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Comment on Finlayson *et al.* 'Continuing the discussion about ecological futures for the lower Murray river (Australia) in the Anthropocene'

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ABSTRACT

The recent commentary by Finlayson *et al.* proposed future management pathways for the Lower Lakes of the Murray–Darling Basin (MDB), including changed barrage operations to facilitate increased tidal exchange. Although we acknowledge that barrage operations require ongoing adaptive management, we present evidence that there are risks with increased opening of them under current reduced inflows. Maintaining a predominantly freshwater system, and thus its values and services, by controlled barrage operations is justifiable and sustainable in the long term.

Keywords: barrages, Coorong, Lower Lakes, Murray–Darling Basin, River Murray, water management.

Historical predominant freshwater conditions

The historical pre-barrage conditions in the Lower Lakes are the subject of much current scientific debate. A recent independent review (Chiew *et al.* 2020, p. 6) concluded:

> The weight of evidence (from palaeoecological records, water balance estimates, hydrological and hydrodynamic modelling, and traditional knowledge of the Ngarrindjeri People and anecdotal accounts of early explorers and colonists) points to the Lower Lakes being largely fresh prior to European settlement.

Finlayson *et al.* (2021) argued that Chiew *et al.* (2020) dismissed 'evidence' of past marine and tidal influences in the Lower Lakes by failing to cite Hubble *et al.* (2020) and Gell (2020*a*, 2020*b*). However, these papers appeared after the report of Chiew *et al.* (2020), which did acknowledge (p. 6) 'moderate tidal influence and incursion of seawater during periods of low Murray River inflow'. Recent suggestions of a stronger marine influence were based on hydrodynamic modelling (Helfensdorfer *et al.* 2019, 2020), and the assumptions and conclusions of this modelling have been questioned by Tibby *et al.* (2020, 2021) and De Deckker and Murray-Wallace (2021). Using these hydrodynamic models to definitively answer a present-day question is not appropriate, as the study authors themselves state (Hubble *et al.* 2020).

Finlayson *et al.* (2021) were also critical of a subsequent Murray–Darling Basin Authority (MDBA) media release that stated it was 'time history to bed' after the release of the independent report of Chiew *et al.* (2020). Finlayson *et al.* (2021) used this to set up a premise throughout their commentary that the science and management in this region was inflexible and not adapting. Although we agree that it was a poor choice of words in the media release, it is not policy or legislation. Neither does it reflect the process of science and management in the Lower Lakes, which as outlined below, continues to respond to new information and adapt.

Risks of opening barrages under contemporary River Murray inflows

Allowing seawater connection into the lakes under the contemporary River Murray flow regime is likely to result in saline–hypersaline conditions for significant time periods (Chiew *et al.* 2020; Gibbs 2020), and, hence, much broader and potentially irreversible adverse ecological and socio-economic impacts than those inferred by Finlayson *et al.* (2021). This is because the natural volumes of River Murray inflows, which formerly flushed the system of salt, are no longer present. Large-scale water diversion and extractions in the Murray–Darling Basin (MDB) have resulted in an average 54% less inflow to the Lower Lakes, but this can lower to <25% during drought conditions (e.g. see 2007–2008 period of Millennium Drought on Fig. 1). The barrages were primarily constructed to retain freshwater and prevent salinity increase resulting from the extraction and diversion of this water upstream. The marked reduction of natural River Murray inflows, which would have flushed salt and other constituents from the Lower Lakes, is a key reason that opening the barrages poses high risks of salt accumulation and salinities beyond the tolerances of most taxa.

In contrast, Finlayson *et al.* (2021) suggested that allowing more seawater intrusion would provide ecological benefits. However, the potential benefits of increased tidal exchange (e.g. for diadromous fish) are likely to be very limited in time, space and number of biotic beneficiaries, and must be traded-off against the high risks to the majority of the ecological values and services of the site from salinisation. Finlayson *et al.* (2021) proposed benefits for fish on the basis of a single estuarine species with a high salinity tolerance (mulloway, *Argyrosomus japonicas*), and suggested negative consequences for common carp (*Cyprinus carpio*). There was no discussion about the likely negative effects on the other 48 native freshwater fish species that occupy the wetland, including Murray cod (*Maccolluochella peelii*), the highly salt-sensitive Yarra pygmy perch (*Nannoperca obscura*), and the other 25 species of flora and fauna that are listed as being of conservation concern (Phillips and Muller 2006). Furthermore, Finlayson *et al.* (2021) overlooked extensive analysis that defined the environmental water requirements of 56 taxa in the Lower Lakes (Lester *et al.* 2011; Maltby and Black 2011).

The Ramsar Convention and *Water Act* 2007 oblige Australia to maintain the ecological character of listed wetlands; accordingly, loss of freshwater values in the Lower Lakes will have implications under these legal agreements (Chiew *et al.* 2020). It should be noted that in the case of the Lower Lakes, the ecological character at the date of Ramsar listing (1985) was already degraded and in need of additional environmental water (Phillips and Muller 2006). There is also a specific Basin Plan freshwater salinity target for Lake Alexandrina at Milang (<1000 µS cm^{-1}, 95% of the time) and a salt-export target of 2 million tonnes per year (Murray–Darling Basin Authority 2020), developed in consultation with the community who have advocated for an end-of-system salinity target since the late 1990s. Discharges from the Murray Mouth remove salt and other constituents (e.g. nutrients, sediment, contaminants) from the whole catchment, thereby helping maintain cultural, ecological and social benefits across the entire MDB. Most environmental water recovered under the Basin Plan delivered to the Lower Lakes has previously been used for upstream environmental watering actions along 1000s of kilometres of river–floodplain system (Chiew *et al.* 2020);

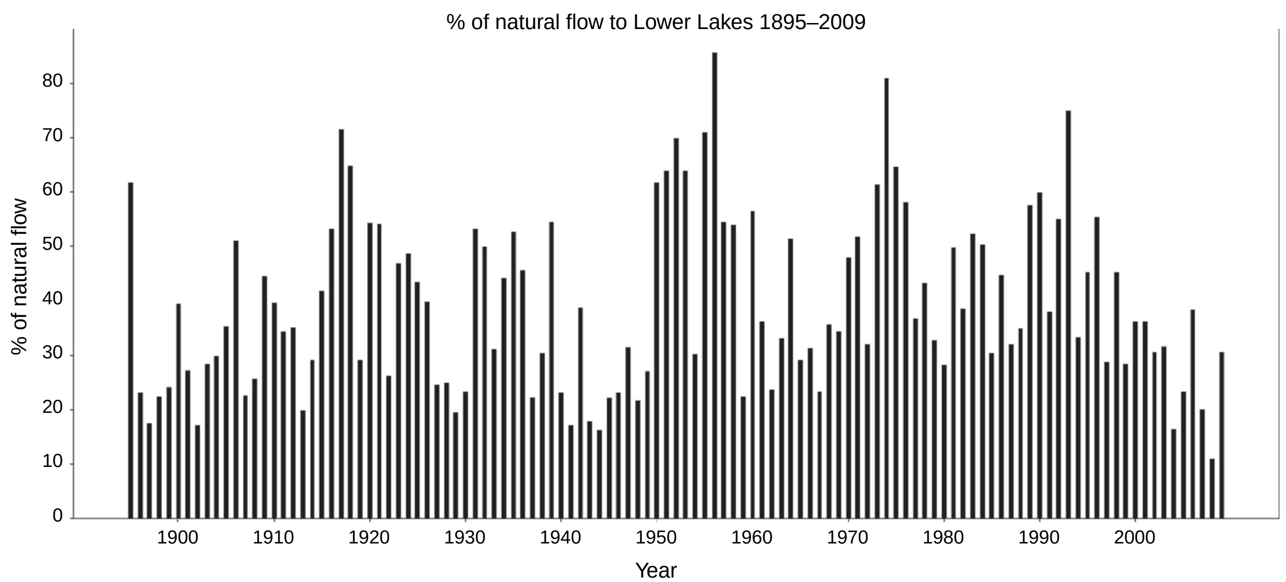

Fig. 1. Percentage of 'natural' (without water-resource development) Lower River Murray flow (at Wellington, just upstream of the Lower Lakes) on the basis of measured and modelled data from 1895 to 2009 (Murray–Darling Basin Authority 2012).

so, there is not a 'downstream' versus 'upstream' divide in terms of benefit from any water delivery. The 'conflict' Finlayson *et al.* (2021) refers to is only from irrigators over 1000 km upstream who have vested interested in lowering freshwater inflows, and that have no personal stake in environmental, socio-ecological, community and First Peoples futures of the CLLMM.

Finlayson *et al.* also overlook that, before unsustainable water-resource development, the River Murray was a perennial lotic river and the reduction in flows, hydrodynamic complexity and habitat has had a major impact on riverine aquatic biota (Mallen-Cooper and Zampatti 2018). Furthermore, higher and more consistent inflows kept the Murray Mouth open without dredging (Bourman *et al.* 2018), helping maintain salt, sediment and nutrient export. Under the higher flows that were more predominant naturally (Fig. 1), the estuary was likely to have been highly dynamic, extending more frequently and extensively into the Coorong (Geddes and Butler 1984). A functioning estuary requires both river inflow and connection to coastal waters. Finlayson *et al.* (2021) present no evidence that facilitating tidal flow through the barrages will create significant new estuarine habitat in the context of reduced contemporary freshwater inflows (Fig. 1).

Allowing uncontrolled seawater ingress to the Lower Lakes would also create risks to potable water sources in the Lower River Murray, necessitating installation of additional regulating structures such as a weir near Wellington, previously proposed during the Millennium Drought (Muller *et al.* 2018). This would be highly likely to generate additional negative outcomes such as reducing water exchange between the river and lakes, and retaining pollutants and enhancing algal blooms in the new Lower River Murray weir pool.

Adaptive management of the lower lakes

It is uncertain whether even the relatively degraded freshwater ecosystems present when the Lower Lakes were designated as a Ramsar site in 1985 can be restored. Although we agree with Finlayson *et al.* (2021) that wise adaptation to a new but different and productive freshwater – estuarine ecosystem can be carefully considered, this still requires delivery of sufficient flows to maintain target salinity values, not simply allowing tidal flows through the barrages as proposed by Finlayson *et al.* (2021).

Finlayson *et al.* (2021) noted that there is lower variability in water levels in the Lower River Murray and Lakes than under natural conditions. However reduced variability in levels is a whole of MDB issue owing to river regulation and water extraction, and one that is being differentially addressed through operational plans for specific infrastructure. We agree with Finlayson *et al.* that wetting and drying cycles are 'critical for the functioning of the Basin's rivers and wetlands', but they are incorrect in claiming that maintaining the lakes 'at a constant level has been attempted since barrage construction' or that this is the 'most intensely regulated section' of the system. Finlayson *et al.* (2021) appear to be unaware that since the end of the Millennium Drought (post-2011), the South Australian Government has developed a long-term adaptive management plan (Department of Environment and Heritage 2010) and also implemented a 'Variable Lower Lakes Strategy' (Department for Environment and Water 2019). Water levels are now managed within a variable operating envelope of +0.5 m to +0.85 m AHD (i.e. an operating band of 35 cm), which is much greater than typical vertical operating bands of 5–10 cm for weirs on the River Murray held at 'normal pool level' (Muller and Creeper 2021). Strong wind action and seiching on the large and shallow Lower Lakes also produce significant additional water level variation. These wind seiching effects are present throughout the weir pool to Lock 1, which is the longest reach between regulating structures downstream of Euston. Upstream of Lock 1, weir pool manipulations are already occurring to provide wetland and channel wetting and drying cycles (Muller and Creeper 2021).

In addition, regardless of the pre-European natural variability in water levels, the current micro-tidal and wave-dominated nature of the Murray Mouth and Coorong region downstream of the barrages means that allowing tidal flows through the barrages will not necessarily create more water level variability. The current diurnal tidal ratio inside the Murray Mouth is typically 20–30 cm (Mosley 2016), which is within the range of the current water level fluctuations in the lakes (Department for Environment and Water 2019).

Potential impacts of the Basin Plan and climate change

Finlayson *et al.* (2021) proposed 'moving away from any pretence that we can restore the lower reaches of the River to its 'natural' state given changes in the catchment, and the influence of climate change'. However there is no 'pretence' as restoration of a 'natural' state is not the aim of the site management plan (Department of Environment and Heritage 2010), the *Water Act* 2007 or the Basin Plan. Even the predicted increased inflows (~16% increase cf. Fig. 1 average) under the Basin Plan (Murray–Darling Basin Authority 2012) may not be being currently realised (Williams and Grafton 2019).

In regard to climate-change threats, the opinion of Finlayson *et al.* (2021) that the barrages and freshwater conditions are not sustainable in the Lower Lakes is also open to debate. Modelling suggests that the Lower Lakes can be maintained in a predominantly freshwater state under medium climate-change scenarios (Chiew *et al.* 2020). The barrages, thus, provide a unique opportunity to protect the Lower Lakes through the 21st Century in the face of climate change. Given that the barrages were completed ~80 years ago, it is conceivable that with modern engineering, they can be replaced and raised to maintain freshwater lakes at higher levels to counter sea-level rise. Increased automation of the barrages could assist fish migration movements and facilitate micro-scale estuarine habitats in response to tidal cycles (under suitable River Murray inflow conditions), in alignment with the principles outlined by Finlayson *et al.* (2021), while minimising risks. Thom *et al.* (2020) suggested that significant sea-level rise will require construction of additional infrastructure (e.g. bunds) across the lower parts of the land surface between the barrages. However, global evidence is emerging of coastal wetlands keeping pace with sea-level rise where sediment and organic matter supply is sufficient (Schuerch *et al.* 2018), which certainly applies in the case of the Murray Mouth region.

Summary

In summary, the proposal of Finlayson *et al.* (2021) will not produce the ecological futures they hypothesise, and instead may create high ecological risks. There may be some merit of allowing more controlled tidal flux through the barrages, if the science supports it and the community also chooses that direction. However, the scope for this is likely to be very limited under current conditions of greatly reduced River Murray inflows and relatively inflexible (limited automation) infrastructure. Adaptive management should continue on the basis of further scientific investigations, modelling of system responses, and consultation with First Peoples and the broader community. The current management of the barrages and water levels enables this Ramsar-listed wetland to maintain vestiges of its historical ecological character and services. With wise use of the MDB water resources, full implementation of the Basin Plan, and continued adaptive management, the Lower Lakes can be sustained as healthy freshwater wetlands of international importance well into the future.

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