Stock Status Summary – 2021

NSW Stock Status Summary – Silver Trevally (Pseudocaranx georgianus)

Assessment Authors and Year

Fowler, A.M. and Chick, R. C. 2021. NSW Stock Status Summary 2020/21 – Ocean Trawl Fishery – Silver Trevally (Pseudocaranx georgianus). NSW Department of Primary Industries, Fisheries. 10 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Silver Trevally are currently assessed as **depleted** for the NSW component of the stock.

Biology and stock structure

Silver Trevally in NSW comprises a single species recently revised as *Pseudocaranx georgianus* (previously considered *P. dentex*; Smith-Vaniz and Jelks 2006, Bearham et al 2019). The species is a medium-bodied bentho-pelagic carnivore inhabiting a broad range of habitats, from shallow estuaries through to the outer continental shelf. Silver Trevally are relatively long-lived and slow growing, attaining a maximum age in excess of 25 years (Rowling and Raines 2000). However, the species is moderately fecund and matures at a relatively early age (2–4 years).

The stock structure of Silver Trevally is uncertain, with no investigations of potential genetic structure within NSW. Investigations of population connectivity and post-settlement movement are also limited. Tag-recapture studies in NSW, Western Australia and New Zealand indicate restricted post-settlement movement of Silver Trevally despite their fast swimming ability, potentially leading to ecological stock structuring over moderate (100s of km) spatial scales (James 1980; Fairclough et al. 2011; Fowler et al. 2018a).

The stock structure of Silver Trevally was reviewed during the 2016 and 2018 Status of Australian Fish Stocks (SAFS) processes (Chick et al. 2016, Fowler et al 2018b). Due to the limited information available, and the complex of *Pseudocaranx* species exploited in some states, the SAFS stock status reports were conducted at the jurisdictional level. Acknowledging these constraints, this assessment is also completed at the NSW jurisdictional level, while considering the stock status determined for the species in the adjacent state of Victoria and the Commonwealth Trawl Sector (CTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF). The CTS was the primary extra-jurisdictional source of mortality for Silver Trevally until 2018; however, recent catches have declined and catch from Victoria was greater than that of the CTS during 2019

Stock Status

The status of the NSW Silver Trevally stock is classified as **depleted**. The status is based on:

1) Declining but variable standardised catch rates in multiple fisheries, areas and time periods, particularly during 1998-2009;

2) Truncation in length structure in the OTF between 1987 and 1999 that has been maintained between 2005 and 2020;

3) B/B_{msy} estimates from a catch-only zBRT model at 20% (equivalent to B/B_0 at 10%), with no improvement when discard estimates were included within catch history;

4) B/B_{msy} estimates from an OCOM model at or below 30% across a range of stock-specific natural mortality estimates (equivalent to B/B_0 at 15%);

5) High but variable F/M values and low SPR values (<0.2) over 11 sampling years.

Fishery statistics summary

Changes in NSW commercial fishery reporting requirements, sources of commercial fishery data and the continuity or otherwise of data sources through time are outlined in Appendix 1 of Fowler and Chick (2020a). Notably, between 1997/98 and 2008/09 (inclusive), fishers reported monthly catch and effort (in days) for each fishing method (gear type). From 2009/10, monthly reports of daily catch and effort (hours) and fishing method have been required. To construct a longer time series of commercial fishery data (i.e. from 1997/98 to present), daily records from 2009/10 have been re-aggregated into monthly catches (kg) by fisher and gear type, with effort in days per month estimated from the number of distinct fishing dates in each month when the method was used and there was a reported landing of the species of interest in that month, irrespective of whether the species was reported on each day, to be consistent with earlier reporting. Fishery-specific catch data from 1955 to 1997 has also been reconstructed using a combination of individual fisher behaviour (1985-1997) and proportional allocation between methods according to knowledge of fishery operations during particular time periods (prior to 1985, Pease and Grinberg 1995, Rowling 2006). The latter dataset was used in catch-only assessment models.

Catch Information – Commercial catch

Silver Trevally are predominantly caught in three commercial fisheries within NSW; the Ocean Trawl Fishery (OTF), the Ocean Trap and Line Fishery (OTLF) and the Estuary General Fishery (EGF). Substantial catches are also occasionally taken in the Ocean Hauling Fishery (OH). During the period 1998–2020, the OTF accounted for 61% of catch by weight (inter-annual range: 25–86%), with catches in the OTLF and EGF accounting for 23% (range: 9–50%) and 12% (range: 4–31%), respectively (Figure 1).

Catches of Silver Trevally in the OTF in NSW have declined, from more than 200 t during 2007 to a low of 7.6 t during 2020 (Figure 1). The substantial decline following 2007 coincided with the introduction of a minimum legal length (MLL, 30 cm total length, TL) for the species and the establishment of the Batemans Marine Park and other areas closed to commercial fishing. Note that 58 t of reported trawl catch from a single operator during 2019/20 was removed from further analysis due to likely misreporting. These catches were not apparent in fish sale records and were associated with disproportionately small effort quantities. Historical commercial catch between 1955 and 2020 showed that trawl catches were initially low (1955-1970) and then increased rapidly to >1100 t during the early 1980's, after which they declined substantially to present day.

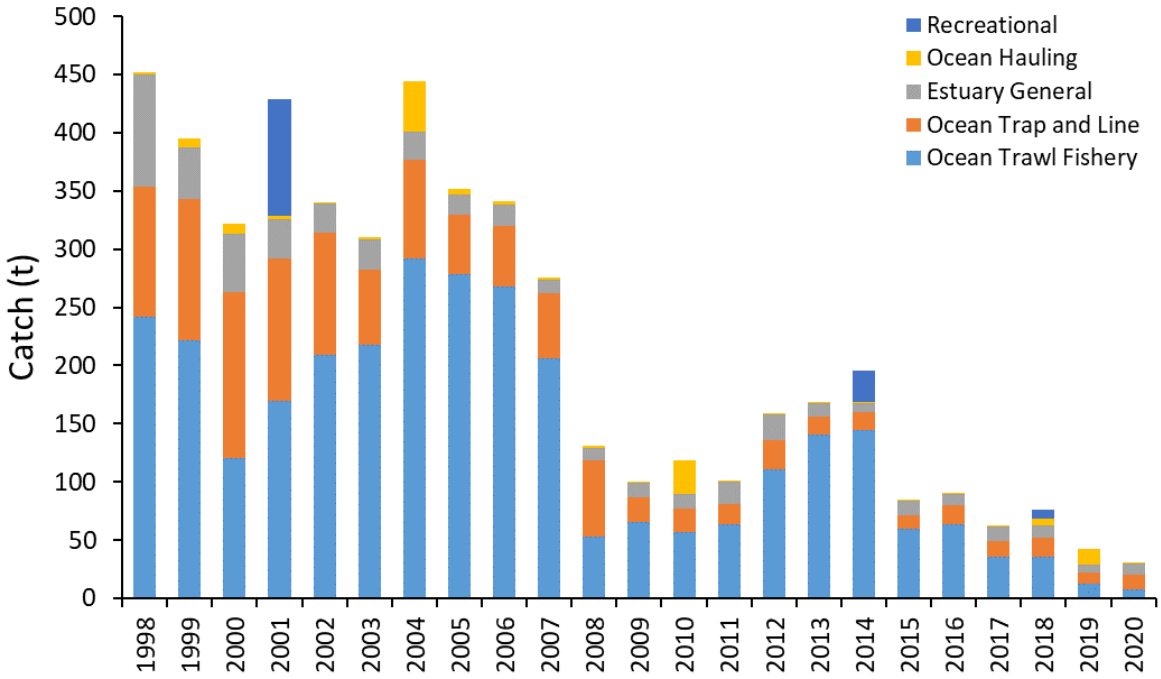

Figure 1 Annual catch (t) of Silver Trevally from NSW Ocean Trawl, Ocean Trap and Line, Estuary General, Ocean Hauling and Recreational fisheries from 1998 to 2020.

Recreational and Indigenous cultural catch

Three surveys of recreational fishing have been conducted at the state-wide level in NSW. Retained landings by recreational fishers resident in NSW have decreased, with landings estimated from off-site telephone/diary surveys declining from approximately 140,000 fish during 2000/01 to around 49,000 individuals during 2013/14 (Henry and Lyle 2003, West et al. 2015) and around 15,000 fish in 2017/18 (Murphy et al. 2020). This corresponds to a decrease in retained catch weight from approximately 100 t during 2000/01 to around 27 t during 2013/14 and 8 t in 2017/18 (Figure 1), based on average body weight for the species (NSW DPI, unpublished). Over half of the retained landings in NSW during 2000/01 were taken by anglers from other states, with an estimated catch of over 250,000 fish when non-NSW anglers were included (Henry and Lyle 2003). An estimate of catch by non-NSW anglers was not available for 2013/14 (West et al. 2015) or 2017/18 (Murphy et al. 2020). The 2017/18 NSW survey sampled individual one- and three-year licence holders present in the NSW Recreational Fishing Fee (RFF) Licence database, whereas the previous NSW survey sampled households from the White Pages (West et al. 2015).

Indigenous catches are unknown.

Illegal, Unregulated and Unreported (IUU)

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

Effort information

Fishing effort (days) in the OTF was relatively high but variable during 1998-2007, then declined rapidly until 2010. Effort has subsequently remained low, with a gradual decline to 265 days in 2020. The trend in number of days fished between 2010 and 2020, derived from summing the number of fishing events recorded within a month, was similar to the trend in hours fished. Hours fished is the required reporting metric on catch returns following changes implemented in 2009.

Catch rate information

Commercial

Catch rates (kg.day^{-1}) were standardised using general linear models in the R package 'cede'. Variables used included month of capture, ocean zone, depth (from 2010 onward), fishing business (as a proxy for 'vessel' in the trawl fishery) and authorised fisher (as a proxy for 'vessel' in the trap fishery). Substantial discarding has been observed within the OTF following the introduction of the MLL in 2007 (NSW DPI, unpublished). To examine the potential effect of discarding on trends in catch rates, discard estimates were added to catch data from 2008 onward and catch rates were re-standardised.

Trends in catch rates of Silver Trevally in the OTF varied between time periods and areas examined. When data for all ocean zones were combined, catch rates declined during both the 1998-2009 and 2010-2020 periods (Figure 2). Catch rates across the entire period also showed the initial decline (1998-2009), but then increased after 2008 and remained relatively stable between 2011 and 2016. Catch rates then declined again, and in 2020 were at the lowest level recorded (Figure 2). The addition of discard estimates to catch after 2007 had little effect on the declining catch rates observed during 1998-2009. However, the recovery of catch rates observed after 2008 increased substantially and consistently across the range of discard additions explored. Despite this increase, catch rates during 2019 and 2020 remained low.

Declining catch rates in the OTF during 1998-2009 were also observed in the OTLF. Substantial declines occurred between 2000 and 2005 when all zones were combined, and in Ocean Zone 5 separately.

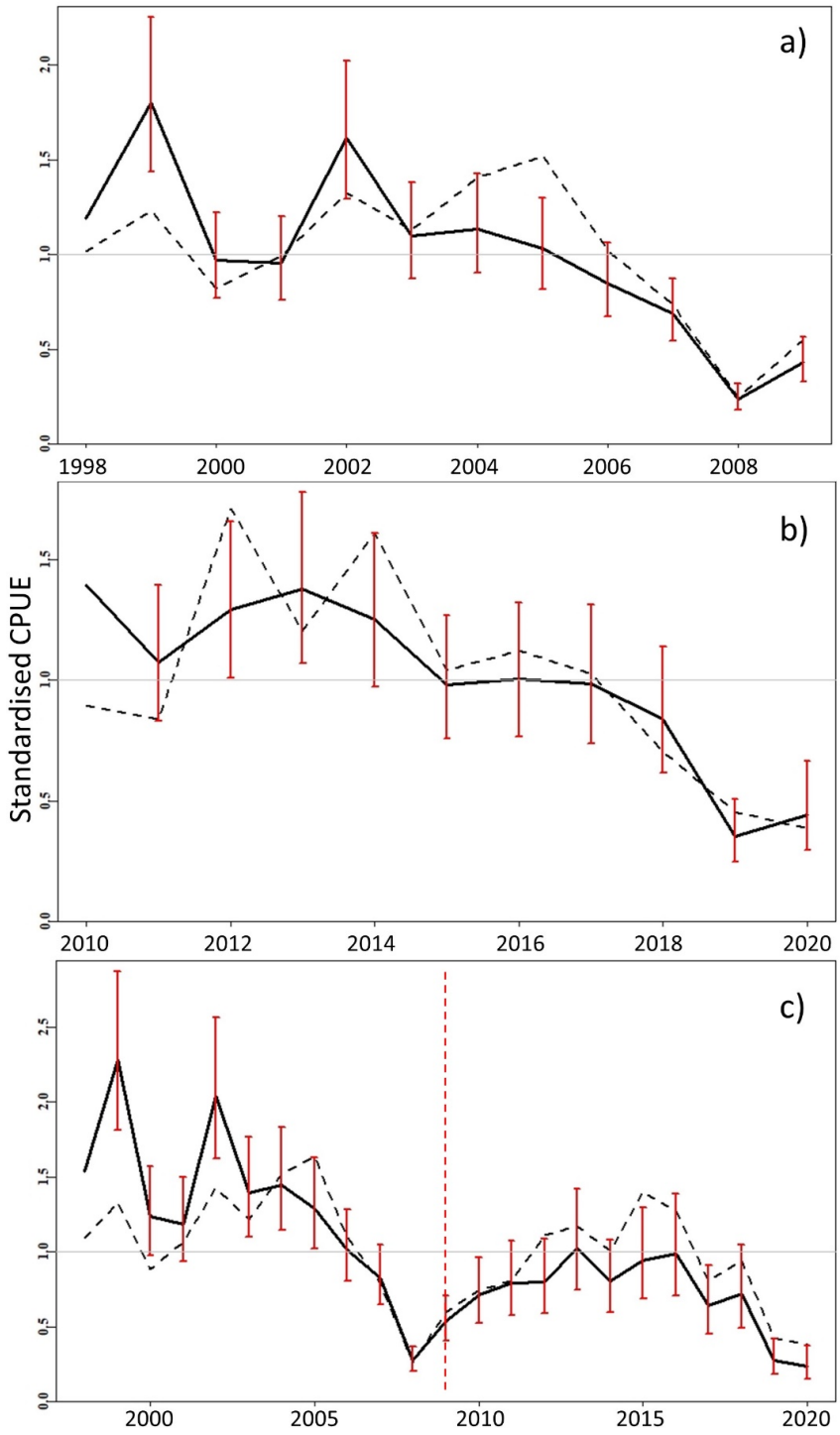

Figure 2 OTF – All ocean zones – Standardised catch rate (solid line) of Silver Trevally by trawling within all ocean zones during: a) 1998 - 2009, b) 2010 - 2020 and c) 1998 - 2020. Units for Panels a and c are kg.day^{-1}, whereas the unit for Panel b is kg.h^{-1}. The dashed black line indicates the geometric mean catch rate. Red bars indicate 95% confidence intervals. The dashed red line indicates the reporting discontinuity.

Length structure

Length data for Silver Trevally from the OTF have been investigated in numerous studies between 1987 and 2015/16, including observer-based investigations and fish market sampling of commercial catches. Truncation of larger size-classes was observed in trawl catches made between 1987 and 1999 (Liggins 1996; Rowling and Raines 2000). Size truncation has been maintained since that period, with individuals larger than 30 cm fork length comprising a small proportion of trawl catches prior to the introduction of the 30 cm MLL following 2007, and commonly steep declines in size structure thereafter, with median values within 1-2 cm of the fork length equivalent to the MLL, according to monitoring of landed catches during fish market sampling.

Catch only and length-based assessment modelling

Two catch-only models were applied to the historical catch data available from the OTF (1955-2020); a boosted regression tree (zBRT) model (Zhou et al. 2017a) and an Optimised Catch-Only Model (OCOM, Zhou et al. 2017b). Estimates of biomass relative to biomass at maximum sustainable yield (B/B_{msy}) from zBRT decreased throughout the period, with a substantial decline in 2016 to low levels that have not appreciably improved. The B/B_{msy} estimate for 2020 was 20% (equivalent to B/B_0 at 10%).

B/B_{msy} estimates from OCOM remained stable and above 1.5 between 1955 and the mid-1970s, then decreased substantially during the 1980s and 1990s, remaining low (≤0.3) and stable from 2000 to 2020. Fishing mortality relative to fishing mortality at maximum sustainable yield (F/F_{msy}) remained below 1 until the early 1980s, after which they increased substantially and remained above 1 until the late 2010s. Trends were similar across the range of natural mortality values examined (0.05-0.15).

To provide a complimentary assessment that does not rely on commercial catch data, a Length Based – Spawning Potential Ratio (LB-SPR) was applied to commercial length data sampled from fish markets during 11 years between 2005 and 2020 (Hordyk et al. 2015). Estimated fishing mortality relative to natural mortality (F/M) was highly variable throughout the period (range: 2.0 to 8.4), with values in the last three years ranging between 2.9 and 4.9. The spawning potential ratio (SPR) was consistently low and stable across years, ranging between 0.10 and 0.18.

Stock assessment – list of indicators

Most recent assessment	2020 – **depleted**
Assessment method	Weight of evidence: - Standardised catch rates (OTF and OTLF) - Length frequency time-series (OTF) - Boosted Regression Tree (zBRT) catch-only model - Optimised Catch Only Model (OCOM) - LB-SPR model

Main data inputs	Commercial catch (t) – 1955 to 2020 Commercial effort (days) – 1998 to 2020 Length data (fork length, cm) – 11 years between 2005 and 2011. Taken from fish markets across trawling, trapping and line methods.
Key model structure and assumptions	Standardised CPUE: Commercial catch per unit effort (CPUE) standardised using a glm including variables of month of capture, ocean zone, depth (from 2010 onward), fishing business (as a proxy for 'vessel' in the trawl fishery) and authorised fisher (as a proxy for 'vessel' in the trap fishery). zBRT: Estimates saturation (i.e. 1- depletion = 0.05*B/BMSY) from 56 catch history statistics, including linear regression coefficients, the subseries before and after the maximum catch, and recent years. Saturation is estimated as the average of the saturation values predicted by two reduced and bias-corrected BRT models (8 and 38 predictors each; Zhou et al. 2017a). OCOM: Stock reduction analysis (SRA) with priors for recruitment and stock depletion derived from natural mortality (0.05-0.15, Rowling and Raines 2000) and saturation from the zBRT model. The SRA uses a Schaefer biomass dynamics model and an algorithm for identifying feasible parameter combinations to estimate a range of biological and relevant quantitative metrics including unfished biomass, depletion and exploitation rates (Zhou et al. 2017b). Catch-only models inherently assume that changes in catch reflect changes in stock biomass. LB-SPR: Uses size structure and SPR in harvested populations, being a function of relative fishing pressure (F/M) and life history ratios. A maximum likelihood approach is used to estimate selectivity, F/M and SPR, with a smoother function used to reduce noise in multi-year estimates (Hordyk et al. 2015).
Sources of uncertainty evaluated	The effect of discarding on catch rate trends and zBRT estimates was evaluated through sensitivity analyses across a range of discarding rates taken from a NSW DPI onboard observer program in the trawl fishery during 2015/16. Uncertainty in natural mortality estimates was evaluated using sensitivity analyses across the range of natural mortality values previously estimated for the NSW Silver Trevally stock (Rowling and Raines 2000). Uncertainty in catch-only model estimates relating to the use of trawl catch, rather than total catch, was evaluated through model application to an additional dataset including catch across all fisheries and methods in NSW.

Status indicators and limits - reference levels

Biomass indicator or proxy	Standardised CPUE, B/B_{msy}, SPR
Biomass limit reference level	NA – no biomass limits or targets have been set
Fishing mortality indicator or proxy	F/F_{msy}, F/M
Fishing mortality limit reference level	NA – no fishing mortality limit has been set
Target reference level	NA – no fishing mortality targets have been set

Stock assessment results – review of indicators

Biomass status in relation to limit	NA – no biomass limits or targets have been set
Fishing mortality in relation to limit	NA – no fishing mortality limit has been set
Previous SAFS stock status	SAFS 2016 (NSW) – Transitional-depleting
Current SAFS stock status	SAFS 2018 (NSW) - Depleting

Fishery interactions

Silver Trevally are fished in the Commonwealth Trawl Sector (CTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF) as well as Victorian fisheries.

Qualifying Comments

NSW catch and effort logbook data vary spatially and temporally across different eras, delineated by changes in fisher reporting requirements and other management changes. The change in the method of effort reporting during 2009/10 limits the certainty with which conclusions can be made regarding shifts in effort and catch rates around that time. The establishment of the Batemans Bay Marine Park may also have affected trends in fishery metrics, potentially reducing catches and catch rates following 2007, however these are likely to be restricted to that area of the coast. Lastly, the introduction of the MLL likely reduced landings across the state after 2007.

Results from data-limited assessment methods must be interpreted with caution, given the limited information used to model population parameters and stock status. Catch-only models inherently assume that changes in catch reflect changes in stock biomass, yet catch is also influenced by a number of other factors including fishery operations.

Factors other than fishing, including climate change and other environmental processes, may affect changes in the abundance and biological functioning of the NSW Silver Trevally stock through time. Temporal and spatial variations in oceanographic conditions, including temperature change, may influence available trophic resources, growth, population connectivity and ultimately recruitment.

References

Bearham, D., Robert, M., Chaplin, J. A., Moore, G. I., Fairclough, D. V., and Bertram, A. 2019. Molecular evidence of three species in the *Pseudocaranx dentex* complex (Carangidae) in Australian waters. Marine and Freshwater Research. doi.org/10.1071/MF18445

Chick, R. Roelofs, A., Green, C., Fairclough, D., Stewart, J., Georgeson, L., and Emery, T. 2016. Silver Trevally *Pseudocaranx georgianus*, *Pseudocaranx* sp. "dentex" and *Pseudocaranx wrighti*. In: Stewardson, C., Andrews, J., Ashby, C., Haddon, M., Hartmann, K., Hone, P., Horvat, P., Mayfield, S., Roelofs, A., Sainsbury, K., Saunders, T., Stewart, J., Stobutzki I. and B. Wise, Eds. Status of Australian fish stocks reports 2016. Fisheries Research and Development Corporation, Canberra.

Fairclough, D. V., Potter, I. C., Lek, E., Bivoltsis, A. K. and Babcock, R. C. 2011. The fish communities and main fish populations of the Jurien Bay Marine Park. Strategic Research Fund for the Marine Environment Final Report. Centre for Fish and Fisheries Research, Murdoch University, Murdoch, Western Australia.

Fowler, A.M. and Chick, R. C. 2020a. Stock assessment report 2020/21 – Ocean Trawl Fishery – Silver Trevally (*Pseudocaranx georgianus*). NSW Department of Primary Industries - Fisheries: 46 pp.

Fowler, A.M. and Chick, R. C. 2020b. Stock assessment report 2019 – Ocean Trawl Fishery - Silver Trevally (*Pseudocaranx georgianus*). NSW Department of Primary Industries – Fisheries, 46 p.

Fowler, A. M., Chick, R. C. and Stewart, J. 2018a. Patterns and drivers of movement for a coastal benthopelagic fish, *Pseudocaranx georgianus*, on Australia's southeast coast. Scientific Reports, 8: 16738.

Fowler, A., Chick, R. Moore, B., Fairclough, D., Womersley, B., Georgeson, L., Albury, L. and Rogers, P. 2018b. Silver Trevally *Pseudocaranx georgianus*, *Pseudocaranx* sp. "dentex" and *Pseudocaranx wrighti*. In: Stewardson, C., Andrews, J., Ashby, C., Haddon, M., Hartmann, K., Hone, P., Horvat, P., Mayfield, S., Roelofs, A., Sainsbury, K., Saunders, T., Stewart, J., Nicol, S. and Wise, B. (eds). Status of Australian fish stocks reports 2018. Fisheries Research and Development Corporation, Canberra.

Henry, G. W. and Lyle, J. M. 2003. The national recreational and Indigenous fishing survey. Fisheries Research and Development Corporation, Canberra.

Hordyk, A., Ono, K., Valencia, S., Loneragan, N., and Prince, J. 2015. A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES Journal of Marine Science, 72: 217-231.

James, G. D. 1980. Tagging experiments on trawl-caught trevally, *Caranx georgianus*, off north-east New Zealand, 1973–79. New Zealand Journal of Marine and Freshwater Research 14: 249-254.

Liggins, G. W. 1996. The interaction between fish trawling (in NSW) and other commercial and recreational fisheries. Final Report, FRDC Project No. 92/79. NSW Fisheries Research Institute, Cronulla.

Murphy, J. J., Ochwada-Doyle, F. A., West, L. D., Stark, K. E. and Hughes, J. M. 2020. The NSW Recreational Fisheries Monitoring Program - survey of recreational fishing, 2017/18. NSW DPI - Fisheries Final Report Series No. 158.

Pease, B.C. and Grinberg, A. 1995. New South Wales Commercial Fisheries Statistics, 1940 to 1992. NSW Fisheries Research Institute, Cronulla.

Rowling, K. R. and Raines, L. P. 2000. Description of the biology and an assessment of the fishery for silver trevally *Pseudocaranx dentex* off New South Wales. NSW Fisheries Final Report Series No. 24. NSW DPI Fisheries, Cronulla.

Rowling, K. R. 2006. Silver Trevally – Estimating catches by fishing method for NSW historic data. NSW DPI Fisheries, Cronulla.

Smith-Vaniz, W. F. and Jelks, H. L. 2006. Australian trevallies of the genus *Pseudocaranx* (Teleostei: Carangidae), with description of a new species from Western Australia. Memoirs of the Museum of Victoria 63: 97-106.

West, L. D., Stark, K. E., Murphy, J. J., Lyle, J. M. and Ochwada-Doyle, F. A. 2015. Survey of recreational fishing in New South Wales and the ACT, 2013/14. Fisheries Final Report Series No. 149. NSW Department of Primary Industries, Wollongong.

Zhou, S., Punt, A.E., Ye, Y., Ellis, N., Dichmont, C.M., Haddon, M., Smith, D.C. and Smith, A.D. 2017a. Estimating stock depletion level from patterns of catch history. Fish and Fisheries 187: 42-751.

Zhou, S., Punt, A.E., Smith, A.D., Ye, Y., Haddon, M., Dichmont, C.M. and Smith, D.C., 2017b. An optimized catch-only assessment method for data poor fisheries. ICES Journal of Marine Science 75: 964-976.