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Marine and Freshwater Research

Supplementary Material

Multi-decadal trends in large-bodied fish populations in the New South Wales Murray–Darling Basin, Australia

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Length–weight relationships

Length–weight relationship were fit to the non-linear length–weight equation:

$$W_i = aL_i^b$$

where W_i is the weight of $fish_i$, L_i is the length of $fish_i$ and, a and b are constants. In practice, we took the natural logarithms of each side of the equation and fit the linear model:

$$\log(W_i) = \log(a) + b \times \log(L_i)$$

This linear form of the model simplifies fitting of the model and homogenises the variances around the fit. To account for the inherit biases when back-transforming logarithms to real values we calculated a correction factor for the predicted weights (Hayes *et al*. 1995). The correction factor was calculated as:

$$e^{\left(\frac{\sigma^2}{2}\right)}$$

where σ is the residual variance from the linear regression equation. The predicted weight is then multiplied by this correction factor to get the final bias corrected weight estimate for a fish.

The final equation for predicting weight (g) from length (mm) for each species was given by the equation:

$$W = e^{(\log(a)+b*\log(L_i))} \times bcf$$

where the log(a), b and bcf values are given in Table S1.

Table S1 Length–weight equation parameters for each of the species in this analysis.

Species	**log(*a*)**	***b***	**Bias correction factor (*bcf*)**
Murray cod	–11.797	3.086	1.019
Golden perch	–11.912	3.141	1.014
Silver perch	–10.653	2.916	1.077
Macquarie perch	–11.449	3.065	1.009
Freshwater catfish	–12.167	3.115	1.035
Common carp	–10.520	2.938	1.014

Temporal trends in relative biomass and length frequency

Murray cod

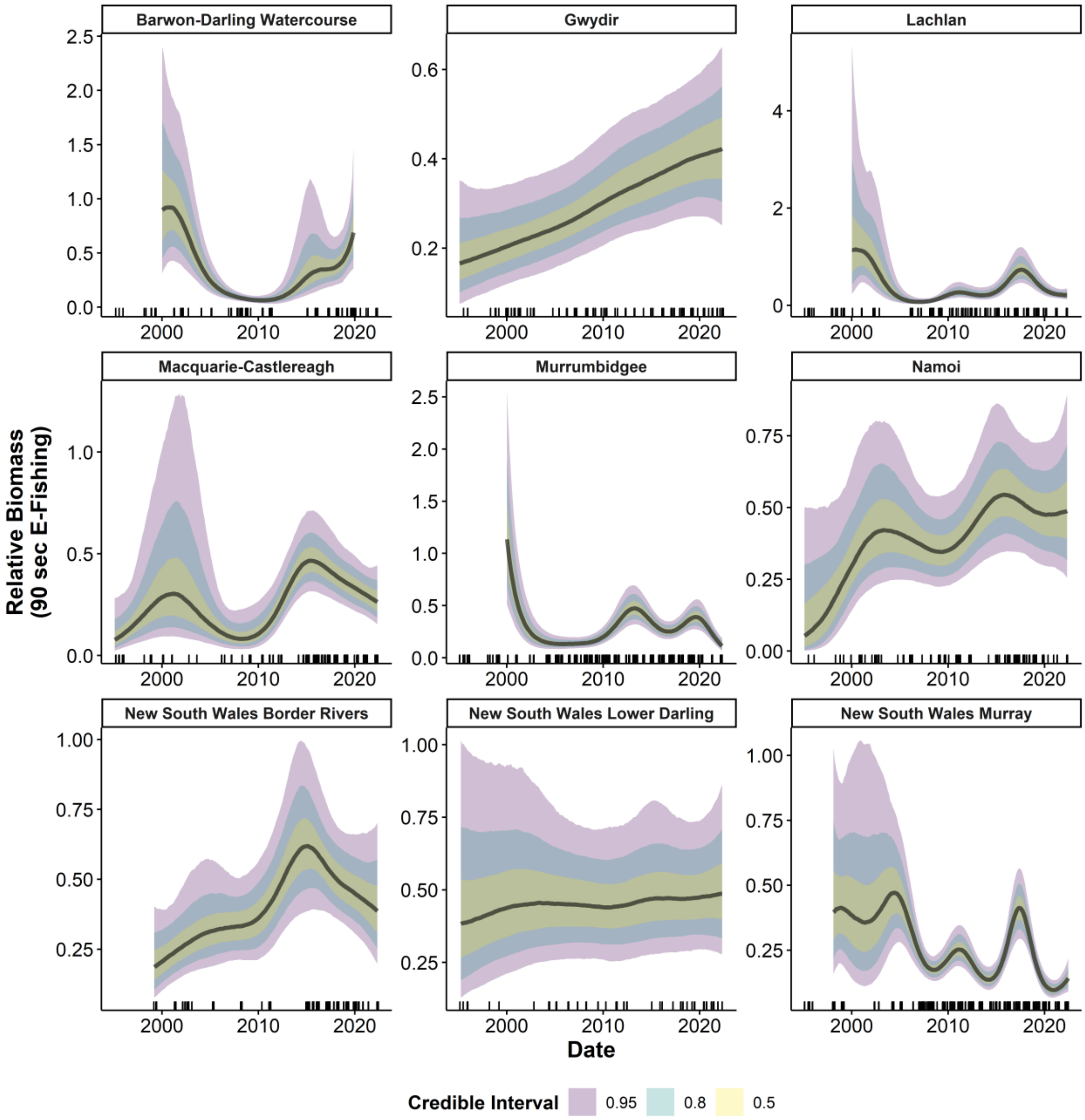

Figure S1. Fitted trends in relative biomass for Murray cod within valleys of the NSW Murray–Darling Basin based upon the GAMM analysis. Rug plots on the *x*-axis show sample distribution through time. Note the Barwon–Darling Watercourse (pre-2000 and post-2020), Lachlan (pre-2000), NSW Murray (pre-1998) and Murrumbidgee (pre-2000) showed extremely large error bars despite being within the bounds of sampling (see rug plots) which have been omitted here to allow visualisation of the time series with more confidence.

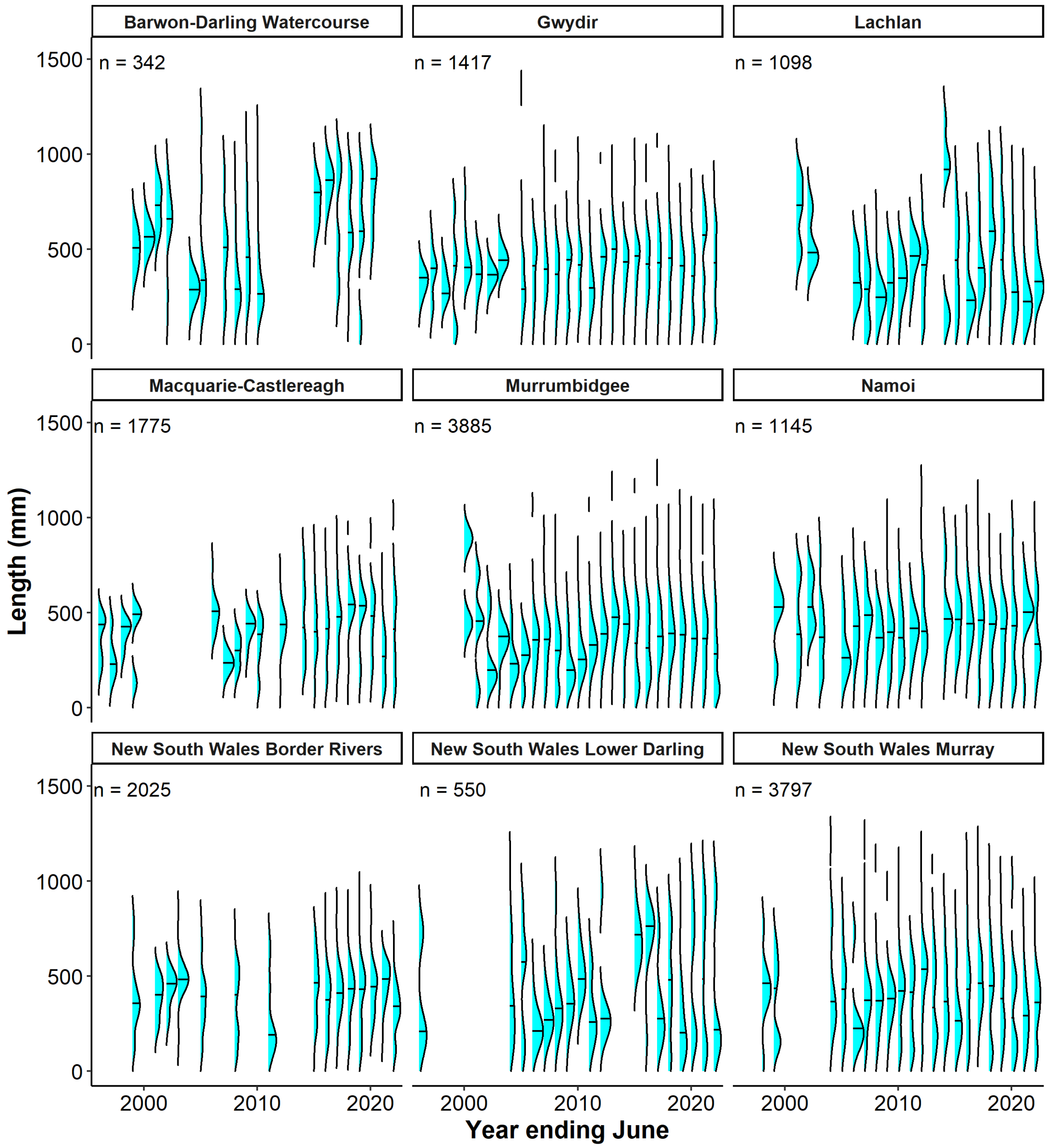

Figure S2. Observed length distributions for Murray cod within each of the valleys of the NSW Murray–Darling Basin for each year. *n* represents the total number of length measurements taken in a valley.

Golden perch

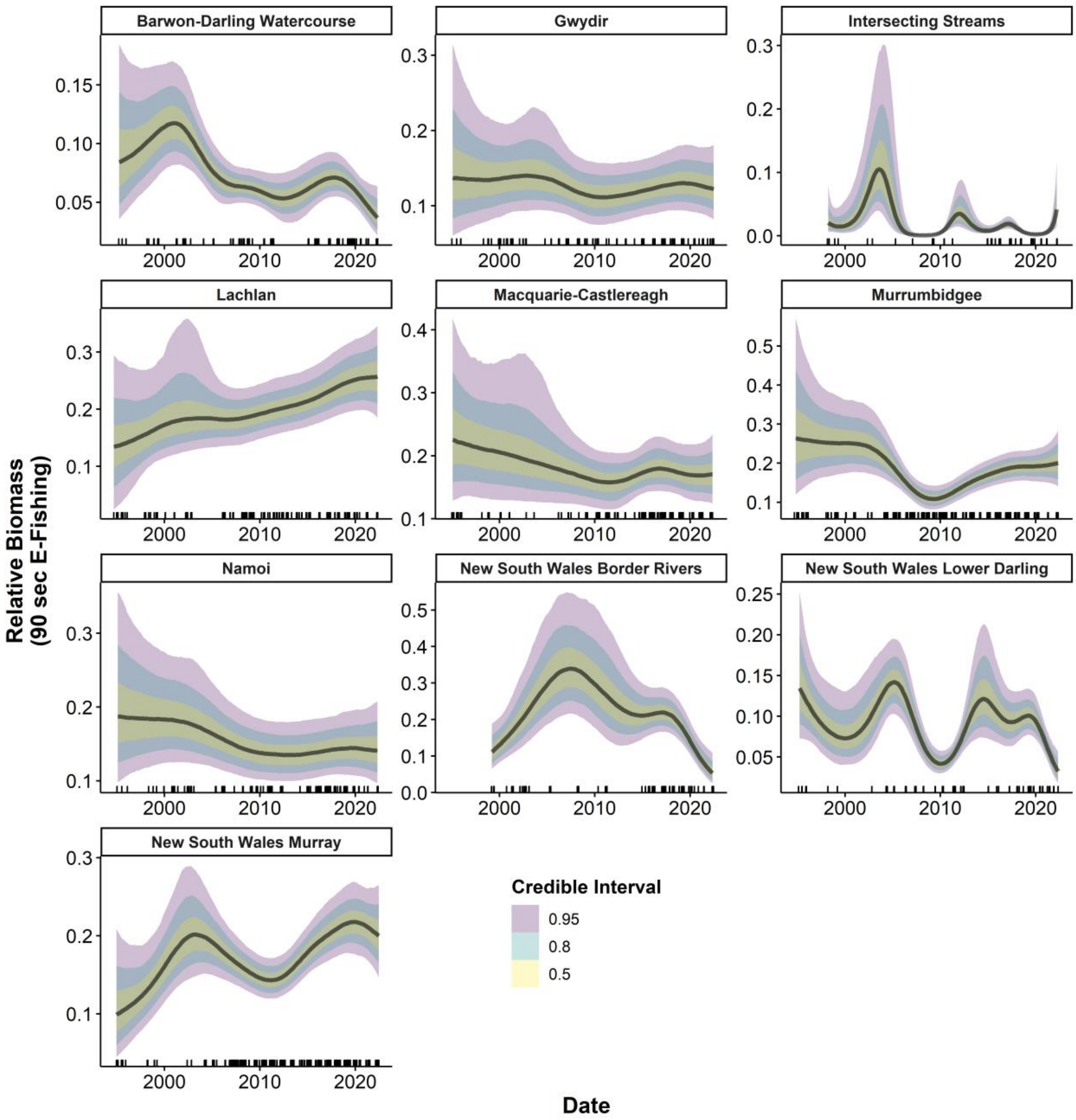

Figure S3. Fitted trends in relative biomass for golden perch within valleys of the NSW Murray–Darling Basin based upon the GAMM analysis. Rug plots on the *x*-axis show sample distribution through time.

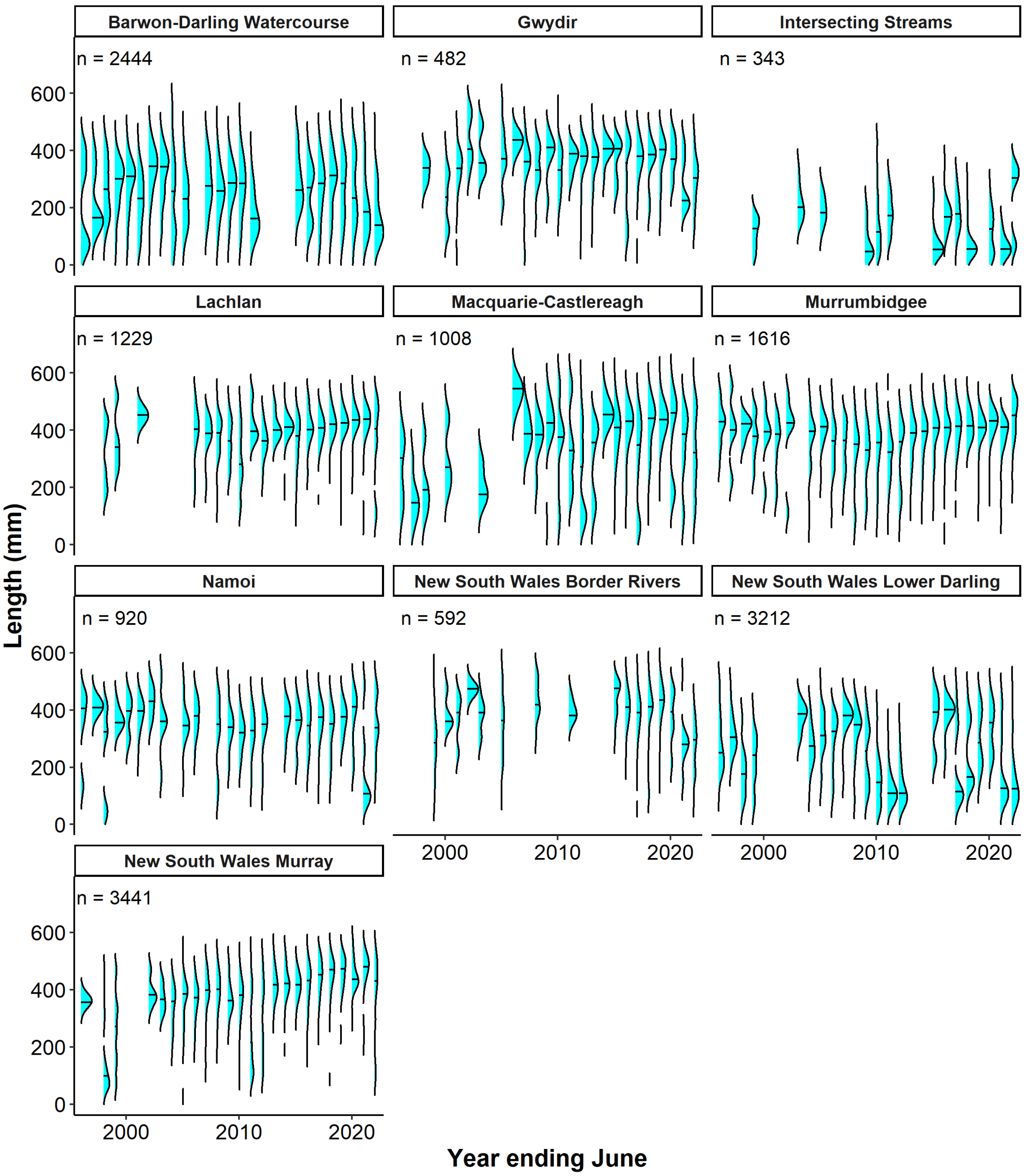

Figure S4. Observed length distributions for golden perch within each of the valleys of the NSW Murray–Darling Basin for each year. *n* represents the total number of length measurements taken in a valley.

Silver perch

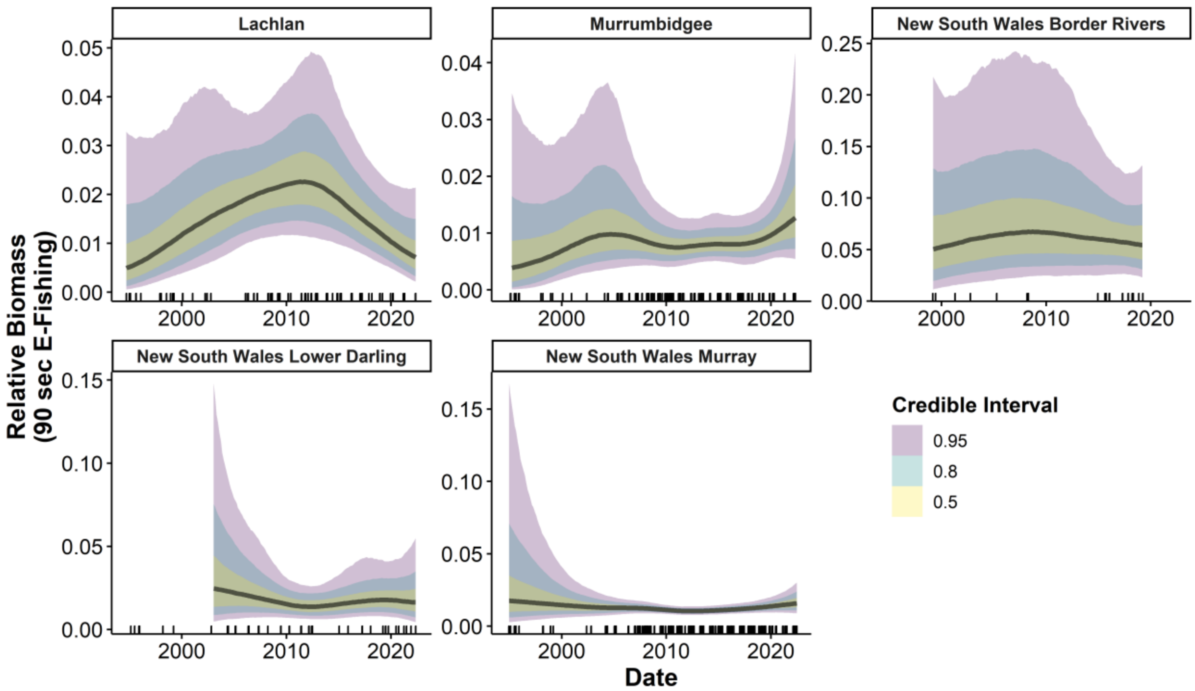

Figure S5. Fitted trends in relative biomass for silver perch within valleys of the NSW Murray–Darling Basin based upon the GAMM analysis. Rug plots on the *x*-axis show sample distribution through time. Note for the NSW Lower Darling, despite early sampling, data prior to 2003 was omitted from the plot as the error bars were extremely large to allow better visualisation of the recent time-series.

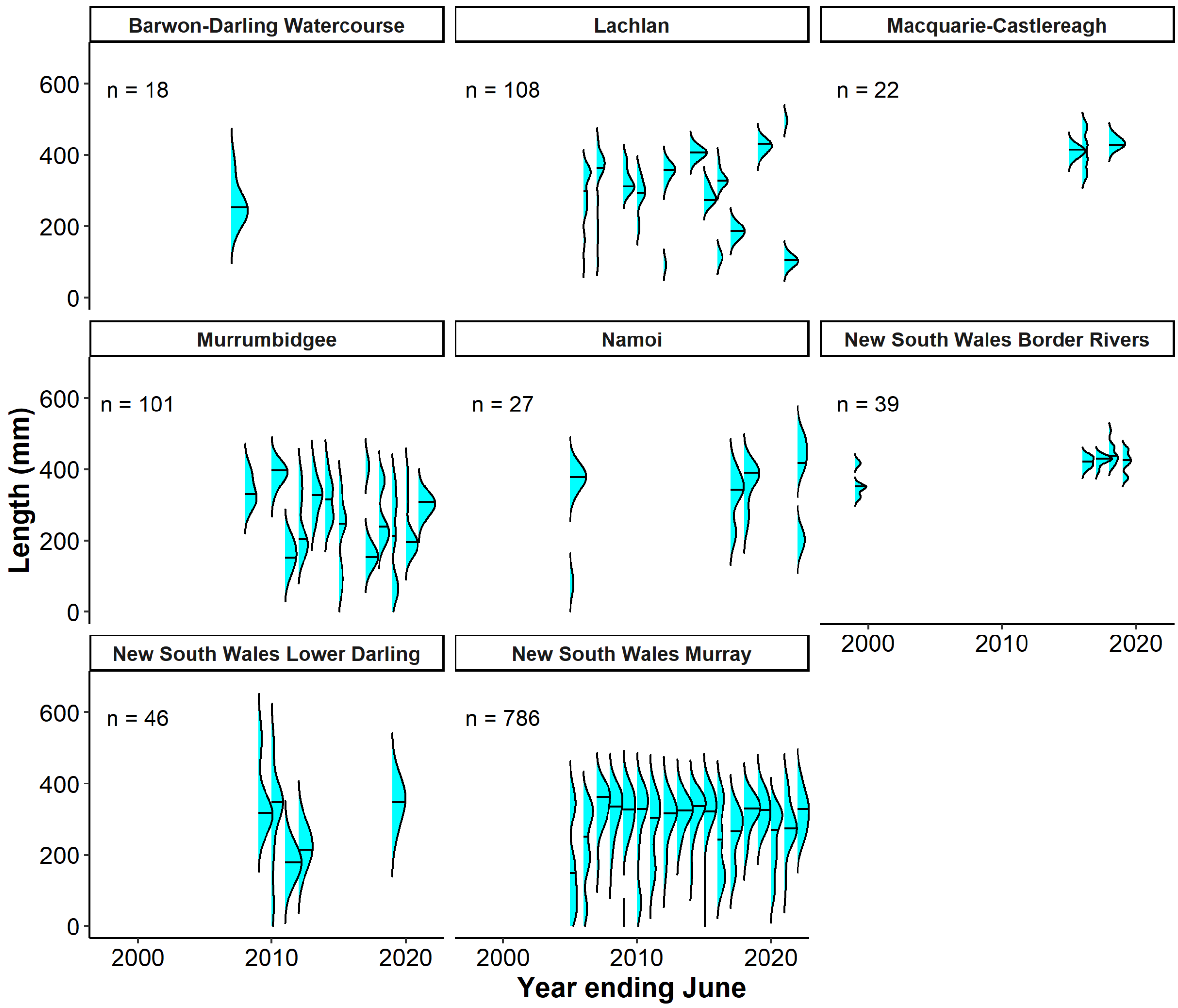

Figure S6. Observed length distributions for silver perch within each of the valleys of the NSW Murray–Darling Basin for each year. *n* represents the total number of length measurements taken in a valley.

Macquarie perch

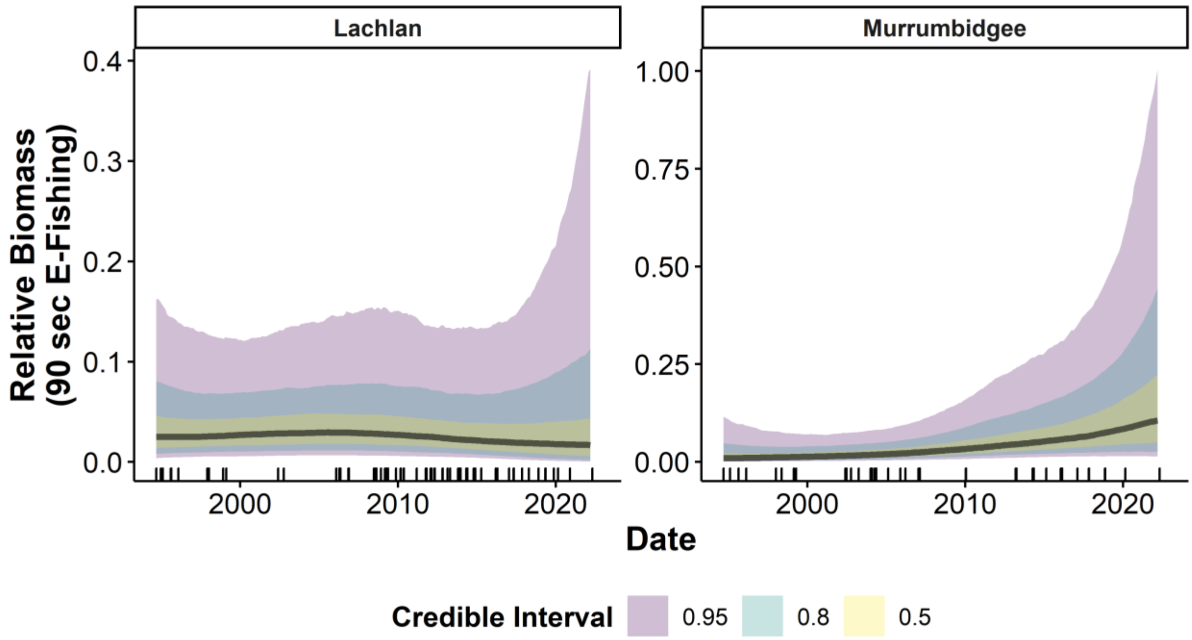

Figure S7. Fitted trends in relative biomass for Macquarie perch within valleys of the NSW Murray–Darling Basin based upon the GAMM analysis. Rug plots on the *x*-axis show sample distribution through time.

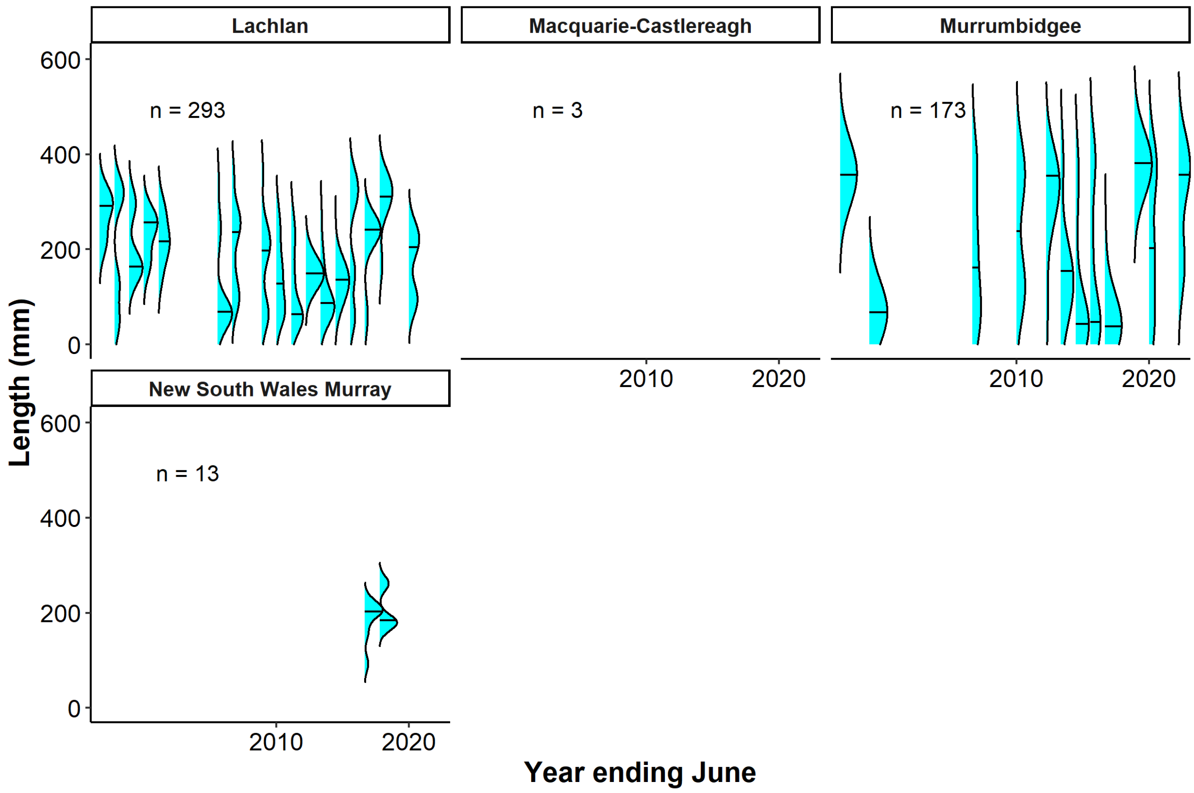

Figure S8. Observed length distributions for Macquarie perch within each of the valleys of the NSW Murray–Darling Basin for each year. *n* represents the total number of length measurements taken in a valley.

Freshwater catfish

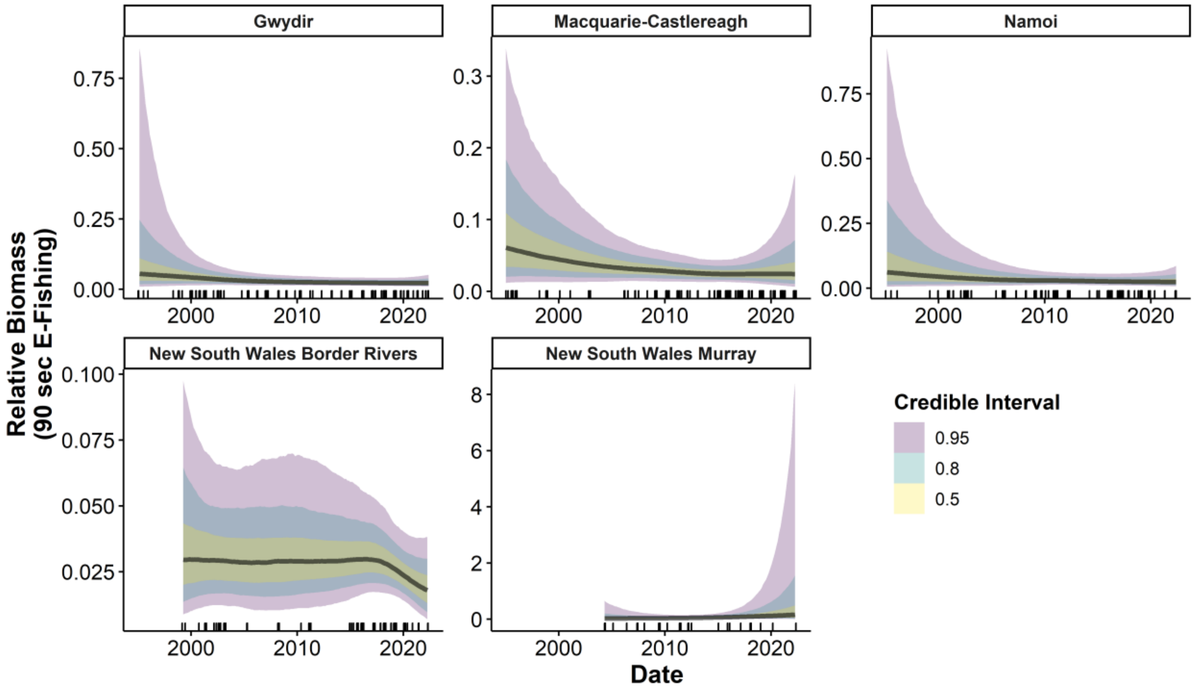

Figure S9. Fitted trends in relative biomass for freshwater catfish within valleys of the NSW Murray–Darling Basin based upon the GAMM analysis. Rug plots on the x-axis show sample distribution through time.

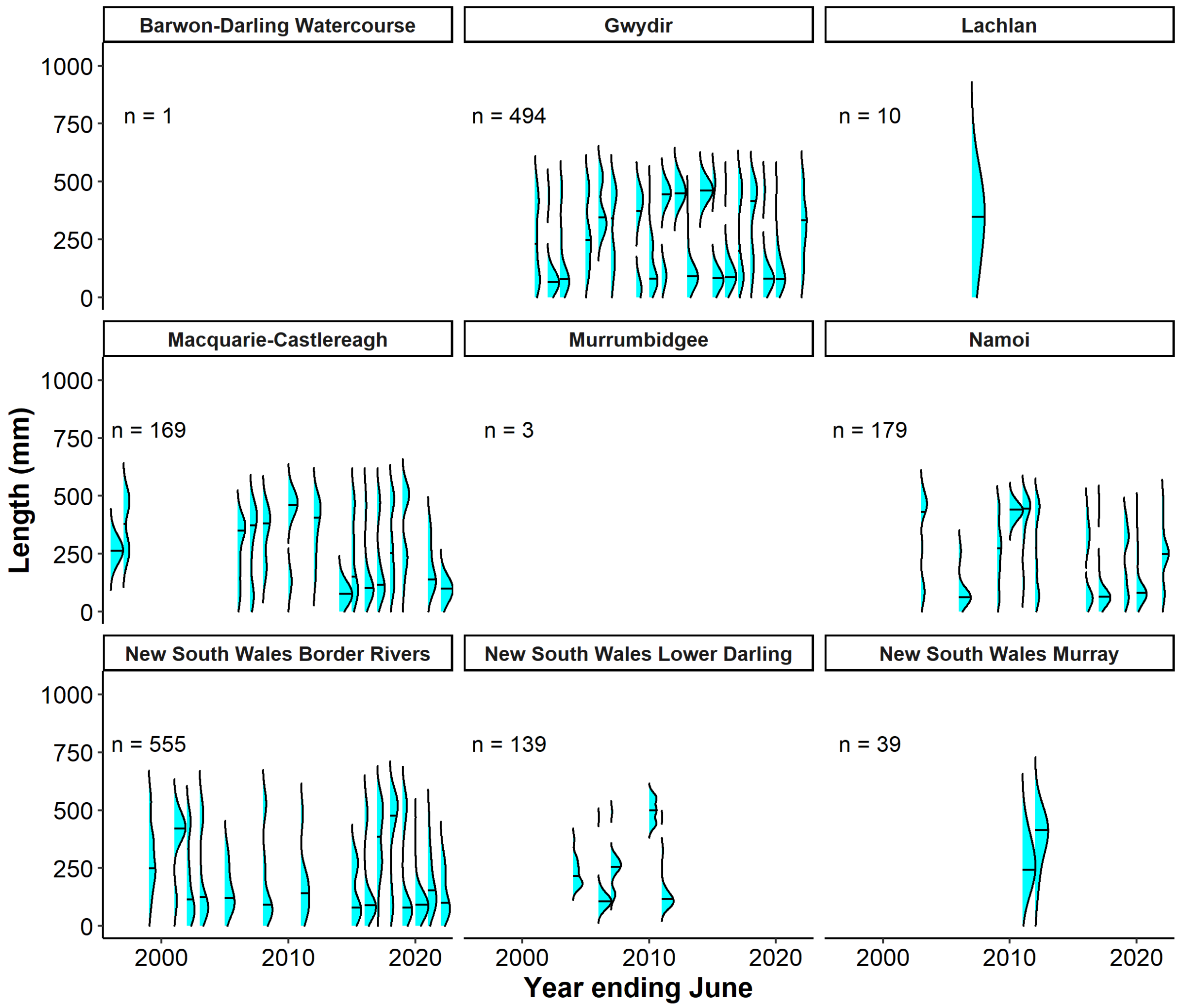

Figure S10. Observed length distributions for freshwater catfish within each of the valleys of the NSW Murray–Darling Basin for each year. *n* represents the total number of length measurements taken in a valley.

Common carp

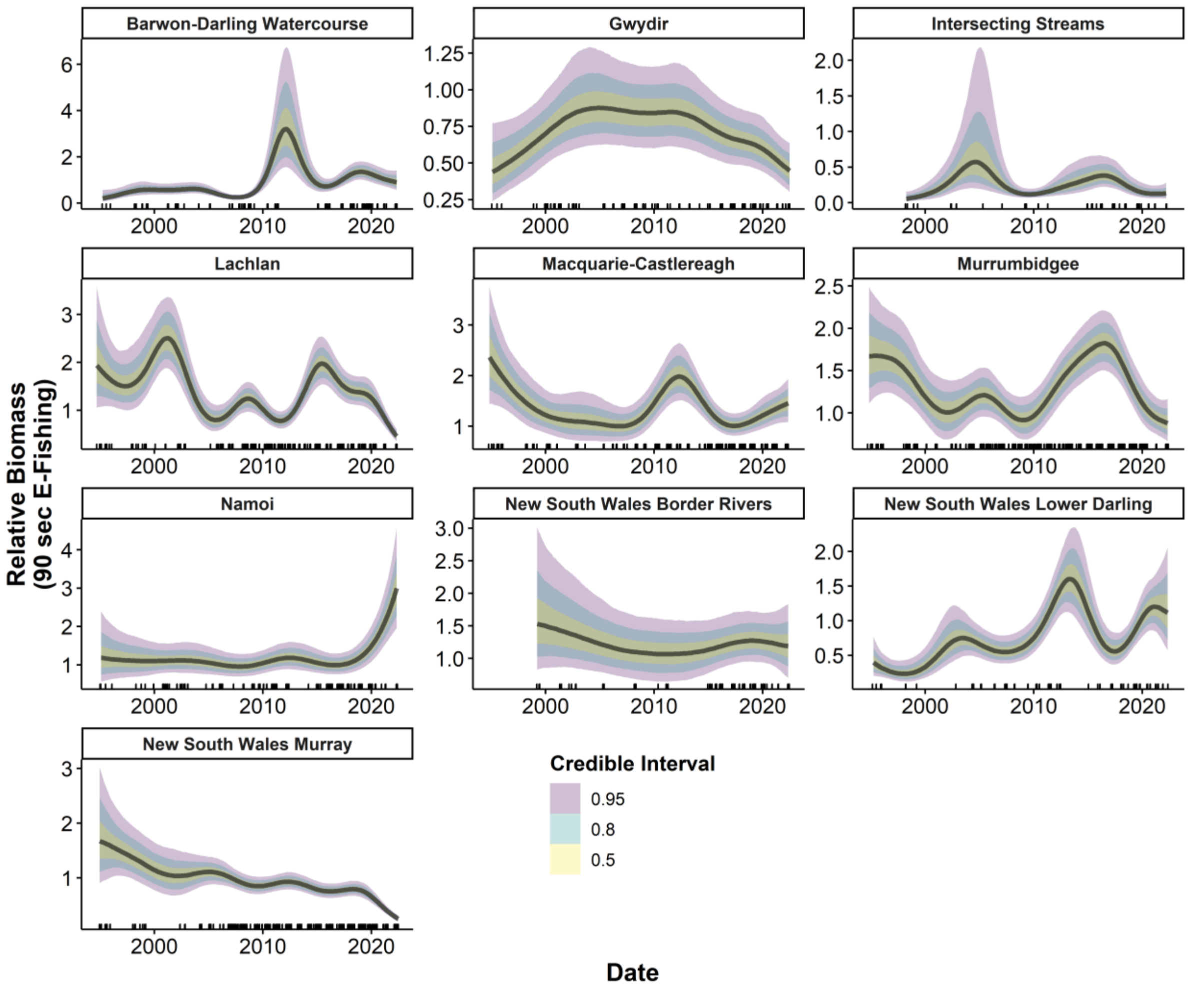

Figure S11. Fitted trends in relative biomass for common carp within valleys of the NSW Murray–Darling Basin based upon the GAMM analysis. Rug plots on the *x*-axis show sample distribution through time.

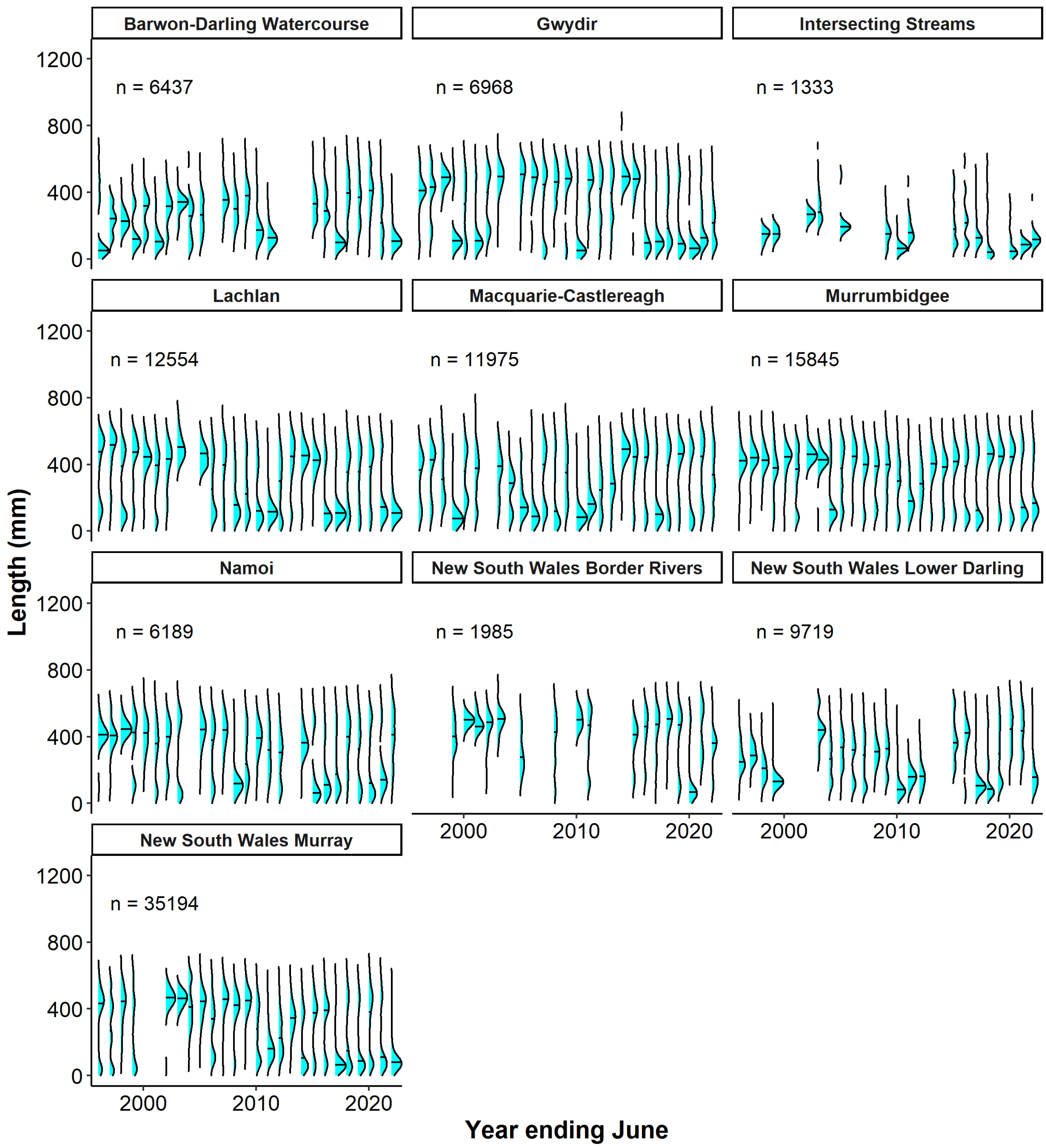

Figure S12. Observed length distributions for common carp within each of the valleys of the NSW Murray–Darling Basin for each year. *n* represents the total number of length measurements taken in a valley.

References

Hayes DB, Brodziak JK, O'Gorman JB (1995) Efficiency and bias of estimators and sampling designs for determining length–weight relationships of fish. *Canadian Journal of Fisheries and Aquatic Sciences* **52**(1), 84–92. doi:10.1139/f95-008