# Stock Status Summary 2021

NSW Stock Status Summary – NSW Eastern School Prawn (*Metapenaeus macleayi*)

## Assessment Authors and Year

Taylor, M.D. 2020. NSW Stock Status Summary 2018/19 – NSW Eastern School Prawn – (*Metapenaeus macleayi).* NSW Department of Primary Industries. Fisheries NSW. 10 pp.

## Stock Status

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| Current stock status | On the basis of the evidence contained within this assessment, NSW Eastern School Prawn is currently assessed as **Sustainable** for the NSW component of the stock. |

## Stock Structure

As a result of uncertainty regarding the biological stock structure of Eastern School Prawn, for the purposes of this assessment, stock status is presented at the jurisdictional level, assuming that all Eastern School Prawn caught within New South Wales constitute one 'stock' for status reporting purposes.

### Stock Status – New South Wales

### Catch Trends

Eastern School Prawn harvest in NSW has been highly variable over the past 3.5 decades (Fig. 1), which is consistent with general observations of recruitment and catch which indicate substantial influence of environmental conditions (especially rainfall) on abundance (Pinto and Maheshwari 2012, Ruello 1973, Taylor and Loneragan 2018). Simulation modelling has also established that environmental factors can have a strong influence on Eastern School Prawn catches (Ives et al. 2009). These traits mean this species displays large inter-annual variations in recruitment, and this is evident in the catch history presented in Fig. 1. The FY2019 total NSW Eastern School Prawn harvest was 470.5 t.

Recent recreational and indigenous catch is uncertain, as the species is not adequately represented within the sampling frame for contemporary recreational fishing surveys. The FY2001 National Recreational and Indigenous Fishing Survey reported recreational and indigenous landings of ALL prawn species in NSW at 104.8 t (Henry and Lyle 2003).

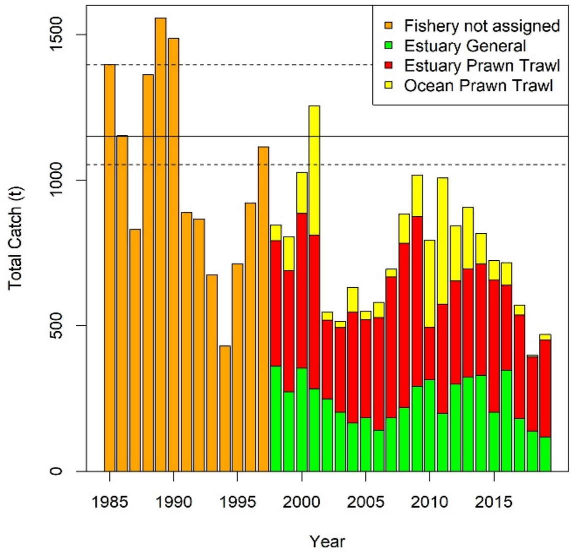


**Figure 1** Total annual Eastern School Prawn catch by reported fishery (commercial only) within New South Wales from 1985 – 2019 (fiscal years [FY]). Maximum Sustainable Yield (MSY) as estimated from Surplus Production Modelling is indicated by a solid horizontal line, and upper and lower 95% MSY confidence intervals shown as horizontal dashed lines.

## Fishing effort trends

Total fishing effort across all methods and fisheries that reported School Prawn catch was 6544 days in FY2019 (Fig. 2). Total effort has consistently declined from a maximum of ~50,000 days at the commencement of the reported time series, over the past 3.5 decades (Fig. 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 (Fig. 2), which may have occurred due to aggregative effort reporting behaviour. This is discussed further in Qualifying Comments below.

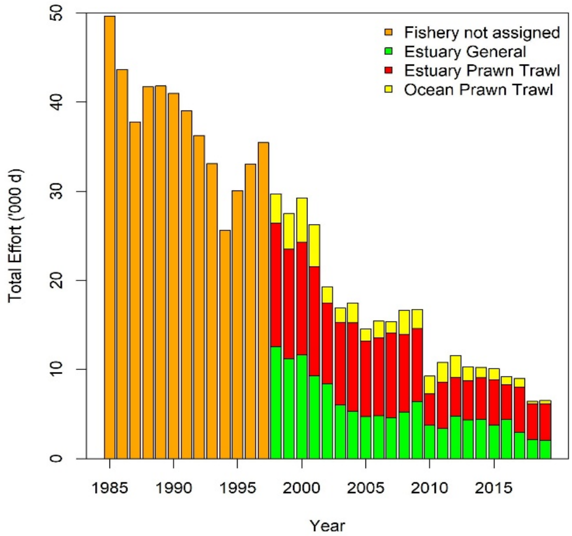


**Figure 2** Total annual days effort associated with Eastern School Prawn catch by reported fishery (commercial only) within New South Wales from 1985 – 2019 (fiscal years [FY]).

## Catch rate trends

Eastern School Prawn standardised catch rates were predicted 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 catch rates. Generalised linear models were fitted in R (R Development Core Team 2017) using the dosingle function in the rforcpue package (Haddon 2018). Models included explanatory variables *Year* (fiscal year [FY]), *Month*, *Area* (estuary), and *Fishing License #* (Licensed Fishing Boat [LFB] number are not used for the NSW Estuary Prawn Trawl, so Fishing License # was assumed to represent vessel/fisher throughout the time series). No data was available to support incorporation of potential changes in fishing power throughout the time series. Only Estuary Prawn Trawl catch-per-unit-effort (CPUE) data was modelled, and was expressed as $log\left(\frac{Catch\ (kg)}{Effort\ (d)}\right)$ for each non-zero monthly catch and effort record in the time series. Estuary Prawn Trawl represents the largest component of harvest for Eastern School Prawn, especially in recent years (Fig. 1).

Standardised commercial catch rates (Fig. 3) is likely to be the most reliable index of relative abundance for Eastern School Prawn. Catch rates substantially increased in the period post-FY2006, and have remained relatively stable since FY2011. Within this recent period, catch rates peaked during FY2015 and 2016 which were considerably wet years for coastal NSW, and were lower than the recent average in FY2018 and FY2019, during a protracted period of drought across NSW. However, there is no evidence of a consistent downward trajectory in catch rates for the species.

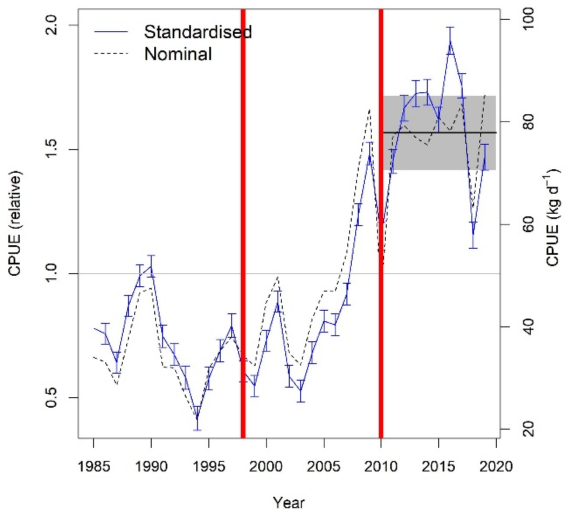


**Figure 3** Standardised (solid blue line, with error bars indicating 95% confidence intervals) and nominal (dashed black line, representing the geometric mean CPUE for each time increment) catch rate series for New South Wales Estuary Prawn Trawl Eastern School Prawn harvest. Both relative (primary -*y*-axis) and scaled (secondary -*y*-axis) axes are presented to aid interpretation. The solid black line indicates the most recent 10-year average, and the grey shaded area indicated the 95% confidence intervals surrounding this mean. The horizontal grey line represents the geometric mean CPUE through the series. The vertical red lines represent implementation of major changes to reporting, which could be considered to result in breaks in the continuous time series.

## Stock Assessment Methodology

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| Year of Most Recent Assessment | 2020 (using data to the end of FY2019) |
| Assessment method | 1. Standardised CPUE time series, specifically the trajectory of standardised CPUE, and comparison against recent mean CPUE;<br><br>2. Surplus Production Model (SPM) using the datalowSA package in R (Haddon *et al*. 2018). The SPM uses population productivity ($r$), carrying capacity ($K$), and initial biomass ($B_{init}$) parameters of an underlying Schaefer production model, to describe the dynamics of the stock in terms of its exploitable biomass. |
| Main data inputs | 1. Commercial catch of Eastern School Prawn landed across all fisheries within New South Wales, from FY1985 – FY2019, derived from the New South Wales ComCatch database for FY1985 – FY2009, and FishOnline database from FY2010 – FY2019. Commercial catch were expressed as the total catch per fiscal year for the period above;<br><br>2. Standardised catch rates for Estuary Prawn Trawl harvest within New South Wales, from 1985 – 2019, derived from the New South Wales ComCatch database for 1985 – 2009, and FishOnline database from 2010 – 2019. All input data were monthly aggregates of catch and effort per fisher-period, with records of <5 days per month excluded (as outlined below). Standardised catch rates were expressed as the geometric mean per fiscal year for the period above. |
| Key model structure and Assumptions | 1. Standardised catch rates<br>*Model structure*: As described in Catch rate trends, above<br>*Assumptions*: The analysis assumes that annual catch rates represent a relative index of abundance, and are not unduly influenced by error in reporting or other factors that are not explicitly or indirectly accounted for through the standardisation model<br><br>2. Surplus Production Model<br>*Model structure*: Uses the Schaefer production model with maximum surplus production assumed to equal $0.5 \cdot K$ (Haddon et al. 2018).<br><br>*Assumptions*: Initial estimates for $r$ and $K$ parameters for the SPM were obtained from preliminary simulations using a Catch-MSY model (Martell and Froese, 2013) within the datalowSA package (Haddon et al. 2018), using the above data sources (and assuming medium resilience). The stock was assumed to have been depleted prior to the time series of data included (this assumption was supported by Catch-MSY modelling which suggested initial depletion of ~0.6), so initial values for the model included $B_{init}$. Starting estimates of $B_{init}$ were optimised by minimisation of negative log-likelihood. |

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| Sources of Uncertainty evaluated | SPM outcomes were explored within a simulation framework testing a range of initial parameters. Outlying estimates were rare, and the median starting values from these simulations were used for model predictions.<br><br>Bootstrapping was used to derive confidence intervals for all parameters, estimates and indicators. |

## Status Indicators and Limits Reference Levels

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| Biomass indicator or proxy | There is no biomass indicator or proxy specified in a formal harvest strategy for Eastern School Prawn.<br><br>For the purposes of this assessment, the mean estimated biomass depletion (expressed as a proportion of *K*) from SPM analyses was selected as a proxy. |
| Biomass Limit Reference Level | There is no Biomass Limit Reference Level specified in a formal harvest strategy for Eastern School Prawn.<br><br>For the purposes of this assessment, the value of 20% of estimated *K* was selected for the limit reference point ($B_{lim}$), and 48% of estimated *K* was selected for the target reference point ($B_{targ}$). |
| Fishing mortality indicator or proxy | There is no fishing mortality indicator or proxy specified in a formal harvest strategy for Eastern School Prawn.<br><br>For the purposes of this assessment, the mean estimated harvest rate from SPM analyses was selected as a proxy. |
| Fishing Mortality Limit Reference Level | There is no Fishing Mortality Limit Reference Level specified in a formal harvest strategy for Eastern School Prawn.<br><br>For the purposes of this assessment, $F_{targ}$ and $F_{lim}$ were specified as the estimated harvest rates which correspond with $B_{targ}$ and $B_{lim}$, respectively. |

## Stock Assessment Results

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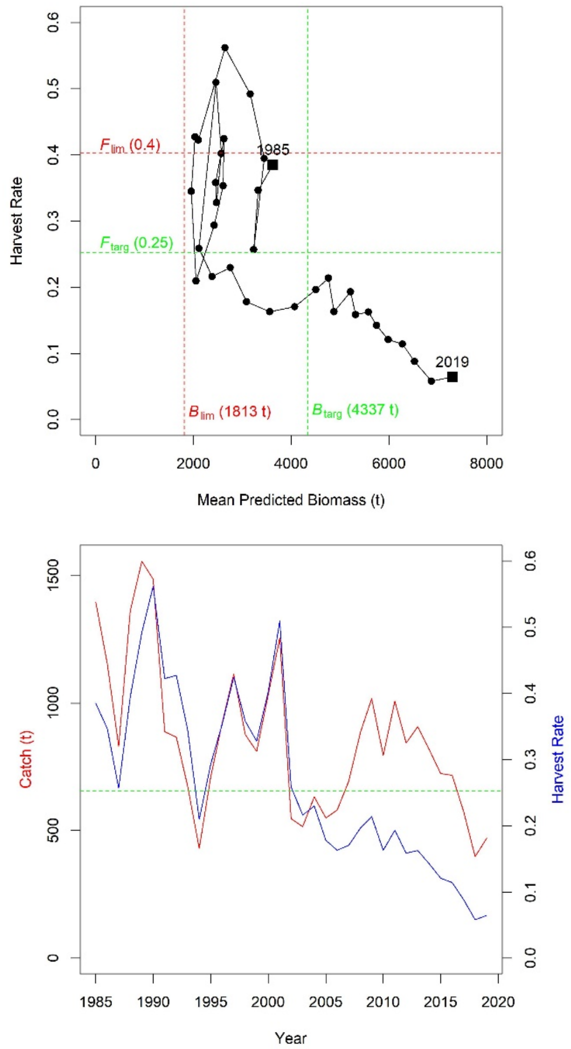
| 1. Standardised catch rates | Assessment of standardised catch rates for NSW Estuary Prawn Trawl Eastern School Prawn harvest is under *Catch rate trends* above. |
| 2. Surplus Production Model<br><br>NSW Eastern School Prawn stock status trajectory from FY1985 – FY2019, showing annual estimated biomass and harvest rate.<br><br>Limit and target reference levels are shown for biomass ($B_{lim} = 0.20 \cdot B_0$; $B_{targ} = 0.48 \cdot B_0$ respectively) and corresponding references for fishing mortality ($F_{lim}$; $F_{targ}$ respectively) are indicated. The start and final year of the time series is indicated.<br><br>The catch history and corresponding harvest rates are also illustrated in the lower panel to aid interpretation of the status trajectory. The horizontal green dashed line indicates $F_{targ}$.<br><br>For FY2019, the estimated biomass is well above the target reference point with a depletion estimate of 0.81, and the harvest rate is well below the target reference point. |  |

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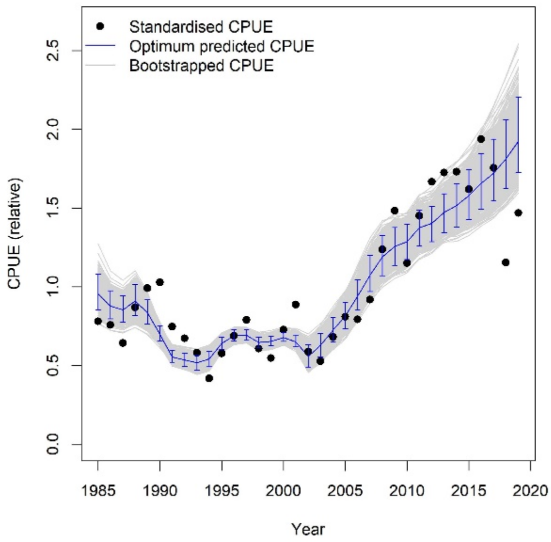
| Original standardised CPUE estimates (black dots), alongside SPM-derived estimated CPUE trajectories (from bootstrapping, grey lines) and optimum predicted CPUE trajectory (blue line, with 90th percentile confidence limits).<br><br>While the SPM estimated standardised CPUE reasonably well, there are some deviations in the series, particularly for the latter 10 years. This may arise as environmental variability becomes more influential on the stock during the latter time series, as harvest rates have decreased and the influence of fishing on stock dynamics has diminished. |  |
| Summary outputs from the SPM assessment for NSW Eastern School Prawn, showing mean (50 %) and 95 % confidence intervals (CIs) for key parameters.<br><br>FY2019 harvest (470.5 t) is well below the lower CI for Maximum Sustainable Yield (1050 t). | see table below |
| Biomass status in relation to Limit | Taking into account marked rainfall variability and drought in recent years, and known effects of on recruitment in Eastern School Prawn, standardised catch rates (as a proxy for stock biomass) approximated recent historic levels, and showed no indication of a downward trend.<br><br>Surplus production modelling estimated that biomass has remained above $B_{targ}$ for the previous 12 years, and the depletion ratio is increasing. The current biomass estimate for the stock of ~7,500 t is well above $B_{targ}$ (4,337 t), and the highest in the time series analysed, as is the lower CI (~6,100 t). |

| Parameter | 2.5 % | 50 % | 97.5 % |
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| *r* | 0.31 | 0.51 | 0.73 |
| *K* (‘000 t) | 5.96 | 8.85 | 17.01 |
| $B_{init}$ (‘000 t) | 2.84 | 3.59 | 4.95 |
| *MSY* (‘000 t) | 1.05 | 1.14 | 1.40 |
| $Depletion_{FY2019}$ | 0.67 | 0.81 | 0.85 |
| $Harvest\text{-}rate_{FY2019}$ | 0.04 | 0.07 | 0.09 |

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| Fishing mortality in relation to Limit | The estimated harvest rate has remained below $F_{targ}$ for around 16 years. The harvest rate has been decreasing during the last 10 years, but has appeared to stabilise during the last two years in this time series. The low harvest rate has meant that the stock biomass has continued to increase over this period. |
| Previous SAFS stock status | Stock status for Eastern School Prawn in NSW was previously (2018) reported as sustainable |
| Current SAFS stock status | On the basis of the evidence provided above, Eastern School Prawn in New South Wales is classified as a **Sustainable stock**. |

## Qualifying Comments

### Effort reporting

Some uncertainties regarding effort reporting are present throughout the time series. First, effort was not directly reported against catch of Eastern School Prawn for records collected pre-FY1998, and the analysis here relied on mapping effort to catch data after the fact. Secondly, for Estuary Prawn Trawl, data exploration revealed potential aggregative reporting behaviour for effort, both for the period when records were reported monthly (pre-FY2010), and when daily records were required (post-FY2009, in this data set daily records were aggregated [summed] by fisher-month to align with pre-FY2010 records). This was evident in the data in two ways. There were distinct peaks in records where 10 d month$^{-1}$ (2 working weeks), 15 d month$^{-1}$ (3 working weeks), and 20 d month$^{-1}$ (4 working weeks) were reported (Fig. 4), suggesting aggregation and rounding into finite weekly units (5 days in a working week) may have been occurring. This pattern diminished in the post-FY2009 period, however, the distribution of recorded effort changed radically (Fig. 4). In particular, records of 1-3 fisher-days per month were heavily over-represented within the data. Fishers are required to submit a separate record for each day on which fishing occurs, but these relationships suggest potential aggregative reporting behaviour whereby fishers are submitting a single record once per month (resulting in 1 d month$^{-1}$ effort), once per fortnight (resulting in 2 d month$^{-1}$ effort), or once per week. This would have the effect of inflating CPUE for these records, as an entire week or month of catch would be divided by an aggregated unit of effort. For this reason, in an effort to ameliorate the potential impact of this, monthly aggregates comprising < 5 days per fisher-month were excluded from the post-FY2009 period prior to CPUE standardisation.

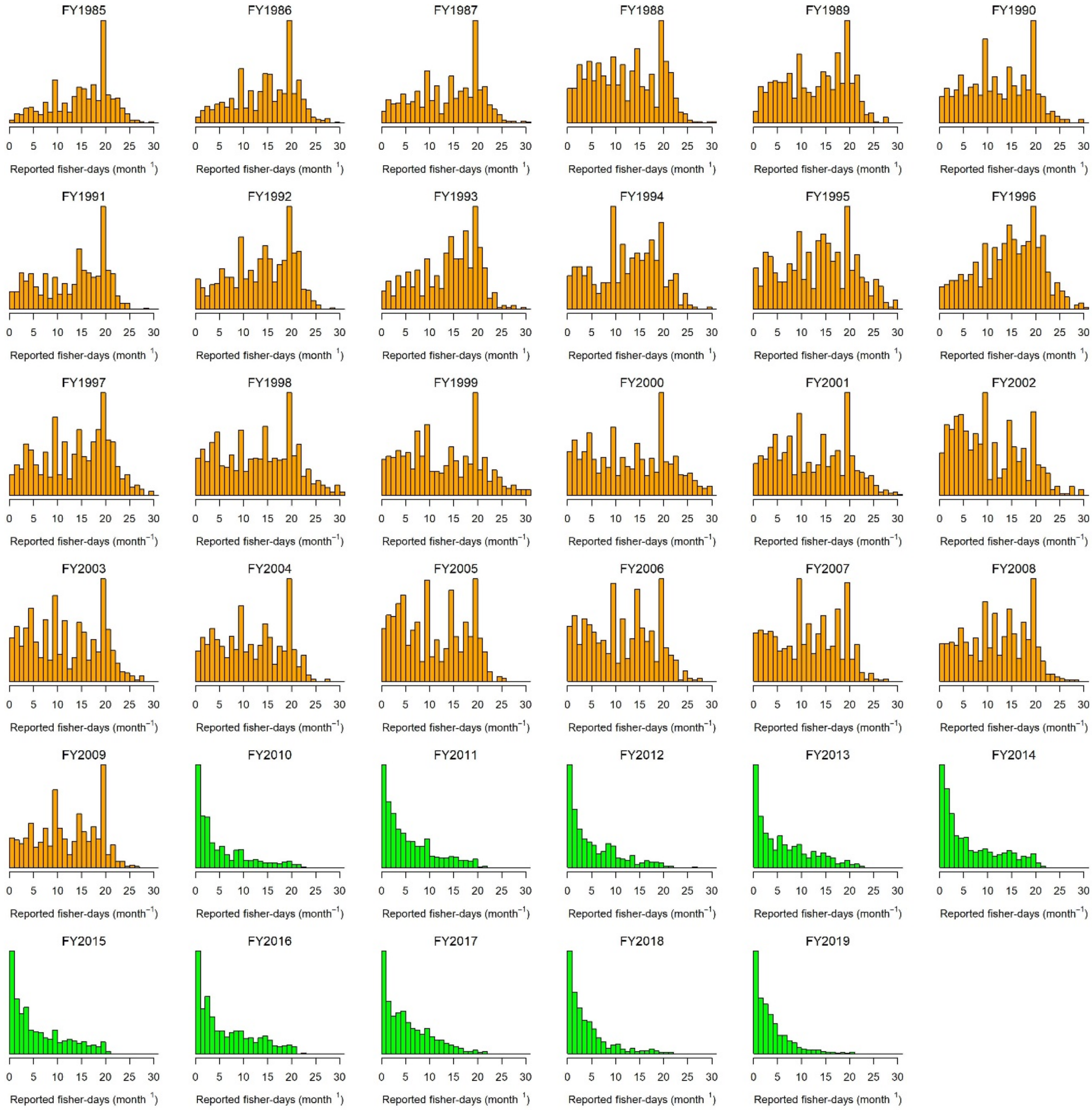


**Figure 4** Histogram showing the distribution of reported Estuary Prawn Trawl effort records across the time series. Monthly records from the ComCatch database (pre-FY2010) are shown in orange, whereas daily records from the FishOnline database aggregated to fisher-month (post-FY2009) are shown in green.

## Standardised CPUE series

Correlation analysis for standardised CPUE and catch data was undertaken across the entire available time series. Outcomes of this analysis suggested strong negative correlation between catch and CPUE for both forward and backward lags for Eastern School Prawn, with an estimated optimal lag around -9 years. This is counter intuitive for a short-lived species, however the analyses may have been detecting long-run cyclicity in the dataset, and may have been heavily influenced by the substantial increases in CPUE between 2006 and 2010.

## Modelling

The modelling approaches used in the current assessment are simplistic and generic by nature; therefore, results should be interpreted with caution. The data presented above suggests a moderate level of uncertainty in all estimates. The modelling approach employed may perform poorly for short-lived species, particularly where stocks may be characterised by episodic recruitment arising through environmental variation. The uncertainty created by aggregative effort reporting behaviour (discussed above) should be considered when interpreting the results of SPM.

## References

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Haddon, M., Punt, A., Burch, P. (2018) simpleSA: A package containing functions to facilitate relatively simple stock assessments. R package version 0.1.18.

Henry GW, Lyle JM (2003) The national recreational and indigenous fishing survey, Canberra: Australian Government Department of Agriculture, Fisheries and Forestry. 188 p.

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Taylor MD, Loneragan NR (2019) Catchment-derived stressors, recruitment, and fisheries productivity in an exploited penaeid shrimp, *Regional Studies in Marine Science*, 29: 100628, doi.org/10.1016/j.rsma.2019.100628