NSW Stock Status Summary – 2023/24

Eastern School Prawn (*Metapenaeus macleayi*)

Assessment Authors and Year

Taylor, M.D. and Helidoniotis, F. 2023. NSW stock status summary 2022/23 – Eastern School Prawn (*Metapenaeus macleayi*). NSW Department of Primary Industries - Fisheries: 12 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Eastern School Prawn are currently assessed as **sustainable**

Stock structure & distribution

Eastern School Prawn are distributed throughout eastern and south-eastern Australia, being most abundant in NSW waters, but also abundant in Queensland at latitudes south of Moreton Bay, and infrequently abundant in eastern Victorian waters (Racek 1959). Allozyme variation has been examined (albeit with a small number of loci) for Eastern School Prawn. While the patterns indicated only minor genetic variation along eastern Australia, the Queensland estuary that was sampled (Noosa River) was distinct from NSW estuaries south of the Tweed River (Mulley and Latter 1981, note that Victoria was not included in this study). While stock structure would benefit from a more comprehensive examination using contemporary genetic marker systems (e.g., Single Nucleotide Polymorphisms [SNPs]), this study is consistent with an assumption that Eastern School Prawn caught within the majority of NSW waters are likely to be part of the same genetic stock.

Scope of this assessment

This stock status summary presents information and results from the most recent assessment of the Eastern School Prawn in NSW (Taylor and Helidoniotis 2023) that aimed to: 1) summarise existing knowledge on the biology and stock structure of the species within NSW; 2) summarise fishery statistics and additional data sources to inform the assessment; 3) assess and determine the biological status of the NSW stock; 4) outline data limitations and uncertainty in the assessment; 5) indicate future research and assessment directions; and 6) inform determination of the 2023-24 Ocean Trawl (Ocean Prawn Trawl) Total Allowable Effort (TAE) allocation.

Biology

Eastern School Prawn has a penaeid Type-II life cycle that is typical of other eastern Australian penaeids (e.g., Eastern King Prawn, Brown Tiger Prawn, Dall *et al.* 1990), which includes an estuarine and an oceanic phase. The species resides in estuaries for the early stages of its life (Taylor *et al.* 2017), but generally moves to inshore waters adjacent to the mouths of estuaries as maturity occurs, and spawning takes place in these habitats. The timing of migrations and life history events varies spatially and with environmental conditions, but generally aligns with the following pattern. Larval development is mostly completed in ocean waters, and recruitment of post-larvae into estuarine nurseries commences from late spring. Post-larvae and juveniles settle in a range of habitats but have a preference for muddy substrates, and extend to the most brackish estuarine reaches. Prawn migration from estuaries to inshore coastal waters is concentrated on the large outgoing spring tides just prior to the new moon, with emigration commonly peaking in autumn, which can lead to dramatic declines in estuarine abundance from April. This is mirrored by concomitant increases in abundance within coastal waters (usually in waters of depth ranging between 20-40 m), with elevated abundance persisting into winter. Adolescent and adult prawns in coastal waters have been shown to undertake modest, primarily northward migrations of up to 70 km, which facilities mixing of individuals among estuaries along the coast (Ruello 1977).

The distribution of animals between estuarine and inshore habitats, and associated reproductive processes, are influenced by estuary inflow (Glaister 1978; Taylor and Johnson 2022) which both stimulates gonadal maturation, but also has an aggregative effect which facilitates exploitation of the species by fishers. While estuarine inflow generally has a positive influence on reproduction and fisheries catch, recent work has shown that flooding can result in poor water quality that impacts species condition (Taylor and Loneragan 2019). Due to the importance of freshwater inflow for the life history of Eastern School Prawn, larger riverine estuaries like the Clarence River and Hawkesbury River are likely to be important for the supply of recruits for capture along large stretches of inshore waters.

Fishery statistics

Catch information

Commercial

Eastern School Prawn harvest in NSW has been highly variable over the past 4 decades (Figure), which is consistent with the substantial influence of environmental conditions (especially rainfall) on abundance and fisher behaviour (Ruello 1973; Pinto and Maheshwari 2012; Taylor and Loneragan 2019). These traits mean this species displays large inter-annual variations in recruitment, which may well constitute a major driver of the catch history presented in Figure . The FY2023 total NSW Eastern School Prawn harvest was 564 t, with harvest dominated by the Estuary Prawn Trawl Fishery (EPTF) and the Ocean Trawl Fishery (OTF). The OTF harvest as a proportion of total harvest is highly variable through time (Figure), with lower proportions roughly coinciding with periods of drought in south-eastern Australia. Drought likely also contributes to the decadal cyclicity that is observed through the 40-year catch series. While there is some spatial consistency in years of high or low catch, there is also substantial spatial variability in temporal trends in catch, and catch from ocean zones in the south of the state have been gradually diminishing over the past 20 years. Of the EPTF estuaries, total catch is normally greatest in the Clarence River, and this also corresponds with OTF total catch being greatest in the adjacent Ocean Zone 2, which is primarily fed from the Clarence River nursery.

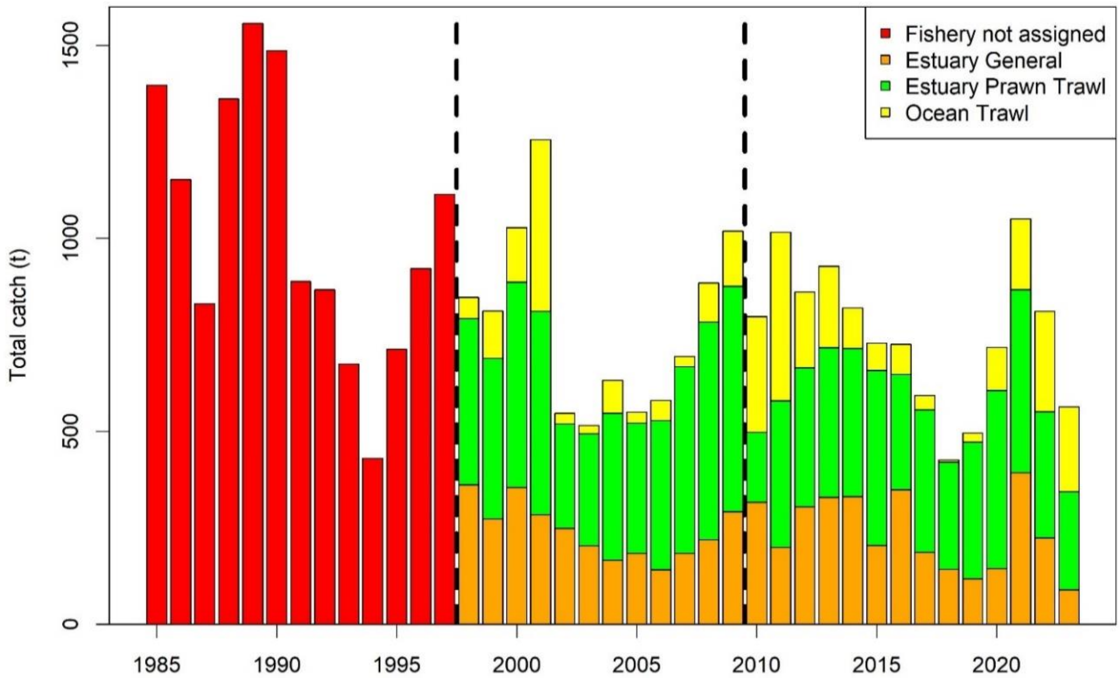

Figure 1 Total annual Eastern School Prawn catch by reported fishery (commercial only) within NSW from FY1985 – FY2023. Dashed lines break different reporting periods

Recreational & Charter boat

The most recent published estimate of recreational catch in NSW was for FY2020 (Murphy *et al.* 2022), with catch of prawns (all species) estimated at 398,068 individuals and a residual standard error (RSE) of 60%. As reflected in the high RSE value, recreational catch is somewhat uncertain, as fishing for the species is a niche and sporadic activity and is generally not well represented within the sampling frame for this fishing survey. Other historic estimates of prawn catch include ~105 t (all species) in FY2001 National Recreational and Indigenous Fishing Survey, and an average of ~32 t (all species, averaged across 1992-1994) per 'recreational prawn fishing season' (November to March, but would approximate annual catch as recreational fishing is minimal outside of these periods) in four of the most important recreationally fished estuaries in NSW (Reid and Montgomery 2005).

Indigenous

There is no information available on the take of Eastern School Prawn by the NSW Aboriginal cultural fishery.

Illegal, Unregulated and Unreported

There is no quantitative information available on the Illegal, unregulated and unreported take of Eastern School Prawn in NSW. NSW DPI-Fisheries compliance officers do however periodically encounter black marketing of prawns in NSW, and there is a suspicion by those in the industry that black market sales are a significant issue for NSW prawn fisheries (Palmer 2004).

Fishing effort information

Total fishing effort across all methods and fisheries that reported School Prawn catch was ~4,500 days in FY2023 (Figure 2). Total effort has declined from a maximum of ~50,000 days at the commencement of the reported time series, over the past 3.5 decades (Figure 2). Changes in reporting mean that effort is not directly comparable throughout the time series. In particular, prior to FY1998, effort of different gear types could not be directly mapped to the species harvested. Also, effort abruptly dropped across all fisheries following the change to daily catch reporting in FY2009 (Figure 2), which may have been influenced by aggregative effort reporting behaviour (Taylor and Helidoniotis 2023).

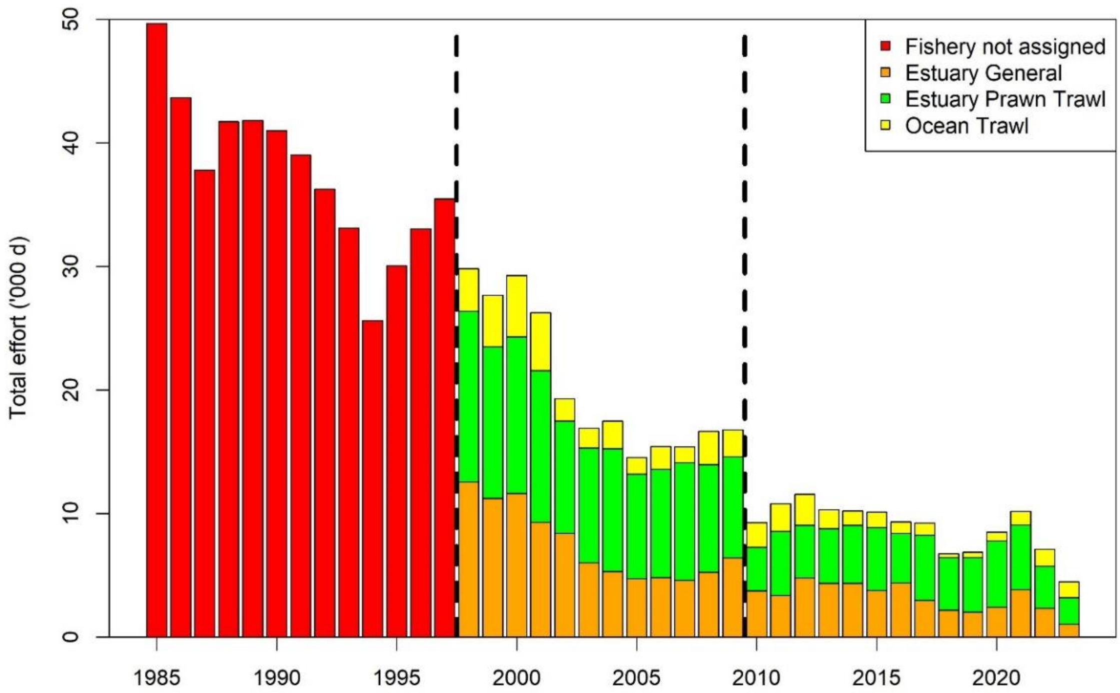

Figure 2 Total annual days effort associated with Eastern School Prawn catch by reported fishery (commercial only) within New South Wales from FY1985 – FY2023. Dashed lines break different reporting periods.

Catch rate information

Eastern School Prawn standardised catch-per-unit-effort (sCPUE) was modelled using generalised linear models (GLMs), which provided an estimate of mean catch rates that were corrected for a number of variables that may have biased nominal CPUE (nCPUE). Four CPUE series were examined: (1) ComCatch EPTF (FY1997-FY2009); (2) ComCatch OTF (FY1997-FY2009); (3) FishOnline EPTF (FY2010-FY2023); and (4) FishOnline OTF (FY2010-FY2023).

Generalised linear models were fitted in R (R Core Team 2023) using the dosingle function in the rforcpue package (https://github.com/haddonm/rforcpue). Models included explanatory variables *Year* (fiscal year), *Month*, *Area* (estuary *or* ocean zone), *Rainfall Index* and *Fishing License Number* (Licensed Fishing Boat [LFB] number are not used for the NSW Estuary Prawn Trawl and have not been required for any vessel in NSW since 2021, so Fishing License Number [for ComCatch] or Authorised Fisher ID [for FishOnline] was assumed to represent vessel/fisher throughout the time series included). Rainfall Index is a variable calculated as part of the NSW Department of Primary Industries Enhanced Drought Information System (EDIS https://edis.dpi.nsw.gov.au/about), a model which integrates meteorological, hydrological and agronomic data to estimate a 'Combined Drought Indicator' for NSW. For the purposes of inclusion in CPUE standardisation for Eastern School Prawn, Rainfall Index is mapped and recalculated for catchments (EDIS generally works at a parish level), and is included as a proxy to reflect estuary inflow and its influence on fishing in the standardisation algorithm. Fishing power was not incorporated in the analysis.

Estuary Prawn Trawl Fishery data was modelled as $log\left(\frac{Catch\,(kg)}{Effort\,(d)}\right)$ or $log\left(\frac{Catch\,(kg)}{Effort\,(h)}\right)$ for each non-zero monthly catch and effort record in the ComCatch and FishOnline time series (respectively, as outlined above), with the Clarence River estuary, Hunter River estuary, and Hawkesbury River estuary included. Ocean Trawl Fishery data was similarly modelled, and the major ocean zones included (Ocean Zone 1, Ocean Zone 2, and Ocean Zone 5). As noted in ***Error! Reference source not found.*** above, the catchment of the largest estuary adjacent to the ocean zone (which was also the home port for much of the fleet fishing that zone) was used for OTF modelling, as this is where many of the prawns captured in inshore waters are most likely to have emigrated from.

Standardised commercial CPUE are likely to be the most reliable index of relative abundance available for Eastern School Prawn. For both the EPTF and OTF (**Error! Reference source not found.**, nominal CPUE is also included in these figures for comparison), sCPUE and nCPUE substantially increased during the period FY2005 to FY2009. Estuary Prawn Trawl Fishery sCPUE was lower than that observed for the OTF. This is likely due to differences in gear and fishing power for the OTF fleet, but may also reflect the aggregative behaviour of the species in inshore waters following estuarine flooding (Taylor and Johnson 2022), and comparatively lesser effort (relative to EPTF). Recent EPTF sCPUE has remained relatively consistent, with minor peaks and troughs. The dip in FY2018 was likely to be drought-related, whereas the dip in FY2022 was likely due to protracted and catastrophic flooding across the NSW coast during the summer-autumn of this period (see NSW DPI Seasonal Conditions Reports). Conversely to the EPTF, recent OTF sCPUE has been highly variable, which reflects the 'boom' nature of inshore Eastern School Prawn catch driven by aggregations of prawns which exit the estuary following certain estuary inflow scenarios, and the broader reliance of catch on estuarine conditions and migration.

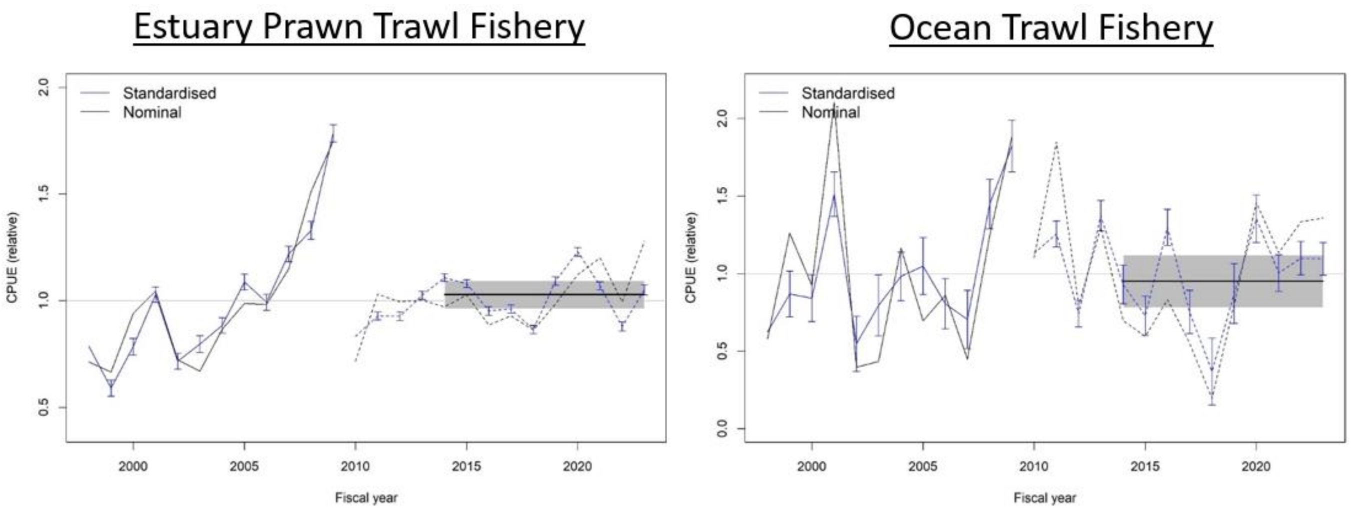

Figure 3 ComCatch (FY1997-FY2009, solid lines) and FishOnline (FY2010-FY2023, dashed lines) standardised (blue line, with standard errors indicated) and nominal (black line, representing the geometric mean catch-per-unit-effort [CPUE] for each fiscal year) CPUE series for EPTF and OTF Eastern School Prawn harvest (units are boat-day or boat-hour). The solid black line indicates the most recent 10-year average, and the grey shaded area indicates the 95% confidence intervals surrounding this mean

Stock Assessment

Stock Assessment Methodology

Year of most recent assessment:

2022/23 (using data to 2022/23)

Assessment method:

A weight-of-evidence approach has been used to classify the biological status of the NSW Eastern School Prawn stock based on:

1) Stability of standardised catch rates (as a proxy for stock biomass)

2) Bayesian state-space surplus production modelling (JABBA, Winker *et al.* 2018)

Main data inputs:

1) Commercial landings from all NSW fisheries from FY1985 to FY2023

2) Commercial catch rates (catch-per-unit-effort, or CPUE) – four series of standardised CPUE were used to calibrate the model:

- NSW OTF from FY1998-FY2009;
- NSW EPTF from FY1998-FY2009;
- NSW OTF from FY2010-FY2023;
- NSW EPTF from FY2010-FY2023;

Key model structure & assumptions:

The JABBA (Just Another Bayesian Biomass Assessment) Bayesian state-space surplus production model (Winker *et al.* 2018) was used to estimate trajectories of annual biomass (*B*), fishing mortality (*F*) and fractions of *B* and *F* relative to their equilibrium values associated with Maximum Sustainable Yield (MSY) and unexploited biomass (B_0). The model was conditioned on catch and calibrated using times-series of indices of abundance (standardised CPUE, as described above), prior probability distributions for the intrinsic rate of population increase (*r*), carrying capacity (*K*; i.e., B_0), depletion of the stock at the start of the catch time-series (*psi*), process error, and estimates catchabilities for each abundance time-series.

Raw catch rates were standardised using general linear models in the R package 'rforcpue' (https://github.com/haddonm/rforcpue). Models included explanatory variables *Year* (fiscal year), *Month*, *Area* (estuary *or* ocean zone), *Rainfall Index* and *Authorised Fisher*.

The base-case model assumed a Pella and Tomlinson production function with B_{msy} occurring at 40% of B_0 (*K*). The time-series of catch was assumed to be accurate, and changes in CPUE were assumed to reflect changes in stock abundance.

Sources of uncertainty evaluated:

In addition to the base-case model (1), five additional sensitivity scenarios were explored, including: (2) using a Schaefer production function instead of a Pella and Thomlinson; (3) including only EPTF-derived indices of abundance; (4) assuming a nominal 50 t of recreational catch (added to commercial catch); (5) specifying a low initial depletion; and (6) assuming a minor (10 %) level of under-reporting earlier in the catch time series

Status Indicators - Limit & Target Reference Levels

Biomass indicator or proxy	B/B_0
Biomass Limit Reference Point	B_{20} (20% of pre-exploitation spawning biomass), reflecting the Australian standard employed in national SAFS reporting
Biomass Target Reference Point	NA

Fishing mortality indicator or proxy	F/F_{msy}
Fishing mortality Limit Reference Point	NA
Fishing Mortality Target Reference Point	NA

Stock Assessment Results

The NSW Eastern School Prawn stock is classified as **sustainable**. The status is based on:

1) Prediction that the current estimated biomass well exceeds both limit (B_{20}) and MSY reference points, and this condition is stable under all the sensitivity and forecast catch scenarios evaluated (Figure 4)

2) Taking into account environmental variability (including drought) and potential effects of these factors on recruitment in Eastern School Prawn, standardised catch rates (as a proxy for stock biomass) remain stable and showed no indication of a downward trend in recent years

The stock biomass has remained well above the MSY reference point for almost 20 years, despite infrequent years of higher and lower catches.

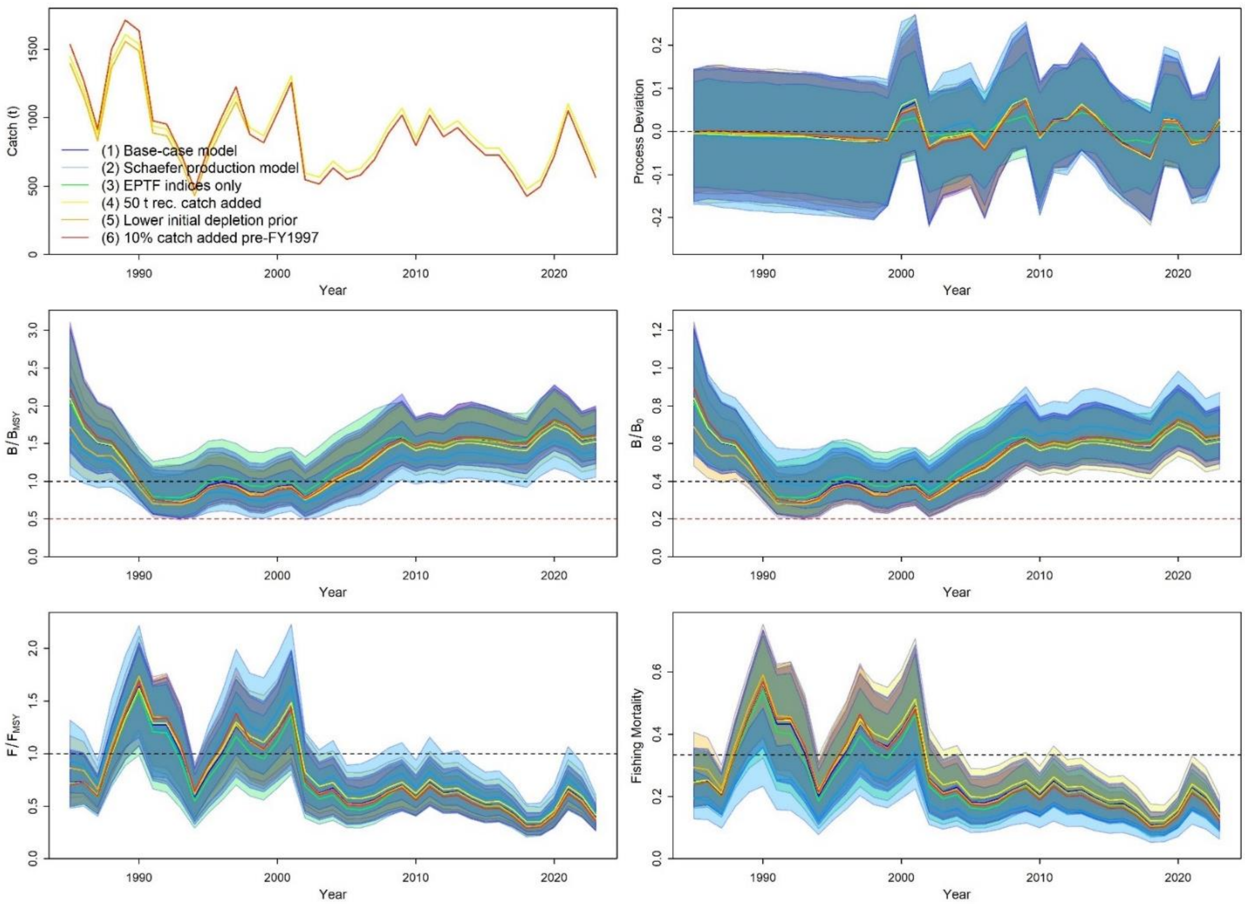

Figure 4 Ensemble plot showing profiles of key metrics (with 95% confidence intervals shaded) estimated from the base-case production model, and all sensitivity scenarios from FY1985-FY2023. The horizontal dashed line indicates maximum sustainable yield (MSY), whereas the dashed red line indicates B_{20} limit reference point.

Results of uncertainty evaluation

Key metrics were all comparatively stable under all sensitivity scenarios, and biomass/harvest metrics for FY2023 all remained well above/below (respectively) MSY reference points.

Stock Assessment Result Summary

Biomass status in relation to Limit	**B/B_0 > 20% in all model scenarios** Production model (base-case, last series value [2021]): B/B_0 = 63%
Biomass status in relation to Target	NA
Fishing mortality in relation to Limit	NA
Fishing mortality in relation to Target	NA
Current SAFS stock status	Sustainable (NSW)
Current Commonwealth stock status	NA

Fishery interactions

The majority of Eastern School Prawn catch is taken via prawn trawl gear within estuarine and inshore ocean waters. Bycatch and impacts on non-target species are common in prawn trawling operations (Kennelly 1995), and diverse assemblages are often captured (Taylor *et al.* 2020). Recent OTF observer surveys showed average discarded catch of up to ~0.5 t per trip, but interactions with threatened and protected species were generally low (Johnson and Barnes 2023). An observer program on the EPTF has not yet been undertaken, however several gear modifications are available to reduce interaction or capture of non-target species (Broadhurst *et al.* 2012), that are used by EPTF fishers to varying degrees.

The methods commonly used to capture Eastern School Prawn in the EGF are reasonably selective, and often exploit aggregations and predictable migratory behaviours to target prawn species explicitly. Consequently, interactions with non-target species for Eastern School Prawn captured within this fishery are low (e.g., Andrew *et al.* 1995; Gray *et al.* 2003), and bycatch is often in good condition upon release.

Stakeholder engagement

Ocean Trawl Fishery shareholders, fishers and/or their representatives were invited to participate in online presentations of OTF-related assessments for Eastern King Prawn and Eastern School Prawn on 14 December 2023, to provide any relevant commentary on the assessment and raise any other relevant information. While several fishers and stakeholder representatives attended the briefing, no major issues or points of discussion were raised.

Qualifying Comments

The biomass dynamics models used in data limited assessments must always be interpreted with caution, particularly for short-lived species such as Eastern School Prawn. Such production models may perform poorly for these species, particularly where stocks may be characterised by episodic recruitment exacerbated through environmental variation, and where new recruitment accounts for most of the biomass available in any particular year (as opposed to existing biomass from the previous year). Zhou *et al.* (2009) examined the suitability of various Bayesian biomass dynamics models for short-lived species using an Australian penaeid prawn (*Penaeus semisulcatus*) fishery as a case study. The study concluded that the conventional production model was largely suitable for this short-lived prawn species, and predicted almost identical biomass trajectories to other more 'data demanding' models.

Declines in fishing effort over decadal scales are likely to have influenced catch levels, regardless of the biomass present in the stock. While this has been partially addressed through the catch rate standardisation process, unknown bias may remain which could influence the production model and the biomass trajectories that are derived from it. The modelling approaches employed in data limited assessments are simplistic and generic by their nature, and a degree of uncertainty is present across all estimates.

The data sources employed to model Eastern School Prawn are derived in their entirety from commercial fisheries, and may therefore be potentially biased by a range of extrinsic and other factors, including but not limited to environmental, operational, economic and social factors. For Eastern School Prawn fishing, this includes nuance that cannot be easily accounted for but may impact catch and catch-rates (examples for Eastern School Prawn include differences in permitted gear through time and even among different areas *within* estuaries, unknown targeting behaviour, changes in fishing power associated with advances in gear technology, imposition of daily catch quotas by *some* fishing co-operatives, to name a few). Finally, it is important to highlight that the data used in this assessment were self-reported by fishers and are subject to errors and omissions that may not be random in their nature. All of the above factors may create bias in the data that have an unknown influence on the relationships modelled. The uncertainty created by aggregative effort reporting behaviour, and the erroneous nature of fisher logbook reporting in NSW more generally, should be especially considered when interpreting the results of models presented.

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