Department of Primary Industries
Department of Regional NSW

NSW Stock Status Summary – 2023/24

Silver Trevally (*Pseudocaranx georgianus*)

Assessment Authors and Year

Burch, P., Fowler, A., Liggins, G., Sporcic, M., Dowling, N., Chick, R., Tuck, G. 2023. A joint Commonwealth and NSW assessment of Silver Trevally (*Pseudocaranx georgianus*). Prepared for the Australian Fisheries Management Authority. 83 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Silver Trevally are currently assessed as recovering.

Stock structure & distribution

Silver Trevally (*Pseudocaranx georgianus*), formerly known as *P. dentex*, have a relatively contiguous distribution from northern NSW to Western Australia, south of 25˚S latitude (Bearham et al. 2020). However, stock structure is poorly understood. Their continuous distribution, the dominance of the East Australian Current, and a recent genetic study, suggest Silver Trevally are likely genetically homogenous on Australia's east coast (Bearham et al. 2020). Tagging studies in Australia and New Zealand suggest that movement after settlement is limited, so there is potential for finer-scale population structure within the east coast population (Fowler et al. 2018).

Scope of this assessment

The stock status for Silver Trevally in NSW is based on a recent model-based stock assessment conducted jointly by NSW and the Commonwealth (hereafter "the assessment"; Burch et al. 2023). The assessment assumes a single biological stock spanning the mainland jurisdictions of NSW, the Commonwealth and Victoria. This reflects likely stock structure (see above) and the fact that the two jurisdictions responsible for greatest catch historically (NSW and the Commonwealth) are primarily separated in an onshore-offshore direction.

The assessment presents results for a single base-case model and a range of alternative scenarios designed to examine the sensitivity of the base-case result to various uncertainties. While most of these scenarios resulted in minimal change to final estimates of biomass depletion (see Appendix 1), the model result was sensitive to the value of natural mortality (*M*) used. The current stock status determination for NSW is therefore based on the results from the base-case model and a sensitivity scenario that used a lower value of *M*. The rationale for this approach is outlined in the Stock Assessment Results section.

Note that the final year of depletion presented in the assessment (2024) actually represents a one-year forecast, to inform upcoming Total Allowable Catch (TAC) determinations in the Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery (SESSF). The NSW stock status in the current report is based on depletion estimates at the start of the preceding year (2023), which is the last year informed by data within the model. All references to current or final biomass estimates in this report therefore refer to 2023.

Biology

Silver Trevally inhabit estuarine and coastal waters to depths of up to 200 m and are moderately long lived with a maximum observed age of 24 years (Rowling and Raines 2000). They are moderately fecund and mature at a relatively early age (2–4 years). The species is a broadcast spawner, with pelagic eggs and larvae distributed by currents prior to settlement on soft sediment habitat. Silver Trevally are fast swimmers but the majority of individuals may not move long distances in the adult phase (Fowler et al. 2018).

Fishery statistics

Catch information

Commercial

Commercial landings (and estimated discards) included in the assessment are shown in Figure 1. Six commercial catch fleets were included in the assessment: NSW fish trawl (NSWFTRL), NSW fish trap (NSWFTRP), NSW line (NSWLN), NSW estuary (NSWEST), Commonwealth trawl (CWTRL) and Vic commercial (VICCOM).

Total reported commercial landings during 2022 were 78.4 t, slightly lower than the preceding year (83.2 t). Total landings in 2022 comprised 8.6 t from NSWFTRL, 6.3 t from NSWFTRP, 2.2 t from NSWLN, 5.6 t from NSWEST, 35.7 t from CWTRL and 19.8 t from VICCOM.

Discarding was negligible prior to 2007 when a minimum legal length (MLL) was introduced in NSW. After that year, an average discard rate of 27% by weight was estimated for NSWFTRL from an onboard observer study (NSW DPI, unpublished).

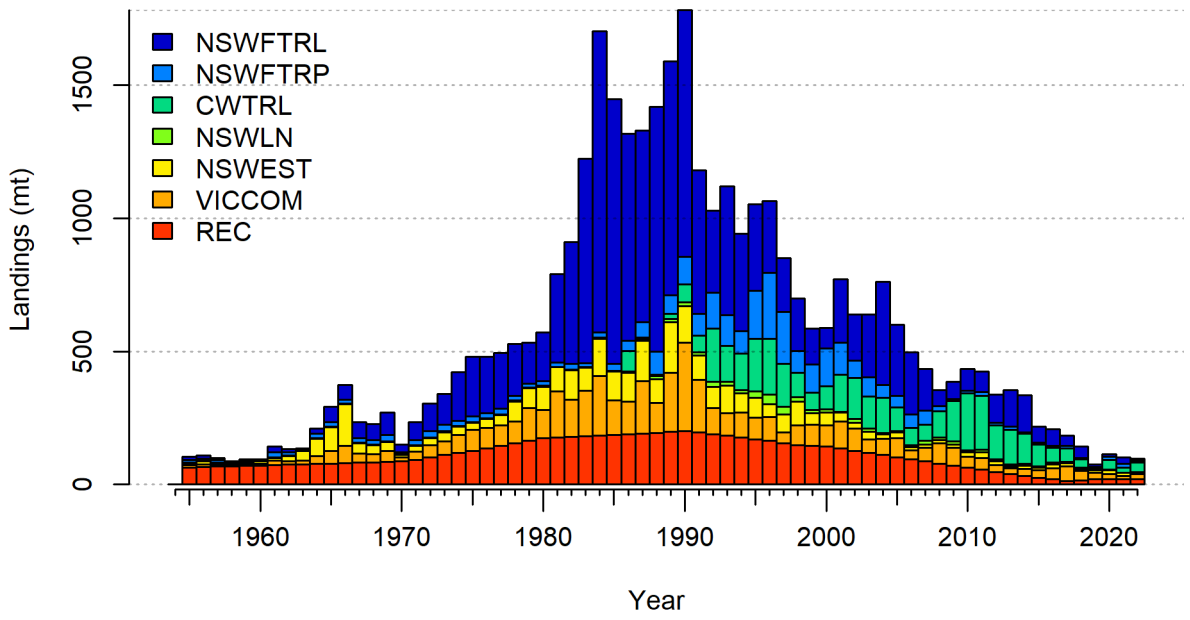

Figure 1. Landed catch and estimated discards of Silver Trevally by fleet. Note that the catches for the NSW and Victorian recreational (REC) and Victorian commercial (VICCOM) fleets have been imputed.

Recreational & Charter boat

Estimates of recreational harvest from NSW and Vic were combined into a single fleet in the assessment (REC, Figure 1).

Four estimates of harvest by recreational fishers resident in NSW were used in the assessment: 140,000 fish during 2000/01 (Henry and Lyle 2003), 49,000 fish during 2013/14 (West et al. 2015), 15,000 fish in 2017/18 (Murphy et al. 2020) and 24,000 fish in 2019/20 (Murphy et al. 2022). Estimates in numbers of individuals were converted to harvest weights for assessment purposes: 100 t during 2000/01, 27 t during 2013/14, 8 t in 2017/18, and 13 t in 2019/20. Victorian recreational harvest was estimated at 42.9 t during 2000/01 using the ratio of NSW to Vic catch in numbers during that year.

Indigenous

Aboriginal cultural catch of Silver Trevally has not been quantified, yet has been assumed to be at a consistent or low level such that it would not substantially influence assessment outcomes.

Illegal, Unregulated and Unreported

The level of Illegal, Unregulated and Unreported (IUU) fishing has not been quantified, yet has been assumed to be at a consistent or low level such that it would not substantially influence assessment outcomes.

Fishing effort information

Fishing effort was used in the calculation of standardised CPUE time-series included in the assessment.

Catch rate information

Time-series of standardised CPUE for three catch fleets were included in the assessment: 1) NSWFTRL, 2) NSWFTRP, and 3) CWTRL (Figure 2). Management changes in NSW during 2007-2009, including introduction of the MLL, necessitated a gap in the series from that jurisdiction. The resulting discontinuity was accommodated in the model by time-blocking catchability.

Patterns in CPUE were inconsistent among series during the earlier period and consistent during the later period, noting that the series for CWTRL commences 12 years prior to those from NSW (Figure 2). From 2010 onward, all series show a decline to 2019 and a subsequent increase during the most recent three years. Best model fits were observed for NSWFTRP. CPUE values for NSWFTRL and CWTRL were underestimated during intermediate years and overestimated during later years.

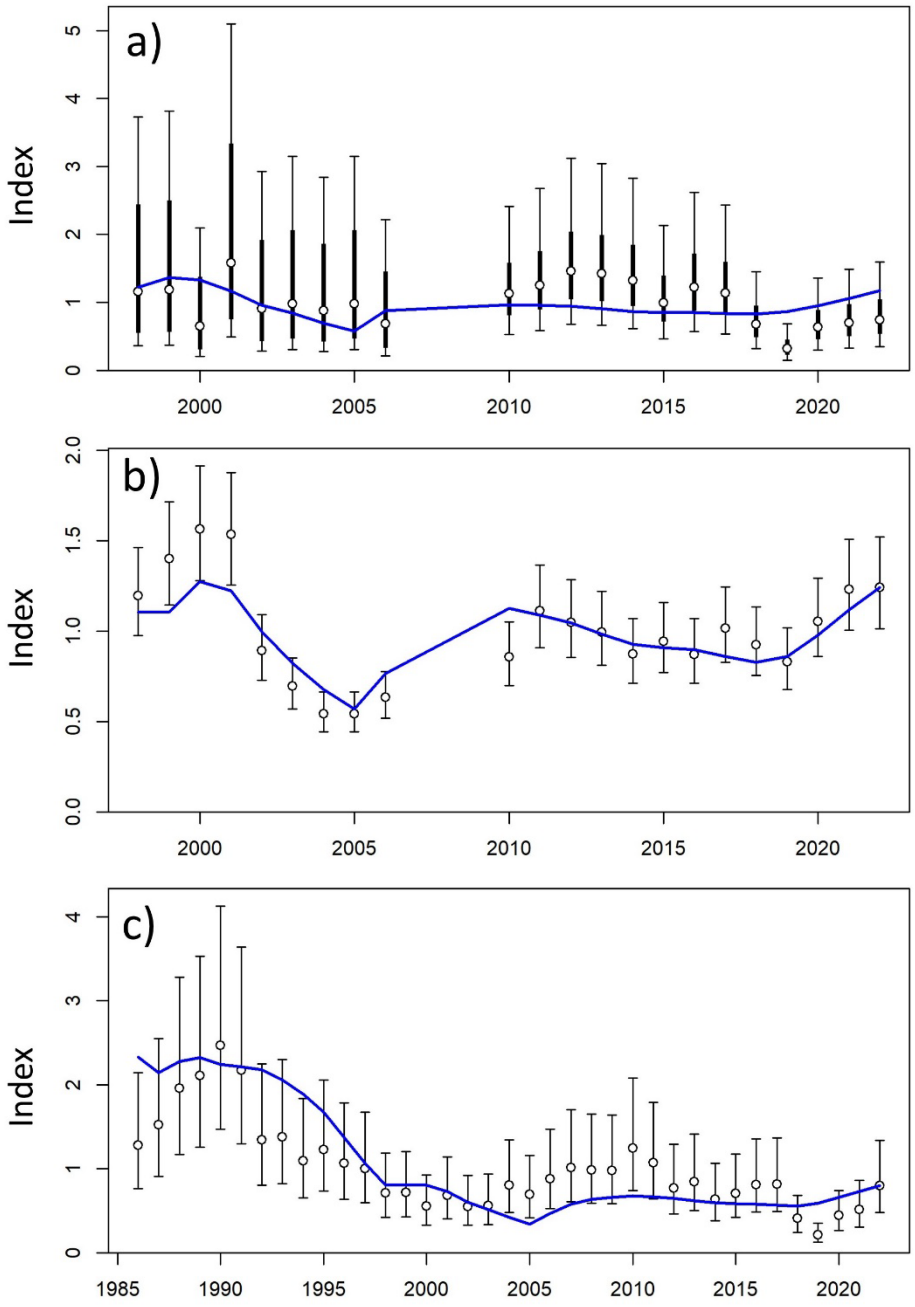

Figure 2. Standardised CPUE series for: a) NSW trawl (NSWFTRL), b) NSW trap (NSWFTRP) and c) Commonwealth trawl (CWTRL) fleets included the assessment. Observed values are indicated by open circles, model estimates are indicated by the blue line. Error bars indicate approximate 95% asymptotic intervals. Note the different time period for CWTRL.

Stock Assessment

Stock Assessment Methodology

Year of most recent assessment:

2023 (using data to 2022)

Assessment method:

An integrated age- and length-structured population model including multiple catch fleets and abundance (CPUE) indices was used for the assessment and was undertaken using Stock Synthesis 3.30.21 (Methot and Wetzel 2013). A single base-case model was developed and the potential effects of various uncertainties on the base case result were explored using a range of alternative (sensitivity) scenarios.

The current stock status determination for NSW is based on two models: 1) the original base case, hereafter 'high-*M* model', and 2) the base case with a lower *M* value, hereafter 'low-*M* model'. Rationale and results for both are provided in the Stock Assessment Results section.

Main data inputs:

- Landings (t) from seven fleets across NSW, Vic and the Commonwealth zones 10, 20 and 60 (the areas off NSW and Victoria) from 1955–2022 were included. Fleets were NSW fish trawl (NSWFTRL), NSW fish trap (NSWFTRP), NSW line (NSWLN), NSW estuary (NSWEST), Commonwealth trawl (CWTRL, 1986-2022), Vic commercial (VICCOM) and recreational (REC). The REC fleet included both NSW and Vic harvest estimates. Annual estimates of recreational harvest were produced by interpolating between recent offsite survey estimates (since 2000) and imputation in prior years. Vic recreational harvest was imputed from NSW estimates using a catch ratio from the single year where estimates for both jurisdictions were available (2000/01, Henry and Lyle, 2003). Vic commercial catch prior to 1979 was imputed based on the mean ratio of Vic to NSW commercial landings during 1979-1985.

- Estimated discards by the NSW trawl fleet after the introduction of the MLL in 2007.

- Three standardised CPUE indices from NSWFTRL (1998-2022), NSWFTRP (1998-2022), and CWTRL (1986-2022). Generalised linear models were used to standardise CPUE values for a range of potential confounding variables, including vessel, month, ocean zone and depth.

- Length data from NSWFTRL, NSWFTRP, NSWLN, NSWEST, CWTRL and REC fisheries, and from the fishery-independent *RV Kapala* surveys. Years of data included for each fleet were: NSWFTRL (19 years between 1987 and 2022), NSWFTRP (12 years between 2005 and 2022), NSWLN (9 years between 2006 and 2021), NSWEST (4 years between 2019 and 2022), CWTRL (22 years between 1993 and 2022), REC (1 year, 1994) and *RV Kapala* (2 years, 1993-94).

- Age-at-length data for 1998 from NSWFTRL, NSWFTRP, NSWLN and NSWEST fisheries.

- Biological parameters, including those for growth and maturity, were obtained from Rowling and Raines (2000). Natural mortality for the high-*M* model was estimated outside of the model using empirical estimators based on maximum age and growth rate (Hamel and Cope 2022). Natural mortality for the low-*M* model was estimated from a likelihood profile run on *M* using the high-*M* model, and supported by historical estimates of M that have been made for the east-coast stock of Silver Trevally (0.12-0.19 yr^{-1}).

Key model structure & assumptions:

An integrated age- and length-structured population model was used for the base case and all sensitivity scenarios in the original assessment. The model is equivalent to a "Tier 1" Commonwealth assessment.

The base case included seven catch fleets, one 'length-only' fleet (*RV Kapala*), three indices of abundance (CPUE), numerous years of length data and one year of age-at-length data (see 'Main data inputs').

Logistic selectivity was applied for all fleets except NSWFTRP and NSWEST, where double normal plateau selectivity was applied.

Selectivity parameters were estimated for all catch fleets with available length data, except NSWFTRL.

The retention function for NSWFTRL was time-blocked before and after 2007.

The catchability parameters (*q*) for NSWFTRL and NSWFTRP CPUE were time-blocked before and after 2007.

Recruitment deviations were estimated between 1955 and 2019, after which recruitment was fixed at the average value for the period 2010-2019.

Natural mortality (*M*) was fixed at 0.18 yr^{-1} for the high-*M* model and 0.14 yr^{-1} for the low-*M* model. *M* is assumed age- and time-invariant.

Steepness (*h*) of the Beverton-Holt stock-recruitment relationship was fixed at 0.7

Recruitment variability (σR) was fixed at 0.7

Growth parameters:

- Asymptotic length (L_{inf}): 43.97 cm FL
- Growth rate (*K*): 0.12 yr^{-1}
- Length at time zero (t_0): -3.89 cm FL

Length at 50% maturity (m_1): 19 cm FL

Length at 95% maturity (m_2): 22.5 cm FL

Relative weighting of data types, and years of data within data types, was achieved via sample numbers and CV values.

Model tuning procedure: the Francis method was used to iteratively reweight the initial sample sizes of length compositions to match the effective sample sizes calculated by the model. Variance input factors were used to weight data with too few samples for the Francis method. Extra variance was

estimated for the NSWFTRL CPUE series. The bias ramp was initially modelled and then pre-specified at plausible model values.

Model projections were made using a range of constant catch scenarios that included catch in the most recent year of data (~100 t, 2022).

A likelihood profile for *M* was completed on the high-*M* model.

Key assumptions are:

- A single stock of Silver Trevally on Australia's east coast.
- That the stock was not exploited prior to 1955 (and prior to 1945 for the relevant sensitivity scenario).
- Commercial catches reported for each fleet are accurate.
- CPUE is linearly related to abundance.
- Selectivity is time-invariant, except for NSWFTRL.
- Recruitment after 2019 is below the long-term average.

Sources of uncertainty evaluated:

Uncertainty was explored in two ways: 1) evaluation of model fits, and 2) modelling of alternative (sensitivity) scenarios to the base case presented in Burch et al. (2023).

Evaluation of model fits involved comparison of model estimations to observed values from CPUE series, length compositions and age compositions. Fits to length and age compositions were considered for each year and aggregated across years within fleets. The appropriateness of estimated selectivity and retention functions was also considered with respect to the length data used to inform them.

Sensitivity scenarios (Francis weighting recalculated):

- Low (M=0.14 yr^{-1}) natural mortality.
- Include the 1997 age data because earlier models appeared to fit well to this data even though the sample size is small (see Appendix A).
- Include catches for 1945–1954, assigned to fleets using the ratio of catch by fleet in 1955. These catches were omitted from the base case because they weren't separated by fleet.
- Remove the NSWFTRP CPUE to test the hypothesis that the CPUE from this fleet, which has relatively low catches, is influential in the assessment outcomes.

Sensitivity scenarios (base-case Francis weighting retained):

- Average recruitment during the projection period.
- Use Commonwealth CPUE for 1992–2022 to test the hypothesis that the large increase in catch and CPUE for 1988–1991 may have resulted from vessels fishing differently.
- Low (h=0.6) or high (h=0.8) steepness of the Beverton-Holt stock recruitment relationship.
- Low (σ_R = 0.6) or high (σ_R = 0.8) recruitment variability.

- Very low (M=0.11yr^{-1}) or high (M=0.22yr^{-1}) natural mortality. These values represent the bounds of the 95% confidence interval derived from the likelihood profile.
- Low (m_l=17cm) or high (m_l=21cm) length at 50% maturity.
- Halve or double the weights assigned to the age and length composition data.
- Halve or double the weights assigned to the CPUE indices.
- Low or high catch scenarios during 1992–2000, the period of double reporting of trawl catches to the Commonwealth and NSW.

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	Depletion of spawning biomass (model estimated)
Biomass Limit Reference Point	B_{20} (20% of pre-exploitation spawning biomass)
Biomass Target Reference Point	B_{48} (48% of pre-exploitation spawning biomass)
Fishing mortality indicator or proxy	Fishing mortality (model estimated)
Fishing mortality Limit Reference Point	N/A
Fishing Mortality Target Reference Point	F_{48} (Fishing mortality rate that achieves B_{48})

Stock Assessment Results

Natural mortality was the primary driver of uncertainty in the model (see Appendix 1), with the estimate of current (2023) biomass either above or below the LRP depending on the value of M. The value of M used in the high-M model, M = 0.18 yr^{-1}, was estimated outside of the model using two accepted empirical methods (Hamel and Cope 2022). However, previous estimates of M from life history studies in south-eastern Australia range from 0.12 to 0.19 yr^{-1}, and a lower estimate (0.10 yr^{-1}) has been made in New Zealand, supporting the low-M model (M = 0.14 yr^{-1}).

Current spawning biomass was estimated at 24.9% of pre-exploitation biomass by the high-M model and 17% by the low-M model (Figure 3). In both models, biomass declined from the start of the series and fell below the LRP in the late ‘90s/early ‘00s. The decline was more rapid in the low-M model, reaching 50% by 1990 and breaching the LRP in 1998. Both models indicated that biomass remained at or below the LRP until at least 2021, with an increasing trend evident from 2019.

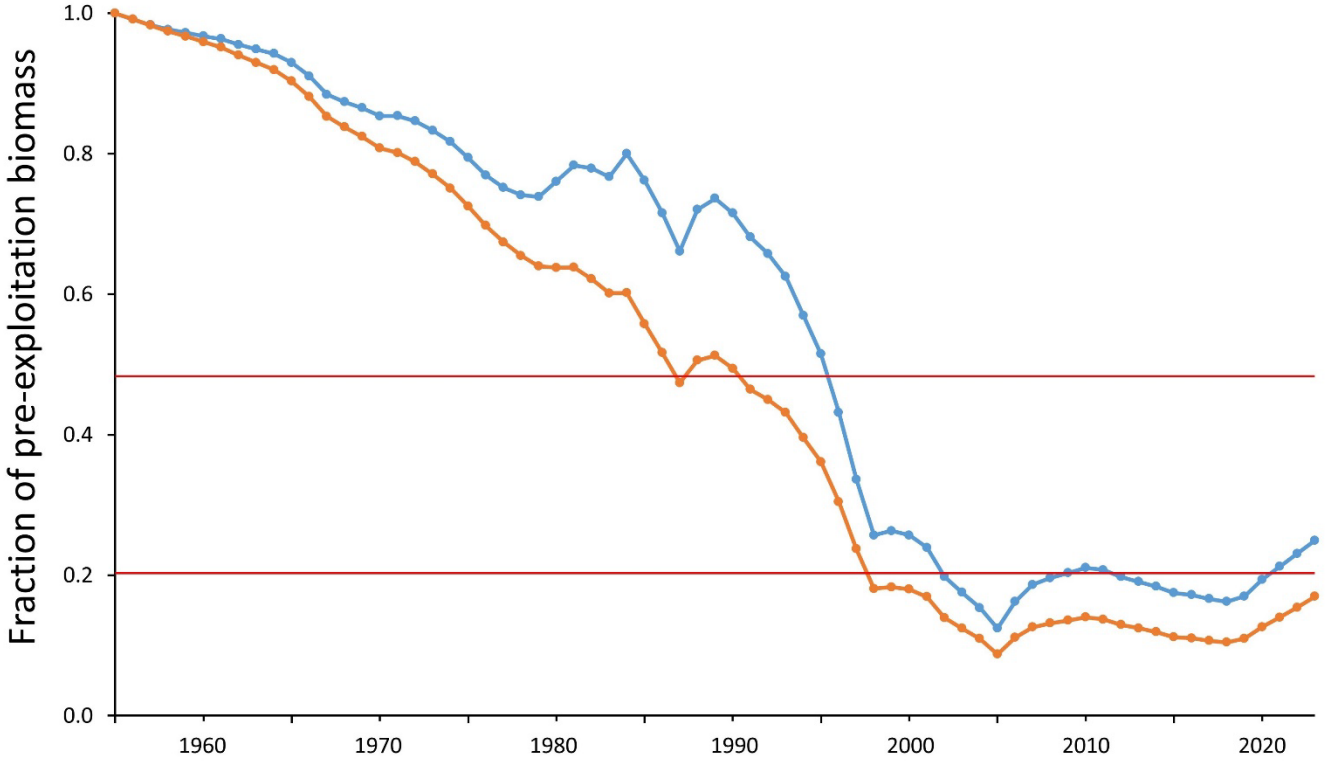

Figure 3. Time-series of biomass relative to pre-exploitation biomass estimated from the high-*M* model (blue line) and the low-*M* model (orange line). Red lines indicate the Commonwealth LRP (20%) and TRP (48%).

The decline in biomass was associated with high fishing mortality (F), which increased from F~1 in the early 1980s to F~2 by 1990 and exceeded F=4 by the mid-2000s. F then declined consistently to <1.0 by 2019 and <0.6 by 2023 in both models. Current F is therefore at a level that should allow the stock to rebuild, assuming that productivity is at least equal to that specified within the models.

Both models predict that biomass will rebuild under all constant catch levels tested (50, 75, 100, 125, and 150 t), which includes the current level of catch (~100 t, 2022). The TRP would be reached in 30 years for all catch levels except 125 t for the high-*M* model (B=47.1%) and 150 t for both models (high-*M* model: B=44.3%, low-*M* model: B=45.8%). Faster rebuilding was predicted by the low-*M* model because average recruitment calculated over 2010-2019 was higher than in the high-*M* model.

Stock Assessment Result Summary

Biomass status in relation to Limit	High-*M* model – B (2023) = 24.9% **> B_{20}** Low-*M* model – B (2023) = 17.0% **< B_{20}**
Biomass status in relation to Target	High-*M* model - B (2023) = 24.9% **<< B_{48}** Low-*M* model – B (2023) = 17.0% **<< B_{48}**
Fishing mortality in relation to Limit	N/A
Fishing mortality in relation to Target	N/A
Current SAFS stock status	**Depleted**
Current Commonwealth stock status	**Overfished** **Uncertain if subject to overfishing**

Fishery interactions

On the east coast, Silver Trevally are caught in fisheries managed by NSW, the Commonwealth and Victoria. North of Barrenjoey Pt, and south of Barrenjoey Pt inside 3 nm, the stock is subject to numerous NSW fisheries (outlined in the fleet descriptions above). South of Barrenjoey Pt outside 3 nm the stock is fished by The Commonwealth Trawl Sector (CTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF).

Qualifying Comments

Conclusions regarding the current status of Silver Trevally depend on the assumptions outlined in the section 'Key model structure & assumptions' and the outcomes of the sensitivity scenarios outlined in the section 'Stock Assessment Results' and Appendix 1.

A 'recovering' status has been applied to Silver Trevally in NSW, rather than 'sustainable', due to the uncertainty regarding current biomass relative to the LRP. Estimated biomass from the high-*M* model was only marginally above the LRP, and biomass from the low-*M* model that used a lower plausible value of *M* was below the LRP. Despite uncertainty regarding current biomass, both models indicated a recent trend of increasing biomass, and projections suggest that biomass should rebuild under either scenario.

In addition to model-based evidence of rebuilding, management measures have been applied to limit mortality of Silver Trevally. The TAC for the NSW Ocean Trawl – Fish Northern Zone (OTFN) has been reduced in the most recent determination (12 t in 2023, down from 20 t in previous years). Although the Southern Fish Trawl (SFT) in NSW is not subject to catch quota, catches in this fishery have been <10 t since 2019. Silver Trevally in the Commonwealth are identified as an overfished stock with a TAC determination of 25 t for the 2023/24 fishing season (Butler et al. 2023).

The joint assessment improves on the separate assessments undertaken by NSW and the Commonwealth in previous years. Although the most recent NSW assessment used a similar coast-wide catch dataset, it applied a weight-of-evidence approach based on two data-limited models (Fowler et al. 2023). In the Commonwealth, Silver Trevally were previously subject to a Tier 4 assessment wherein recent estimates of trawl CPUE (standardised) were compared to reference points derived from a historical reference period. Biomass series from previous NSW assessments and the current joint assessment suggest that the reference period used in previous Tier 4 assessments does not represent a period when the stock was at target biomass depletion (48%), which is an assumption of the Tier 4 approach.

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Appendices

Considerations for interpreting assessment results for stock status and TAC determination in NSW

Results of sensitivity scenario modelling

The 95% confidence interval for *M* from the likelihood profile spanned 0.11 and 0.18 yr^{-1}. Estimated current biomass from models with *M* of 0.11 and 0.18 yr^{-1} were 10.5% and 24.9%, respectively.

Both the high-*M* and low-*M* models assumed below-average recruitment from 2019 onward, calculated as the average of recruitment deviations over the previous 10 years. When average recruitment throughout the entire series was assumed, estimated biomass in 2023 was 30.0%.

Biomass estimates were also sensitive to steepness (*h*) and the CPUE data inclusions and weightings, with current biomass 2–4% lower than the base case when *h*=0.6, the NSW trap CPUE was removed, the Commonwealth CPUE time series was restricted to 1992–2022, or the weighting of the CPUE in the likelihood was halved. Conversely, when *h*=0.8 or the weighting on the CPUE in the likelihood was doubled, current stock status was 2–4% higher than the base case. Including the 1997 age data or the 1945–1954 catches, varying the length at maturity or the recruitment variability, or changing the likelihood weighting of the age and length composition data resulted in <1% change in the estimates of current stock status, compared with the base case.

Additional considerations for TAC determination in NSW

Determination of a TAC for Silver Trevally in the NSW Ocean Trawl – Fish Northern Zone (OTFN) for the 2023-24 fishing period may be informed by the following:

1. The Southern Fish Trawl (SFT) in NSW is not subject to TAC and has, historically, been responsible for the majority of catch in NSW.
2. Although relatively insignificant historically, Victorian commercial catch is now a substantial proportion (25% in 2022) of total catch on the east coast.
3. There is no harvest strategy for Silver Trevally in NSW, so no reference points are specified. For the purpose of classifying exploitation status under SAFS criteria, NSW adopts a default 20% depletion of spawning biomass as an LRP. This is consistent with the Commonwealth's LRP of 20% depletion under the SESSF HSP. The Commonwealth's TRP for Silver Trevally is 48% depletion of spawning biomass.
4. There is currently no resource sharing policy between NSW, the Commonwealth or other jurisdictions relating to the shared stock of Silver Trevally.
5. As a consequence of there being no harvest strategy ("3" above) and no resource sharing policy ("4" above), assessing the consequences of alternative TACs for Silver Trevally in NSW waters alone is problematic.