Stock Status Summary – 2022/23

NSW Stock Status Summary – Golden perch
(Macquaria ambigua) riverine fishery

Assessment Authors and Year

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Stock Status

Current stock status	On the basis of the evidence contained in this assessment, the riverine NSW Golden perch stock is classified as **depleted**.

Stock structure & distribution

Golden perch *Macquaria ambigua* has a broad distribution across low- to mid-altitudinal regions of the Murray-Darling Basin (MDB), including NSW, Victoria, South Australia, Queensland, and the ACT. Genetically distinct sub-species are also found in the Lake Eyre catchment, Bulloo River, and the Fitzroy River in Queensland. Genetic analyses of Golden perch demonstrate high gene flow across the MDB, suggesting connectivity among catchments and a lack of spatial population structure (Attard et al. 2017). On this basis, and in alignment with the Status of Australian Fish Stocks reporting framework (Earl et al. 2020), Golden perch are assessed as a single stock across the NSW jurisdiction.

Biology

Golden perch is a medium-large species which may reach 550 mm total length (TL) and a maximum recorded age of 26 years. Sexual maturation in males occurs at ~2-3 years and in females at ~4 years (Mallen-Cooper and Stuart 2003). Growth rates are highly variable and size at sexual maturity varies strongly among geographic locations (Wright et al. 2020; Koehn et al. 2020). Estimated LM50 (mean length at 50% maturity) values for Golden perch are 360 mm TL (95% CI: 341-373) in the Murray River and 371 mm TL (95% CI: 358-384) in the Murrumbidgee River (Forbes et al. 2015). Spawning has been suggested to occur in fish as small as 100 mm TL in the northern MDB (Koehn et al. 2020).

Golden perch are highly fecund, with large females capable of producing >500,000 eggs (Harris and Rowland 1996). Spawning occurs in river channels coincident with overbank or within-channel high flow events, and the pelagic eggs and larvae drift downstream before settling into nursery habitats (King et al. 2016; Stuart and Sharpe 2020). The timing of spawning is flexible in the northern tributaries of the MDB and the Darling-Baaka River and occurs mainly in late Spring and Summer in the Murray catchment (Ebner et al. 2009; King et al. 2016; Thiem et al. 2023).

Recruitment of young-of-year fish is episodic and strongly linked to high flow events and other aspects of river hydrology (Zampatti and Leigh 2013). Although spawning occurs in the Murray River and its major tributaries, length-frequency data suggest that most young-of-year recruitment occurs in northern tributaries of the MDB and the Darling-Baaka River (Stuart and Sharpe 2020; Crook et al. 2023). Natural recruitment of Golden perch is augmented by stocking of hatchery-produced fingerings which can make a substantial contribution to the spawning biomass, especially in impoundments and rivers fragmented by artificial barriers (Crook et al. 2015; Forbes et al. 2015; Attard et al. 2022; Fig. 1).

Golden perch exhibit strong site attachment for prolonged periods (Crook 2004; O'Connor et al. 2005) but may undertake large-scale migrations during high flow conditions that may cover distances of 10s of km to >1,000 km (Reynolds 1983; Marshall et al. 2016; Zampatti et al. 2018). They exhibit a complex 'metapopulation' structure, with large-scale dispersal across river catchments creating a mosaic of connected source and sink sub-populations (Bond et al. 2015; Stuart and Sharpe 2020).

FISHERY STATISTICS

Catch information

Commercial

Until the early 2000s, a significant inland commercial fishery for Golden Perch operated in NSW, with historical records dating back to 1883 when the fishery was established. Commercial fishery data spanning 1947 to 1996 show peak annual catches of 310 tonnes (t) in 1954–55, 293 t in 1975–76, and 173 t in 1993–94 (Reid et al. 1997). These peaks in yearly harvest can be attributed to relationships among fishing effort, catchability, and recruitment events, with largest catches associated with periods of high river flow (Reid et al. 1997). The commercial fishery for Golden perch in NSW was substantially reduced by the 1990s and the commercial fishery was closed in September 2001. Incidental catches of Golden Perch still occur in the Common Carp commercial fishery in NSW, but this bycatch is small and has negligible effects on Golden Perch populations. A commercial fishery for Golden perch still exists in the lower Murray River system in South Australia (Earl et al. 2022).

Recreational

Golden Perch constitutes a significant component of the freshwater recreational fishery in NSW, with anglers often pursuing them in conjunction with Murray Cod and other species in both rivers and impoundments. Recreational fishing for Golden Perch in NSW is open year-round, with harvest restrictions of a minimum legal length of 300 mm, a daily bag limit of 5 fish, and a possession limit of 10 fish per licence holder. The NSW Golden perch fishery is augmented by stocking large numbers of hatchery-produced juvenile fish into waterways on an annual basis (Fig. 1). Stocking commenced in 1961 and has been conducted annually since 1976. These fish are produced by independent and NSW Government hatcheries, and stocking is managed under a permitting system operated by NSW DPI Fisheries.

Recreational Golden perch fisheries in NSW can be broadly categorised as impoundment or riverine fisheries. Impoundment fisheries for Golden perch are defined as those located in the lentic (non-flowing) habitat upstream of major dams on rivers. More than 50 impoundments in NSW are regularly stocked with Golden perch, including major fisheries in Lake Hume (Murray River), Lake Burrinjuck (Murrumbidgee), Talbingo Reservoir (Tumut River), Lake Keepit (Namoi River), Wyangala Dam (Lachlan River), Burrendong Dam (Macquarie River) and Copeton Dam (Gwydir River). Impoundments are generally considered as 'put-and-take' fisheries for Golden perch in NSW because natural recruitment is absent or very limited, and the viability of the fishery is reliant on continued stocking of hatchery-reared fish. Impoundment fisheries require location-specific stocking strategies and stock status assessments and are, therefore, excluded from further consideration in this stock status summary.

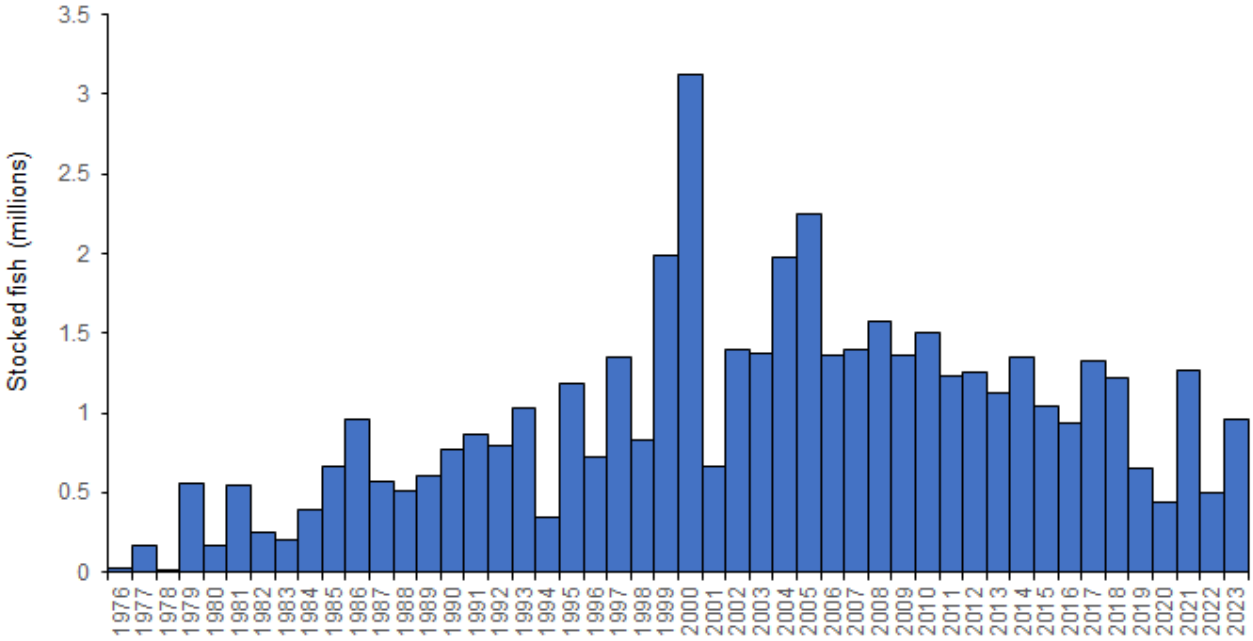

Figure 1: Numbers of hatchery-produced Golden perch stocked into NSW waterways since annual stocking began in 1976. Years represent 1st July – 30th June, ending June 30th of the year displayed.

Riverine fisheries for Golden perch are located in rivers and streams, as well as associated wetlands and off-channel storages (e.g., Menindee Lakes). Smaller weirs on main river channels are also considered part of the riverine fishery (e.g., Hay Weir pool on the Murrumbidgee River). In contrast to impoundment fisheries, riverine Golden perch fisheries are 'open' systems that may be supported by both natural recruitment and stocking (the relative contribution of natural and stocked recruits varies considerably among locations; Crook et al. 2015). Fish assemblage survey data, including information on Golden perch populations, has been collected by monitoring and research programs in riverine habitats across NSW since the early 1990's. This information is used to support the current assessment of the riverine Golden perch fishery in NSW (see below).

Data on the recreational catch of Golden perch in NSW and the ACT was collected around the time of the commercial fishery closure as part of the National Recreational and Indigenous Fishing Survey (Henry and Lyle 2003). An additional survey was conducted in 2013/14 as part of the Survey of Recreational Fishing in New South Wales and the ACT (West et al. 2015). Data from both studies were derived from surveys of responders accessed via the White Pages. Results from these surveys demonstrate a sharp decline in retained (kept) and returned (catch-and-release) Golden perch between 2000/01 and 2013/14 (Fig. 2).

Data on the recreational catch of Golden perch in 2017/18, 2019/20 and 2021/22 were collected via offsite telephone-diary surveys of recreational fishing licence (RFL) households in NSW/ACT (West et al. 2015; Murphy et al. 2020, 2022; NSW DPI unpubl. data). The change in methodology from White Pages to RFL precludes direct comparisons between the 2000/01 and more recent catch estimates. However, a subset of data collected for 2013/14 used the RFL methodology and allows for comparison between 2013/14 and subsequent years. This comparison demonstrates that the retained and returned catches of Golden perch have continued to decline since 2013/14 (Figure 3). The most recent, comparable estimates of retained catch (numbers of fish) in the riverine fishery are 51,604 (±12,422 SE) in 2017/18, 38,521 (±15,565 SE) in 2019/20 and 14,994 (±4,699 SE) in 2021/22.

Rates of catch-and-release for Golden perch in NSW are high and have generally increased over time, with rates of ≈40% in 2000/01 increasing to 81% in 2021/22 (NSW DPI unpubl. data). Post-

release mortality of Golden perch is dependent on fishing method, time of year, holding times and fish size (Hall et al. 2012; 2015). Based on post-release survival rates and angler survey data, it is estimated that ≈10% of released Golden perch experience post-release mortality. However, further research is required to develop a more precise estimate of post-release mortality in the fishery.

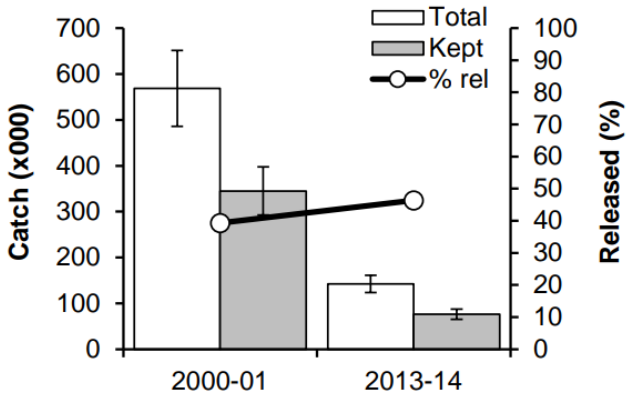

Figure 2: Total catch numbers (kept and released), harvest numbers (kept), and proportion (%) of the total catch released for Golden perch in NSW/ACT, by residents aged five years and older who fished in NSW/ACT waters during 2000/01, compared with 2013/14. These surveys used data from respondents accessed via the White pages. Error bars represent one standard error (reproduced from West et al. 2015).

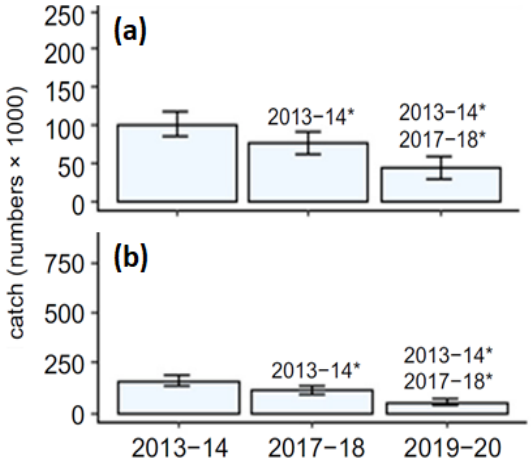

Figure 3: Estimated catch of golden perch (a) retained and (b) released through recreational fishing activity in NSW and ACT in 2013–14, 2017–18 and 2019–20. Error bars represent 1 standard error of the total estimated effort. Significant P-values (α = 0.05) from pairwise comparisons of years are indicated by an asterisk (*), with the associated year in the comparison being labelled. These data were collected via offsite telephone-diary surveys of recreational fishing licence (RFL) households, excluding RFL households in Queensland (reproduced from Ochwada-Doyle et al. 2023).

Aboriginal cultural fishery

Golden perch have very high cultural significance for Aboriginal people across NSW (Humphries 2007). Archaeological evidence from midden sites and fish traps shows that Golden perch have supported traditional fisheries for ~30,000 years (Balme 1995; Martin et al. 2023). The current level of Indigenous fishing for Golden perch in NSW has not been quantified.

Illegal, Unregulated and Unreported

The level of Illegal Unregulated and Unreported (IUU) fishing has not been quantified.

Fishing effort information

Data on recreational fishing effort in freshwater in NSW and the ACT was collected via offsite telephone-diary surveys in 2013/14, 2017/18 and 2019/20 (West et al. 2015; Murphy et al. 2020, 2022). Declines in fishing effort have been attributed to the severe 'Millennium' drought, the 'Black Summer' bushfires, widespread flooding in 2019-21, and the COVID-19 pandemic, all of which had adverse effects on human mobility (Ochwada-Doyle et al. 2023).

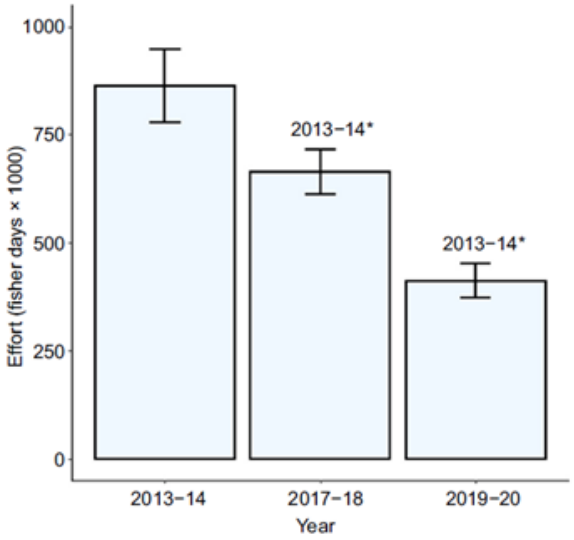

Fig. 4. Estimated total recreational fishing effort in NSW and ACT freshwaters in 2013–14, 2017–18 and 2019–20. Error bars represent 1 standard error of the total estimated effort. Significant P-values (α = 0.05) from pairwise comparisons of years are indicated by an asterisk (*), with the associated year in the comparison being labelled (reproduced from Ochwada-Doyle et al. 2023).

Catch Rate information

Fishery independent, effort-adjusted monitoring data have been collected for riverine sites by NSW DPI Fisheries since 1994. These data are collected using a standardised electrofishing protocol to facilitate calculation of catch-per-unit-effort (CPUE) over time. CPUE data was analysed using generalised additive mixed models (GAMMs) to directly estimate trends relative abundance, relative biomass and recruitment of Golden perch from 1994 to 2023 (see Crook et al. 2023 for details of the analytical method). Data from angler surveys (2013/14, 2017/18, 2019/20, 2021/22) were also used to examine variation in recreational fishing harvest (West et al. 2015; Murphy et al. 2020, 2022).

Trends in abundance and biomass

Trends in relative abundance and relative biomass estimated from electrofishing surveys conducted between 1994 and 2023 are presented in Figures 5 and 6. The total relative abundance of Golden perch increased after the 1990's and early 2000's, with a strong peak occurring during consecutive flood years in 2010/11 and 2011/12 (Fig. 5a). This peak was associated with high young-of-year (YOY) abundance in 2011/12 and 2012/13 (Fig. 7). Relative abundance of legal-sized (>300 mm TL) Golden perch has approximately doubled since the 1990's and early 2000's (Fig. 5b).

The total relative biomass of Golden perch has fluctuated considerably across the time series, with peaks around 1994, 2003 and 2018, and troughs around 1998 and 2009 (Fig. 6a). The troughs in biomass occurred in years where the population had a relatively high proportion of small fish

(Fig. 6). Relative biomass estimates of legal-sized Golden perch are also variable, with a severe trough around 2009 followed by a subsequent recovery to levels similar to the early 2000s (Fig. 5b).

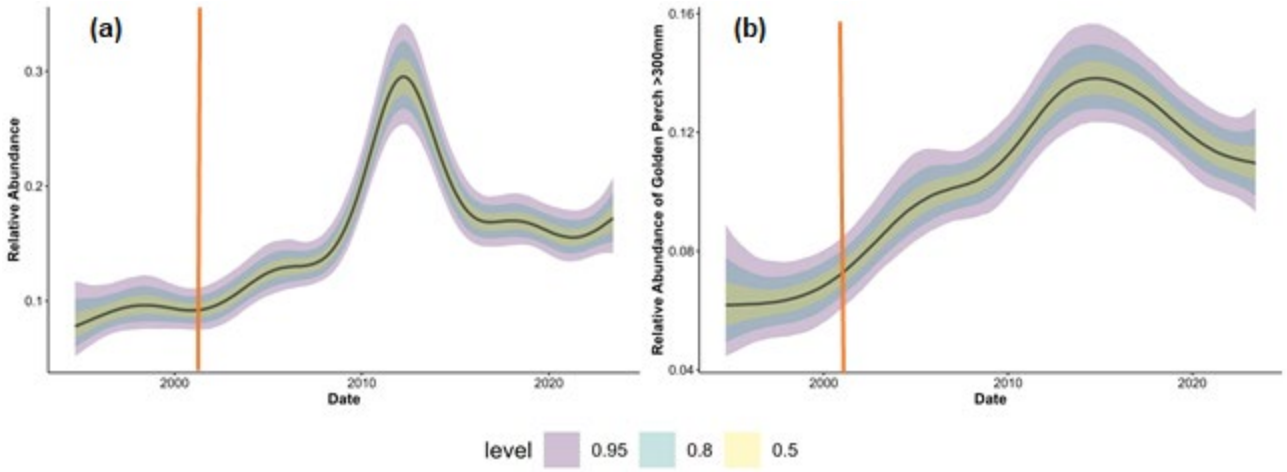

Fig. 5. (a) Total relative abundance and (b) relative abundance of legal-sized fish (>300 mm TL) in NSW since standardised electrofishing surveys commenced in 1994 based on a generalised additive mixed model. Credible intervals around the estimate (black line) are shown. Red line shows approximate timing of commercial fishery closure. Note different y-axis scales.

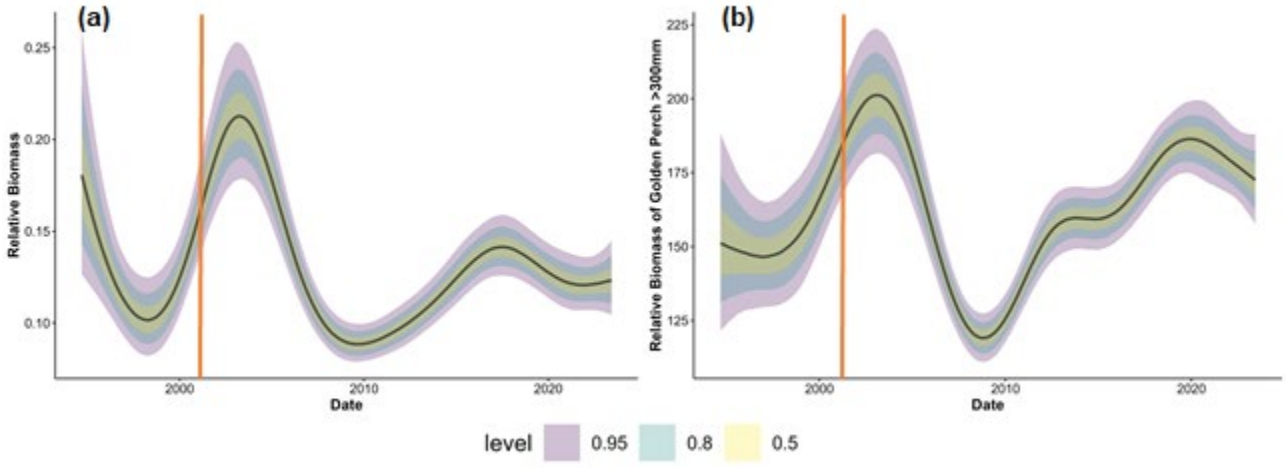

Fig. 6. (a) Total relative biomass and (b) relative biomass of legal-sized fish (>300 mm TL) in NSW since standardised electrofishing surveys commenced in 1994 based on a generalised additive mixed model. Credible intervals around the estimate (black line) are shown. Red line shows approximate timing of commercial fishery closure. Note different y-axis scales.

Recruitment

Length-frequency data for Golden perch collected across the MDB by electrofishing surveys since the 1990s shows that recruitment is highly episodic (Fig. 7). Several sequential years of high YOY abundance have occurred on an approximately decadal frequency in association with periods of

relatively high river flow (1998-2001, 2010-2013, 2021-2022). A recent analysis conducted at the river scale demonstrated that ≈66% of all observed young-of-year (YOY; <124 mm- TL) golden perch in NSW were collected in the Darling-Baaka, Barwon and Warrego rivers (NSW DPI Fisheries unpubl. data). The analysis showed a strong correlation between YOY abundance and river flow in the months preceding sample collection in these three rivers, as well a significant positive effect of stocking rate on YOY abundance (NSW DPI Fisheries unpubl. data).

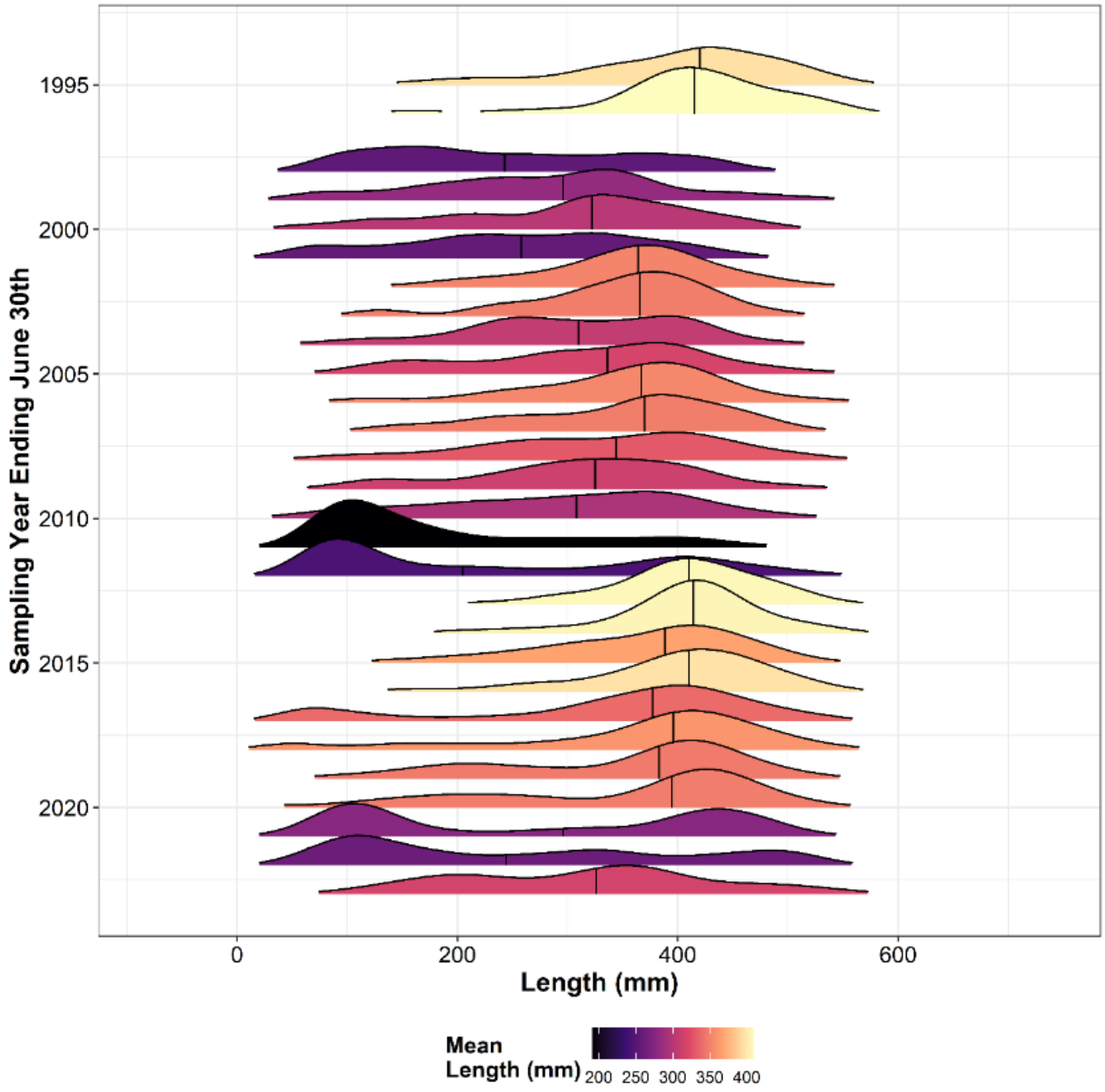

Fig. 7. Length-frequency (total length) distributions of riverine Golden perch in NSW since standardised electrofishing surveys commenced in 1994. Vertical lines on the plots show the median size and colours show the mean length for each year.

STOCK ASSESSMENT

Stock Assessment Methodology

Year of most recent assessment

2022/23

Assessment method

A review of indicators (weight-of-evidence approach) was used to assess the status of the riverine NSW Golden perch stock. Quantitative stock assessment based on fishery catch data was not possible because commercial fishing for Golden perch ceased in 2001 and there are currently insufficient data on recreational and Indigenous harvest to support quantitative stock assessment.

A Harvest Strategy or equivalent management framework has not yet been developed for Golden perch in NSW and, hence, there are no previously established status indicators upon which to assess the Golden perch fishery. Estimates based on expert opinion suggest that native fish stocks in the MDB may have declined by 90% since European settlement (MDBC 2003); however, such estimates are general in nature (i.e., do not apply specifically to Golden perch) and have high levels of uncertainty (i.e., they are 'guesstimates', Kopf et al. 2019). Additionally, there are likely to have been broad-scale declines in the carrying capacity of habitat to support native fish biomass in the MDB due to habitat degradation and other anthropogenic disturbances over the past two centuries (Kopf et al. 2019). For these reasons, estimation of the unfished biomass of Golden perch (i.e., the pre-European settlement condition) is not considered as a suitable approach for the development of reference points for the contemporary fishery.

For the purposes of this report, estimates of relative biomass from fishery independent surveys (Fig. 6) are used as indicators of stock status. Relative biomass of legal sized fish (>300 mm TL) at the time of closure of the commercial fishery (2001) is used as the Limit Reference Point. This reference point assumes that in 2001 the stock was depleted (see Harris and Gehrke 1997; MDBA 2003) and, therefore, that stock biomass below 2001 levels poses a high risk of impaired recruitment.

Estimates of retained catch from recreational fishery surveys are used as indicators of fishing mortality. The retained catch in the riverine fishery at the time of the commercial fishery closure is used as the Fishing Mortality Limit Reference Point based on results from the 2000/01 recreational fishing survey (Henry and Lyle 2003). Very little data is currently available on the effects of fishing mortality on the biomass of the NSW Golden perch stock, although a recent study by Nixon et al. (2022) reported a negative correlation between Golden perch biomass and waterhole remoteness from town centres (proxy for fishing pressure) in Queensland. Use of the 2000/01 retained catch as the Fishing Mortality Limit Reference Point recognises that fishing mortality has potential impacts on the NSW stock and assumes that increases in fishing mortality above 2000/01 levels may pose an increased risk of impaired recruitment.

Main data inputs

- Fishery independent, effort-adjusted monitoring data collected using electrofishing from 1994 to 2023 (NSW DPI Freshwater Ecosystems Unit database; Crook et al. 2023).
- Recreational fishing catch and effort data for NSW/ACT collected via household surveys from White Pages in 2000/01 and 2013/14 (Henry and Lyle 2003; West et al. 2015) and offsite telephone-diary surveys of RFL households in 2013/14, 2017/18, 2019/20 and 2021/22 (West et al. 2015; Murphy et al. 2020, 2022; NSW DPI unpubl. data).

Key model structure & assumptions

There are several key analytical considerations for interpreting the GAMM outputs (see Crook, Schilling et al. 2023 for a detailed discussion). These include the efficiency of electrofishing, which can vary considerably based on species, size classes within species, and environmental factors like water conductivity, depth, and turbidity. Random effects were used in the statistical analyses to account for detection probabilities and estimate trends in relative abundance and biomass. The representativeness of sampling sites also has important implications and may be influenced by the initial sampling design or limitations posed by environmental conditions like drought. Site weighting was not used to account for potential site selection bias; however, the analysis is considered robust due to the large number of widespread sites and consistent sampling methodology over the time series.

The modelling approach optimises the available data but doesn't address situations with no data or differentiate mechanisms governing fish abundance. For example, intense droughts can lead to unsampled dry sites, potentially biasing relative abundance estimates. Although few dry sites were encountered, their exclusion might slightly alter model outcomes. Concentration of fish in remaining waterholes during low water levels might also obscure trends, and the random effect structure in the model partially addresses this variability. Predictions during extreme water levels should be approached with caution, as they might not fully depict actual abundance patterns. Changes in sampling efficiency over time, such as due to technological upgrades, have the potential to influence the model outputs. However, standardized sampling procedures using consistent electrofishing equipment were closely followed throughout the study period, minimizing concerns regarding the impact of technological improvements on the analyses.

A detailed discussion of the structure and assumptions associated with the NSW recreational fishing survey data is provided by Murphy et al. (2022).

Sources of uncertainty evaluated

General data limitations and uncertainty was considered in the weight-of-evidence approach. Uncertainty in the modelled estimates of relative abundance and relative biomass is represented by credible intervals along the time series.

Status Indicators - Limit & Target Reference Levels

Biomass Indicator or proxy	Estimates of relative biomass (CPUE) of legal-sized fish from fishery independent surveys
Biomass Limit Reference Point	Relative biomass (CPUE) of legal-sized fish at the time of commercial fishery closure (2001)
Target Reference Point	N/A
Fishing Mortality indicator or proxy	Retained catch estimates from recreational fishing surveys
Fishing Mortality Limit Reference Point	Retained catch based on 2000/01 recreational fishing survey results (240,000 fish pa, rivers only, based on ≈67% of total catch)
Fishing Mortality Target Reference Point	N/A

Stock Assessment Results

The NSW Golden perch stock is classified as **depleted**. The status is based on:

- Fishery independent, effort-adjusted catch data from the riverine fishery demonstrates no overall trend in relative biomass of legal-sized fish since 2001.

Stock Assessment Result Summary

Status in relation to Limit	No overall trend in relative biomass (CPUE) of legal-sized fish since 2001
Status in relation to Target	N/A
Fishing mortality in relation to Limit	Retained catch has decreased substantially since 2000/01 and 2013/14 recreational fishing surveys. Retained catch estimate (rivers only) for 2021/22 is 14,994 fish ± 4699 SE (NSW DPI unpubl. data)
Fishing mortality in relation to Target	N/A
Current SAFS stock status	Undefined

Fishery interactions

N/A

Qualifying Comments

Although there is evidence of an increasing trend in relative abundance and a sharp decline in fishing mortality associated with the recreational fishery since 2001, the NSW Golden perch stock is assessed as 'depleted' due to the lack of a recovery in stock biomass since closure of the commercial fishery in 2001.

There is strong evidence that environmental forcing is an overriding driver of recruitment to the Golden perch fishery. For example, episodic recruitment events occur in response to high flows (Fig. 3; Thiem et al. 2023), flow regulation and fragmentation has adverse effects on recruitment across the MDB (Koehn et al. 2014), and large-scale fish kills during hypoxic conditions have caused severe depletion in affected regions (Stocks et al. 2021). Given the sharp decline in retained catch since 2001 and the existing minimum size and bag limits, fishing mortality is considered to have only a minor effect on the NSW stock in comparison with environmental disturbances. The long-term sustainability of Golden perch populations in NSW is contingent on appropriate water and habitat management to ameliorate the threats posed by human disturbance and climate change.

This assessment has used available information to derive biomass indicators and limit reference points for Golden perch. The Fishing Mortality Limit Reference Point of 240,000 fish pa from the riverine fishery is based on data from the National Recreational and Indigenous Fishing Survey which used the White Pages survey methodology (Henry and Lyle 2003). This methodology has been superseded in subsequent recreational fishing surveys which have accessed information from RFL households. As a consequence, data from the 2001/01 and 2013/14 cannot be directly compared to recent surveys. Assessment of the status of the NSW Golden perch stock in relation to the Fishing Mortality Limit Reference Point needs to account for differences in the survey

methodology. In this assessment, the retained catch estimate of 14,994 ± 4699 SE for 2021/22 is well below comparable data for previous years (see Fig. 3), confirming that the Fishing Mortality Limit Reference Point was not close to being exceeded in the most recent available recreational fishing survey.

The development of formalised methods for establishing suitable indicators/proxies, limit reference points, and target reference points to support standardised quantitative stock assessment is a high priority for future stock status summaries for freshwater species.

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