Stock Status Summary – 2022/23

NSW Stock Status Summary – Eastern School Whiting
(Sillago flindersi)

Assessment Authors and Year

Hall, K. C. 2023. NSW Stock Status Summary 2022/23 – Eastern School Whiting (*Sillago flindersi*). NSW Department of Primary Industries, Fisheries. 19 pp.

Stock Status

Current stock status	On the basis of the evidence contained within this assessment, Eastern School Whiting is currently assessed as **sustainable** for the NSW part of the stock.

Stock structure & distribution

Eastern School Whiting is a temperate inshore demersal species that occurs in oceanic waters to a depth of about 100 m, from southern Queensland to South Australia, and including north-eastern Tasmania. The stock structure is currently unknown. Some historic genetic and growth data suggests there may be separate northern and southern stocks, with a division around Forster (Dixon et al. 1987). However, the power of the methods used to detect a difference was limited, and the results were difficult to interpret, with no clear geographic pattern in the genetic variation detected. Overall, the hypothesis of a single, genetically diverse panmictic stock could not be rejected, and the species has been assessed as a single south-eastern Australia biological stock (Conron et al. 2018).

Scope of this assessment

The data presented in this summary relate to the NSW part of the stock (reproduced from Hall 2023). This was an interim stock assessment for Eastern School Whiting, and summarises the primary biomass indicator results from the most recent 2020 Commonwealth Tier 1 assessment (based on data up to and including 2019, Day et al. 2020) and updates NSW fisheries statistics and secondary indicator information (for data up to and including 2021). The NSW part of the stock was assessed according to the *Status of Australian Fish Stocks* criteria (Piddocke et al. 2021) and with reference to the *NSW Trawl Whiting Harvest Strategy* (NSW DPI 2022).

A basket total allowable commercial catch (TACC) for 'Trawl Whiting' (combined Eastern School Whiting and Stout Whiting, *Sillago robusta*) was first introduced for the Ocean Trawl Fishery in the 2019-20 fishing season (1 May 2019 to 30 April 2020) and was set at 1,189 t. It was subsequently adjusted to 898 t for 2020-21 and 1,066 t for the 2021-22 and 2022-23 fishing seasons (Mapstone et al. 2020; NSW TAF Committee 2021; NSW TAF Committee 2022). The NSW TAF Committee recommended that the current multi-year TACC remain at the same level in 2023-24 (NSW TAF Committee 2022).

Biology

Eastern School Whiting reaches a maximum size of about 32 cm fork length (FL), but few individuals in commercial catches exceed 25 cm FL (Gray et al. 2014a). It is a relatively fast-growing and short-lived species, reaching a maximum recorded age of 9 years (Day 2017).

Maturity occurs at about 2 years of age and 15 cm in length (Gray et al. 2014a), although age and size at maturity and spawning season may show some latitudinal variation (Day 2017).

Distribution and size composition data from independent trawl surveys using the *FRV Kapala* in the early 1990s found larger Eastern School Whiting in offshore waters (60–80 m depth), while smaller juveniles mainly occurred in inshore waters (10–30 m depth) (Graham et al. 1993a; Graham et al. 1993b; Graham and Wood 1997). Similar patterns were found during a chartered prawn trawl survey in 2006–2007 (Gray et al. 2014b). Overall, greater numbers of Eastern School Whiting are caught in offshore waters than in inshore waters, particularly in the mid-depth strata of 37–55 m (Graham and Wood 1997; Gray et al. 2014b).

FISHERY STATISTICS

Catch information

Commercial

Annual commercial catches of Eastern School Whiting in NSW state waters (following adjustment for inaccurate species reporting in northern NSW) peaked at 1,167 t in 1998 and remained above 700 t until 2012, after which catches decreased to a recent minimum of 494 t in 2014 (Fig. 1). Over subsequent years, catches rapidly increased to 1,187 t in 2017, 1,155 t in 2018 and 1,230 t in 2019 in the lead up to quota introduction, but have since decreased to 837 t in 2020 and 506 t in 2021 (Fig. 1).

Most of commercial catch of Eastern School Whiting from NSW waters is taken by fish and ocean prawn trawlers in the Ocean Trawl Fishery (OTF) and Southern Fish Trawl Restricted Fishery (SFT) (Fig. 2). A small number of NSW Danish seine operators have also targeted trawl whiting in NSW since 2010. Danish seine and SFT catches have been combined with northern fish trawl (NFT) catches and are collectively referred to as the ‘fish trawl sector’. Historically, Eastern School Whiting catches were larger for the ocean prawn trawl sector than the fish trawl sector and showed latitudinal variation across ocean zones (OZ1 to OZ10, north to south along the coastline), with larger catches in the north (OZ1 to OZ4) where the prawn trawl sector mainly operates (Figs 2 and 3). However, since 2007 this trend has gradually reversed, and the recent fluctuations in the commercial catches are largely influenced by northern fish trawl catches from OZ5 (Figs 2 and 3).

Eastern School Whiting is also targeted by Danish seine and trawl vessels in the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) in offshore waters (>3 nm from the coastline) south of Barrenjoey Point (Fig. 1). Total Commonwealth catches (based on CDR data, not including discards) were 550.3 t in 2020 and 497.2 t in 2021 (Althaus et al. 2022) and recent TACs have been considerably under-caught. Much smaller commercial catches are also taken by trawl vessels in Victorian and Tasmanian state waters that on average account for less than 2% of the total catch (Conron et al. 2018).

Total commercial discards across all jurisdictions are estimated as part of the Commonwealth Tier 1 stock assessment modelling, which was updated in 2020 using data up to and including 2019 (Day et al. 2020). Total discards were estimated to be 388 t in 2020 assuming a total catch of 1,752 t (actual catch was 1,379 t) and 370 t in 2021 assuming the estimated RBC of 2,140 t was fully caught.

NSW Stock Status Summary – Eastern School Whiting
(Sillago flindersi)

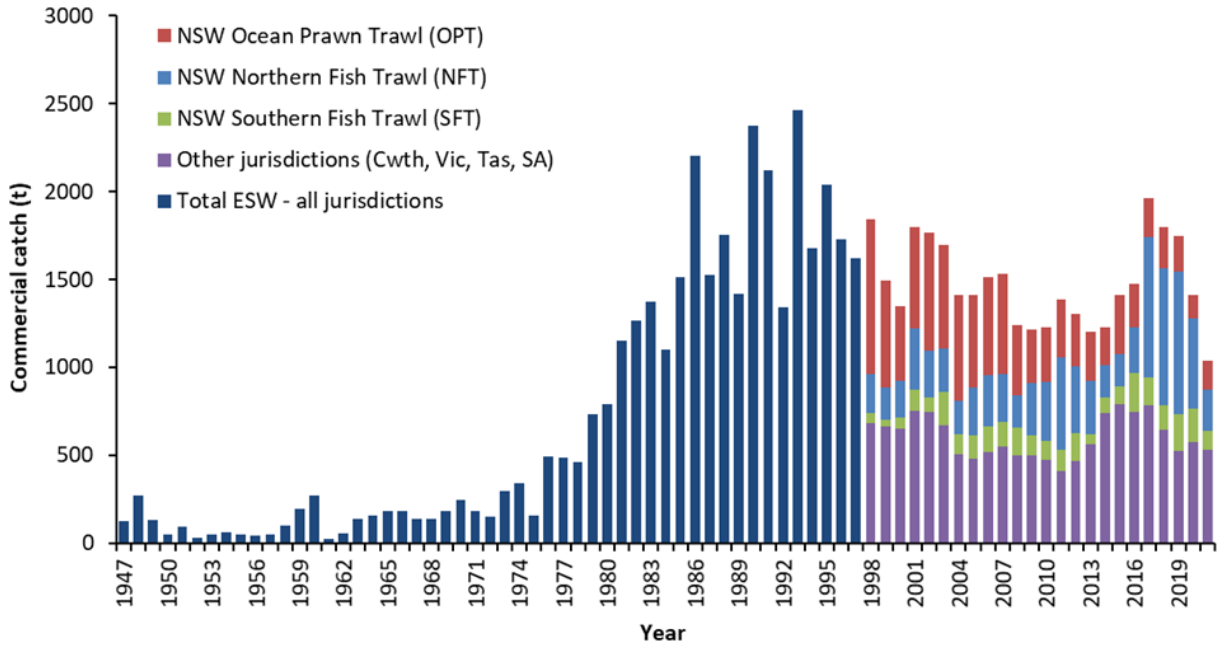

Figure 1 **Annual adjusted commercial catches (tonnes) of Eastern School Whiting (ESW) for all jurisdictions combined (1947–1997) and for sectors of the NSW Ocean Trawl Fishery relative to the combined catches of other jurisdictions (1998–2021), including Commonwealth (Cwth), Victorian (Vic), Tasmanian (Tas) and South Australian (SA) waters. Data for other jurisdictions are from Day et al. (2020) and Althaus et al. (2022).**

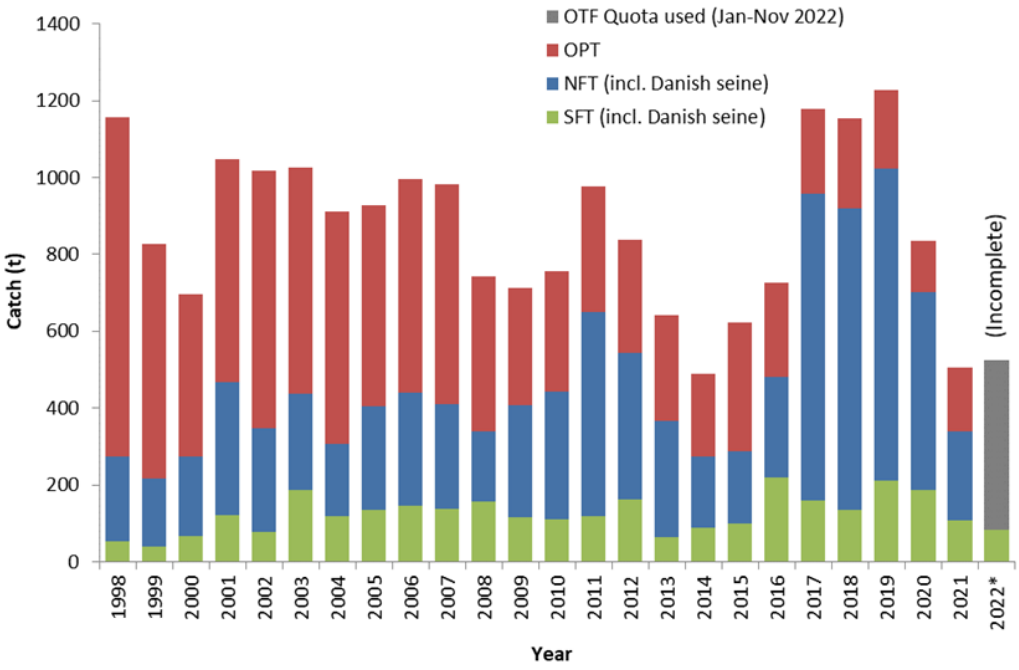

Figure 2 **Annual adjusted commercial catches (tonnes) of Eastern School Whiting in NSW waters (1998–2022) for different sectors and endorsements in the NSW Ocean Trawl Fishery. OPT=ocean prawn trawl, NFT=northern fish trawl, SFT=southern fish trawl.**

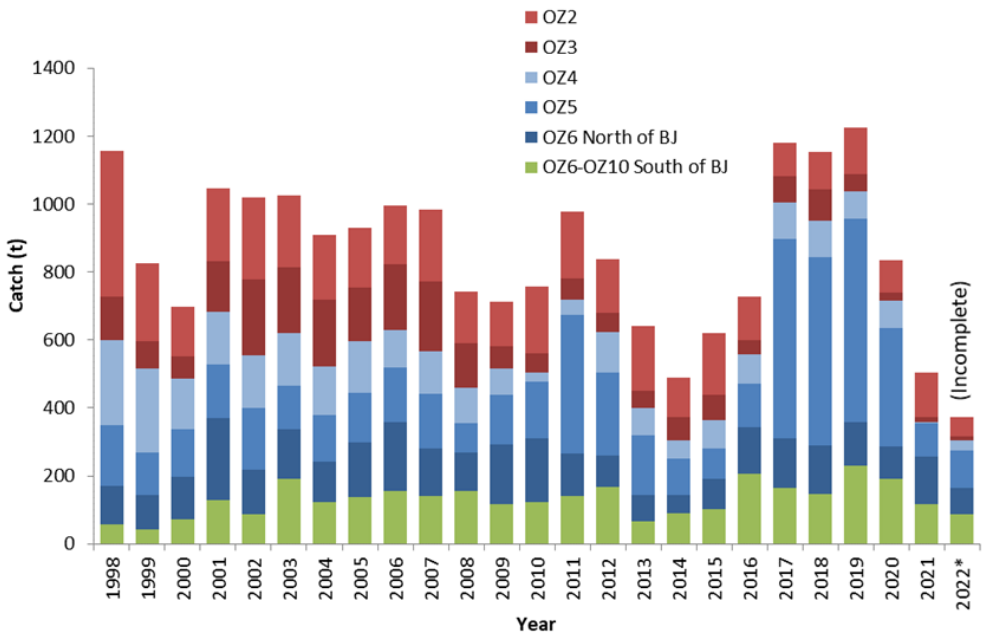

Figure 3 **Annual adjusted commercial catches (tonnes) of Eastern School Whiting from the NSW Ocean Trawl Fishery (1998–2022) reported in different fishing zones (OZ1–OZ10), with catches in OZ6 divided into amounts taken from north and south of Barrenjoey Point (BJ) and zones south of BJ aggregated for confidentiality reasons.**

Recreational & Charter boat

The most recent estimate of the recreational harvest of combined trawl whiting (Eastern School Whiting and Stout Whiting) in NSW was approximately 9,882 fish or around 1.4 t during 2019/20 (Murphy et al. 2022). This estimate was based on a survey of Recreational Fishing Licence (RFL) Households, comprised of at least one fisher possessing a long-term (1 or 3 years duration) fishing licence and any other fishers resident within their household, excluding other long-term licence holders. However, because these catches are so small the reliability of the estimates is questionable. Nevertheless, relative to the commercial catch, recreational catches are clearly negligible, and comprise approximately 0.1% of the total harvest from NSW waters.

Eastern School Whiting are also rarely reported in logbook catches and observer surveys of the NSW Charter Boat Fishery and catches are considered insignificant in comparison with commercial catches (Gray and Kennelly 2016; Hughes et al. 2021).

Indigenous

The annual Aboriginal harvest of Eastern School Whiting in NSW waters is currently unknown, but is also assumed to be small and to have a negligible impact on the stock biomass.

Illegal, Unregulated and Unreported

The level of illegal, unregulated and unreported fishing is unknown; however, there is considerable inaccurate species reporting on catch returns, particularly in northern NSW waters since July 2009, when separate species reporting was first introduced for trawl whiting. A large quantity of trawl

whiting catch in 2016–2018 was reported without accurate location information and other large catches in 2019 and 2020 on the south coast (in OZ8) were deemed invalid, which contribute towards greater uncertainty in total catch data.

Other IUU catches are likely to occur through fishers that are dual endorsed in either Queensland and Commonwealth fisheries taking catches of trawl whiting from NSW waters and landing them in another jurisdiction. Many NSW OTF fishers hold dual endorsements with other jurisdictions and anecdotal evidence suggests this practice may have increased since NSW quotas were introduced.

Fishing effort information

Commercial fishing effort for Eastern School Whiting was collected as number of days fished on monthly records prior to July 2009 and as numbers of hours fished per daily event after July 2009. To form a longer time series of effort, recent daily events were re-aggregated, with effort in days fished estimated from the number of fishing events entered for each fisher in each month where Eastern School Whiting was reported on at least one day; and were adjusted for multi-day trips reported as a single fishing event by dividing the total number of hours by 12.

The reported effort for Eastern School whiting (in total days fished) by the prawn trawl sector declined rapidly from around 12,000 days fished and 120,000 trawl hours in the early 2000s to 4,270 days fished and 39,125 hours trawled in 2009 (Fig. 4). Effort was more stable between 2010 and 2018, after which it declined rapidly again following recent structural reforms and the introduction of quota. Prawn trawl effort for Eastern School Whiting was just 2,072 days fished and 12,108 hours trawled in 2021 (Fig. 4). In contrast, reported effort for Eastern School Whiting in the fish trawl sector was initially more variable and continued to decline after the reporting change in 2009. Following a slight increase just prior to quota introduction, fish trawl effort has rapidly declined over the last 2 years to just 657 days fished and 5,068 hours trawled in 2021 (Fig. 5).

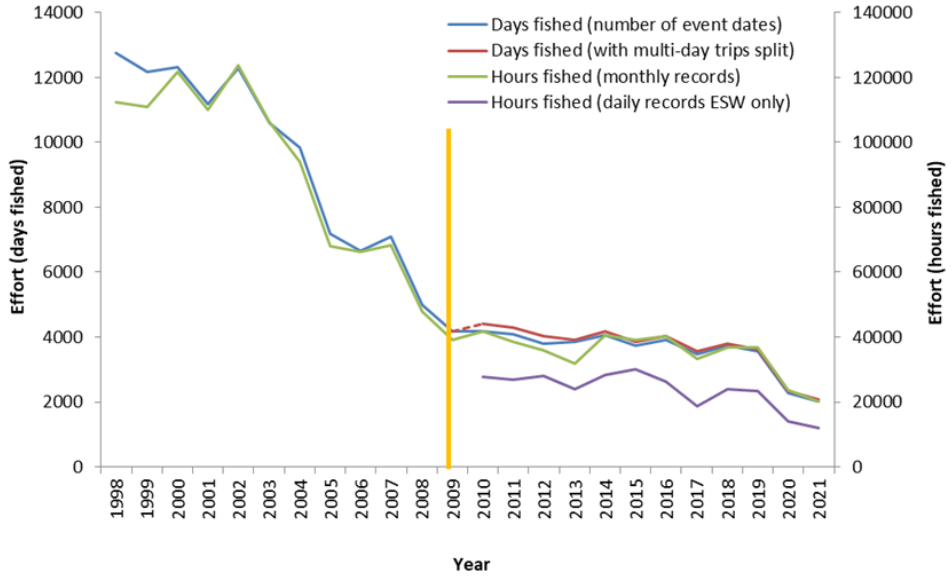

Figure 4 **Annual adjusted effort (days and hours fished) for prawn trawl fishers that reported landing Eastern School Whiting (ESW) on at least one day in a given month.**

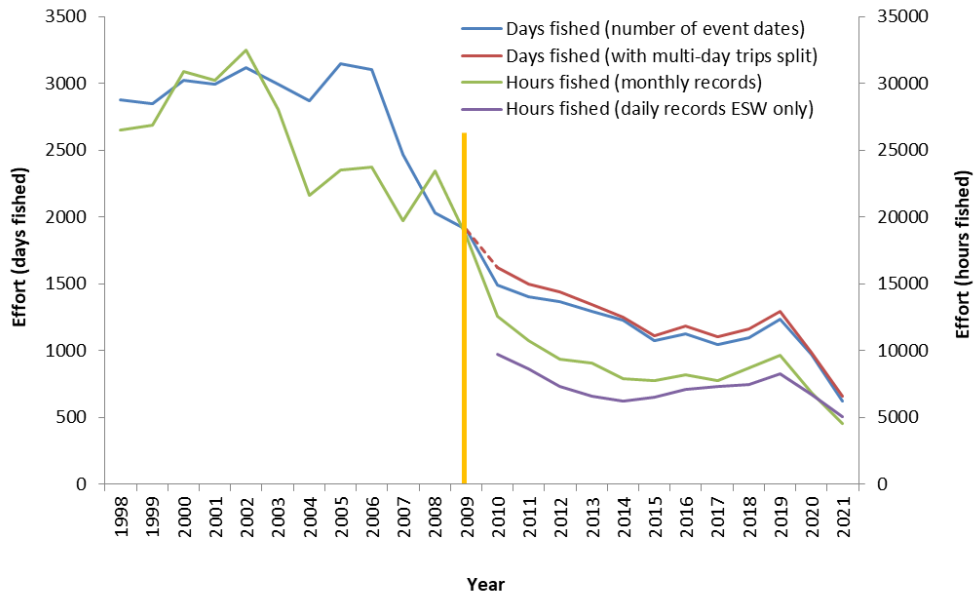

Figure 5 **Annual adjusted effort (days and hours fished) for fish trawl (including Danish seine) fishers that reported landing Eastern School Whiting (ESW) on at least one day in a given month.**

Catch Rate information

Monthly catch rates (catch-per-unit-effort, CPUE in kg per day fished) for Eastern School Whiting taken by the fish trawl (excluding Danish seine) and ocean prawn trawl sectors were compiled from monthly records between 1998 and 2008 and re-aggregated daily records between 2010 and 2020. Catch rates were standardized for month, ocean zone and vessel using the r-package 'cede' (Haddon 2018). Continuity of the time series across the catch reporting change in July 2009 must be interpreted with caution. Daily catch rates (CPUE in kg per hour trawled) were also compiled from daily fishing event records from 2010 to 2020 and standardised for month, ocean zone, vessel and capture depth (taken from the mean depth of the reported c-square).

The mean standardized catch rates of Eastern School Whiting have been consistently lower for the prawn trawl sector compared to the fish trawl sector (Figs 6 and 7). The two sectors operate in mostly different ocean zones, use different gears and vary in their targeted fishing practices, which account for these differences. The temporal trends in the two series over the last 22 years also vary.

Historic monthly catch rates of the prawn trawl sector (averaged across the State) rapidly declined between 1998 and 2000 to more than 50% below the long-term average, then steadily increased over the next 8 years to be well above the historic average in 2008 (Fig. 6). This suggests that the stock in northern NSW may have initially declined following the peak catches in the late 1990s, but then recovered. However, during the 2000s, changes to legislated whiting codend configurations may have also influenced catch rates (Graham et al. 2009).

Trends in both the re-aggregated monthly and daily event series show a decrease from 2010 to 2014, a spike in 2015 and then a return to levels near the 12-year average over the last 5 years. Both indices have declined slightly over the last 2 years to below the long-term average (Fig. 6).

Monthly catch rates of the fish trawl sector (average across the State) fluctuated around the long-term average in the early 2000s and then steadily increased after 2004 to a peak in 2008 (Figure 10). Monthly re-aggregated and daily event CPUE series over the last 12 years show a similar trend with a steady decline between 2011 and 2013 and then recovery from 2016 to above or near the 12-year trend. Both indices show a strong increase in 2020 and 2021 to well above the long-term average (Fig. 7).

Eastern School Whiting catch rate series for both sectors across different ocean zones (for which sufficient data are available) show some latitudinal variation in magnitude and temporal trends. This spatial variation suggests that some finer scale population dynamics may be occurring.

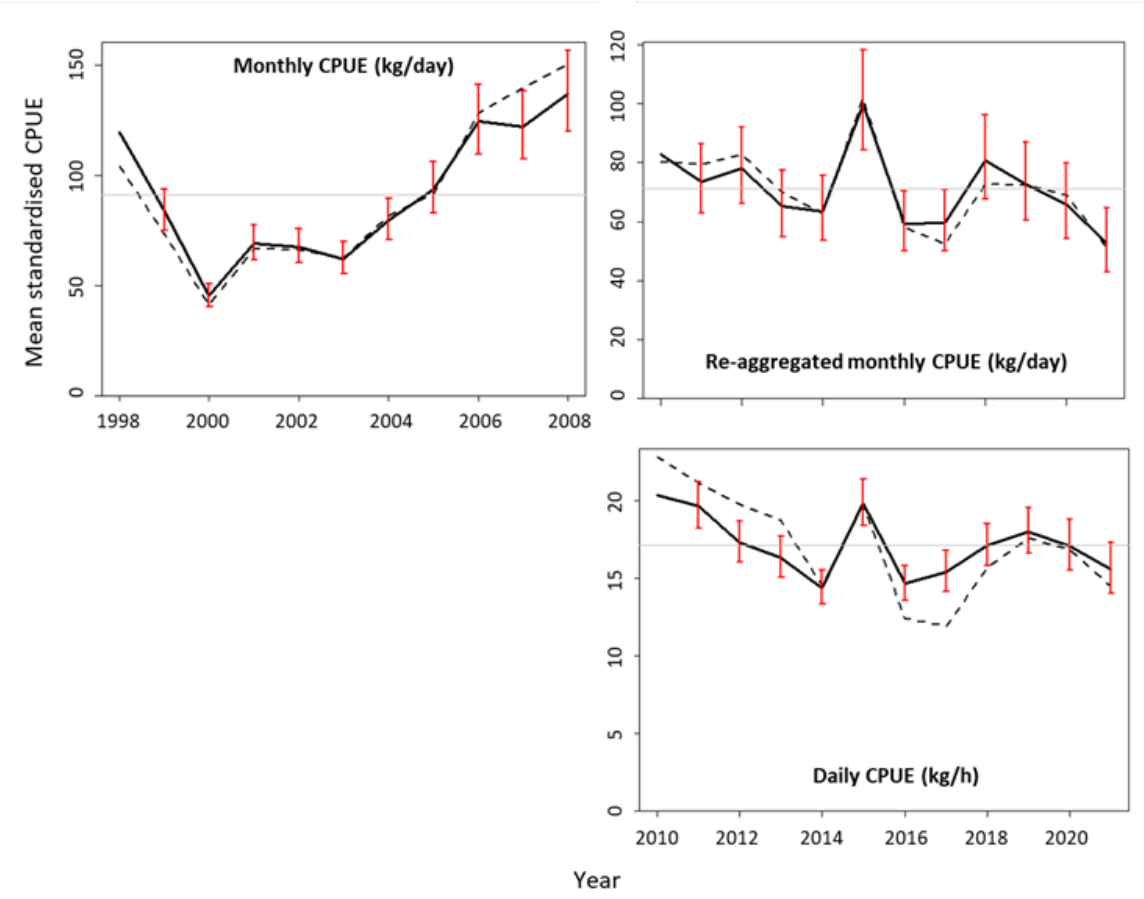

Figure 6 **Mean standardised catch rates (catch-per-unit-effort, CPUE) of Eastern School Whiting for the ocean prawn trawl sector of the NSW Ocean Trawl Fishery, estimated from monthly records (1998–2009) and re-aggregated daily records (2010–2021) in kg per days fished and from daily fishing event records (2010–2021) in kg per hours trawled. The dashed and solid lines indicate the nominal and standardised mean CPUE (± 95% confidence intervals), respectively; and the grey horizontal line indicates the long-term averages for each series.**

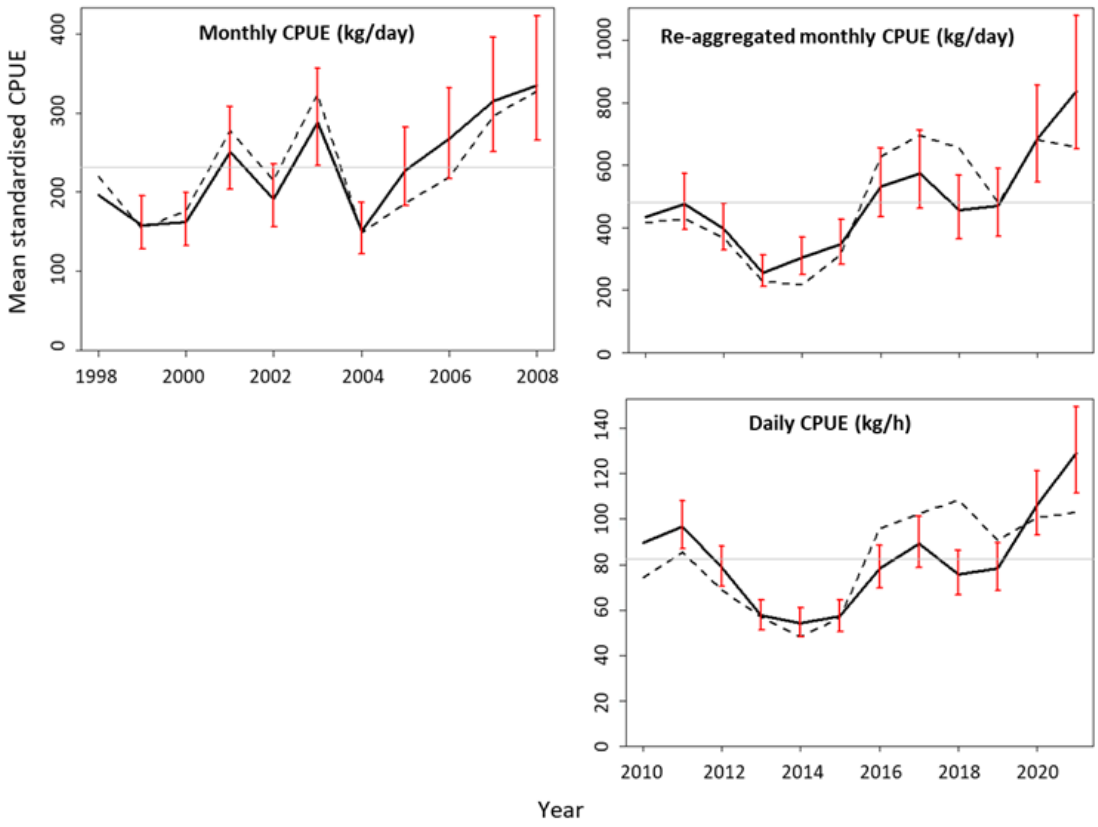

Figure 7 **Mean standardised catch rates (catch-per-unit-effort, CPUE) of Eastern School Whiting for the fish trawl sector (excluding Danish seine) of the NSW Ocean Trawl Fishery, estimated from monthly records (1998–2009) and re-aggregated daily records (2010–2020) in kg per days fished and from daily fishing event records (2010–2021) in kg per hours trawled. The dashed and solid lines indicate the nominal and standardised mean CPUE (± 95% confidence intervals), respectively; and the grey horizontal line indicates the long-term averages for each series.**

STOCK ASSESSMENT

The *Draft NSW Trawl Whiting Harvest Strategy* (NSW DPI 2022) outlines separate decision rules for primary biomass indicators in years when a quantitative stock assessment is available for Eastern School Whiting (typically completed every 3 to 5 years) and a range of secondary indicators to be monitored in interim years. The most recent quantitative stock assessment for Eastern School Whiting was completed in 2020, so 2022 was considered an interim year for stock assessment purposes. The following stock assessment section summarises available information for the primary spawning stock biomass indicators (from the quantitative stock assessment) and updates information for the range of secondary indicators used in interim years.

Stock Assessment Methodology

Year of most recent assessment:

2020 using data up to 2019, Commonwealth Tier 1 stock assessment completed by CSIRO on behalf of AFMA (Day et al. 2020); and 2022 using data up to 2021, NSW assessment of primary and secondary indicators outlined in the draft NSW harvest strategy for an interim year (Hall 2023).

Assessment method:

2020, a five-fleet integrated age-structured population dynamics model fitted using Stock Synthesis SS-V3.30.16 (Methot et al. 2020); and 2022, weighted-average percent changes in catch rates of the prawn and fish trawl sectors of the NSW Ocean Trawl Fishery, standardised using the r-package 'cede' (Haddon 2018)..

Main data inputs:

Commercial landings – reported annual catch, taken from fisher logbooks of various sources compiled into five fleets – Commonwealth Danish seine (combined with Tasmanian and Victorian); Commonwealth otter trawl (combined with Victorian and NSW Southern Fish Trawl); NSW Danish seine, NSW fish trawl (north of Barrenjoey Point) and NSW prawn trawl; 1942–2021. For the model estimated RBC projections, the 2020 total catch was assumed to be equivalent to the 2019 catch.

Estimated discards and rates – from an onboard observer program for four fleets (excluding NSW Danish seine fleet, which was assumed to have no discarding); Commonwealth data available 1994–2019, with some years missing; NSW data for two time periods.

Commercial catch rates – reported annual CPUE data for four fleets – Commonwealth Danish seine (in catch-per-shot, 1986–2019), Commonwealth trawl (in catch-per-h, 1995–2019), NSW fish trawl and prawn trawl (in catch-per-day from monthly records, 1998–2008 and catch-per-h from daily events, 2010–2021).

Length compositions – from Commonwealth and NSW fleets for retained and discarded catches from onboard observer programs (weighted by number of shots, 1990–2019); and for retained catches from port monitoring (weighted by number of trips, 1951–2019, many early years missing).

Age-at-length and ageing error data – from sectioned otoliths processed by Fish Ageing Services Pty Ltd for fish sampled from the Commonwealth Danish seine fleet (1991–2019) and trawl fleet (2001–2019, with some years missing); and processed by the NSW DPI ageing laboratory for the NSW fish and prawn trawl fleets for two time periods.

Life-history parameters – many were estimated from the modelling (e.g., all four von Bertalanffy growth parameters, recruitment and selectivity parameters for each fleet); others were taken from relevant literature (e.g., age and size at sexual maturity of 2 years and 16 cm FL, fecundity assumed to be proportional to spawning biomass, natural mortality fixed to M=0.6, steepness of the stock-recruitment relationship was set at h=0.75 and length–weight relationship parameters of a=1.32 x 10-5 and b=2.93).

Key model structure & assumptions:

Population dynamics modelling

Assumptions: a single-sex model (length data are not available by sex); single season of spawning assumed across the whole stock; the population was at an unfished biomass and equilibrium age-structure at the start of 1942; population abundance is proportional to standardised catch rates; the selectivity of fleets, rate of natural mortality and growth (mean size-at-age) are constant over time; selectivity is logistic for all fleets; and average annual recruitment follows a Beverton–Holt stock–

recruitment relationship. For more details on model assumptions see Day (2020) and Methot and Wetzel (2013).

Standardised catch rates

Assumptions: annual catch rates are a relative index of abundance and not unduly influenced by other factors that are not accounted for through standardisation.

Sources of uncertainty evaluated:

Twenty-five different model sensitivities were tested in the 2020 Tier 1 assessment (Day et al. 2020), including the effects of:

- varying the stock–recruitment steepness parameter (from h=0.75 to 0.65 or 0.85);
- varying the natural mortality (from M=0.6 to 0.5 or 0.75 per year);
- varying the age at 50% maturity (from 16 to 14 or 18 cm FL);
- varying the recruitment process error (from σ_R=0.7 to 0.6 or 0.8);
- placing different weightings on length (x 2 or x 0.5), age (x 2 or x 0.75) and survey CPUE data (x 1.5 or x 0.5);
- excluding each CPUE series in turn or including only that CPUE series; and
- reverting to the original 3-fleet, base-case model from 2017.

In addition, likelihood profiles of key parameters, retrospective analyses and jitter analyses were run as additional diagnostic tools to assess the model fits obtained from both the updated three-fleet model and new five-fleet model, along with assessment of the effects of a low-recruitment scenario on the estimated spawning biomass and forward catch projections (Day et al. 2020).

Status Indicators - Limit & Target Reference Levels

The stock status of Eastern School Whiting was assessed against the following performance indicators and reference points outlined in the *NSW Trawl Whiting Harvest Strategy* (NSW DPI 2022).

Biomass indicator or proxy	Spawning stock biomass depletion (as a percentage of the estimated unfished spawning stock biomass) estimated every 3–5 years from population biomass modelling; and standardised CPUE-based reference points in interim years.
Biomass Limit Reference Point	Blim of 20% of unfished spawning stock biomass. Current catch rates are assessed relative to long-term averages and levels in the last full assessment year.
Biomass Target Reference Point	Btarg of 48% of unfished spawning stock biomass, with a trigger reference point of 35% of unfished spawning stock biomass.
Fishing mortality indicator or proxy	Spawning potential ratio (1-SPR) as a proxy for fishing mortality that integrates fishing mortality across all fleets in the fishery, estimated every 3-5 years from population biomass modelling; fishing

	mortality estimates from catch-curve analyses and and total catches and discards relative to estimated RBCs in interim years.
Fishing mortality Limit Reference Point	Level of fishing mortality (Flim) above which overfishing is occurring and biomass is depleting toward Blim.
Fishing Mortality Target Reference Point	Level of fishing mortality (Ftarg) that would result in a spawning stock biomass of Btarg.

Stock Assessment Results

Primary indicators

- Spawning stock biomass

The 2020 Commonwealth Tier 1 stock assessment (using data up to and including 2019), developed a five-fleet base-case model that included an increased amount of NSW fisheries and biological data, including two CPUE series from NSW waters. The model estimated the spawning stock biomass of Eastern School Whiting was at 33% of unfished biomass in 2020 and will recover to 41% in 2021 assuming average recruitment (Day et al. 2020). Development of the five-fleet model with additional NSW data improved the uncertainty in the biomass depletion estimate (95% asymptotic intervals of 35–45%).

Under the agreed 20:35:48 harvest control rule for a Commonwealth Tier 1 assessment (AFMA 2017) that has also been adopted in the Draft NSW Trawl Whiting Harvest Strategy, an RBC of 2,140 t for 2021 was estimated for the entire eastern Australian stock of Eastern School Whiting, with a long-term yield of 2,448 t, assuming average recruitment into the future. The RBC estimate for the five-fleet model included a larger combined jurisdictional discard estimate of 370 t for 2021, but overall suggested the stock was more productive.

The results of the 25 sensitivity analyses suggested that changes to some of the fixed parameters had a significant influence on the model fits and stock status estimates. Results were particularly sensitive to adjustments in the recruitment steepness parameter, h, natural mortality estimates, M, and the size at 50% maturity, with estimates of spawning stock biomass ranging between 31% and 57% (Day et al. 2020). This range is well above the adopted limit reference point of 20% depletion.

Secondary indicators

- Fishing mortality

The Commonwealth Tier 1 assessment in 2017 estimated an average RBC of 1,615 t for the whole stock for the 3 years from 2018 to 2020 (Day 2017). The total combined catches over this period were 1,970 t in 2017, 1,802 t in 2018 and 1,752 t in 2019 (catch chart). When combined with the weighted average discards (estimated as 103.9 t for the 2018–19 year by the 2017 model, ABARES 2019) the total mortality substantially exceeded the estimated RBC over those three years. Furthermore, the partial update of the assessment in 2019 revised the predicated RBC under an average recruitment scenario to 1,165 t for 2020 (Day 2019).

Results of the updated Commonwealth Tier 1 assessment in 2020 indicated through the spawning potential ratio, that the target fishing mortality had exceeded the target mortality in each of the last 3 years (Day et al. 2020). However, the stock overall was modelled as a more productive system, which increased the estimated RBC for 2021 to 2,140 t, including increased discards of 370 t. Therefore, the current level of fishing pressure is unlikely to exceed this new RBC estimate.

The New South Wales basket TAC was reduced from 1,189 t in 2018-19 to 898 t for the 2019-20 fishing season, and although this was readjusted to 1,066 t for the 2020–21 fishing season, total Eastern School Whiting catches from NSW waters were substantially smaller in 2020 and 2021 at 837.3 t and 505.7 t, respectively.

- Annual total catches and discards in NSW and other jurisdictions

Forward projections in the 2020 Commonwealth Tier 1 assessment to estimate an RBC for Eastern School Whiting assumed a 2020 and 2021 catch equivalent to the 2019 total catch of 1,752 t (combined across all fleets and jurisdictions) (Day et al. 2020). The realised total Eastern School Whiting catch across all jurisdictions in 2020 and 2021 was much lower at 1,414 t and 1,038 t, respectively. Overall, there was a weighted average percent decrease in Eastern School Whiting catches of 29.9% between 2019 and 2021. The model also estimated combined discards of 388 t for 2020 and 370 t for 2021, however, this was based on the assumed higher total catches equivalent to the RBC in each year. Therefore, realised discards may also have been lower than model estimates.

- Proportion of total catch caught by each jurisdiction for each species

The proportion of the total catch taken by NSW fisheries (58%) versus that taken by other jurisdictions (42%) in 2020, differed from that in the previous assessment year, when unusually large catches were being take from NSW waters in the lead up to quota introduction (Fig. 8). However, the percentage breakdown was almost identical to the 10-year average catch breakdown.

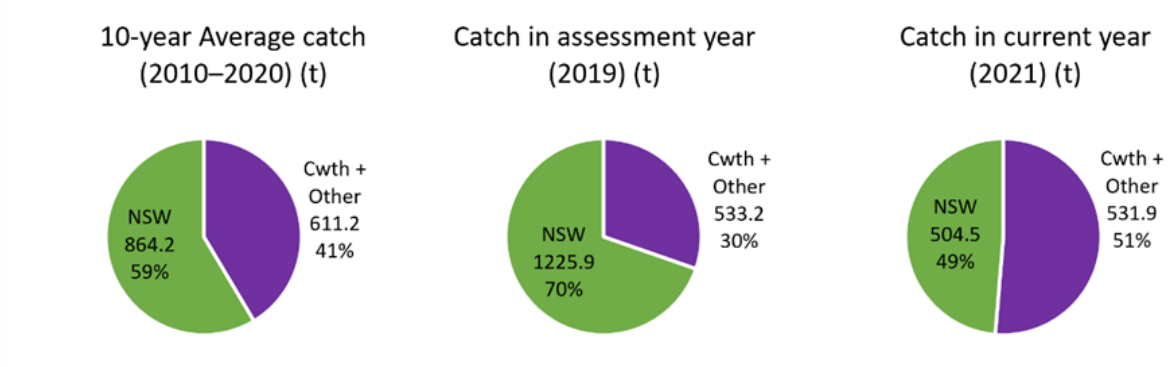

Figure 8 **Breakdown of Eastern School Whiting total catches according to jurisdictions.**

- Species composition of NSW catch relative to predicted species composition from the preliminary TACs

The preliminary TACs for each species used to derive the NSW basket Trawl Whiting TACC of 1,066 t for the 2021-22 fishing season, were reported by the TAF Committee as 217 t of Stout Whiting and 848 t of Eastern School Whiting (NSW TAF Committee 2021). These equate to 20.4%

Stout Whiting and 79.6% of Eastern School Whiting. The species composition of reported landings that was realised during 2021 (after data adjustments in OZ1 and OZ2 for inaccurate species reporting) were 209.9 t (or 29%) of Stout Whiting and 504.5 t (or 71%) of Eastern School Whiting (Figure 16). Therefore, Stout Whiting comprised a greater percentage of the harvest under the combined TAC in 2021 than predicted.

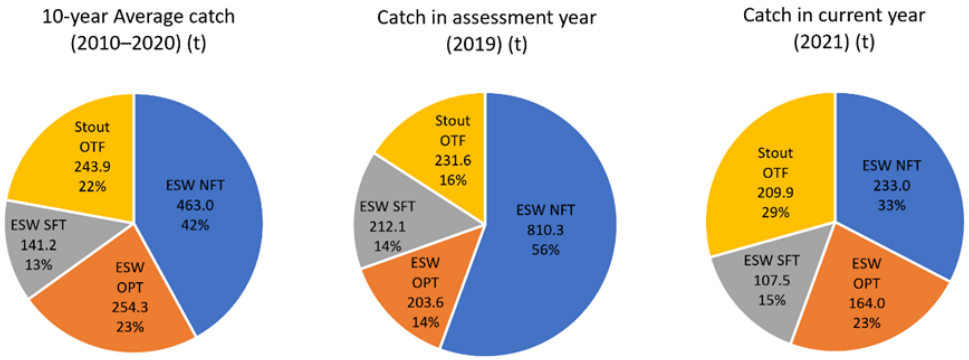

Figure 9 **Breakdown of the NSW Ocean Trawl Fishery commercial catches of Eastern School Whiting (ESW) and Stout Whiting (Stout) according to species and sector. NB: Danish seine catches are included within the Northern Fish Trawl (NFT) and Southern Fish Trawl (SFT) sectors. OPT = Ocean Prawn Trawl.**

- Standardised catch rates by fleet and weighted averages in NSW and in other jurisdictions

Over the last 2 years since the most recent full stock assessment was completed for each stock, catch rates for the NSW prawn trawl fleet were relatively stable, while those of the fish trawl fleet increased by 99%. Overall, there was a weighted average percent increase of 48% in the CPUE indices of NSW Ocean Trawl Fishery sectors that target trawl whiting

- Catch rates for the most recent fishing period relative to projected catch rates from the quantitative stock assessment

Information on projected catch rates were not available from either quantitative stock assessment to inform this current stock assessment. However, as both stocks were estimated to be at around 40% of unfished biomass levels and were to be harvested according to the predicted RBCs to rebuild the stocks towards targets of 48% of unfished biomass, catch rates would be expected to increase over subsequent years. As detailed above, NSW catch rates for Eastern School Whiting in the fish trawl and prawn trawl sectors both increased by 99.4% and 13.1%, respectively. These results suggest that the biomass of Eastern School Whiting may be recovering towards the target; however, there is some regional variation evident.

- Size and age-structure of the catch

No new data on the size and age-structure of the commercial catch of either Eastern School Whiting or Stout Whiting were analysed for the current assessment. Earlier data collated and analysed in 2019, suggested that the mean lengths and size distributions of Eastern School Whiting in recently retained catches, while variable, had not changed significantly from historical catches in the 1950s and 1970s (Hall 2021). Likewise, the age structures determined for recent

samples of Eastern School Whiting collected from observer surveys and port monitoring (2014 to 2019) were very similar to those determined from the chartered prawn trawl survey 10 years before in (2004 to 2006), with most of the fish in the 1 to 4 year old age classes

Stock Assessment Result Summary

Biomass status in relation to Limit	The 2020 five-fleet base-case model estimated that the spawning stock biomass of Eastern School Whiting was at 33% of unfished biomass in 2020 and would recover to 41% in 2021 (with 95% asymptotic intervals of 35–45%), assuming average recruitment (Day et al. 2020). These estimates are well above the nominated limit reference point of 20% of unfished biomass. Updated data from NSW suggest that recent prawn trawl catch rates varied spatially across ocean zones (OZ), so although statewide indices decreased slightly between 2019 and 2021, the preferred index (north of Barrenjoey Point, excluding OZ2) was marginally higher in 2021. Over the same period, NSW fish trawl catch rates showed substantial and consistent increases. Overall, there was a 48% weighted average increase in NSW CPUE indices since 2020. On the basis of the above evidence, the biomass of the Eastern School Whiting stock is unlikely to be recruitment impaired.
Biomass status in relation to Target	The most recent estimate of current spawning stock biomass depletion in 2021 (41% of unfished biomass) suggested that the stock had recovered substantially from the low of 33% of unfished biomass in 2020, but that it was still below the target reference point of 48% of unfished biomass. Model projections under a fixed average recruitment scenario and assuming the full RBC was harvested each year, predicted the spawning stock biomass would approach the target reference point by 2026. However, if a low recruitment scenario prevailed between 2017 and 2023, with average recruitment thereafter, the spawning stock biomass was not expected to reach the target reference point until after 2040 (Day et al. 2020). The increasing catch rate trends across several sectors and spatial zones suggest that the biomass may be increasing towards the target under the current management arrangements.
Fishing mortality in relation to Limit	Results of the updated Commonwealth Tier 1 assessment in 2020 indicated through the spawning potential ratio, that fishing mortality had exceeded the target mortality in the preceding 3 years (Day et al. 2020). However, the stock overall was modelled as a more productive system, which increased the estimated RBC for 2021 from 1,610 t to 2,140 t and the 3-year average to 2,237 t. Estimates of total removals over the last 2 years suggest that the current level of fishing pressure is unlikely to exceed these new RBC estimates.

	The New South Wales basket TAC north of Barrenjoey Point was set at 1,066 t for the 2020–21 and 2022-23 fishing seasons. Over this period Eastern School Whiting catches from NSW waters have decreased from above 1,000 t in the 3 years before quota introduction to 837 t in 2020 and 506 t in 2021. On the basis of the above evidence, the current level of fishing mortality is considered unlikely to cause the biomass to become recruitment impaired.
Fishing mortality in relation to Target	Combined total catches and discards across all jurisdictions in 2020 and 2021 were 1,767 t and 1408 t, respectively, which was well below the estimated three-year average RBC of 2,237 t. Therefore, the current combined level of fishing mortality should permit further rebuilding of the stock towards the target reference point.
Current SAFS stock status	Eastern School Whiting was assessed as a **sustainable stock** under the SAFS framework in 2020 (Hall et al. 2021).
Current Commonwealth stock status	The Commonwealth part of the stock was assessed as **not overfished** and **not subject to overfishing** in 2022 based on the update of the Tier 1 stock assessment in 2020 (Emery et al. 2022).

Fishery interactions

The OTF trawl fishing gears interact with other commercial and non-commercial by-catch marine species, a range of endangered, threatened and/or protected (ETP) species and marine habitats. The OTF share management plan mandates that otter trawl nets must be fitted with at least one BRD of an approved design to reduce the by-catch of small prawns and juvenile fish. Mesh size and other gear restrictions are regulated to increase the target species selectivity of otter trawl and Danish seine nets and cod ends. Research results to date suggest that these measures significantly decrease the levels of by-catch associated with these fishing gears (Broadhurst and Kennelly 1996; Broadhurst et al. 1999 ; Broadhurst et al. 1996 ; Broadhurst et al. 1997; Broadhurst et al. 2006; Broadhurst et al. 2005).

Interactions with animals protected under the *Environment Protection and Biodiversity Conservation Act* 1999 include marine mammals (dolphins, seals and sea lions), seabirds, some shark species, and seahorses and pipefish (sygnathids). The ETP species that interact with the OTF were subjected to a detailed risk assessment in the environmental impact statement (EIS) for the fishery (NSW DPI 2004). All 11 ETP species identified in the EIS were considered to be at moderate/low or low risk. An updated threat and risk assessment for all components of the NSW marine estate was completed in 2017 (Fletcher and Fisk 2017). The OTF was considered a moderate threat to ETP species along the north coast and a low threat to ETP species along the south coast. Interactions with grey nurse sharks and sygnathids were identified as the main concerns.

Compulsory reporting in commercial logbooks of all interactions with ETP species was mandated for the OTF in 2005 and these are reported annually to the Department of Environment and Energy (NSW DPI 2017). Data on incidental interactions with by-catch, ETP species and associated

mortalities were also collected during a recent fish trawl (2014–2016) and prawn trawl (2017–2019) observer surveys.

The majority of available trawl ground in NSW waters is likely to be dominated by sandy habitat with little reef structure, and fishers typically try to avoid high topography, hard, structured habitats to prevent net damage. Large areas within NSW marine parks are closed to trawling and provide areas for habitat protection. The use of bobbins on ground ropes of fish trawl nets is prohibited north of Seal Rocks and the maximum size of bobbins is limited south of Seal Rocks to minimise damage to reef habitats. More information on the potential effects of trawl gears on the soft seabed biota is warranted, as impacts to these less protected habitats are likely to be more significant.

Qualifying Comments

While current stock assessment results indicate no concerns for the current status of the stock, it is pertinent to raise the following issues that should be considered when interpreting these results.

(1) There remains ongoing uncertainty with respect to the species composition of trawl whiting catches in northern and now central NSW, which in turn increases the uncertainty in the data inputs that underpin the current biomass models. Especially given the sudden increase in Stout Whiting catches reported for the fish trawl sector in central NSW in 2020, that are possibly related to greater industry awareness of species reporting issues. Only catches in northern NSW are currently adjusted for inaccurate species reporting and these recent discrepancies suggest that a greater proportion of Stout Whiting may have been previously caught in the central region than reported. This has implications for the accuracy of the catch series for each species used in the current biomass models.

(2) The stock structure of Eastern School Whiting also remains uncertain and some regional variation in indicators is evident. This issue is currently being addressed by an FRDC funded project that is applying modern molecular and otolith chemistry techniques to clarify the stock structure prior to the next update of the Tier 1 Commonwealth assessment.

(3) The latter is especially pertinent given the substantial decline in Danish seine catches off the Victorian coast over many recent years, and any possible longer-term influences of the seismic testing in that region on NSW populations if Eastern School Whiting is determined to be a single biological stock.

(4) The recent increase in frequency of poor recruitment years and their strong influence on spawning stock biomass of Eastern School Whiting is also concerning. The current model predicts that the stock biomass will only increase from 33% in 2020 to 41% in 2021 under an average recruitment scenario and under a low recruitment scenario would not rebuild to target levels until 2040. Current RBC predictions are also based on the stock reaching 41% of unfished biomass by 2021. Fortunately, catches in 2020 and 2021 were well below the estimated RBC, which should help to rebuild the stock further and offset any variation due to poor recruitment.

(5) And last but not least, current discard rates are unquantified and may be in excess of the recent observer survey estimates that were used in the biomass modelling. These were collected prior to quota introduction and anecdotal evidence from fishers suggests that discard rates have changed since then.

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Appendix 1

Reliability and Relevance of the <Commonwealth> Assessment to assessment of stock status in NSW

The principal source of information available to assess the current spawning stock biomass of Eastern School Whiting is the most recent Tier 1 Commonwealth stock assessment (Day et al. 2020). The most recent update of the Commonwealth Tier 1 assessment in 2020 (using data up to and including 2019), developed a five-fleet base-case model that included increased NSW fisheries and biological data, including two CPUE series (fish trawl and prawn trawl indices for north or Barrenjoey Point), lengths, ages and discard rates. Outcomes from this updated assessment are considered particularly relevant for determining the stock status of the NSW part of the stock and informing TAC determination in NSW waters.

Furthermore, NSW prawn trawl and fish trawl catch rates show similar trends to the Commonwealth otter trawl fleet in many years, although during some periods with an apparent 1 or 2-year lag effect. However, neither of the NSW series match the recent gradually declining trend in the Commonwealth Danish seine series (Fig. 10).

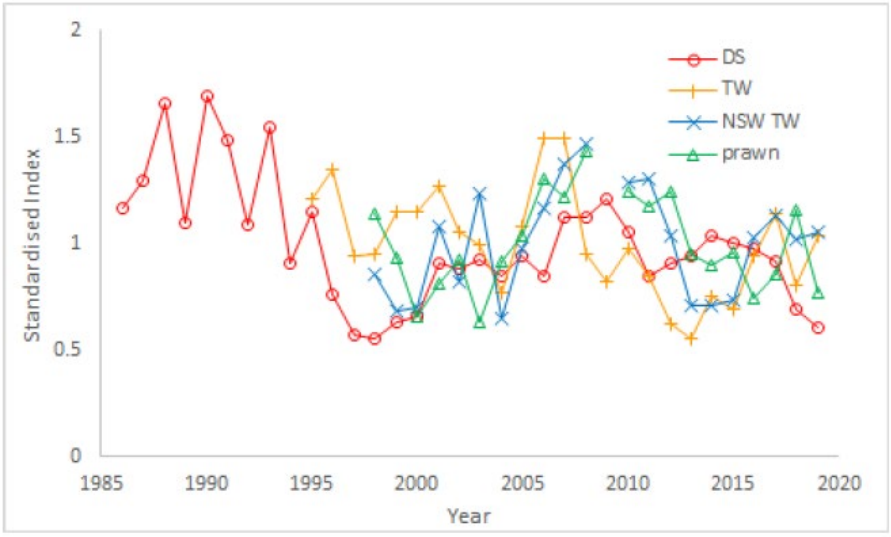

Figure 10 **Standardised annual catch rates (CPUE) of Eastern School Whiting taken by the Commonwealth Danish seine fleet (red) from 1986 to 2019 and otter trawl fleet (orange) fleet from 1995 to 2019. The standardised annual catch rates for the NSW fish trawl (blue) and prawn trawl (green) fleets derived from monthly records between 1998 and 2008 and daily records between 2010 and 2019 are also indicated. All series have been plotted on a normalised scale (mean of each series equals 1) to enable comparison. Figure reproduced from Day et al. (2020).**