 53 | Wollongong NSW 2520 Australia

Additional method details

Statistical analysis

We predicted the mean, maximum and minimum natural daily water temperature of the post-regulated Snowy River directly below Jindabyne Dam for the period from 2011 to 2013 using validated generalised additive model (GAM) models (mgcv package). All GAM models were validated using the split-sample method. Thirty per cent of the sample was set aside to evaluate the model and 70% was used to create the model.

We used multiple graphical and statistical techniques to compare modelled natural daily water temperatures to observed data for the pre-regulated Snowy River, post-regulated Snowy River, Thredbo River and Mowamba River.

References

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